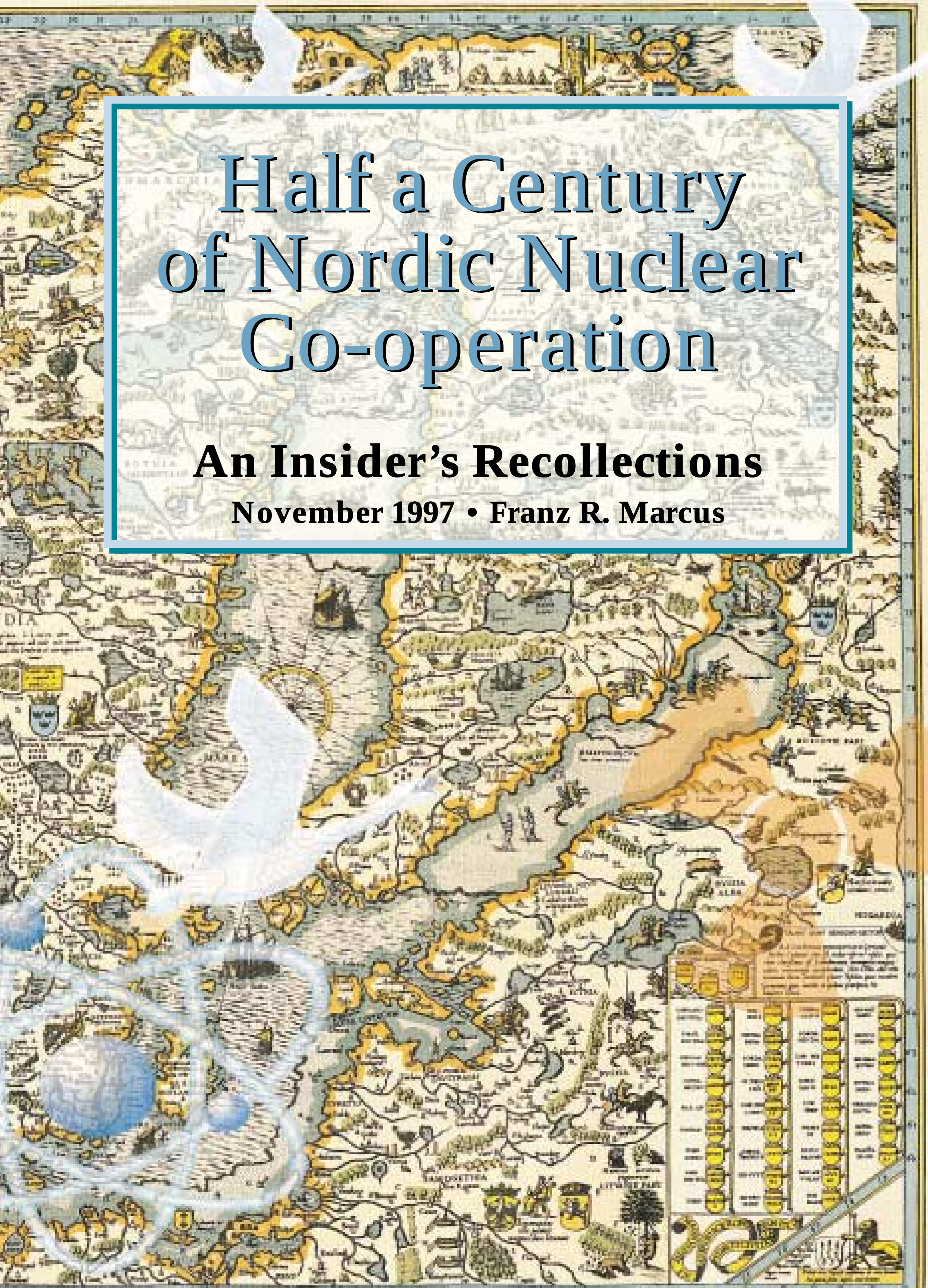
Half a Century of Nordic Nuclear Co-operation

An Insider's Recollections

November 1997 • Franz R. Marcus



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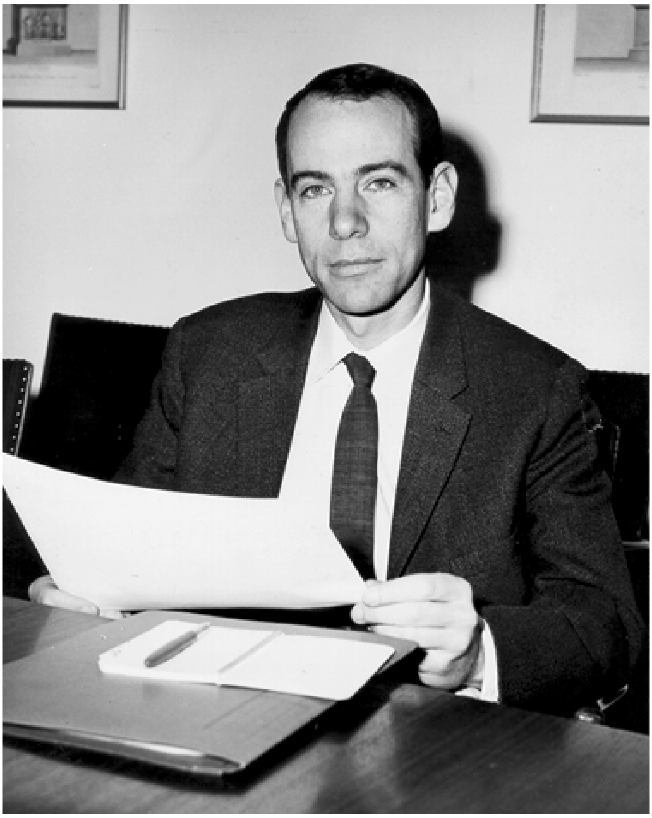

The author taking up his job as a Nordic employee in 1967

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Introduction

Introduction

This is the story of one of the most enduring cases of co-operation among the Nordic countries in any field in the twentieth century. It started after the Second World War and is still continuing as the millennium approaches. The story covers important events that took place in or around the Nordic area and that influenced the development in the nuclear field.

These notes may recall memories for some, or serve as background for later historians who could set this co-operation into the broader context of the overall developments in the Nordic area in the second half of the century. Alternatively, it may provide a source for those who are interested in regional and specifically Nordic co-operation from which to draw some conclusions with respect to their own work.

The story is inevitably seen from the level and through the eyes of the author, whose work involved him closely in organising, promoting and improving this co-operation. There have been successes and disappointments, but the task has never been disagreeable. With very few exceptions, everybody participated with pleasure and met new proposals with a positive and open mind. But individuals have had to act as their organisations, their countries, required.

There are certainly other explanations of the influences that shaped the development of this co-operation over the years. National accounts of the same events which are now being written may shed some more light on the background of individual countries' actions on the Nordic scene. It is the author's hope that this story may help those who are actually engaged in historical research on the origins and development in the nuclear field in the Nordic countries.

No central archive exists for the activities described in the text. It was therefore important to collect this information while it could still be caught.

Four types of source have been used.

Firstly, the minutes of meetings from many of the Nordic groups dealt with in this document, which are filed in various archives in the Nordic countries. Such minutes are not in themselves, however, official documents. They are all in Scandinavian languages.

Secondly, published books, papers and investigations. Some of these are mentioned in the references. Some were issued in different Nordic series, mainly those of the Nordic Council of Ministers.

Thirdly, the author's own notes dotted down in notebooks and on sheets of paper over the years.

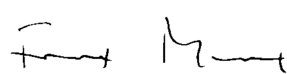
Lastly, personal recollections of the author and of a great number of people he interviewed who have been generous in sharing their recollections with him. Their accounts give some life to the history, but here memory may also have slipped in some cases. In hindsight the past stands in a different light: things can be seen in many ways and errors can be difficult to avoid. The author offers his apologies for any such instances.

The subject of this paper is mainly the organised co-operation between the Nordic countries, as seen through the committees, relations with different authorities and financing bodies. Equally important is direct and non-bureaucratic co-operation among specialists who find advantage in working together. There have long been widespread links of this kind in the Nordic region, but their story does not fit into the frame of the present history.

Many individuals mentioned played a role in Nordic issues, but they are only a few of those who were involved overall. Many other names might as well have been included.

The text was discussed - and subsequently improved - in a meeting in 1997 with some of those who played a role in this story: Bo Aler, Magnus von Bonsdorff, Hans von Bülow, Lennart Hammar, Ilkka Mäkipentti and Nils Godtfred Aamodt. Several others have assisted by reviewing part or all of the text.

The author thanks all those who have helped to make this record as correct and complete as possible at this stage. This of course does not relieve him of his responsibility for the final text. He also extends his thanks to NKS, which made it possible for him to spend time in 1996 and 1997 writing this history.



Risø, November 1997

Nordic names, translations and abbreviations

Nordisk Kontaktorgan for atomenergispørgsmål, NKA

[Nordic Liaison Committee for Atomic Energy]

the *Kontaktorgan*

NKA's kontaktmandsgruppe

[the Contact Persons Group in the *Kontaktorgan*]

the *Contact Group*

Nordisk atomsamarbejdsgruppe

[Nordic Atom Co-operation Group]

NA

Nordiska atomkoordineringskommittéen, NAK

[Nordic Co-ordination Committee for Atomic Energy]

the *Committee*

Nordisk institutchefkomité, NIS

[Nordic Committee of Institute Directors]

the *Directors*

Nordisk arbejdsgruppe for reaktorsikkerhed

[Nordic Working Group on Reactor Safety]

NARS

Nordic Atomic Libraries Joint Secretariat

NALJS

Nordiska kommittén för kärnsäkerhetsforskning

[Nordic Committee for Nuclear Safety Research]

NKS

Nordisk Ministerråd, NMR

[Nordic Council of Ministers]

the *Ministers*

Ämbetsmannakommittén för (industri och) energipolitik, ÄK-E

[Committee of Senior Officials for (Industry and) Energy]

the *Officials*

Myndigheds-cheferne

[the chiefs of the Radiation protection/safety authorities]

the *Chiefs*

Eksekutivsekreteren

[the Secretary-general]

the *Nordic Secretary*

Many abbreviations were used over the years for the various Nordic groups dealt with in this story, such as NKA, NA, NUNA, NAK, NARS, KM, NIS, EK, as well as NKS with all its programme areas

Summary

Half a century of joint Nordic efforts

One of the most long-lasting areas of co-operation among the five Nordic countries[1] has been concerned with nuclear questions. This co-operation is special not only in its duration - half a century - but also in the flexibility of its organisation, which has kept it sustainable while adjusting it to international developments and the changing needs in each of the countries in the Nordic area. Although the development of this co-operation has been shaped by the course of events in each of these countries, it at the same time closely reflects what happened on the international scene.

A schematic view of the evolution of Nordic nuclear co-operation

External influences	Nordic collaboration	Related Nordic factors
	1940	
Atomic bombs over Japan, 1945		
General restrictions on information and nuclear materials		
	Norwegian-Swedish contacts, 1947	
	Scandinavian meetings from 1949	
	1950	
Atmospheric bomb tests		Establishment of Nordic Council, 1952
Atoms for Peace initiative, 1953		
UNSCEAR, 1956		
Suez crisis and awareness of dependence on imported oil, 1956		

[1] Denmark, Finland, Iceland, Norway, Sweden

Foundation of IAEA, ENEA and Euratom, 1957	Foundation of *Kontakt-organ*, 1957 (Liaison committee)	
	1960	
New atmospheric bomb tests, 1961-1962	First meeting of Radiation protection *Chiefs*, 1961	Denmark joins the EEC and Euratom, 1963
First commercial nuclear power plant ordered, 1963 (Oyster Creek, USA)		Realisation of potential for industrial development. Creation of ASEA-Atom in Sweden, 1968
Club of Rome and limits to growth concept, 1968	Co-ordination *Committee*, 1968	Enhanced plans for nuclear power
	NARS, 1969	Attempts to create a Nordic common market (NORDEK), 1968
	1970	
Non-Proliferation Treaty (NPT), 1970		Foundation of Nordic Council of Ministers, 1971
		Nordic Committees of Senior *Officials*, 1972
Energy crisis, 1973		Desire for increased use of nuclear power and search for alternative electricity generation
		Nordic project budget, 1973
Carter INFCE initiative, 1977	*Committee* establishes energy group, 1977	
	Kontaktorgan waste initiatives	
	First NKS programme, 1977-1980	
TMI accident, 1979 Reconsideration of nuclear power		Need to focus on human behaviour factors
Change of public opinion, accident concerns		

	1980	
	Second NKS programme 1981-1985	Diversification from nuclear research
	End of *Committee*, 1982	
Chernobyl accident, 1986	Third NKS programme, 1985-1989	Focus on emergency preparedness
Brundtland report, 1987		Strive for sustainable development and renewable energies
	End of *Kontaktorgan*, 1989	
	Foundation of NKS Consortium, 1989	
	1990	
Fall of the Iron Curtain	Fourth NKS programme, 1990-1993	Opening to the East (Baltic Sea States)
		Fear of accidents and contamination from the East and Northeast
EU enlargement, 1995	Fifth NKS programme, 1994-1997	Finland and Sweden enter the EU

How this intensive co-operation developed and how it was adapted to the radical alterations that necessarily occurred over this long period may serve as an example of how regional co-operation on a sensitive subject can be managed.

The co-operation involved a complex set of activities, evolving from initial exchanges of information and experience among ministries and experts to joint projects - at first with a view to making practical use of atomic energy and later to assuring its safety - to joint interpretation of international recommendations, the establishment of working groups between authorities and the formation of *Nordic groups* that could act jointly vis-à-vis the outside world.

This co-operation was the precursor for many other forms of Nordic collaboration and for a number of years it accounted for a large share of the joint Nordic budget for projects. Its success can be measured in many ways: the practical tools that have been developed, the attainment of national needs, the many first-of-its-kind agreements and above all the enduring personal relationships and networks that have been created.

How it all began

The Second World War left the five Nordic countries in very different conditions. Towards the end of the 1940s, the shock of the destructive powers of atomic bombs that had ended the war was, among some people, transformed into a distant vision of hope for the peaceful use of energy from the splitting of the atom.

An early start

Although nuclear techniques were kept secret by the big powers in order to prevent other countries from developing nuclear arms, both Norway and Sweden managed an early entry into the atomic age without official help from those few countries that then possessed the necessary knowledge and adequate nuclear materials.

In *Sweden* electricity was generated almost entirely from hydropower, and access to cheap energy was seen as a precondition for industrial expansion. Studies of the peaceful uses of atomic energy started with the creation of the shareholding company AB Atomenergi in 1947, which benefited from knowledge gained in defence efforts that had already been set in motion as part of the country's determination to remain neutral. Industry was quite naturally interested in future exploitation of this new technique and joined the new research organisation.

Early developments in *Norway* were driven by farsighted personalities who saw this new energy source as a gleam of light in the nation's recovery after five years of war. The construction in Norway by 1951 of the first reactor outside the pioneer countries USA, UK, Soviet Union and France was made possible by the availability of remaining stock of pre-war heavy water and by uranium from the Netherlands.

This early entry into the nuclear age gave Norway and Sweden leading roles for several years on the international scene.

Denmark was interested in using atomic energy over a broad area of peaceful applications. This was made possible after the USA Atoms for Peace initiative in 1953 and resulted in the creation of an Atomic Energy Commission and a nuclear research centre in 1958. *Finland*'s entry into the nuclear age was tempered by its limited room for action after losing the war with its powerful neighbour, the USSR. An energy commission was set up in 1957 and use was made of research facilities at the University of Technology at Helsinki. *Iceland* was primarily interested in developing its domestic energy sources and envisaged the prospects of using them to produce heavy water, which might become a precious component for nuclear reactors abroad.

Perspectives for co-operation

The long-standing tradition of collaboration among these five northern European countries, with their common history, environment and culture was intensified in the late 1940s, resulting in mutual support at a time when a variety of new international groupings was developing. New Nordic initiatives were taken in many fields, the most spectacular being perhaps the creation of the Scandinavian Airlines Systems (SAS) by three of the countries in 1946. In 1952 an official framework for further Nordic co-operation appeared with the creation of the Nordic Council, an advisory body of parliamentarians where proposals to the five Nordic governments could be promoted.

The practical uses of this new source of energy provided the stimulus for joint activities in the nuclear field, for example with the goal of building the necessary facilities and in order to gain some independence from outside supply.

Early co-operation up to 1957

Contacts on nuclear issues were already taking place in the 1940s between Norway and Sweden as they both headed towards the construction of a reactor. This resulted in some exchange of knowledge, but basically each country was moving independently towards its own goal. However, all five Nordic countries became active participants when the new international organisations were planned in the mid-1950s and contacts among them turned out to be useful. Strong personalities from the Nordic countries were among those pushing for a relaxation of the secrecy surrounding nuclear techniques. It was in Norway that the very first international nuclear conference was organised in 1953, two years ahead of the first of the United Nations' conference on the Peaceful Uses of Atomic Energy (the *Geneva conferences*). Initial thoughts about the necessity of safeguards were also influenced by Nordic attitudes, as was the creation in 1954 of the European Atomic Energy Society (EAES), the 'club' of leading personalities in the nuclear field.

Intensification of efforts in the nuclear field were influenced by a number of events including the Suez crisis in 1956, which highlighted the dependence on imported oil; the radioactive fallout observed in northern Scandinavia following the atmospheric bomb tests in the mid-1950s; and by the negotiations under way between the six countries that created the European Atomic Energy Community (Euratom) in 1957.

The informal contacts that had been promoted by leading figures in the Nordic countries were so positive that in 1956 a group of ministers from the five countries gathered to evaluate the prospects for joint action in this new field. These appeared favourable. They led to three proposals in the Nordic Council, two of them in 1957 and the third in 1959, which resulted in the creation of

- a joint institute for theoretic atomic physics (NORDITA)
- a Liaison Committee to follow the development in the nuclear field (here called the *Kontaktorgan*)
- a Nordic group on radiation protection (later called the *Chiefs* group).

The first formal period of co-operation from 1957 to 1967

The situation in each of the five countries differed considerably when the *Kontaktorgan* held its first meeting in Copenhagen in June 1957. In *Denmark* a nuclear research centre (Risø) was under construction, aimed at providing the country with a basis for multiple practical uses of atomic energy. Nothing similar existed in *Finland*, but here a group of key young individuals was put together to lead the way towards nuclear power, which was seen as essential for the development of industry and forestry. *Norway*, with its well established Institute for Atomic Energy at Kjeller, continued to develop heavy water reactors which were believed to offer an alternative means of propulsion of the large Norwegian merchant marine. In *Sweden* the nuclear research centre (Studsvik) was being extended and had advanced plans for constructing heavy water reactors of industrial size. *Iceland* watched these developments from a distance, while keeping open the option of producing heavy water.

Nordic and international endeavours

Despite these differences, co-operation progressed over a number of fronts simultaneously. The *Kontaktorgan* provided a useful forum for the exchange of thoughts among leading personalities in the nuclear field, appointed by the respective ministries, on both administrative and technical matters. In its meetings, international developments and the Nordic countries' position vis-à-vis new ventures were discussed. Political as well as industrial questions were on the agenda, for example the arrangement whereby the Nordic countries would take it in turns to occupy one seat on the Governing Board of the IAEA, thus securing a continuous Nordic voice in that assembly.

The establishment of the *Kontaktorgan* created the goodwill which facilitated practical co-operation at the level of the research institutes. Many items were examined for possible joint action: the production of radioisotopes for use in industry and medicine; the development of codes to be used in reactor physics for the design of reactor cores and fuel elements; the reprocessing of irradiated fuel so as to separate plutonium and thus ensure independence from foreign supply of nuclear material, etc. Risks related to the use of nuclear power, both terrestrial and maritime, were quickly recognised, and as early as 1963 four of the Nordic countries together with the IAEA entered into an innovative agreement on mutual assistance in case of a radiation emergency.

In addition, the creation by Norway and the Organisation for European Economic Co-operation in 1958 of the international Halden project provided a unique facility in which young engineers from the Nordic countries could participate. This fostered a feeling of Nordic coherence which bore fruit for many years.

Movements on essential fronts: industry, utilities, research

Industrial groups were created in each of the countries to take part in the expected industrial development, for example Finnatom, which managed to obtain several orders for the Swedish plants which were being built. In 1963, Scanatom, under the leadership of the Swedish firm ASEA even made an offer to deliver a power reactor to Pakistan from the Nordic countries. However, this did not materialise, mainly because of failing credits.

Perhaps inspired by the activities of the *Kontaktorgan,* also the major Nordic electricity utilities established their own network for co-operation in 1962, NORDEL, to pave the way for easy exchange of both information and electricity. The national utilities had their own study groups which were impressed by the advances made by the light water reactors that were now being offered commercially at competitive prices in the USA, such as the one at Oyster Creek, ordered in 1963.

The three national research institutes continued their work on heavy water reactors and reinforced each other by entering into agreements on the further development of this type of reactor.

Risks from nuclear activities

A new series of atmospheric bomb tests at the beginning of the 1960s and the need to evaluate safety in view of planned visits by nuclear propelled ships to Nordic harbours, shaped the meetings among those responsible for radiation protection. It was in northern Scandinavia that a food chain was observed where radionuclides from fallout were concentrated in reindeer meat. This led to early Nordic contributions to the work of the United Nations' UNSCEAR committee and of the IAEA. The *Radioactivity in Scandinavia* seminars in the 1960s attracted international interest.

Intensified co-operation from 1967 up to the 1979 TMI accident

Light water reactors were entering the market. The first commercial order for a nuclear power plant in Sweden (Oskarshamn 1) had been placed with ASEA in 1965, a commercial development looked upon with some envy in the other Nordic countries. The research institutes however, continued to follow the heavy water reactor line, which brought them into opposition with the utilities. In a new initiative, ASEA tried to initiate Nordic co-operation in the development of fast breeder reactors, which looked like being the next generation of reactors. Developments on the nuclear scene went so fast in the mid-1960s that the framework for practical Nordic co-operation appeared inadequate. In 1966 the expected impact of nuclear power led to a proposal in the Nordic Council to review the existing co-operation in the framework of the *Kontaktorgan*.

A bright outlook

In view of predicted energy needs, prospects for extended co-operation looked good on several fronts: on the industrial side to cover the domestic Nordic market, in joint research and development efforts, in working out a common approach for approval of nuclear power plants by the safety authorities, and in reviewing the Nordic electricity net to accommodate the predicted considerable number of large generating units.

At the same time as making recommendations along these lines to the Nordic governments, the *Kontaktorgan* looked at the pattern of future co-operation among the research institutions. It outlined four possibilities, ranging from complete integration to the maintenance of only occasional contacts. Following this investigation, a Nordic Co-ordination Committee for Atomic Energy (the *Committee*) was established with leading people from the research institutions. However, this was almost the least ambitious of the four levels. Through an agreement between four of the countries a Nordic working group on reactor safety (*NARS*) was also created with the task of specifying everything that should be documented in a licence application for a nuclear power plant. The position of a Nordic member of the *Committee* was also created (the *Nordic Secretary*) and financed jointly by the four countries to promote practical Nordic co-operation and provide a link between the various circles involved.

A multitude of initiatives

Once established, the *Committee* embarked on initiatives in a great number of different research areas where co-operation seemed warranted. Some were directed towards industrial applications. Thus two large Swedish projects were included as Nordic ventures: the development of a reactor tank of pre-stressed concrete to replace large steel tanks in boiling water reactors, and experimental verification of the flow of coolant (a mixture of water and steam) around fuel elements in reactors. Considerable efforts were also made to improve the tools needed to predict the behaviour of water and steam in a reactor core by developing models for their dynamic behaviour, while other projects were in the field of materials for reactors and fuel elements.

These and many other projects, for example the production of isotopes, were investigated and many projects started, but the research institutes remained largely independent, mainly pursuing their separate national goals.

Integrating all forces?

A more advanced co-operation scheme was considered in 1969 as part of a major attempt to create a Nordic Economic Community (NORDEK). The plan in the nuclear field was to set-up a Nordic reactor vendor to cover a yet to be created home market for nuclear power. The basic discussion was on whether the Swedish company ASEA-Atom, formed in 1968 by combining ASEA's nuclear activities with part of AB Atomenergi, could be converted to a Nordic reactor firm along the same principles as SAS in the air transportation field. This would require the integration of essential parts of the various research institutes to provide efficient support.

Ultimately the negotiations for an SAS-type participation in ASEA-Atom did not work out. The plan for a Nordic Economic Community had to be abandoned in 1970, perhaps because Finland was not able to participate, perhaps because Denmark and Norway were more attracted by possible entry into an enlarged European Common Market. Direct bilateral co-operation in the reactor field did, however, come about when Finnish utilities ordered two reactors from Sweden in the first half of the 1970s. This developed into an extensive area of co-operation which was prosperous for both countries. Another indirect result was the creation of the Norwegian nuclear consulting company Scandpower, which engaged in many Nordic activities over the years.

Establishing long-lasting contacts

The launch of the Ringhals Experience Centre in 1970 within the NORDEL framework was another successful form of Nordic co-operation. Engineers from Nordic utilities got initial training by participating in the planning of this nuclear power complex where several power reactors were to be built. This proved particularly valuable when the first Finnish reactors for the Loviisa site were ordered from the Soviet Union in 1969 and 1972. It also led the *Kontaktorgan* to organise a permanent exchange of information with NORDEL and its relevant committees that were later established, such as the Nuclear Power Committee (later the Thermal Heat Committee). Reliability was the first issue to be taken up jointly.

Another area of successful collaboration developed when plans for computerising library systems gave rise to a Nordic agreement with the US Atomic Energy Commission in 1970. From then on the libraries of the Nordic nuclear research organisations constituted a regional centre for literature in the nuclear field, which greatly facilitated access to the entire corpus of foreign literature on nuclear energy throughout the Nordic countries. The agreement was later extended to cover the whole energy field.

The ministries' own Nordic platform?

In the same year, the *Kontaktorgan* established a permanent *Contact Group* with those members of the national ministries responsible for nuclear questions. This turned out to be a strategically valuable group with members who were instrumental in forming national policies. Together with the *Nordic Secretary*, now officially in charge of *Kontaktorgan* matters, this group generated many new Nordic initiatives that corresponded to actual developments in the various countries. The Nordic countries were active in extending the European Nuclear Agency, following discussions in 1972 in the *Kontaktorgan*, to OECD's Nuclear Energy Agency, and their participation in working groups of the new International Energy Agency were similarly discussed in 1976.

Safety - an obvious area for co-operation

Reactor safety seemed an evident area for co-operation between the research institutes, since they had the theoretical knowledge and the subject matter - by its very nature - was less competitive. They were natural contributors to the development of Nordic requirements for license applications, being undertaken by *NARS*.

The need for large-scale experimental verification of theoretical calculations related to safety was increasingly felt once the large power reactors came on to the market. A Swedish facility for this purpose unexpectedly became available at Marviken in 1971 when it was decided to discontinue the original project for an advanced heavy water reactor. Nordic participation helped to turn this into an international venture. In another project (NORHAV) the research institutes jointly developed a set of analytical tools for the calculation of sequences in reactor accidents. The results were used as input to the large-scale LOFT (Loss Of Fluid Test) experiment of the US Nuclear Regulatory Commission (NRC), in which a *Nordic group* became an important participant in 1976.

New views on reactor safety were aired in the reactor safety study of the NRC (known as the Rasmussen WASH-1400 report) and a simultaneous Swedish study. A Nordic group compared these two investigations in 1974 and was able to notify Rasmussen of certain inconsistencies in his report.

NARS finalised its recommendations about documentation on reactor safety in 1974. It also saw the need for inter-country contacts if a nuclear plant were to be built close to the border of another Nordic country, as had already happened with the Halden reactor and with the planned Barsebäck reactors close to Copenhagen. In the first case an oral agreement for early warning had been made with the Swedish authorities. In the second case consultations between Swedish and Danish authorities had been started as early as 1968 - at a time when it was believed that nuclear power plants could be located close to the centres of cities. Now a general first-of-its-kind Nordic Border Reactor Agreement was worked out giving a neighbouring country the right to prior information and consultations.

External influences

Opposition to nuclear power emerged in the Nordic countries in the early 1970s, mainly spread from the USA but reinforced by sequels to the youth uprising of 1968 and perhaps influenced by the report *A limit to growth* of the Club of Rome in the same year. This indirectly led authorities and research organisations to focus more on safety and waste issues, where the latter had been considered a purely technical question for which a solution was being developed as for any other technical matter.

On the international scene people from the Nordic countries were active in developing a shift from bilateral safeguards agreements with countries supplying nuclear materials towards a more general IAEA regime, and in the planning of the Non-Proliferation Treaty (NPT) in 1970.

Only Denmark finally joined the Common Market and Euratom in 1973, but this did not reduce the Danes' involvement in Nordic ventures. In fact, much of the project work related to Euratom could be combined with Nordic projects, so that know-how passed in both directions.

Nuclear energy to replace oil imports?

Views on nuclear energy were profoundly influenced by the energy crisis in 1973. On the one hand the responsible Nordic ministers declared their willingness to consider increasing nuclear power generation, provided its safety could be guaranteed, in order to reduce dependence on oil for electricity production. On the other hand, research into other energy sources and ways of energy savings was now promoted and an attempt was made to establish a new Nordic set-up similar to the activities that had been successfully managed by the *Kontaktorgan* for more than fifteen years. The consequence was that the new field of energy research began to compete with nuclear research at a time when resistance to nuclear technology was rising.

Six power reactors were in operation in Sweden in 1973 and planning for six others was more or less advanced. Four reactors had been ordered in Finland, including two from Sweden. In Denmark and Norway plans were to introduce nuclear power in the first half of the 1980s.

A new Nordic authority

Based on the foundered NORDEK plan for economic co-operation and as a sort of compensation, a Nordic Council of Ministers was created in 1971. It was endowed with a secretariat in 1972 and a budget for Nordic projects which was administered by committees of Senior Officials (the *Officials*) in various sectors. Energy policies and ministries responsible for energy questions now existed in all countries and, following the energy crisis, the ministers for industry actively promoted energy research, also including nuclear questions.

In order to avoid possible rivalry between the *Kontaktorgan* and the new *Officials*, an attempt was made by Sweden in 1975 to transform the *Kontaktorgan* into a Nordic committee for energy questions. The Finns agreed but the plan did not succeed, partly because the Norwegians did not want any changes until their new Ministry for Petroleum and Energy had been set up in 1978, partly because those responsible for nuclear questions preferred to preserve their own discussion forum.

A new basis for safety research

In view of the need to assure the safety of an extended use of nuclear power and following the creation of a Nordic project budget, the *Kontaktorgan* established an ad hoc committee on nuclear safety research (*NKS*) in 1975 to prepare a research programme which would take up current safety issues. In practice it took until 1977 before project work could start and then only with a small sum of money reluctantly accorded from the Nordic budget.

A formalised structure was laid down for the NKS programme with steering groups, host organisations taking over responsibility for project funds, and project leaders for the professional management, all co-ordinated by the *Kontaktorgan*, its *Contact Group* and the *Nordic Secretary*. Care was taken to distribute the positions on the various new committees equally among the four Nordic countries. Participating organisations were asked to make contributions (mainly in-kind) to a level at least corresponding to the Nordic financing.

In the following years the NKS programme enjoyed considerable goodwill and its budgets increased to such an extent that the *Kontaktorgan* was soon the biggest consumer of funds from the Nordic project budget. At that time not many other Nordic groups could present comprehensive project proposals in fields that were of current interest to all the countries.

The *management of radioactive waste* had recently attracted public interest. Opponents of nuclear power argued that the waste question had not been - and never could be - solved. Waste questions were therefore included in the NKS programme. This programme also incorporated work on *quality assurance*, which was particularly important for the utilities engaged in reactor construction. New thinking about the design of *control rooms* was taken up in view of the great responsibility carried by operators of nuclear power plants which has to be operated from a central location. *Radioecology* was included in the programme in view of the importance of measurements of possible releases from nuclear installations. A positive gain in this connection was the resumption in a new form of the broad contacts created in the 1960s through seminars about radioactivity in the Nordic region.

Alternative energies?

The nuclear research institutions were slowly moving towards general energy research with Studsvik leading the way in co-operation with the multi-sector Finnish VTT organisation, although the institutes' main tasks were still in the nuclear area. The *Committee* established its own energy group in 1977, thinking that the research institutes would thereby obtain a share of the budget of the newly established Nordic Industrial Fund. However, they were up against serious competition and in the meantime the *Officials* dealing with energy questions started managing its own projects and did not favour the nuclear research institutes for such tasks. Thus, when a project concerning the environmental effects of various forms of electricity production was started by the *Committee*'s energy group, it was questioned whether such a study could be regarded as impartial in view of the group's affiliation to nuclear institutions.

An attempt was also made to rename the *Committee* so that it reflected the emphasis it now put on energy matters.

Solve the waste question!

The growing opposition to nuclear power resulted in the Swedish Stipulation Law of 1977, according to which waste questions had to be safely resolved before any of the six new reactors could be taken into operation. This was at the time when the American President Jimmy Carter was starting the International Fuel Cycle Evaluation (INFCE) with the ultimate aim of excluding plutonium from appearing in the nuclear fuel cycle. Four of the Nordic countries participated in this evaluation. The Swedish utilities created a new company SKBF (later changed to SKB) to demonstrate that highly radioactive waste could be safely disposed of in Swedish bedrock. SKBF became an important partner for waste groups in the other Nordic countries, e.g. for Danish investigations of the feasibility of salt domes for the final disposal of highly radioactive waste. The Swedish safety authorities accepted the first SKBF report in March 1979 - the night before the accident at the Three Mile Island (TMI) reactor in Harrisburg in the USA!

From Three Mile Island 1979 to Chernobyl 1986

The TMI accident changed the attitude to nuclear power in all the Nordic countries. Evaluations of safety and waste questions continued, but Danish and Norwegian politicians were less interested in the outcome of these evaluations than in popular opposition to nuclear energy. In Norway a decision to abandon nuclear power at least "until the end of the current century" was taken in 1980, while in

Denmark it was not until 1985 that domestic nuclear power "with the present reactor technology" was eliminated from energy planning. In Sweden, on the other hand, a referendum in 1980 prompted by the accident was planned in a sophisticated way and resulted in a parliamentary approval to add the last six reactors, provided that the Stipulation Law could be satisfied.

The Nordic electricity supply network had been tied together with many transfer lines on the recommendation of NORDEL. Once the last Swedish reactors came into operation, the 16 reactors on the Nordic grid represented one quarter of the total electricity generating capacity of the four countries involved.

New trends in research co-operation

Co-operation between the research institutes did continue in the nuclear field, partly in the framework of the NKS programme where considerable financing became available (a total of NOK 27 million - around ECU 4 million - for the First programme 1977-80), partly in specialised groups such as those on atmospheric dispersion and dose calculation, or on the behaviour of fuel elements. Waste questions were discussed in a new Nordic *waste contact forum*, first organised in 1982, which permitted practically all those involved in waste research in the Nordic countries to come together to give a short, concise overview of their ongoing activities.

The *Directors* of the four national research organisations had reorganised and simplified their joint activities in 1977 in view of the planned NKS programme. In 1982 they decided to discontinue the *Committee* and to try a new approach to co-operation. Thus in their own meetings, they investigated whether the four institutes could divide some major tasks between themselves so that each of them would specialise in one particular field such as wind energy, offshore oil technology, or combustion techniques. But none of the institutes wanted to lose their domestic customers, so this attempt again failed. The *Directors* continued their meetings for many years however, exchanging experience on the management of their institutes, even in a period when nuclear questions were becoming of secondary interest.

Much of the experience built up at the nuclear research institutes in Denmark, Norway and Sweden could also be used in other fields. Finland's VTT had in any case always covered a much wider field. Norway took the lead in applying knowledge about corrosion and flow of liquid/gas mixtures in the new offshore oil and gas industry. All three institutes changed their names and objectives in the decade following TMI, but it took a long time before it was generally realised that they had changed emphasis, especially in Denmark.

Related Nordic initiatives

The *Kontaktorgan* engaged in several activities other than NKS work. On a Finnish initiative, a working group produced a report in 1983 recommending that non-technical obstacles that might complicate the transfer between the Nordic countries of nuclear material, including waste, should be removed in advance. This was not followed up in practice and the countries never officially investigated the possibility of a joint waste repository in one of the Nordic countries. On the contrary, they supported the Swedish position that every country should take care of its own nuclear waste, regardless of how small the quantities are, or of possible differences in their potential for disposal.

Independent nuclear safety inspectorates had been created in the 1970s and reinforced after the Three Mile Island accident. They participated in the *Kontaktorgan*'s activities, where they made sure that their regulatory function was not affected. They also held yearly Nordic meetings with the radiation protection authorities (the *Chiefs* group) who themselves had a network of Nordic groups. The Nordic transport group, originally created by NKS, was subsequently taken over by the authorities and continued to develop Nordic positions on international transport regulations.

Safety research in the energy production field

A Second NKS programme was launched in 1980. Following evaluation of the First programme it was clear that projects should either provide a generic build-up of competence, or be aimed at clearly defined technical results. Since it was also considered that results had not been disseminated widely enough, project leaders were thereafter asked for final reports and a system was worked out to reach targeted groups of readers.

The Second NKS programme (1981-1985) was influenced by the experience from the Three Mile Island accident and included a programme on the *reliability of operators* faced with crisis situations in a control room, and a programme on *reactor safety* with a first project on probabilistic methods. The title of this Second NKS programme was *Safety Research in the Energy Production Field*, indicating the endeavour to transfer methods developed in the nuclear field to other industries. The other programme areas were again on *waste management*, on *radioecology*, and a not very successful attempt to transfer knowledge from the previous *quality assurance* programme to other risk-prone industries. Some international projects launched from Sweden were also included in the programme to help them in their start-up phase.

A separate set of projects concerning the environmental effects of energy production was also worked out, but the *Kontaktorgan* decided that this was outside its domain and turned it over to the Environment *Officials*. The Second NKS programme came to an end in 1985 with 17 final reports and an impressive number of Nordic seminars. Almost 26 million Kroner[1] (ECU 4 million) had been awarded by the *Ministers*, and the *Kontaktorgan* was still the biggest item on their project budget.

Much detailed work had been done in many areas, but in the evaluation it was recommended that future work should concentrate on fewer topics where a firm basis could be provided by national institutions to assure their actual interest.

The annual sessions of the Nordic Council were opportunities for opponents to attack the safety of nuclear power. They used these occasions to criticise the *Kontaktorgan* activities and to challenge the relatively large amounts of money set aside for *NKS* from the Nordic project budget.

For the *Ministers* it was still important that NKS' results could be used also in non-nuclear fields. It was in this spirit that the Third NKS programme, which started in 1985, included a programme area on *risk analysis and safety philosophy* and another on *radioactive releases from a reactor core and their dispersion and environmental impact*. Both turned out to be relevant when the Chernobyl accident occurred in 1986. Probabilistic safety methods were one area of development, although these met with some scepticism from those engaged in risk philosophy. The other programme areas were on *radioactive waste management*, advanced *information technology* and, for the first time, *materials research*.

Almost 30 million Kroner (ECU 5 million) were allotted for the Third programme 1985-1989, but now there was real competition for Nordic project money and the *Ministers*' bureaucracy with their many *Officials* complicated management. In this Third programme a more stringent distinction was made in the steering groups between executing bodies and those ordering and using the outcome of the work. This in a certain sense reduced the influence of the research institutes and increased that of the authorities, who were one important target group for the research results.

The evaluators of the Third NKS programme found that it had been useful in improving a basic understanding of safety in a wide sense. They underlined the particular situation of nuclear plants, where safety is extended to protecting not only

[1] Kroner as used here encompass an average value of Nordic currencies

the installation itself and its staff but also the general public and the environment, contrary to what had so far been required from conventional industries.

The influence of Chernobyl 1986 - 1997

The Chernobyl accident in 1986 shocked the world, and it had both an immediate and a long-term influence on Nordic co-operation. In the short term, the personal contacts which had been built up at many levels over so many years of joint work, and the feeling of closeness and trust among people in the Nordic area were of great value. These contacts were used to the fullest extent possible in the time available in view of the pressing domestic tasks at hand, particularly in informing the populations of possible risks arising from the accident.

Nordic initiatives after Chernobyl

The *Kontaktorgan* as such was not geared to react to this type of challenge and a number of other Nordic groups suddenly seemed to take responsibility for questions related to nuclear matters. Numerous Nordic meetings and conferences were arranged, but when the *Contact Group* proposed a Nordic seminar on issues related to the accident it was met with reservations. Finally the *Nordic Secretary* was authorised to organise a seminar at expert level, expressly on behalf of the environmental and radiation protection authorities. This seminar was held in November 1986 and was an important step in defining fields where action had become vital after the accident. In a longer perspective the conclusions from this seminar formed the basis for future NKS activities.

Several new proposals for Nordic project work were worked out in the months following the accident. One was to test models for calculating long-range dispersion of a radioactive release by using measured values after releases from Chernobyl (the TRANSAM project). Another was related to routine measurement of airborne radioactivity and transfer of measured values between countries (the VAR project). However, no money was found for these projects. The IAEA and the European Commission later took up the TRANSAM concept. The ideas of the VAR project were carried over to subsequent NKS programmes after 1990.

Radioecology had been dropped from the Third NKS programme because of the low concentrations remaining from fallout after the atmospheric bomb tests. After the Chernobyl accident attempts were made to revive Nordic radioecology activities, especially because a new generation of radioecologists had suddenly appeared after Chernobyl, mainly in Norway, and they had no knowledge of the experience already built up through many years of work in the Nordic countries. It was not until the Fourth NKS programme in 1990 that these attempts were successful.

Changing views on co-operation

Increasing resistance to the *Kontaktorgan*'s activities appeared in some anti-nuclear circles following Chernobyl. Lack of confidence was expressed by members of the Nordic Council although this in fact emanated from those who were already persuaded that nuclear power should be phased out and be replaced by renewable forms of energy. They considered the *Kontaktorgan* as favouring nuclear power and its NKS programme was accused of consuming an unreasonable share of the Nordic project budget.

In 1987, *NKS* commissioned a report on the future of its activities from one of the Norwegian 'grand old men' familiar with its field. This was partly a move to counterbalance a suggestion by the *Ministers* who had wanted an external evaluation of the *Kontaktorgan*'s activities. The report recommended that there should be a new NKS programme, but that it should be distinctly influenced by the situation after Chernobyl, i.e. related to possible risks in nuclear installations, and cover all aspects from the technological level to accidents and their consequences for humans and the environment.

While this report was commissioned by the *Kontaktorgan* itself, the same year the Environment *Ministers* asked its Nordic secretariat to establish an external expert group to review work in the field of radiation protection, emergency provision, mutual assistance, safety and other questions, including research. The outcome of this report was also positive for continued work in the NKS framework.

Was the *Kontaktorgan* still justified?

The meetings of the *Kontaktorgan* changed character with time. A new generation of civil servants dealt with nuclear questions at the ministries, both those engaged in international relations and in energy questions, and for them Nordic co-operation was just one aspect among many others. They had also other occasions to meet. Meetings in the *Kontaktorgan* were for information only, real decisions never being taken except those concerned with the NKS work, although the informal exchange of view concerning international matters were still valuable for the participants. Also the fact that sometimes the Nordic countries now took opposite stands in international fora did not promote positive attitudes towards the *Kontaktorgan*.

The attacks on the *Kontaktorgan* continued in the following years. It was discovered that there had never been formal statutes for the *Kontaktorgan* although it administered programmes financed by Nordic funds. Those responsible for *Kontaktorgan* activities in the ministries became prudent in order to avoid being subjected to justified attacks. This was clearly felt in the daily work, especially in the *Contact Group* where Swedish caution was particularly evident.

It took a great deal of efforts to formulate statutes that could be agreed by all parties. The text then had to be accepted by the ministers and reported to the Nordic Council. Statutes were finally approved in June 1987 for the *Kontaktorgan* which had in fact been in existence since 1957.

Our common future

Fear of exhausting the planet's resources and deteriorating the environment became a leading theme in public affairs and political parties in the late 1980s. The report *Our Common Future* (the Brundtland report) did not regard nuclear power as a feasible contributor to sustainable development. Danish anti-nuclear politicians were eager followers of these ideas and refused to sanction continued Nordic financing of the four-year NKS programmes. But the Swedes countered this attitude; to them the NKS programme was valuable and in fact the essential part of *Kontaktorgan* activities. In 1989 it became clear that the Danes would not agree to a Fourth NKS programme being financed from the Nordic budget. This prompted Sweden to withdraw from the work of the *Kontaktorgan*.

The end of an era

The statutes were abolished in November 1989, two and a half years after they had come into force. This meant in practice that regular *Kontaktorgan* activities ended with its 68th meeting in Helsinki in October 1990, thirty-three years after they began.

A number of final activities carried on, however, even after the dissolution of the *Kontaktorgan*. A Nordic *Information Contact Forum* met for the first time in 1988 and discussed ways of improving information channels both to the public and between the national authorities. This was to avoid a repetition of the Chernobyl situation when public faith in the responsible authorities had been impaired by the dissimilar information and countermeasures promulgated in the different countries. Contacts were now improved and meetings of this *Contact Forum* were arranged several times in the 1990s in conjunction with corresponding NKS activities.

The *Kontaktorgan* had drawn attention to the serious need to upgrade competence so as to compensate for the great number of experts who were reaching retirement age. The forthcoming NKS programme, with its project work and emergency drills, was intended to improve that situation.

A third initiative was the exchange of information about *Euratom* in a period where Finland, Norway and Sweden were considering membership.

In 1990 a *Nordic Society for Safeguards* was also proposed to improve understanding among people routinely involved in international non-proliferation matters and those who keep daily account of safeguards or who conduct safeguards research. Although the Society did not obtain formal status (perhaps in view of the existence of relevant Euratom activities), Nordic meetings on safeguards had their purpose and did continue.

Contacts on international topics between Nordic participants also continued, in particular regarding IAEA matters, but surprisingly less so in relation to European Union questions once Finland and Sweden became members in 1995. However, on occasions when Nordic members of the EU developed differing attitudes towards nuclear matters, the close relations between their ministries were not hampered, all still having similar concerns for global safety and security.

New responsibilities for safety research

Even though the Swedish Government withdrew from the *Kontaktorgan*, it still instructed Swedish authorities to prepare and partly finance continued Nordic project work in the framework of NKS. A plan for a new Consortium funded by the five Nordic countries was developed in 1989. Financing from the three countries without nuclear power initially seemed to pose a problem, since they had no national funds from which the programme could be funded. Thanks to dedicated individuals from ministries and authorities in these countries however, sufficient national contributions to the joint basic financing was provided, thus permitting all five countries to join the new Consortium.

The Fourth NKS programme lasted from 1990 to 1994 and for the first time it included a programme on *emergency provisions*, which together with *radioecology* took up many of the problems raised after the Chernobyl accident. Other programme areas were *waste management* and *reactor safety*. During this period a succession of young participants joined in the process and in 1994 a new Secretary-general was engaged to replace the original *Nordic Secretary*, who had been active since 1967. Reference groups and co-ordinators were appointed for each of the four programme areas, while the *NKS* group had the overall management of the programme on behalf of the Consortium. Since the basic contributions now came from each of the countries, a new accounting system was created with NKS bank accounts in individual countries. Iceland, which up to the 1980s had rarely been involved in project work was now fully engaged in NKS. Additional sponsors were solicited, who contributed around one tenth of the basic financing of the programme.

When the Fourth NKS programme was evaluated in 1994 it was found that many of its results had in fact been of practical interest for the authorities, for example those related to radioactivity in foodstuffs, or maintenance routines in nuclear power plants.

After the disappearance of the Iron Curtain

In the early 1990s direct contact with nuclear installations in the former Soviet republics became possible. Several installations were understood to provide a threat to the Nordic area, in particular the reactors at Ignalina in Lithuania, the Russian reactors near Saint Petersburg and on the Kola Peninsula, and military facilities at Murmansk and in the Arctic Sea. Although there was no mechanism (or no wish) to organise joint Nordic assistance programmes, information contacts were organised and a certain division of tasks agreed. All the Nordic countries participated in the *Working Group on Nuclear and Radiation Safety* of the Commission of Baltic Sea States.

Preparations for the Fifth NKS programme started in 1993. The possibility of involving the Baltic countries was considered but rejected on the grounds that direct involvement would hamper the uncomplicated nature of Nordic co-operation, with its preferential use of national languages. Instead it was decided to involve Baltic people in specific tasks rather than in the whole programme.

A young crew

The Fifth NKS programme started in 1994. This time all the project leaders came from the younger generation and half of them were female. An attempt was made to combine radioecology with emergency provisions in one *environmental* programme, but although it was expected that the end-users of the results would be identical, it turned out that the projects were too specific to generate mutual interest. In spite of initial difficulties in defining its contents, there was yet another *waste* programme and a large programme on strategies for *reactor safety* and severe accident phenomena.

Projects on information were now given a more important role. The extent to which contacts were actually taken between Nordic authorities was checked during international emergency drills. In 1995 a field test of measuring devices for radioactivity was arranged; this turned out to be so interesting that it was accepted for repetition on a larger scale in the EU Framework Programme in 1998.

Once Finland and Sweden joined the EU it was natural that consideration should be given to establishing a closer relationship between future NKS work and EU Framework Programmes. Informal contacts were arranged from 1995 to find ways of using Nordic project work in the wider EU context, for example through pilot projects such as that on field measurements, or through work on specific questions related to reactor safety.

Concluding remarks

Fifty years of co-operation in the nuclear field between the five Nordic countries have resulted in a great number of achievements, partly professional, partly through the common understanding that has been fostered through close contacts on many levels in the countries. This example of the Nordic *sense of fellowship* demonstrates how far it is possible to go with informal but steered arrangements and with a flexibility that permits steady adaptation to outside evolution.

Nordic co-operation has also had a considerable international impact. Many concepts and initiatives advanced by these countries in international fora have been based on the solid foundation created by discussions and common understanding at the Nordic level.

Developments in the Nordic countries and in their co-operation reflect all those external factors that have influenced the international nuclear scene: initial secrecy after the war, opening up of the knowledge, the years of optimism, the fight against misuse of nuclear material, industrial possibilities, slowly rising mistrust, the energy crisis, North Sea oil and gas finds, the two accidents and their reversal of attitudes, diminishing industrial prospects, rising environmental awareness and, finally the disappearance of the Iron Curtain.

1. The early days, up to 1957

1.1 The international background

After the Second World War, atomic energy appeared to offer a new and unlimited source of energy for the future. It was also seen as a key to scientific advancement in a wide range of fields such as medicine, industry and research. In the process of recovery after the war a direct connection between energy production and prosperity was identified. In all the Nordic countries this question became a main focus although little progress could be made as long as essential information about atomic energy remained classified and access to the necessary materials was restricted. Fear of the proliferation of nuclear weapons technology, reinforced by the race towards the H-bomb in the 1950s, meant that absolute priority was given to the control of nuclear technology, material and equipment.

It was only after President Eisenhower's Atoms for Peace address to the United Nations in 1953 and the *Geneva Conferences* on the Peaceful Uses of Atomic Energy in 1955 and 1958 that knowledge of atomic energy became officially available. The first Geneva Conference also showed that the development of atomic energy involved problems of such size and complexity that international co-operation would be required to solve them.

The founding of the International Atomic Energy Agency (IAEA) in 1957 was intended to secure the provision of uranium for peaceful uses and at the same time prevent the use of atomic energy for military purposes. However, for many years the trade in fissionable or other special nuclear material and all nuclear technology was governed by bilateral agreements between a nuclear supplier country and a receiver country, such as the Nordic countries. The supplier country - in practice the USA or the Soviet Union - retained the right to safeguard both the nuclear material and technology thus delivered. This remained the case until the beginning of the 1970s and the signing of the Non-Proliferation Treaty (NPT) and safeguards agreements with the IAEA.

Any country that wanted to develop its own atomic energy thus had to acquire - or to produce - the necessary know-how and the special materials needed. Heavy water and natural uranium were within the reach of some countries and determined the choice of early reactor concepts.

1.2 Early developments in the Nordic countries

After the Second World War, the individual Nordic countries[1] were in quite different situations. Iceland had just established its independence from Denmark which, together with Norway, had been occupied by Germany. Both Denmark and Norway joined the North Atlantic Treaty Organisation (NATO) at its creation in 1949, after Nordic thoughts about a defence union had failed. Finland was rebuilding the country after the war and was heavily committed to war reparations to the Soviet Union. Sweden, centrally positioned between the main power blocs, was determined to continue the strong defence of its neutrality. All the countries needed to rebuild their economies and stimulate industrial growth.

Denmark, Finland and Sweden were heavily dependent on imported oil and coal, with nuclear energy only a distant possibility. Although atomic questions immediately following the war necessarily covered both defensive and peaceful applications, the overriding emphasis in the Nordic countries was on peaceful uses of atomic energy.

Two of the Nordic countries (Norway and Sweden) managed to embark on domestic programmes as early as the 1940s, despite the difficulty in obtaining secret information. In the mid-1950s Denmark decided to explore the use of atomic energy in science and technology. Atomic questions did not become an issue in Finland until a few years later and then with the distant goal of providing the country's own nuclear power generation.

Norway, where plans had been developed since 1946, was the first to build its own reactor. This was made possible by a remaining pre-war stock of heavy water and by uranium hidden in the Netherlands. It also managed to obtain certain information from the USA. After some discussion it was decided that the civil rather than the military authorities should direct atomic energy research and the Institute for Atomic Energy (**IFA**) was created at the beginning of 1948. Three years later, in March 1951, a Dutch-Norwegian Joint Establishment for Nuclear Energy Research (JENER) was created at the Kjeller site near Oslo. The initiative for these activities came from Gunnar Randers, who later played an important role in the field of peaceful nuclear energy through the creation of international collaborative ventures.

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[1] The five countries Denmark, Iceland, Finland, Norway and Sweden had a total of 18 million inhabitants at that time. Today that figure is almost 24 million. Together with the three regions of Greenland, Faroe Islands and Åland, they constitute the *Nordic countries*, sometimes called Scandinavia, although this term in fact only covers mainland Denmark, Norway and Sweden

Queen Juliana arriving at Kjeller to visit the Joint Establishment Experimental Pile (the JEEP reactor), which had been inaugurated in 1951, next to Gunnar Randers. Behind: Prince Bernhard and Jens Chr. Hauge; King Olav and Odd Dahl

In *Sweden* nuclear activities were promoted by the future Prime Minister, Tage Erlander. As early as November 1945 he established an Atomic Energy Commission. The creation of Aktiebolaget Atomenergi (**AE**) dedicated to the peaceful use of nuclear technology, followed two years later. Taking over key personnel from the defence organisation in 1950, this became the national nuclear organisation, later located at **Studsvik**, south of Stockholm. Sweden was able to acquire uranium from France in 1950 and heavy water from Norway for its first reactor, the R1 research reactor, which was built underground at the Royal Institute of Technology in Stockholm under the leadership of AE director Sigvard Eklund and began operating in 1954.

This was at a time of rapid expansion in Swedish industry. The government recognised the need to keep up with the expected high energy demands, and it was also determined to continue its policy of neutrality between the main blocs. The logical consequence of these imperatives was the development of an independent supply of energy, especially when the Suez crisis in 1956 resulted in sky-high oil prices. The *Swedish line* was therefore based on the use of natural uranium from domestic sources in combination with heavy water, to leave the way open both for independence of supply and for defence applications. A decision on military use was never taken and the question lost its relevance in the early 1960s. Sweden became deeply engaged in the negotiations on the Non-Proliferation Treaty which came into force in 1970 (page 89), signing it in 1968.

The third country to embark on nuclear activities was *Denmark*. In 1955, based on a report from a committee chaired by Nobel Prize laureate Niels Bohr, the government set up an Atomic Energy Commission (**AEK**) with the purpose of furthering the peaceful use of atomic energy for the benefit of the Danish community. A nuclear research centre was inaugurated at **Risø** east of Copenhagen in 1958, equipped with a large number of specialised laboratories. A small training reactor and two research reactors, all with enriched uranium, were ordered, the first two from the USA in 1956 and the third and largest from the UK in 1957. Although the eventual aim of using atomic energy to generate electricity was a major political motivation behind the establishment of Risø, no power plants were actually planned since electricity supply was an entirely private industry and economically viable nuclear power was not yet in sight. However, plans for uranium prospecting in Greenland were developed. Risø engaged in a wide range of research, including reactor studies and prepared for active participation in international ventures.

In *Finland* a committee examined future energy needs in 1956 and recommended the establishment of an Atomic Energy Commission, which was appointed in 1957 as an advisory body to the Ministry of Trade and Industry. The first actions proposed for the future use of atomic energy was the creation of education possibilities, which was regarded as a key issue. For this end, Finland already in 1956 managed to order natural uranium from the Soviet Union via the IAEA for an experimental zero-energy device. After the second Geneva Conference in 1958 Finland purchased a TRIGA research reactor from the USA, also via the IAEA, to start operation in 1962. By going through the IAEA, Finland avoided being linked to any of the big blocs. On the initiative of Erkki Laurila, it was decided not to create a separate nuclear research centre but to make use of facilities at the University of Technology at Otaniemi near Helsinki. Training activities in conjunction with various aspects of Nordic co-operation appeared a fruitful way to create a generation of young people who could later run a nuclear scheme.

Iceland had no need of nuclear power, but investigations had been undertaken since 1949 into the use of domestic energy sources for the production of heavy water. In 1956 a Nuclear Science Commission was set up under Magnús Magnússon. After the first Geneva Conference the Organisation for European Economic Co-operation (OEEC) took up the question of heavy water production (page 46) which was of great interest to Iceland in view of expected large-scale needs for emerging reactor projects.

Each of the five Nordic countries thus entered the nuclear era with its own interests, ambitions and limitations.

1.3 Early Nordic co-operation

Throughout the Nordic countries there were numerous informal contacts based on personal initiatives. Largely because of the central figure of Niels Bohr and his Institute of Theoretical Physics in Copenhagen, young physicists in these countries traditionally favoured Nordic contacts. This scientific background in physics indirectly contributed to the development of nuclear techniques and industrial activities and further contacts among the Nordic countries. As an example, Bohr was in touch with the Swedish Minister of Education, Tage Erlander, who was aware of the perspectives for atomic energy.

Bust by Harald Isenstein

In the 1940s, both Norway and Sweden were engaged in extraction of uranium from domestic sources for their first reactors, leading Gunnar Randers to propose informal collaboration with the Swedish National Defence Research Institute[1] in 1946, initially on uranium analysis. A link between the two countries' nuclear research efforts was also contemplated, but these plans lost importance in 1948, possibly because each country wanted to pursue its own goals, and perhaps also because many essential questions related to atomic energy were secret and Norway was on its way towards membership of NATO, while Sweden remained neutral. But in Norway there was still a desire to acquire Swedish uranium and graphite and in Sweden a need for heavy water.

[1] among others he met Sigvard Eklund, Torsten Magnusson and Gustav Ljunggren, the latter being responsible for the chemistry department

From 1949, meetings were held between Danish, Norwegian and Swedish advisory groups on atomic energy. This led to revival of the Norwegian-Swedish contacts about atomic matters and led to exchange of experience among staff members. They knew each other and met occasionally to discuss, for example, metallurgy. In the early 1950s, joint experiments in physics where made at the ZEBRA model of a reactor core in Stockholm. Harry Brynielsson, the director of AE, proposed that experience from AE should be made available to Denmark and Norway. Questions on isotope production and plutonium extraction were also taken up.

With the foundation of the Nordic Council in 1952 (Finland joined in 1955), a new promoter for Nordic ventures appeared on the scene. The Nordic Council (which is still in existence) is an advisory body with a Plenary Assembly composed of delegates from the national parliaments.

One of its first areas of activity was the removal of trade restrictions between the Nordic countries. Over the years the Nordic Council has made several pronouncements on nuclear matters, thereby having a certain influence, first on the creation of the *Kontaktorgan* (page 39) and then on its work.

The first international conference after President Eisenhower's Atoms for Peace address in 1953 was the JENER heavy water conference held in Oslo in August that year, which gave Danish, Norwegian and Swedish participants the occasion to discuss common questions. This was an important precursor for the disclosure of hitherto secret information on nuclear techniques, which took place two years later at the first Geneva Conference.

In 1955, under the impact of the atmospheric bomb tests, IFA's Gunnar Randers suggested that the meteorological institutes should measure radioactivity in air. The Swedes also raised the idea of a United Nations committee to study the biological effects of radiation.

Participation in the first Geneva Conference was also discussed in a Scandinavian forum, the aim being to demonstrate that even small countries could make important accomplishments in this new field.

A Nordic Council for Atomic Energy

In April 1956 the five Nordic Foreign Ministers decided to establish a Nordic co-ordination group, replacing the existing committee of the three advisory groups on atomic energy. They also held a preparatory discussion with parliamentarians of the Nordic Council. This new co-ordination group, under the chairmanship of the Danish Minister of Trade Viggo Kampmann, discussed the organisation of future Nordic co-operation in the atomic field and nominated an expert group which included some of the people[1] who were subsequently to play a leading role in Nordic co-operation.

It now became clear that co-operation in this field should include all five countries and be handled through a new committee answerable directly to governments rather than to the Nordic Council. The aim was co-operation in those fields where each country would find such co-operation useful, rather than joint activities.

[1] H.H. Koch from Denmark, Erkki Laurila from Finland, Odd Gøthe from Norway and Gustav Cederwall from Sweden

2. First formal co-operation: 1957 - 1967

The Nordic countries participated actively in moves to develop international and European relationships in the nuclear field. This development was influenced by the Suez crisis of 1956, which highlighted the extension to which Europe was dependent on imported oil.

In December 1957, the Steering Committee for Nuclear Energy of the Organisation for European Economic Co-operation (OEEC, to-day's OECD) was transformed into the European Nuclear Energy Agency (ENEA, to-day's NEA) and thus became a forum to promote co-operation in the nuclear field among the industrialised countries of western Europe. Also in 1957, the six European countries already engaged in the Coal and Steel Community, decided to set-up both a Common Market and a European Atomic Energy Community (Euratom). The atomic area was expected to lead to a new industrial and technical revolution, with implications over a wide range of sectors.

2.1 Creation of the *Kontaktorgan*

The use of atomic energy was one area where all the countries showed sufficient interest for the Nordic Council to promote a joint line of action. In its second meeting in January 1957, the co-ordination group under Kampmann drew up a proposal for a permanent co-ordination committee to deal with nuclear matters. It also proposed that Nordic co-operation in this field should not be exclusive but open to others and that it should favour Nordic participation in international ventures.

This concept has dominated this co-operation ever since. Nordic co-operation has always been an *à la carte* process and never an end in itself. The main aims were for it to be useful for the individual countries and a means to strengthen their positions internationally, to gain a stronger voice.

The Nordic Council adopted the resolution, based on the thoughts developed by the co-ordination group, at its fifth session held in Helsinki in February 1957. It asked the governments to set up a joint Liaison Committee, to follow the planning and activities in the field of atomic energy closely and to promote the resulting possibilities for Nordic co-operation, including industrial co-operation in the field of reactors. Years later this committee adopted the acronym NKA (**N**ordisk **K**ontaktorgan for **A**tomenergispørgsmål), subsequently called the *Kontaktorgan*. Two members were appointed from each of the Nordic countries, and the first meeting took place in June 1957 in Copenhagen (see Note 2.1 for list of participants).

During the same session, the Nordic Council recommended that the Nordic governments should set up a Nordic Institute for Theoretical Atomic Physics in Copenhagen and appoint a Board to be responsible for Nordic co-operation in nuclear physical science. This was later called NORDITA and was located at the Institute for Theoretical Physics, later renamed the Niels Bohr Institute.

2.2 The *Kontaktorgan* and European ventures

In the 1950s, international travel and telephone communication was more complicated and time consuming than in to-day's jet and electronic communication era. Many people responsible for the emerging atomic issues felt isolated and welcomed the new concept of formalised international contacts. The atomic field, with its intermixing of political and technical problems, became a forerunner for international co-operation. Both at governmental and technical levels it was considered important to make international contacts through personal relationships. Nordic contacts were a natural step in this development.

Those responsible in the Nordic countries felt a need to find mutual support in view of the international bodies being formed. They recognised that joint opinions would carry more weight in international groups than those of individual Nordic countries. Here the *Kontaktorgan* offered a useful forum for informal Nordic contacts. Therefore, high level officials, representing the ministries responsible for atomic questions and the Foreign Ministries, were appointed as members of the *Kontaktorgan*. For the practical work it was equally important that they were accompanied by leading experts from research centres and sometimes also, from industry. The five Nordic countries became eager players in this new international scene and participated within the many international groups being created in the 1950s.

During the early years the *Kontaktorgan* centred discussions on the attitudes of the Nordic countries to questions raised by international organisations. As an example they discussed the appointment of representatives to these organisations. Two personalities from Scandinavia came to play an important role in the 1960s: Sigvard Eklund, who in 1961 became Director General of the IAEA – the second in turn, and Einar Sæland from Norway who was ENEA's second in command and became its director from 1964.

The Nordic countries also made arrangements so that they in practice would share one seat on the IAEA Board of Governors where they succeeded each other. This assured a continuous Nordic presence for many years to come.

The *Kontaktorgan* also dealt with various proposals which individual countries put forward in the OEEC, such as participation in the three OEEC projects Eurochemic, Halden and Dragon. This opened up opportunities which would have been impossible for the small countries to realise in isolation. Joining the projects also supported European co-operation, which was an important goal for the Nordic countries.

Through negotiations in 1957 and 1958, the Norwegian member of the OEEC steering committee, the former minister Jens Chr. Hauge, together with Pierre Huet of ENEA succeeded in putting together the international Halden Agreement. Several countries, including Denmark and Sweden shared the financing, according to their relative interests. In February 1959 arrangements were made for Finland to be unofficially represented by Norway until such time that Finland could become a member of the OEEC. Its Atomic Energy Commission then entered the Halden Agreement in the period starting in 1963.

The heavy water reactor at the Norwegian city of Halden went into operation in 1959, only three years after the decision to build it. The people behind it, besides Gunnar Randers, included Nils Hidle and Odd Dahl (here seen on the top of the reactor[1]). The Halden project was particularly important to practical Nordic co-operation. The fuel for the Halden reactor was manufactured by AE in Stockholm.

Whenever the three-year international Halden agreements came up for renewal, the Nordic countries strongly supported their continuation. In the 1970s, the Nordic countries contributed more than half of the budget, when the basic Norwegian

[1] facing, from left: Svenn Larsen, Einar Jamne and Holger Lindskog

share was included. Nordic members on its board such as the Finnish representative Ilkka Mäkipentti - who was a member from 1967 until his retirement in 1993 - were generally supportive of the activities.

At Halden a positive attitude was forged to Nordic co-operation. Over the years, the Halden project became a focal point for contacts amongst technical staff from the Nordic countries. Several people mentioned later in this story where parts of early Halden staff[1] and many of those who participated actively, later went on to play leading roles in their countries. The project contributed to Sweden's knowledge of reactor technology. It was also especially important for Finland for whom Halden constituted a major source of information in a similar way as the Netherlands-Norwegian reactor school at Kjeller. This, for the participants equalled a 'university' for teaching in the nuclear field, as important as Niels Bohr's institute in Denmark for the study of nuclear physics.

When the directors of Nordic research institutes met in international fora, they had many questions of joint interest to discuss. An example of such a forum is the non-governmental European Atomic Energy Society (EAES) in which they joined their European colleagues. Its initial meeting was held in June 1954, again at the initiative of IFA's director Gunnar Randers, one year before the opening up of nuclear issues at the first Geneva Conference.

Over the years, the EAES provided an excellent forum for the Nordic participants to exchange viewpoints. Denmark joined in 1956 and Finland in the late 1960s. For many of the leading personalities in the nuclear field the meetings of the EAES, like those of the *Kontaktorgan*, helped to prepare them for appearances in the more formal international assemblies. The meetings also influenced the conception of their national policies. At a much later date, at its meeting at Studsvik in September 1979 - when EAES discussed the role which could be played by nuclear research institutes in energy research - the Nordic collaboration scheme was presented as an example of successful regional co-operation.

2.3 Co-operation in radiation protection

In the field of radiation protection, there had been early contacts between Rolf Sievert in Sweden and Nelius Moksnes in Norway. Following detection of the effects from the atmospheric atomic bomb tests in the Northern hemisphere, Sievert organised a meeting in March 1957 for mutual information about abnormal radioactivity detected in rain and fallout. In November 1958, at a second

[1] such as Pehr Blomberg, Tapio Eurola, Frank Højerup, Nils Rydell, Evelyn Sokolowski and Olavi Vapaavuori

Nordic meeting, participants discussed the resulting radiation burden to the Nordic populations. The fallout question was of particular importance in the northern regions of Finland, Norway and Sweden due to the strong concentration of radionuclides in lichen and its subsequent consumption by reindeer, and these meetings provided a sort of information network.

From fallout questions a desire for more regular co-operation developed. In 1958, Danish authorities believed that drinking water from the island of Saltholm, located between Copenhagen and the Swedish City of Malmö, was contaminated. This triggered contacts with Norwegian and Swedish experts. Although it turned out to be a false alarm, these contacts led to a proposal to the Nordic Council which, at its meeting in November 1959, recommended that the governments should promote co-operation among institutions responsible for radiation protection in the Nordic countries. Questions proposed for joint action included radiation protection associated with planned visits by nuclear seagoing vessels to Nordic waters.

Following the Nordic Council's recommendation, regular expert meetings started[1] amongst involved authorities. A total of eleven meetings between 1961 and 1972 dealt mainly with questions related to radioactive fallout.

Research groups[2] in Finland, Norway and Sweden made fallout measurements. When the second bomb test period started in September 1961, Dietrich Merten at the IAEA hurriedly convened a meeting with mainly Nordic participants. Here they discussed the uptake of radionuclides in animals and people in Northern Scandinavia and similar regions. There was true concern that the Sami herdsmen were in danger because of their special diet based on reindeer meat, which was enriched in radionuclides through the food chain from lichen. Investigations were made in close contact between Lidén's and Miettinen's institutes. A change of diet for the Laplanders based on porridge was actually proposed.

Calibration of instruments, used to measure contamination, was made possible through Nordic contacts. Swedish equipment, located in mobile vehicles, was made available for whole-body measurements of radioactivity in Finnish and Norwegian Laplanders from the contaminated regions. In 1961, Norwegian Laplanders were driven to Sweden, since the Swedish buses, provided by the army for this purpose, were not allowed to transit Finnish territory. As recompense, the

[1] they were initiated by personalities like Sievert from Sweden and Juul Henningsen from Denmark, seconded by Raider Eker from Norway and Sakari Mustakallio from Finland

[2] Jorma K. Miettinen from the University of Helsinki, Thorleif Hvinden from the Norwegian Defence Research Establishment and Kurt Lidén from the University of Lund

Laplanders were offered half a bottle of *snaps*. Consequently, it was difficult to collect them for the return journey from their sleeping hides in the forest. The year after, the Finns had fitted up their own buses.

Following the bomb tests there was great concern about possible biological - or even genetic - effects due to fallout. The Nordic findings were of international interest - the Laplanders being more readily available for tests than, for example, Eskimos in Alaska. Nordic observations, including those from Finland, which would otherwise not be known in the West, were made available internationally. They were reported to the UN by its Scientific Committee on the Effects of Atomic Radiation, UNSCEAR. This committee had been established in 1956 with Sweden as a founding member. Initially, Sweden assured the contacts to the other Nordic countries.

Analytical skills did not exist everywhere. Once the measurements of fallout had started around the new Risø establishment in the late 1950s, a meeting was arranged at the Institute of Radiophysics (the later Radiation Protection Institute, SSI) in Stockholm. When presented with the Danish counting equipment for beta radiation - which had been under development at Risø[1] since 1956 – Sievert was highly impressed and exclaimed, “but we are far behind...”. The first chemist at his institute in Stockholm was Danish and the second Norwegian[2].

The scientific interpretation of the measurements in the Lapland regions was included in discussions at a series of five meetings in the Nordic countries, from 1962 through 1969, *Radioactivity in Scandinavia* (the RIS meetings)[3]. Other countries participating included the USA and, at the last meeting, even the Soviet Union. The knowledge gained from these meetings served as a background for the first international symposium on radioecology arranged by Sievert in Stockholm in April 1966.

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[1] by Jørgen Lippert together with Pall Theodorsson from Iceland

[2] Ragnar Boge who later played an important role in Nordic project work

[3] These meetings were initiated by Jorma K. Miettinen and Kurt Lidén, with the active collaboration of IAEA's Dietrich Merten

In November 1962 a Danish-Swedish meeting held in Copenhagen at the initiative of Rolf Sievert, discussed procedures for warning in Sweden in case of a nuclear accident at Risø. A ‘gentlemen’s agreement’ was made without excessive formalities.

A similar arrangement had already been made for the Halden reactor. This followed a visit to the plant by Arne Hedgran from the Swedish Reactor Siting Committee together with the governor (*landshövding*) Per Nyström in Gothenburg, located 200 kilometres south of Halden. They realised that the surroundings on the Swedish side of the border were essentially uninhabited. These informal arrangements were precursors for a more formal ‘Nordic Border Reactor Agreement’ (page 83) and international conventions following the Chernobyl accident.

2.4 The *Kontaktorgan* and joint Nordic activities

The *Kontaktorgan* held regular semi-annual meetings. There were two official members from each of the four countries and one from Iceland. The President of the Republic appointed the Finnish members while in the other countries the ministries responsible for atomic energy questions decided the membership. The *Kontaktorgan* aimed to establish contacts between ongoing activities in individual Nordic countries, mainly through exchanging scientists and experts.

Of common interest were questions related to the nuclear fuel cycle, reactor design, use of isotopes and several scientific aspects of atomic energy. Underlying some of these interests was the wish to become independent of domination by the great powers and also the desire to promote industrial activities nationally.

A joint Nordic exhibition at the second Geneva Conference in 1958 presented the three nuclear research institutions in Scandinavia: Risø, IFA and AE.

Isotopes

In November 1957, IFA suggested that research reactors in the Nordic countries should share the production of radioactive isotopes for medical and other use. Kjeller, which was most advanced, proposed to produce isotopes requiring chemical separation, while larger irradiation sources would be manufactured in Denmark and Sweden. Although there was agreement about the principle, a Norwegian proposal for a binding written agreement was considered unnecessary by the other parties. They considered that there would be no great economic profit in this activity, particularly when the cost of reactor operation was considered. Perhaps in reality, each country was reluctant to close its option for independent activities. In 1959 therefore, the issue of a Nordic ‘isotope pool’ was closed without leading to a practical result.

Reprocessing

In view of difficulties in obtaining fissile material for use in reactor fuel, reprocessing of spent fuel was considered an essential part of the nuclear fuel cycle. Domestic plants for recovery of uranium and plutonium from spent fuel offered a possible solution. Discussions on reprocessing therefore, appeared several times on the *Kontaktorgan*'s agenda. Already in 1954, the first tiny amounts of plutonium had been isolated in Sweden.

In 1957, JENER planned a reprocessing pilot plant at Kjeller. As a Danish engineer, the author of this story was seconded to the project. The following year an agreement was made with AE to install specially designed equipment to separate plutonium at Kjeller. This made construction of a pilot plant at Studsvik superfluous. Spent fuel from the JEEP reactor, together with equipment for its dissolution, made it possible for the Swedes to test chemical processes, which they developed to purify plutonium. The Kjeller plant was further extended in 1960 by an additional Swedish installation.

Three of the Nordic countries were active participants in the Eurochemic project of the OEEC (page 41) which was repeatedly discussed in the *Kontaktorgan*. Both Denmark and Norway initially proposed to site this European pilot plant, but it was subsequently built in Belgium during the early 1960s. Interest for a reprocessing plant in the Nordic countries cooled off as the Eurochemic project became a reality. However, in 1962 a Swedish pilot project was worked out for a reprocessing plant to be located on the coast north of Gothenburg (at Sannäsfjorden).

When the Kjeller pilot plant closed down in 1968, Norwegian-Swedish co-operation carried on with attempts to isolate plutonium-238 for use in pacemakers. During the early 1980s the co-operation continued when a Swedish team attempted to separate actinides (that emit alpha radiation) from the waste solutions still stored at Kjeller. The 1990-93 NKS programme (page 227) included a project related to final decommissioning of the pilot plant.

Heavy water

An OEEC study in 1958 predicted that the expected use of heavy water reactors would lead to an annual European demand for 100 tonnes of heavy water. There was a strong Icelandic interest to use geothermal heat to produce an estimated 1000 tonnes annually. The *Kontaktorgan* offered assistance and discussed the matter in detail at its meeting in Reykjavik in 1960. However, the predicted demand, based on a large construction programme for heavy water reactors never materialised.

Reactor physics

In 1961 the first of a long series of Nordic meetings on reactor physics was organised (the *Scandinavian Reactor Physics Meeting*). The three countries originally involved shared a seat on ENEA's European-American Committee on Reactor Physics when it was created in 1962. Special questions such as using thorium for reactor fuel were taken up and computations from individual countries were compared. In 1967, after the first plans for nuclear power came into existence and membership of the OECD was a reality, Finland joined and the official name became the *Nordic Reactor Physics Committee*.

The three Scandinavian countries also shared one seat on ENEA's Nuclear data committee.

Reactor technology

In the early 1960s intensive work on heavy water reactors (HWRs) was under way in all three Scandinavian countries.

In Norway the JEEP and Halden experience looked promising for marine reactors. Joint discussions were held with Swedish marine engineers on the use of reactors for naval propulsion. Projects for ship reactors had been on Norwegian minds since the late 1950s and led to the formation of 'Rederiatom'. The question of marine reactors was raised in the *Kontaktorgan* in the early 1960s when an international project through ENEA did not materialise. Several Nordic countries showed interest and one proposal came from the 'Malmö International Team'. Four major Swedish shipbuilding yards were involved in naval propulsion work, and Danish ship-builders also showed interest.

A Norwegian-Swedish project[1] started in 1963, with a major contribution from Swedish shipbuilders' organisations. Eric Olderin from the Swedish Navalatom worked at IFA for two years before joining the Swedish organisations that continued their own joint venture with AE. One project was for a 67,000 tonne ore carrying ship. IFA's 'rock-and-roll' project - which examined the behaviour of a reactor core subjected to sea movement - represented a substantial effort in adapting reactors for marine use. But prevailing low oil prices meant that the economic climate was unfavourable towards nuclear power for civil marine propulsion. Marine reactors did appear applicable for use in polar waters, but this was of in no interest to the West. In addition, obtaining permits for access to harbours seemed to pose continued problems.

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[1] under Jens Wilhemsen at IFA

The Norwegian-Swedish ship project was cancelled in 1965. In a certain way the projects were a success: it had been shown that competition from nuclear vessels was not a risk to the vast Norwegian merchant marine.

The *Swedish line*, based on uranium from Kvarntorp (and from 1965 the Ranstad mine) advanced towards its first achievement, the Ågesta reactor. Its main purpose was to generate heat for the Farsta suburb of Stockholm. Assumptions for the design of the Ågesta core were confirmed experimentally through measurements in the Finnish TRIGA reactor[1]. In 1961 staff from the Nordic countries became involved in the preparatory work for the advanced Swedish HWR project at Marviken[2].

Following important discoveries of uranium in Greenland, the Danish AEK embarked on its heavy water DOR project based on natural uranium and an organic coolant.

It was quite natural that AE in Sweden, IFA in Norway and the Danish AEK decided to co-operate on the development of heavy water reactors in 1964. This reactor type did not need enriched uranium, which in practice was only available from the USA or the Soviet Union.

AE and AEK in particular, worked closely together and exchanged information and drawings. AE was actively engaged on Sweden's programme on HWRs: Ågesta was to start in 1964, followed by Marviken. AEK abandoned its DOR project in 1964 and now worked on a 'double size' Marviken concept[3]. The two research institutes formalised their co-operation by signing an agreement about HWRs in January 1965.

Nordic co-operation on heavy water reactors was only part of a concept proposed by ASEA's Curt Mileikovsky in 1963. According to this, Norwegian efforts would focus on reactors for ship propulsion while Danish development work would concentrate on fast breeder reactors. Sweden would centre on water cooled reactors, an area which in the short term promised the biggest economic gain.

[1] at this time under Bjarne Regnell

[2] Ingvald Haga and Jan Nistad from Norway, Magnus von Bonsdorff from Finland

[3] the DK-400 project under Søren Mehlsen

The first official Danish visit to Studsvik took place around 1963. From left to right: Mogens Møller-Madsen, Søren Mehlsen, Flemming Juul, Hans von Bülow, the host Harry Brynielsson, Hans Henrik Koch, Christian L. Thomsen

Mutual assistance

Questions about reactor safety were raised in the *Kontaktorgan* in 1959. Responding to these concerns, Sweden proposed an arrangement for mutual assistance in case of an accident. A motive may have been the increasing belief in the future of nuclear powered vessels and perceived risks as they sailed off the coasts of Nordic countries. A Nordic agreement on mutual emergency assistance in case of radiation accidents was signed in 1963. The agreement regulated conditions under which assistance might be provided - against reimbursement - to any of the other States in case of a nuclear accident. In order to enhance international co-operation, the IAEA became party to the agreement, which in turn initiated activities in the field of emergency preparedness at the Agency. The Nordic-IAEA agreement was a first-of-its-kind international ‘convention’ in this field. Much later, after the 1986 Chernobyl accident, similar international agreements followed.

During the years leading up to 1964, the national safety authorities were busy evaluating the safety of the nuclear powered vessel N/S Savannah, which was to enter harbours in Scandinavia.

The question of liability in case of an accident involving radioactive material was one of the issues to be resolved before the ship's visit. The *Kontaktorgan* also discussed the required extent of cover to be specified in the Paris and Brussels conventions about Third Party Liability.

A US bomber plane crashed at Thule in Greenland in January 1968, scattering plutonium over the ice. The incident prompted Iceland, who had no nuclear installations, to recognise the necessity of joining the Nordic mutual assistance agreement. This was simply settled through telephone calls 'among friends' and confirmed by an exchange of letters with the Danish AEK.

NORDEL

A number of factors bound the major electricity producers in the Nordic countries together; numerous interconnections between national electricity grids, similar working patterns, and a diversity of electricity production systems led them to formalise their relationships by creating the NORDEL organisation in December 1962. One inspiration for NORDEL may have been the existence of the *Kontaktorgan* with its close and informal relationships developed across Nordic borders by its leading personalities. NORDEL decided to periodically inform the Nordic Council about its activities. Still in existence, NORDEL is a grouping of leading personalities from Nordic utilities that advises electricity producers in the five Nordic countries to promote Nordic and international co-operation.

Industrial projects

In 1965, ASEA in Sweden proposed to establish a Scandinavian consortium (Scanatom) which was formed in September of that year to deliver a heavy water reactor to Pakistan. This was to be of simplified design, with slightly enriched fuel. Three different projects were formulated and several Nordic industrial firms participated so that a combined Nordic offer could be made. However, the project failed, mainly due to difficulties in providing the necessary financing, e.g. from Nordic assistance programmes for developing countries. At this time it was a 'buyers' market and the Scanatom group was not in a position to furnish all related services.

The year after another initiative, from the AE technical director Göthe Malmlöw, proposed to enlarge the existing Nordic co-operation on heavy water reactor technology to include fast breeder reactors. This would require both industry and the research institutes to work closer together. In the *Kontaktorgan*, Erkki Laurila raised the subject of the fuel cycle, including enrichment and reprocessing as a possible new field for Nordic co-operation.

Time for new initiatives

In 1966, after nine years of existence and on the request of the Nordic Council, the *Kontaktorgan* embarked on a survey of what had been achieved so far. Up to now several Nordic co-operation schemes had evolved over a broad range of fields. There were friendly relations among the three nuclear research institutes and their Finnish counterparts. The three institutes were strongly engaged in heavy water reactor development, while the utilities turned towards the light water type, now commercially available. A Nordic consortium with industrial undertakings had attempted to commercialise its knowledge. The new survey was to review the co-operation between the Nordic ministries, with their atomic energy commissions and research establishments and investigate how this could be extended. It was also to examine how economies and gains in efficiency could be achieved through a division of efforts and through other forms of co-operation.

The research institutes wishing to consolidate their positions at a difficult time in their domestic situations may have stimulated the initiative for this review. Whatever the reason, it opened up the next phase in Nordic co-operation in the nuclear field.

The Kontaktorgan meetings helped to reinforce the Nordic countries' position on international issues. During the Kontaktorgan meeting at Reykjavik in September 1967 future forms of co-operation were also discussed. Among others (left to right): Ilkka Mäkipentti, Knut Gussgard, Erkki Laurila, Gert Vigh, Harry Brynielsson, Jens Chr. Hauge, Hans v. Bülow, Odd Gøthe, during its excursion at Þingvellir.

3. Intensified co-operation from 1967

During the late 1960s the economic growth both raised demand for electricity and provided the funds for reactor development work at the nuclear research institutes. Public opinion favoured this new energy source that promised to be both cheap and clean. Nuclear power was being commercialised and a number of reactor vendors appeared on the scene.

3.1 Background in the Nordic countries

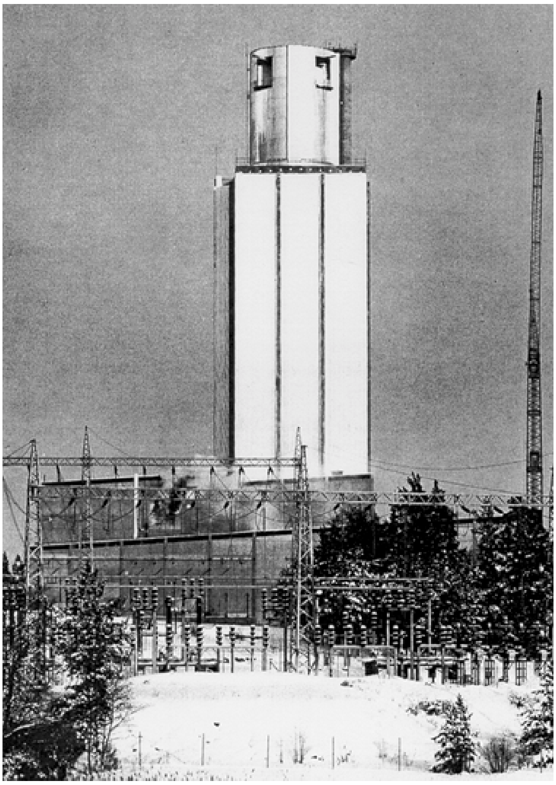
By 1967, nuclear development work in Denmark, Norway and Sweden was intense. In Finland, the introduction of nuclear power had become a key political issue and the country had yet to decide its nuclear future.

Co-operation among the three nuclear research institutes continued as they worked to develop heavy water reactors. Relations with industry became clouded however, because heavy water projects to some extent deviated from the priorities of the utilities. These were impressed by the progress of light water reactors (LWR) in the USA. Here in 1963, the first full sized nuclear power plant - a pressurised water reactor at Oyster Creek - was ordered for operation in 1969. Fuel for this reactor type was now also easier to obtain. This was a consequence of an agreement signed in 1965 between Euratom and the USA, covering the purchase of slightly enriched uranium for use in LWRs.

An intensified approach to Nordic co-operation was clearly needed. It would strengthen the position of the research institutes in their national settings and enable them to carry out research along the line now needed by the utilities. In industrial circles opportunities in reactor delivery, fuel element fabrication and equipment manufacture now appeared within reach.

In *Sweden*, plans for the first full-size nuclear power plants were under way.

In 1965, site work started for the Marviken reactor, converted to an advanced HWR project following the success at Ågesta.



In 1967 the practical Marviken work at AE was in the hands of Göthe Malmlöw and Peter Margen. Several engineers from other Nordic countries were employed[1].

Although ASEA gained its experience through work on heavy water reactors, it had also been working on LWR concepts since 1963. When the Swedish Atomic Power Consortium (AKK) - formed in 1955 by eight utilities - requested a bid for a large power reactor, ASEA planned to offer a LWR. A visit to AE in Stockholm by a Danish delegation at the end of November 1964 coincided with the deadline date for the bid. One of the participants recalls that when at midnight, ASEA's Curt Mileikowsky unveiled its contents, the Danish delegation shared the disappointment of the AE directors when it was confirmed that the plant offered by ASEA was a LWR. This was remarkable because it was done without a licence to manufacture LWRs from the USA. The order was subsequently signed in 1965, by the new Oskarshamn power group (OKG), for delivery in 1970. This was the start of what was to be a major successful engagement in the nuclear field by Swedish industry. When the Swedish State Power Board (Vattenfall) also ordered a LWR reactor from ASEA in 1968, Krister Wichman, who was responsible for nuclear matters at the ministry, recognised the need to combine all of Sweden's available resources. Consequently, ASEA-Atom was established to build nuclear reactors and manufacture fuel elements. ASEA held half of the assets, the Swedish state the remainder.

[1] They included Bjørn Ringstad and Jan Nistad from Norway, the latter heading the functions analysis group that divulged certain shortcomings in the design

This resulted in a significant change for AE. Some of its nuclear experts transferred to the new company together with essential equipment, and many of its activities now became commercially tied to the new company. This was due in part, to a specific agreement for AE to carry out LWR development work for ASEA-Atom. These changes, together with increasing requirements for economy in project work, made Studsvik's position in relation to Nordic research projects more difficult.

In the second half of the 1960s it became apparent that, with increasing fuel *burn-up* (page 101), the Marviken reactor core would be unstable and develop undesirable power coefficients[1].

In 1970, at a time when the site work was practically complete, further work on this quite advanced HWR was stopped. Instead, available Swedish resources would concentrate on LWRs. Anyway, operational experience from Marviken would have come too late to be of use at the newly ordered LWR power plants. Marviken did however, have a part to play. The plant was used for safety experiments and this made it a focal point of Nordic co-operation (page 75).

In *Norway* work towards a first power reactor intensified during the 1960s. Norway had already acquired experience by building the second JEEP reactor at Kjeller, which started operation in 1966. A site in the Fjord of Oslo (Herøya) was identified, under the leadership of Noratom[2], for an underground reactor location. This area was selected because electricity demand was increasing around the capital while the major hydro power sources were located on the distant West coast. IFA played a central role in this and similar projects initiated by the state utility NVE.

Finland adopted a 'wait and see' policy preferring to wait for the introduction of the first power reactor to establish the related industrial activities. Meanwhile, a team of highly competent persons was constituted to form a nucleus around which later activities could be built. In the 1960s the annual number of post-graduate students in various atomic training programmes amounted to about one hundred.

According to an agreement, reached in the late 1960s, the first nuclear unit would be ordered by the State owned utility Imatran Voima Oy (IVO). In September 1969, after two unsuccessful attempts to arrive at a contract by means of commer-

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[1] Danish-Swedish co-operation perhaps contributed to this conclusion through work by Risø's reactor physicist Paul Ølgaard who in August 1968 revealed a shortcoming in calculations of neutron behaviour in the reactor core

[2] under Fredrik Møller and Nils Hidle

cial bidding, IVO placed an order for a VVER reactor with the Soviet firm Technopromexport. The electricity generating cost for this plant was to be as low as 0.02 FIM/kWh (below 0.004 ECU/kWh). A second unit was ordered in 1972. The plant was to be located near Loviisa about 100 km east of Helsinki.

A new company Teollisuuden Voima Oy (TVO) was established in 1969 to produce electricity for its sixteen owners in the wood and pulp industry. In view of the sensitive implication of foreign politics in the area of nuclear power, a cautious selection process was followed. This involved first examining designs offered by Western suppliers and then starting negotiations with ASEA-Atom only. The first TVO reactor, to be located at Olkiluoto, 250 km north-west of Helsinki, was ordered in 1973. An option for a second unit was taken up in 1974 after the energy crisis when it was feared that the cost of energy would rise.

This order led to close Finnish-Swedish co-operation in all phases of construction and operation. Finnish manufacturing industry was to participate intensively in both projects, thereby taking advantage from their synergy effect.

Since no separate nuclear research institute had been created, most research activities, including use of the ministry owned TRIGA reactor, were transferred to the Finnish State's Technical Research Centre (VTT) in 1971. Experience gained from Nordic projects in fields such as Quality Assurance, reliability and materials significantly helped the Finns to carry out their role as a competent buyer. Initial thoughts to construct a Finnish materials testing reactor were abandoned due to the existence of such reactors both at Risø and Studsvik. Available capacities in other Nordic countries were also utilised in other areas. An example was the decision to use existing Nordic hot-cell facilities instead of building new ones at home (page 71). This led to close co-operation and to transfer of knowledge, especially in fields such as fuel technology and materials science.

In *Denmark* several technological studies were performed at Risø to pave the way for nuclear powered electricity generation by Danish utilities. Attempts were also made to involve Danish industry. The target was for a first nuclear power plant to be in operation before 1980. In addition to the simplified Marviken type HWR project (DK-400), the AEK also embarked on a study of a pressurised heavy water reactor. Capacities of these plants suited the Danish power supply network. Uranium sources in Greenland appeared sufficient for a large HWR nuclear programme lasting for several decades. Simultaneously, some utilities were working in the opposite direction on light water reactors to establish their independent knowledge base.

Iceland's interest still centred on its possible use of indigenous energy sources for heavy water production.

During this period, national institutes responsible for radiation protection emerged. They originated from those that had mainly controlled the use of radiation sources to sterilise medical equipment. Safety experts at the Atomic Energy Commissions and nuclear research institutes addressed technically oriented questions on reactor safety.

3.2 Investigations leading to the *Committee* and *NARS*

In February 1967 the *Kontaktorgan* responded to the request from the Nordic Council (page 51) to assess the prospects for greater co-operation, by setting up an expert group, Nordisk Atomsamarbejdsgruppe (***NA***). Chaired by Hans von Bülow, most of its members represented ministries and research organisations, while Finnish participants mainly came from the industrial sector (Note 3.2).

In March 1967 a Nordic member was attached to the group investigating closer Nordic co-operation in nuclear research, to act as its executive member. Here Franz Marcus is welcomed by AE director Harry Brynielsson who shows a sample of uranium from the Swedish Kvarntorp formation, in the presence of Göthe Malmlöw.

During 1967 the group investigated many areas for possible co-operation. They included questions in the domain of the research institutes together with wider co-operative ventures for the *Kontaktorgan* to consider.

Large projects related to nuclear technology

As part of a new Nordic scheme, the other countries were invited to participate in two large projects already under way in Sweden. The aim was to strengthen the knowledge needed to develop domestic nuclear power plants.

Under the scheme, AE proposed the other countries to join the FRIGG[1] project at a pilot plant in Vesterås. Set up to investigate the flow of coolant around nuclear fuel elements, the project became a forerunner for other similar Nordic projects.

AE also invited the other countries to participate in the development of a reactor vessel made from pre-stressed concrete, to replace steel vessels in large Boiling Water Reactors (BWR). Building upon the experience of gas-cooled reactors, the objective was to improve LWR reactor vessels' reliability by integrating into the design, cables to take up any containment leaks. This project would create a platform for the research institutes – and Studsvik in particular – to participate in the industrial exploitation of power reactors.

Advanced reactors

In the field of fast breeder reactors there were Swedish ambitions to enter a market that, at the end of the 1960s, seemed only a few years away. At this time, some development work had already been made in Sweden. This included measurements on a fast reactor configuration using enriched uranium from the USA and plutonium from the UK. However, in 1966 AE's appropriations for fast reactors had been reduced. Therefore, a joint Nordic effort, with division of work, might offer a route to progress in the vast field of fast reactors. While both AE and ASEA worked on fast reactor technology, the other Nordic countries were more interested in conventional reactor types and other aspects of nuclear energy.

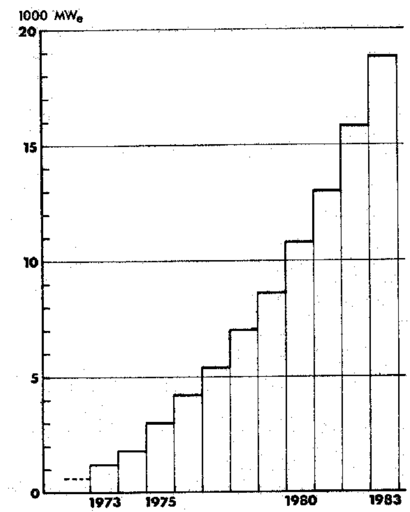
NA organised a seminar in Studsvik in June 1967, to assess interest in this Swedish proposal. Here, the other Nordic countries expressed dissatisfaction, that co-operation on the commercially more attractive thermal reactors was not on the agenda. In particular, the Norwegian representative at the seminar, Roar Rose, sarcastically refuted Swedish ideas on joint financing for fast reactor development. Such dissension effectively closed this issue in the *NA* context.

Swedish efforts for co-operation in this area nevertheless continued. In May of the following year, at the initiative of ASEA chairman Curt Nicolin, a Nordic meet-

[1] in the Nordic mythology, *Frigg* is Odin's wife, defender of matrimony

ing among industry representatives discussed fast breeder reactor development. He proposed establishing a Nordic consortium, with a staff of fifty. The States were supposed to contribute 50% of the costs. Nicolin further discussed the modalities for such a consortium with the *Kontaktorgan* in September 1968. The expression used by ASEA director Torsten Lindström when talking about Nordic co-operation in the reactor field was, "that train (LWR) has already left - but it is time to jump on to the other train - the fast one".

In a second *NA* seminar on advanced converter reactors, held at Risø in September 1967, it appeared - in the light of optimistic planning figures for coming nuclear power plants - that a shortage of uranium could be expected. Participants therefore concluded that long-term supply of uranium should be secured to cover the large need predicted for all the power reactors in the Nordic area by 1980, as seen in this diagram from 1967.



Other initiatives

A third *NA* seminar planned to take place in Helsinki during the spring of 1968 was to discuss methods to evaluate bids from suppliers. However, this was cancelled due to the fact that the Finns were currently engaged in negotiations for the first nuclear power unit with different suppliers (page 56).

The *NA* group established several other ventures and appointed participants to working groups to draft recommendations for joint efforts.

In May 1967, Studsvik's Lars Carlbom helped to arrange a significant meeting at the Ministry in Stockholm. This was the first meeting to be attended by those responsible for reactor safety in the Nordic countries. Although personal contacts did exist, differences in procedures used in the countries soon became apparent and a need for closer contacts appeared desirable. The representative of the Danish National Board of Health was obviously offended when, at the end of the meeting he discovered that the initiative for this meeting came from an 'outside' Nordic group that had induced the authorities to talk together. Despite these initial complications, the meeting started an era of long lasting co-operation between the reactor safety authorities.

In the following months, further opportunities for joint work in the safety field were examined. In August 1968, a meeting, again organised at the initiative of Lars Carlbom, discussed the formation of a Nordic committee on reactor safety.

Conclusions of the *NA* investigation

The *NA* report was finalised in early 1968. In view of the positive outlook for nuclear power it recommended extensive Nordic co-operation in the nuclear field, including R&D, industrial ventures, the fuel cycle, reactor components, and safety issues. Four possible degrees of co-ordination among the research institutes were highlighted. They spanned from continuation of the informal set-up through to total integration of all work related to reactor technology.

The creation of NAK, the *Committee*

In February 1968 the *Kontaktorgan* acted on the initiative of *NA*'s interim report. As will be described in Section 3.3 below, another drive towards a comprehensive Nordic co-operation scheme was initiated in 1968. In June of the same year, the *Kontaktorgan* referred to both initiatives in its recommendations to the Nordic governments. These were: to undertake a further rationalisation of nuclear research activities, and to work towards uniformity in the national authorities' handling of safety issues related to nuclear installations.

The three research institutes, together with representatives from the Finnish Ministry of Trade and Industry, went on to establish a permanent Nordic Co-ordination Committee for Atomic Energy, here referred to as the *Committee*. Of the four alternatives, this was one of the least binding forms of co-operation. The *Committee* met for the first time in June 1968.

In the same year the safety authorities prepared joint work on licence applications, in anticipation of the *NARS* working group (page 81).

3.3 Attempts for unification. NORDEK

In April 1968 the Nordic Prime Ministers initiated discussions for greater Nordic governmental co-operation. Known as the NORDEK plan, it sought to create a Nordic equivalent to the European Economic Community (EEC) which at the time, was closed to new adherents. In January 1969, the Nordic Prime Ministers decided to include nuclear power as part of this initiative. Therefore, in March of this year, the Nordic Ministers of Industry appointed a group of senior civil servants to explore opportunities for closer co-operation in the nuclear field.

The group would investigate areas such as: R&D, the effect of nuclear plants on the electricity supply grid, fuel cycle questions (including production of heavy water) and industrial co-operation. It was no coincidence that these same items were listed by NA and included in the *Kontaktorgan* report the year before. The senior civil servants[1] were also permanent members of the *Kontaktorgan*; it was therefore logical for them to draw on its meetings to develop their ideas.

At the political level, nuclear power seemed an answer to the future energy supply problem. For the utilities, Heavy Water reactors - with domestic natural uranium - were less attractive than light water technology, for the reasons explained above. Although in theory the prospects for joint Nordic endeavours looked good, the recent formation of ASEA-Atom complicated the issue - also because AE was obliged to deliver know-how and manpower to the new company. Swedish industry with its traditional high ambitions was already well on its way; it had the greatest knowledge and a ready domestic market. It was therefore reluctant to compromise its lead through a Nordic deal.

Although Nordic utilities favoured light water reactors, a new market for heavy water seemed to be emerging in South America, Asia and the UK. The prospect of using geothermal steam as an energy source to produce heavy water, was renewed early in 1969. With heavy water production again on the agenda, Magnús Magnússon joined the group of senior civil servants. A Nordic expert group was subsequently formed to carry out technical and economic feasibility studies. For large volumes (several hundred tons of heavy water per year), production in Iceland could be economically viable, while for smaller quantities, renewed production at Norsk Hydro would appear more attractive.

The senior civil servants (the *Gøthe Group*) explored the feasibility of a Nordic reactor supplier. Modelled on the same principles as the Scandinavian Airline System (SAS), this would require two simultaneous moves. *Firstly,* ASEA-Atom

[1] Bo Aler, Odd Gøthe, H.H. Koch, Erkki Laurila

would combine with Nordic component manufacturers to create a ‘reactor-SAS’. *Secondly*, the nuclear research institutes would have to work closely together to provide the expertise required by the reactor supplier.

The idea of creating a Nordic reactor-SAS was raised by Norway’s Jens Chr. Hauge who had been active in establishing SAS. He had introduced the concept for discussion by the *Kontaktorgan* in September 1968.

Both the *Kontaktorgan* and the *Committee*[1] intensified their action in support of the *Gøthe Group*.

In July 1969 the group outlined the framework for the co-operative venture in a so-called NUNA paper. The strategy included a convention between the governments, a development organisation, and an industrial consortium.

A detailed plan followed in which all disciplines important for reactor construction, including fuel fabrication, would be co-ordinated. The *Committee* estimated the actual combined turnover of the three research institutes (Risø, IFA and AE) in reactor technology to be DKK 130 million (around ECU 20 million) of which Sweden alone accounted for 70 per cent. Annual development costs for the consortium were estimated to be three times as high (3-400 million). This amount included provision in the programme for work on advanced BWRs and fast breeders. To carry out the development work, the governments would create a Nordic nuclear research consortium. A plan was ready by early 1970, which required this development organisation to absorb related activities from the existing research institutes.

The plan assumed that, besides Finland and Sweden - where nuclear power was anyhow on its way - Denmark and Norway would also order their first nuclear power plants. These orders, together with a prototype fast reactor, which the programme included, would provide a market for the industrial consortium. A cloud appeared on the horizon however, when NORDEL chairman Carl Andersen announced that the economic conditions for nuclear power in Denmark and Norway would be unfavourable until 1980. Oil prices were expected to remain low for Denmark, and Norway had ample hydro reserves.

Industry throughout the Nordic countries was to manufacture essential components. The industries included: a Danish nuclear reactor consortium Danatom[2];

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[1] which was under its first chairman, Viking O. Eriksen

[2] DANATOM had existed since 1956 and participated in the Nordic export venture for Pakistan, page 50

the Finnish nuclear industries group (from 1971: Finnatom), combining many Finnish firms already involved in component manufacture for Swedish plants; from Norway Noratom/Norcontrol together with numerous industries mostly from the shipbuilding field, and the Swedish Monitor and Johnsson concerns who were already involved in building Swedish nuclear installations.

Direct negotiations with industry started in 1970 to reach agreement for the Nordic industrial consortium (baptised Scanatom after the 1965 consortium, page 50). The discussions highlighted difficulties in giving freedom of action to ASEA-Atom at the same time as making it part of a joint Nordic firm obliged to use predetermined subcontractors. These same constrains may have complicated the first Scanatom project. On the other hand, ASEA-Atom wished to permanently engage Finnatom as its subcontractor. This conflicted with Finnish requirements for freedom of choice when ordering its first power reactors.

"When each of the Nordic countries gets advantages at the expense of the others, then NORDEK will work quite well"

Although ASEA-Atom's holding stock was only SEK 60 million (around ECU 10 million) its assets and orders were valued in Sweden at approximately SEK 500 million. This was the reason why in October 1969 ASEA's director and the

Swedish Government representative claimed a price equivalent to 1000% of the holding stock of their joint company to give access to the other countries. Years later, people recalled a dry remark made by the Finnish representative Erkki Laurila who, when presented with this concept, said, “I was taught in school that so many percents do not exist”.

At the final meeting of the Industry Ministers at the old Akershus fortress in Oslo in November 1969 a Swedish proposal, to go back to a price of 50% above parity was surprisingly put forward. This may have been an attempt to save some form of industrial co-operation in the nuclear field if the remainder of the NORDEK venture failed. Years later, in a casual affair[1], the Swedish State sold its 50% share to ASEA-Atom for only SEK 50 million.

The Nordic Council in fact adopted the NORDEK treaty in February 1970 during its meeting in Reykjavik. Typically for this period, most of the officials participating in the meeting were male. When the success of the meeting was celebrated by a dancing party there were so few local females present that only the ministers found a partner to dance with.

However, the treaty was not ratified. Perhaps because Finland decided not to join or maybe because the pull of the EEC was too strong at a time when Denmark and Norway contemplated following the UK and Ireland into the EEC. As a result, the NORDEK plan was abandoned a few weeks later in the spring of 1970, ending this chapter in the history of Nordic co-operation.

The moves towards joint nuclear industrial and research consortia were also shelved. Further nuclear co-operation was again referred to the *Kontaktorgan* framework. Nuclear power programmes were however advancing in Sweden and Finland where, by the end of 1970, seven reactors were under construction or ordered. This resulted in extensive interaction between the two countries in the nuclear field. This co-operation covered the industrial sector as well as research, and between safety authorities. A new dimension for Nordic nuclear co-operation was opened with many joint interests between these two countries. Another consequence was an approach during the NORDEK negotiations between Norwegian industrial firms and IFA, which led to the formation of the consulting firm Scandpower (page 91). This company subsequently became an important player in many Nordic projects.

[1] in 1982, without any thorough discussion or information to the decision makers

By way of compensation and to salvage as much as possible of the collaboration foreseen by the NORDEK treaty, the original 1962 *Treaty of Helsinki* on Nordic co-operation was extended in 1971 by creating a Nordic Council of Ministers. This was similar to that which existed in the three European treaties (Coal and Steel Union, Euratom, Common Market).

The Council of Ministers would comprise the five Ministers responsible for co-ordinating Nordic co-operation or, depending on the affairs under consideration, those Ministers accountable for the particular domain being dealt with. The Nordic Council of Ministers (here denominated the *Ministers*) were to administer collaboration between the five Nordic Governments and act as the executive body of the Nordic Council (page 36).

Also in 1971, the Nordic Treaty on Cultural Co-operation was founded, with a secretariat in Copenhagen and a committee of Senior Officials. It led to activities within education and research. The Nordic Cultural secretariat took over financing major projects in its field, including NORDITA (page 40).

One year later, the scope of the *Ministers*' work was extended to preserve and further develop Nordic co-operation in the legal, cultural, educational, social and economic fields. This also encompassed communication and the environment. A single common Nordic secretariat and a number of Senior Officials committees (here denominated *Officials*) were to be established. The secretariat was based in Oslo from 1973. Recommendations from the Nordic Council were now put before the *Ministers* and channelled out to the various *Officials* committees.

3.4 The *Committee* (Nordiska Atomkoordineringskomittén, NAK)

The Nordic atomic co-ordination *Committee* remained active for 13 years, from 1968 until 1982. It became the initiator of many joint actions in nuclear R&D.

Organisation

At the outset, the *Committee* comprised the managing director, a research director and a staff member from each of the research organisations in Denmark, Finland, Norway and Sweden. The committee had two shapes: a permanent working group, subsequently taking over the name Nordiska Atomkoordineringskommittén (NAK), here called the *Committee*, and a separate group formed later by the directors of the research organisations.

Committee brochure showing 'Nuclear Scandinavia'

The original members of the working group are shown in Note 3.4. V.O. Eriksen chaired the group up to October 1970 when he handed over to Gunnar Holte. Franz Marcus was appointed joint Nordic member and Secretary-general (hereafter denominated the *Nordic Secretary*). Contact persons from each of the four countries followed progress, issued minutes from the meetings and discussed future actions with the *Nordic Secretary*.

The group formed by the directors met for the first time in October 1970. In the chair was Bo Aler who had recently replaced Harry Brynielsson as AE's director. This *Directors* group[1] provided opportunities for the leaders of the various institutes to discuss their strategies and to exchange experience gained by their sister organisations. Decisions on joint ventures by the institutes were, however rare and in practice initiatives to take joint action were soon passed to the permanent working group.

[1] with V.O. Eriksen from IFA, Pekka Jauho from VTT, initially K.O. Nielsen from Risø

The group of *Directors* formally separated from the *Committee* in 1973 when the new Risø director Allan Mackintosh became its chairman (the *Directors* again took the name NA). It held 6 meetings in the period up to 1977.

Isotopes

One of the *Committee*'s first activities was to revive earlier plans for joint Nordic radioisotope production (the *Scanisotope* project), using the reactors at Kjeller, Otaniemi, Risø and Studsvik. Although no contract had been signed in 1959 (page 45), at least the Danish AEK had kept to the spirit of the drafted agreement and refrained from producing certain isotopes.

After several meetings, in which also the research institute directors responsible for this area[1] took part, the various parties reached almost complete agreement on a rationalised production and marketing scheme. However, it was difficult for IFA[2] to abandon a profitable activity. Existing commercial agreements were also hard to ignore by Studsvik. Unexpectedly, in early 1971, the Norwegian ministry stepped down from the agreement. Its withdrawal, on the grounds that the agreement was in conflict with the EFTA Treaty, effectively closed the issue. The ambitious plan for a joint organisation was replaced by a decision to establish a Nordic Isotope Committee. This was to meet annually to exchange information. Although useful when dealing with issues such as specifications for radiopharmaka, it was much less ambitious. True co-operation would have required the isotope sections to surrender part of their sovereignty, and this could not be achieved. In some way a commercial competition continued, mainly between IFA and Studsvik.

Reactor core calculations

The experimental FRIGG project at Vesterås, started already in 1967 during the *NA* period, continued its advanced investigations. This 6 MW facility enabled hydraulic tests to be carried out for the dimensioning of full-scale fuel elements for reactors of both the Marviken (heavy water) and Oskarshamn (light water) type.

[1] Risø's C.F. Jacobsen, IFA's N.G. Aamodt and AE's Erik Svenke

[2] and the head of its isotope laboratory Ulf Been

Theoretical work proceeded in parallel with the experiments, to confirm the fuel element design for power reactors. Domestic manufacture of fuel elements for future power reactors was seen as an essential task for industries in the Nordic countries. As part of the project, engineers from the Scandinavian countries were stationed at research facilities (Västerås, Studsvik and Stockholm), while theoretical work at Risø generated calculational models, making use of experimental results.

This area of investigations continued in various forms. The need to compare codes, developed at national institutes, was identified in 1966 when, in conjunction with the Halden project, a Nordic comparison was organised among the codes' authors. A series of small-scale experiments helped to validate certain of the assumptions made. Two large Nordic projects followed:

First the Scandinavian Reactor Dynamics project (**SRD**) under Studsvik's Pehr Blomberg which took account of physical parameters in calculations of reactor core stability. A Nordic group worked at IFA from 1969 to 1972 to produce a first-of-its-kind three-dimensional model ('ANDYCAP') for BWRs.

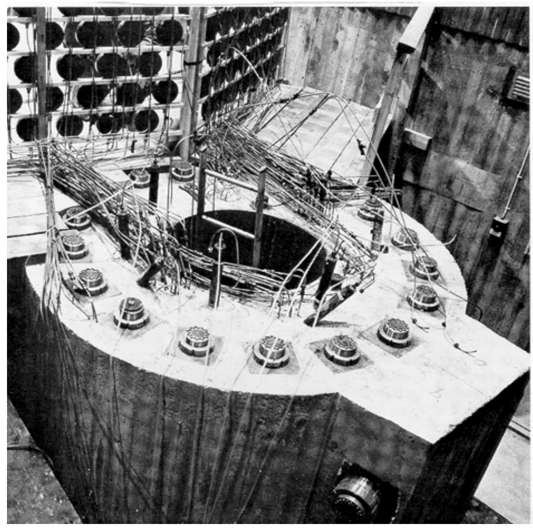
Secondly, the Scandinavian fuel channel ('Subchannel') project (**SDS**) to study the role of thermohydraulics in the formation of steam in fuel channels. Led by Risø's Aksel Olsen from 1970 to 1974, it carried out theoretical work at Risø to develop a code. Experiments at all three research institutes supported this. It was followed by a period of code verification at the participating organisations and eventually reported in 1976.

In these projects the Nordic participants worked as a single group. For each project the participating organisations concluded an agreement and the *Committee* developed rules for use of know-how and patents. While co-operation between the research institutes during the development work was good, difficulties arose when it came to exploit the results; in particular when both ASEA-Atom and some research institutes planned to capitalise on the results commercially. Project results were however used by consulting firms for engineering services and also by VTT for the Loviisa plant.

Experience from these projects showed that even in a joint venture of this kind, strong project leadership is both possible and necessary. This was a useful lesson for future Nordic projects.

Concrete reactor tank

Nordic work on a large model of a concrete reactor tank built in Studsvik in 1969 (page 55) was followed by studies of applications to large Boiling Heavy Water reactors. In addition, a Nordic-US study (with the Northern Bechtel corporation) integrated this tank concept into a 750 MW reference BWR of US design.



The concrete tank design was thought to have significant advantages over steel reactor tanks, the reliability of which was difficult to predict.

A Nordic team[1] evaluated the general design with Bechtel, while the research institutes dealt with various design details.

Further development work followed using the 900 MW Forsmark reactor design as a reference. These studies included tests under extreme conditions. It was for this that in 1972 Risø's P.E. Becher made the first probabilistic approach to estimate the possible failure of a reactor tank. This approach subsequently found general use in reactor safety studies and played an important role in Nordic projects (page 160). The studies were terminated in 1973. A model concrete reactor vessel shown at the Nordic stand of the NUCLEX exhibit in Basle aroused international interest.

In 1974, a verification project[2] with additional participants from France and UK heralded a new phase. In spite of participation by several Nordic industrial companies, some of which performed tests on components in Denmark and Norway, the new Nordic Fund for Technology and Industrial Development (the *Nordic Industrial Fund*) refused to sponsor the project which it viewed as a doubtful industrial venture. Nevertheless, work continued until 1976, with a strong French-Swedish attempt to get an ASEA-Atom reactor design - using a concrete tank - licensed in France. However, this coincided with France's decision to concentrate

[1] including Magnus von Bonsdorff, Thorstein Bøhler, Stig Kärker

[2] directed by Shankar Menon at Studsvik

on pressurised water reactors for which only steel tanks are suitable. This decision effectively ended the prospects for industrial use of concrete tanks for water cooled reactors.

Special agreements containing clauses defining the right to industrial property had been negotiated. Nordic participants in the project made several attempts to use design features from the development work on conventional projects. The lid design for example, was utilised for the closure of a vast high-pressure tank to test submarine equipment. The design was also used later by ASEA-Atom in its advanced BWR reactor concept 'PIUS'.

Separate governing boards were created for this and other similar Nordic projects. A text on patent rights was prepared so that it could be included in similar agreements.

Other activities

Several other *Committee* initiatives resulted in minor, but nevertheless rewarding joint actions. Radiation chemistry is one example of an early initiative, where co-operation between AE and Risø started in 1965, now including the use of radiation to improve material properties. A seminar in Helsinki in 1968[1] featured radiation induced curing of wood-plastic materials. A Nordic Society for Radiation Research and Technology was planned in 1969. Similar to the Nordic Society for Radiation Protection (page 79), it held several seminars in the following years.

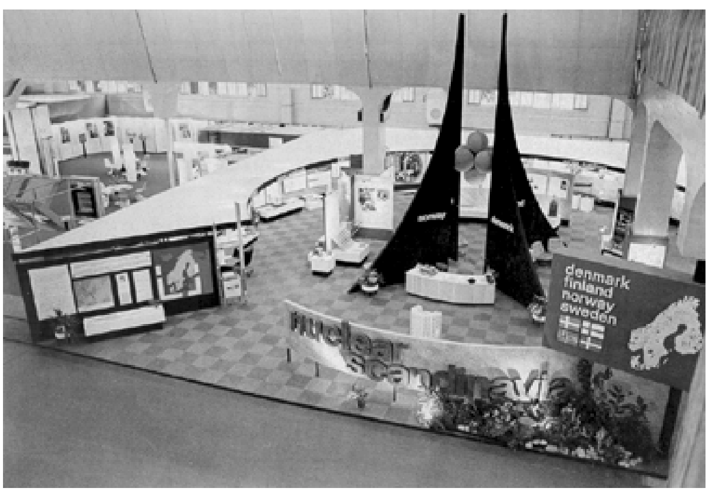
A Nordic working group specialised in materials behaviour compared the suitability of various steels for pressure vessels. Samples were irradiated at Risø and Studsvik and their properties compared after examination in hot-cells. The studies included an attempt to improve zirconium alloys for use as fuel cladding. In 1969 the project, which involved several manufacturers of zirconium alloy, became a joint Scandinavian-UK initiative known as 'Scanuk'. Finland joined later and the project ran until 1977 when an improved material composition was developed. There is little doubt that the work made some contribution to the understanding of materials' properties for fuel cladding. The benefit to Nordic industries however, is more difficult to quantify. Co-operation in this field continued through informal contacts which paved the way for investigations into the behaviour of fuel elements under high heat loads. These later studies aimed to address the phenomena known as 'ballooning'.

[1] organised by Jorma K. Miettinen

Hot-cells for examining irradiated materials existed at the three nuclear research institutes. Therefore the three teams at Risø, IFA and Studsvik formed a Nordic post-irradiation group (‘Nordpie’). Although in competition to examine fuel elements irradiated for member organisations of the Halden project, there was a desire to share experience in this field. Also Finland considered building its own hot-cell installation, but concluded that use of existing Scandinavian facilities on a commercial basis was a more viable option. For IFA these contacts were of great value since its hot-cells have been well utilised throughout the Halden project to examine experimental fuel coming from this reactor.

Other areas of co-operation included measurements on plutonium configurations in Studsvik and production of plutonium pellets.

In 1970 meetings started between Risø and Studsvik to discuss collaboration between Danish research directed at improving reactor control rooms and Studsvik’s development centred on a training simulator. These contacts were to lay the ground for future programmes covering the interface between operators and control panels during the NKS period (page 110).



*The Nordic exhibit **Nuclear Scandinavia** at the fourth Geneva Conference in 1971 was popular not least because of the availability of Danish beer. One day the supply was exhausted in the hot September weather, but the Risø director Flemming Juul made use of his personal relations with the Carlsberg boss, so within few hours visitors again rushed to the Nordic stand. This exhibit was a result of combined efforts with a Swedish contractor and an organising committee established by the Committee[1] (photo: B. Aarset)*

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[1] with Risø's N.E. Kaiser as co-ordinator

The first of a series of Nordic specialist meetings on radioactive waste was held at Kjeller in August 1973[1]. It revealed the prospects for future cooperative ventures. This was followed up after a seminar organised by the *Kontaktorgan* in 1974 (page 91).

Another committee investigated standardisation of components used in nuclear installations. In 1970 it recommended joint efforts to compile information on reliability, including methods and data on component behaviour. This issue was later followed up in conjunction with NORDEL.

Safety aspects

In this period, it was mainly the nuclear research institutes who had the expertise in reactor safety. In 1970, the *Committee* started investigating opportunities for joint safety actions to be performed in parallel with the authority oriented *NARS* working group (page 81).

In the 1960s serious consideration was given to siting reactors close to centres of population including large cities. The Ågesta reactor was operating in a suburb of Stockholm and the Halden reactor within the boundaries of the city of Halden. Finnish, Norwegian and Swedish concepts, to site nuclear power plants underground, were discussed at several meetings. The *Committee* discussed the Swedish Urban Siting Study[2], which followed proposals in 1968 to build a combined district heating and power plant at Värtan in central Stockholm.

The national research institutes reorganised their work on reactor safety during 1972-73. A survey undertaken by the *Committee* in 1972 revealed that Risø carried out most work related to safety, followed by Studsvik. Finland reorganised its safety activities following recommendations in a report on safety work by a group headed by Antti Vuorinen. In 1972, under the re-organisation, groups that had been started in 1969 by the Finnish ministry in fields such as reactor dynamics, material, reliability etc., transferred to VTT where all major nuclear studies came under Veikko Palva. The ministry therefore ordered its future safety related work from VTT, in particular work related to the first Loviisa reactor. At IFA a new department for safety technology[3] was created in 1973.

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[1] under the chairmanship of Studsvik's Per Linder

[2] led by AE’s Stig O. Bergström

[3] headed by Jan Døderlein

Stig Bergström chaired a Nordic working group on reactor safety. This discussed how to predict the consequences of a large reactor accident by combining models from a variety of ongoing studies.

In the early 1970s, US opposition groups raised concern about the consequences of a loss-of-coolant accident, following rupture of a large pipe in the reactor's primary cooling circuit. This was relevant to all four Nordic countries and led to intensified work on technical aspects of reactor safety. In this situation, a Nordic 'accident group' was assembled to pursue the positive experience of joint work in the 'Subchannel' project mentioned above.

In 1971 the research institutes started joint work on accident analysis programmes. At this time the institutes made calculations for the Urban Siting Study and the upcoming Marviken experiments. ASEA-Atom did not participate because it wanted to keep its lead in calculational models.

Emergency cooling continued to dominate discussions as specialists sought to find out which codes actually existed and to identify areas in which further work was needed. Consequently, in 1972, a Nordic group[1] reviewed existing computer codes used in accident analysis. It recommended a cooperative effort to produce a computational system to analyse loss-of-coolant accidents. This was formalised in an agreement known as **NORHAV**, which was signed by the four research organisations in November 1973. The main goal was a code that would model various phases of an emergency cooling sequence. Many people from the four countries were involved, some of them based at Risø, but neither industry nor authorities participated. Aksel Olsen was appointed chairman of the NORHAV Programme Council.

In this phase, informal contacts were established with the US AEC, which made the Nordic work known in that country. The NORHAV work was later used as a Nordic in-kind payment for the upcoming US international LOFT (Loss-Of-Fluid-Test) programme (page 97). This demonstrated how a group of small countries working together could play an important role in a large international venture. When in 1981, the SÄK programme started (page 160), some of the NORHAV activities became part of the Second NKS programme. As a result, most of the NORHAV Programme Council members were also participants at SÄK technical meetings.

[1] with, among others, Studsvik's Björn Kjellström, IFA's Dag Malnes, Aksel Olsen from Risø, and VTT's Jaakko Saastamoinen

New authorities, responsible for nuclear safety, were separated from the research institutes during the early 1970s when it was accepted that “a promoter should not control himself” (page 80).

From 1973 a new Swedish fund ‘Kärnsäkforsk’ provided additional financing for safety projects. The assets originated from the nuclear power utilities and went mainly to AE at Studsvik. Authority to allocate funds however, remained with the ministry. When the Swedish Nuclear Power Inspectorate (**SKI)** was created in 1974, it successively took over management of the fund.

The Swedish Urban Siting Study, published in 1974, related the risk of locating nuclear power reactors close to cities to a loss-of-coolant accident, the probability of which was calculated to be in the order of 1-10 in a million. Although at that time this seemed acceptable when compared with the effects of normal releases during operation, it recommended first gaining further experience. This order of magnitude coincided with the finding of Norman Rasmussen in the *WASH-1400* report of the US Nuclear Regulatory Commission (NRC). Instead of defining a ‘maximum permissible’ accident, both studies used a new approach to reactor accidents scenarios. This approach analysed the probabilities of various sequences that might lead to accidental conditions.

The *Nordic Secretary* attended Rasmussens summer course on nuclear safety in the USA in 1974. He invited Rasmussen to tour Scandinavia in November[1] of the same year to discuss his results with Nordic experts. Following this visit a Nordic working group started a systematic review of his report in 1975. Comparison with results of the Swedish Urban Siting Study highlighted certain inconsistencies in the US study. These were notified to Rasmussen. The comparison was of particular interest in Finland, where in 1975 an evaluation started for a large nuclear power plant at Kopparnäs, only 40 km from Helsinki.

Norwegian and Swedish utilities continued to study locating nuclear power plants underground.

The Marviken experiments

Increasing concern over the possible consequences of a reactor accident emphasised the need to experimentally verify mathematical models predicting possible consequences. These models were complicated and contained many unknowns. There was therefore an obvious need to experimentally investigate the sequence

[1] his visits to the countries were arranged by Risø's Mackintosh, VTT's Silvennoinen, AE's Carlbom and IFA's Lingjærde

of events following a break in the primary circuit to verify the theoretical calculations used. Experimental safety work, using the Marviken reactor had been planned since 1970, after it became apparent that the original reactor project would not materialise. The containment of this, almost complete, large power reactor would be ideal for full-scale experiments.

In 1971, Nordic specialists from the ‘accident group’ assisted the project leader[1] with initial calculations. The project subsequently grew into an international venture. In Europe at this time only Germany and the Nordic countries made significant efforts to assess light water reactor safety. Parallel discussions took place in Sweden, by the *Committee* for Nordic participation and by the *Gesellschaft für Kernenergiverwertung in Schiffbau und Schiffahrt* for Germany. These discussions led to the so-called Marviken **MX** experiments[2]. During those early days a *Nordic group* provided a major input. Later, under strong Swedish leadership, the experiments became international ventures. Nevertheless, the Nordic countries played a significant role for many years.

The first Nordic-German phase of the MX experiments focused on the behaviour of reactor containment following a major pipe rupture. It started in 1972 with ample technical participation by Nordic countries, before the US AEC joined in 1973. This phase was followed, first in 1975 and then in 1977, by further projects with larger international participation. These widened the studies to include investigation of pressure oscillations within the reactor containment, and the release of iodine and fission products. A separate Nordic project was also organised to develop simple methods to calculate oscillations and their impact.

The information obtained in the MX experiments was used to verify theoretical computer codes. It also provided valuable insight in the processes taking place during a large reactor accident and on the behaviour of reactor containment. The experimental series continued into the mid-1980s, by which time the only participation from the Nordic scene was Finnish.

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[1] Hans-Göran Thorén from Studsvik

[2] headed by Studsvik's Ragnar Nilsson

The Committee at its Kjeller meeting in September 1973 recommended that the Nordic countries form a block during negotiations for a second phase of the Marviken experiments. From left to right Marcus, Gunnar Holte, Veikko Palva, Ilkka Mäkipentti, Jon Berg, Risto Tarjanne, Niels W. Holm, Mogens Møller-Madsen, Aksel Olsen. Studsvik's contact person, Pehr Blomberg, was later sorry that he was absent when this photograph, the only of the Committee, was taken.

Environmental impact

Organised opposition to nuclear power which originated in the US, reached the Nordic countries in the mid-1960s. Among those joining the movement was the Swedish nuclear physicist and Nobel Prize laureate Hannes Alfvén. He left AE's Board in 1968 and saw his own research funding dwindling. More substantial opposition spread during the early 1970s, when there was fertile soil after the 1968 social unrest in Europe. A new generation that had not experienced the Second World War had appeared. The Club of Rome's dark forecasts *limits to growth* published in 1968 also prepared the ground for opposition against modern technology. It raised concerns about the environment and heightened fears of pollution and waste management risks.

In 1971, the American 'scientist' Ernest Sternglass appeared at meetings in Norway, where a moratorium on nuclear plants was proposed. Norwegian plans to build a large reactor in the Oslo fjord in 1973 (page 55), to be ready in the early 1980s met a wave of opposition. This was at the time of the first oil and gas finds in the North Sea, the economic implications of which however were uncertain.

In Sweden, parliament requested new studies on waste management and plutonium before agreeing to more nuclear power. In 1970, protesters organised a great march on the site reserved for a reprocessing plant at Sannäsfjorden (page 46). In Denmark also, public debate increased strongly in the mid-1970s.

Slowly, the opposition movement spread from Sweden to Finland. In 1972, Finnish ecologists still supported nuclear power. When the Swedish antinuclear 'environmentalist' Björn Gillberg came to Helsinki together with a fellow opponent, to give a talk on the dangers of nuclear energy, the audience courteously applauded but, when asked to start the debate, did not pose a single question. Gillberg was furious and swore never to return.

In 1972 the *Committee* established a contact group for environmental information, the members of which[1] were to exchange information about risks and environmental effects related to nuclear power. The group was instructed to produce factual information, not biased in favour of nuclear. One of their first initiatives was to identify persons who had professional knowledge of the questions raised in public debate and who could be contacted for information[2].

The contacts turned out to be very efficient and in urgent cases information exchange between members would even include calls to their homes. In many cases members responded quickly to the media, with whom they established a good rapport to avoid misinterpretation of incidents. This network was later renewed when the Nordic Information Contact Forum was established after the Chernobyl accident (page 238).

The Contact Group reviewed arguments put forward by American opponents such as Sternglass, Kendall (Union of concerned scientists) and Lovins (Friends of the earth). This followed the opponents' meeting in the USA in November 1974 when it became clear that their principal goal was to stop an extension of energy production. Nuclear power therefore, was a prime target for this campaign. The main themes in the nuclear controversy included accidents, releases during operation, transport and disposal of waste, effects of radiation, and plutonium.

All these question were taken up in the following years in Nordic co-operative ventures.

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[1] IFA's K.P. Lien, AE's Sten Sandström, Ahti Toivola from Finland and Ole Walmod-Larsen from Risø

[2] Relevant lists were put together by Per I. Wethe at IFA

3.5 Co-operation among safety authorities

Ever since 1959 those responsible for radiation protection in the Nordic countries maintained contact through meetings initiated by the Nordic Council (page 43). At the outset the yearly Nordic meetings discussed fallout from bomb tests. Other relevant authorities and researchers participated in the meetings, and the latter made predictions of anticipated radiation doses to various sections of the Nordic populations. These reached a maximum the year after the Treaty on a partial atmospheric test ban in 1963. Rolf Sievert was the master of the meetings and put his personal touch on them. One young participant recalls when, after dinner at the Stallmästargården restaurant in Stockholm, which he paid for, Sievert finished his cigar and then quietly folded his leg behind his neck...

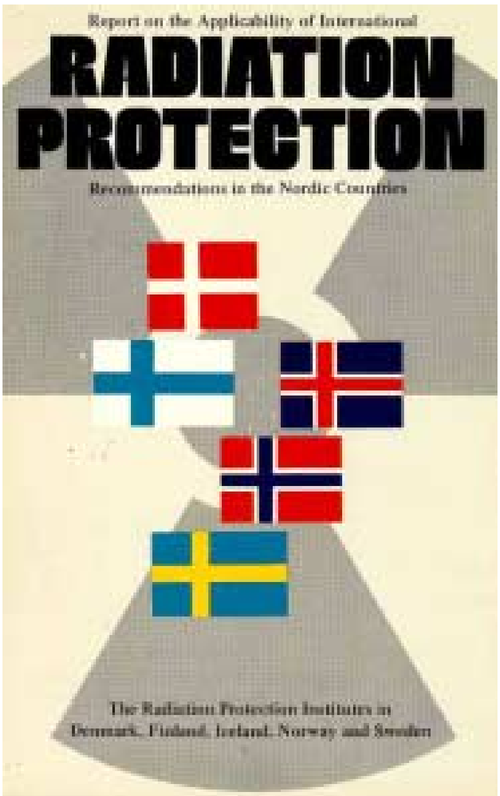
Rolf Sievert participated for the last time in a Nordic meeting in Iceland in July 1965. Here with Bo Lindell, Arne Nelson, Juel Henningsen and Per Grande (photograph: Olli Paakkola).

In the early 1970s the authorities in the field of radiation protection were:

- The Danish Radiation Hygiene Laboratory,
- The Finnish Institute of Radiation Physics (from 1975 the Institute of Radiation Protection),
- The Norwegian State Institute of Radiation Hygiene (while the Advisory Council in Radiation Protection was more visible),
- The Swedish National Institute of Radiation Protection,
- The Icelandic State Laboratory for Radiation Hygiene, not actively participating in this period.

The Nordic ‘Flag-Books’ are one outcome of the direct co-operation between these authorities. They deal with international recommendations on radiation protection and adapt them to the conditions prevailing in the Nordic countries. The work was decided in 1969 and several working groups were established.

The first Flag-Book on radiation protection standards was issued in 1976. It was followed by others dealing with more specific issues, such as natural radiation, release from reactors, radioactive waste, etc.



The ‘Flag-Books’ were written in English, following an early compromise with the Finnish participants and to make wider use possible.

Thanks to joint work on radiation protection standards, national regulations, although still independent, are on the same basis. The similar approach helps practical co-operation in areas such as equipment transfer between the countries. Once an application, say for using a radiation source, has been examined and approved in one country, subsequent approval is easily obtained in another Nordic country.

The Nordic *Society for Radiation Protection* provides a particular forum for Nordic contacts in this field. It was founded in 1964 at a moment when the Soviet bomb tests at Novaya Zemlya caused increasing concern in the Nordic area. The initiative came from Rolf Sievert, who was also its first president. He took this as a very personal duty and involved his wife who sometimes prepared Swedish meat balls for participants at meetings.

This is an example of a single society representing all five Nordic countries at the international level, at the International Radiation Protection Association (IRPA), where most other members are national societies.

The Society provides a forum for exchange of views among professionals in all aspects of radiation protection and holds Nordic meetings at least every third year.

Its discussion in 1968 about the risk curve proposed by F.R. Farmer and its application in the Nordic countries is typical of the areas considered. Another example is the meeting at Visby in 1977, where for the first time, natural radiation was discussed by the Nordic radiation protection community. During the panel discussion an eloquent participant held a long monologue and finally said, “are there any comments from the panel?” Upon which the only reaction came from Anneli Salo who acted as chairperson and dryly remarked, “hardly”.

Such a formal framework for co-operation did not exist with the emerging competent authorities responsible for reactor safety, which were:

- the Danish AEK’s Risø, replaced from 1973 by a new Nuclear Inspectorate with former *Committee* member Møller-Madsen as director,
- in 1975 a new reactor safety department, with Antti Vuorinen, of the Finnish Radiation Protection Institute (which was under Aulis Isola),
- the Norwegian Nuclear Energy Safety Authority starting in February 1973, which came under Martin Mølsæter,
- the Swedish Delegation for Atomic Questions with its Reactor Siting Committee under Torsten Magnusson and Arne Hedgran, replaced in 1974 by SKI, the Nuclear Power Inspectorate.

When the question of nuclear safety was first addressed in the *Kontaktorgan* around 1960, it was primarily because of the expected visit by the US nuclear vessel N/S Savannah (page 49). Its planned visit to several harbours in western Scandinavia in 1964 placed a heavy burden on the responsible authorities in the various countries. There were also plans for a visit by the German N/S Otto Hahn. The N/S Savannah had refrained from entering Finland since the authorities here would have asked to make their own safety review onboard the ship in order to avoid a Soviet requirement to inspect the USA vessel.

The twelfth meeting among the radiation protection authorities in September 1972 was enlarged to include reactor safety questions. Although not formalised, it was the first joint meeting of all related authorities that covered this whole field. At the time applications for first power reactors in Denmark and Norway were expected. The emerging reactor safety authorities were therefore preparing themselves for their new tasks.

When the *Nordic Secretary* attended the radiation protection authorities’ meeting for the first time, the chairman Bo Lindell asked whether he could take over the role as a permanent meeting secretary. He refused this proposal because he always made sure that someone else took notes during all meetings that he organised. In hindsight however, friction between the *Kontaktorgan* and the authorities might have been avoided through such an arrangement. Nevertheless, the *Nordic Secretary* was frequently invited to join meetings of the radiation protection authorities.

When the directors for both radiation protection and nuclear safety authorities held their first joint meeting in 1977, they established a permanent Nordic forum (later called the *Chiefs* group, page 241). Here, all competent authorities involved in questions related to nuclear safety could meet regularly. Meetings were held annually, in which the *Nordic Secretary* participated. Over several years he even became a driving force. Twenty years later, the new *Nordic Secretary* also became a participant in the *Chiefs*' meetings, which again improved the contact with other ongoing Nordic activities.

Not all of these joint meetings were totally peaceful; there was occasional tension between the two authority groups. Once the *NKS* chairman Thomas Eckered, who was the Swedish Nuclear Inspectorate's representative in the group, countered the Radiation Protection boss with the words, "you read the paper [about NKS] as the devil reads the bible".

But in general there was a friendly atmosphere. Thomas Eckered organised the last meeting in Stockholm in 1979 before he left SKI to take up his work with Swedish utilities. The traditional dinner after the meeting took place in one of the city's ancestor restaurants, 'Gyllene Freden' in the old town which was patronised by Bellman some hundred years earlier. This was a big treat but Eckered's successor, Lars Nordström, later complained that SKI's dinner allowances for the entire year were non-existent following that evening.

The Nordic working group on reactor safety, *NARS*

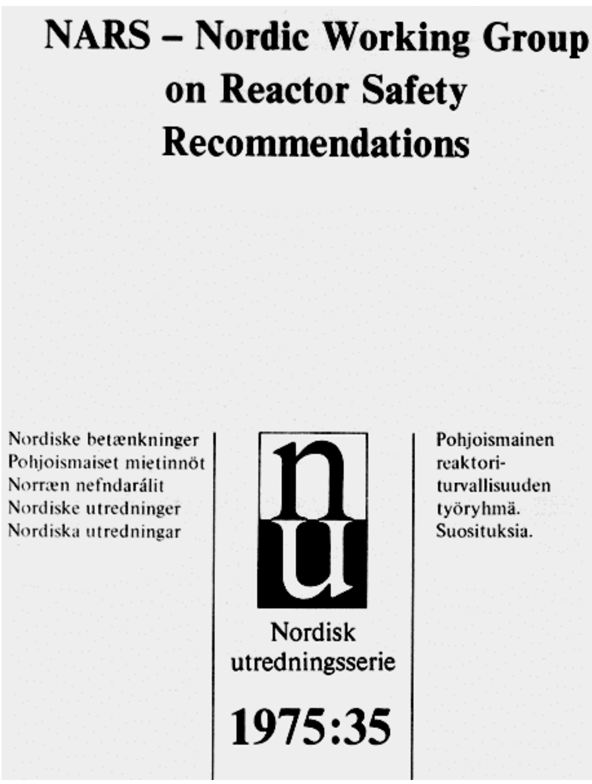
Following the recommendations of the *Kontaktorgan* (page 60) the competent authorities established the Nordic group on Reactor Safety, *NARS*. It held its first meeting in 1969, with two participants from each of the four countries[1] (Note 3.5). An agreement between the four governments was initially signed in July 1970 and extended in 1973. It had a budget of SEK 2 million (ECU 0.4 million).

The main purpose of *NARS* was to provide common guidelines to be used by the nuclear safety authorities in the Nordic countries to specify the contents of licence

[1] Henning Jensen from Risø was its first chairman

applications. One objective was to make application documentation systematic and complete. *NARS*' work also included harmonising safety criteria and emergency procedures for nuclear sites. Before *NARS* started its work, national competent authorities dealt with such issues in their individual manner.

Establishing *NARS* brought together several specialised working groups with people from the research institutes and authorities. This in turn led to improvements in national safety-related work. Many of those participating in these activities later acquired leading positions in the safety organisations of their countries[1]. Event trees and cause-consequence diagrams developed in a *NARS* project helped pave the way towards probabilistic safety analyses (PSA), which became a major tool in reactor safety.


NARS – Nordic Working Group on Reactor Safety Recommendations

Nordiske betænkninger
Pohjoismaiset mietinnöt
Norræn nefndarálit
Nordiske utredninger
Nordiska utredningar

Nordisk utredningsserie

1975:35

Pohjoismainen reaktori-turvallisuuden työryhmä. Suosituksia.

NARS' publications were sent out for comments by 1974. These were incorporated in the final edition - in English at the request of the Finnish participants - published through the Nordic Council of Ministers

Some utilities gave *NARS*' proposal a lukewarm response; to rationalise work, they preferred to simply base their application on the vendors' safety reports, which satisfied requirements from USA authorities. However, there was a distinct difference in the approach by the Nordic safety authorities: here it was up to the applicant to demonstrate safety, not just by fulfilling certain requirements stipulated by the authorities, but - according to *NARS*' advice - to systematically go through all safety related aspects.

[1] e.g. Kåre Øfjord in Norway and Antti Vuorinen in Finland

The increased responsibility for safety, placed on the operator and accepted by the authorities, became a feature of nuclear plant safety in the Nordic countries. It undoubtedly contributed to the positive relationship between authorities and utilities. For the Finnish safety authorities who dealt with Soviet suppliers, *NARS* was an important element in a process which constrained them to formulate their own safety requirements.

The principles behind the *NARS* recommendations later formed the basis of more detailed national regulations formulated by the individual authorities. The cause-consequence diagrams described by *NARS*, which also appeared in the US WASH-1400 report in 1974, were used in safety evaluations - both in Nordic projects (in work on probabilistic safety assessments) during the NKS period from 1981 (page 165) - and in individual countries.

The original *NARS* agreement was limited in time. On several occasions the *Kontaktorgan* reflected that the *NARS* framework should be permanent, to maintain contacts among the safety authorities. Continuation beyond 1974 was planned but never signed. Later in the 1970s when a future safety research programme was discussed (the NKS programme, page 104) it was suggested that *NARS* might provide a suitable frame for related Nordic project work. This would be financed by those ministries dealing with nuclear power and who were represented in the *Kontaktorgan*. At that point the safety authorities preferred to keep their position independent of these ministries, though these in fact financed the *NARS* activities.

Reactors near frontiers. The Barsebäck case

During its work *NARS* found that there was a need to ensure contact, at an early stage, if a new nuclear plant was planned close to the border of another Nordic country. Exchange of information with a neighbouring country's authorities should be mandatory and the neighbouring country should have the right to request consultation.

The *Kontaktorgan* took up this issue and in January 1973 assured that it was dealt with by the responsible ministries. The Nordic *Ministers* accepted the proposal and its secretariat forwarded it to a newly formed Nordic environmental contact body. It was finally formalised in all the four countries in November 1976. This was cited as a specific case in a more general Nordic convention on environment protection from 1974. Twenty years later concepts similar to this 'Border Reactor Agreement' were introduced in the 1994 IAEA Nuclear Safety Convention.

Contacts between Swedish and Danish authorities, concerning safety aspects of the planned Barsebäck plant had been established in 1968. In May of that year, the leaders of the Swedish safety authorities[1] requested a meeting in Copenhagen with the Danish safety authorities. The purpose was to exchange information about planned nuclear sites in the two countries and discuss emergency plans related to visits of nuclear powered vessels. In view of the forthcoming application for the first Barsebäck reactor - to be sited on the Swedish side, but close to Copenhagen - the authorities exchanged information. The issue also had implications for a planned airport to be located on the island of Saltholm, between Denmark and Sweden. This project was favoured by politicians and had been thoroughly discussed in the Nordic Council. The plans were later abandoned, but if the airport was built, it would have posed a major problem for the location. Additional evaluations requested by the Swedish authorities had shown the probability of a plane crash onto the reactor, as one in ten million.

From the beginning of 1970, contact persons for the Barsebäck project were appointed in both countries. Before issuing a construction licence, the Swedish authorities passed all relevant information for the first and the second unit to the Danish authorities for examination. Over the years, this information exchange continued through the operational phase and included reporting abnormal occurrences. Danish participation in emergency drills was also arranged.

Initially, one fifth of the output of the first Barsebäck reactor - 100 MW - was contracted to Danish utilities for a period of five years. In practice the power transfer, after commissioning in 1975, was smaller, but it attracted public interest at a time when Danish opposition to nuclear power was increasing. During a moment of disturbance to the electricity supply in Copenhagen, it was not popular to remark that “it must be a failure at Barsebäck!”

Over the years many calculations were made to estimate possible effects in Denmark following a hypothetical accident at Barsebäck. In 1978 Danish calculations were submitted to the Swedish Energy Commission to show that conclusions drawn by consultants for the Swedish authorities, predicting serious consequences, were unreasonable. They had made unrealistic assumptions to arrive at the high number of casualties suggested in these reports.

[1] Torsten Magnusson and Arne Hedgran

3.6 Electricity producers, NORDEL

Nuclear training passed a milestone in 1968 when the Swedish Vattenfall, through NORDEL, invited utilities in the Nordic countries to send people to join its new Ringhals Centre for Exchange of Experience. This initiative can be considered as a follow-up to successful Nordic participation in the Marviken project (page 48). Many of those later involved in Nordic project work were given their introductions to nuclear power through the Ringhals Centre. Most worked at the Vattenfall headquarters at Rocksta near Stockholm[1]. This arrangement was of particular value to the Finnish IVO company when it ordered its first nuclear power plant from the Soviet Union in 1969 (page 56).

In 1971 the *Kontaktorgan* established an arrangement for contacts with NORDEL, primarily to exchange information and, later to discuss co-ordination of work. The *Nordic Secretary* filled this contact function for the *Kontaktorgan*, while initially Rolf Heggenhaugen acted for NORDEL.

The main issue, apart from continuing information exchange, was the reliability of nuclear power plant components. Later the question of operators in control rooms also became an important area of mutual interest.

In 1971-72 ELKRAFT’s Ehlert Knudsen and Marcus produced a joint report on reliability techniques. The report proposed a division of efforts. NORDEL would collect data on component reliability at operating nuclear power plants. The research institutes would show the practical application of reliability methods and maintain the relevant knowledge. This led the *Committee* to establish a reliability group[2] in 1973. This group became responsible for development work.

The joint report was submitted to NORDEL and the *Kontaktorgan* in 1973 and finally edited in 1974. Reliability questions were among the most important issues addressed in later phases of Nordic co-operation. The *Kontaktorgan* held its first ‘NKA-seminar’ on this issue, organised jointly with NORDEL, in Finland in September 1973. A mixed organisation committee[3] prepared the seminar and subsequently discussed its follow-up. In 1974, the three Swedish utilities that operated nuclear power plants established the ATV system for data collection and analysis. They were later joined by the Finnish TVO utility.

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[1] among them Jan Nistad, Bjarne Regnell and many engineers from the Danish ELSAM

[2] on the initiative of Kjell Johansson from Studsvik

[3] under VTT's Veikko Palva and with Juhani Ervamaa as secretary

People from the major electricity generating bodies involved in the Ringhals Experience Centre initiative now proposed to set up a NORDEL Nuclear Power Committee[1]. For some unknown reason, TVO was excluded from membership.

This committee became NORDEL's partner in relation to the *Kontaktorgan* and consequently the *Nordic Secretary* attended its meetings. An early meeting was held at Loviisa in October 1973. Although it was bitterly cold, participants took the opportunity to climb the outside of the first reactor shell. Afterwards, they endured a cold journey back to the city by a small boat, eagerly accepting chairman Numminen's invitation to regain heat with some Cognac he had brought along.

The Nuclear Power Committee discussed many questions which lay in the same areas as those addressed by the *Kontaktorgan*. Many issues addressed by the *Committee* were relevant to the utilities, such as high temperature reactors, breeders, underground location, the fuel cycle, etc. The meeting of the Nuclear Power Committee at Studsvik in September 1974 provided an opportunity to present some *Committee* project initiatives in these fields. Exchanging information at this level, with some division of work, enabled utilities to remain independent of the ministries taking part in the *Kontaktorgan*. Simultaneously it fostered good-will between the two parties that could even result in contacts at the national level.

After the 1973 reliability seminar an action plan laid down procedures according to which a committee in the NORDEL organisation was to evaluate reliability data collected from operating power plants. In 1975, the NORDEL Nuclear Power Committee chairman decided to combine this task with collecting availability data from conventional power plants in the Nordic countries. The *Committee*'s reliability group continued its more theoretical work on 'reliability engineering' models, including maintenance and repair. The data was urgently needed to calculate the probability of accident sequences. A 'joint body' was formed comprising representatives from the utilities and members from the *Committee*'s reliability group.

Following NORDEL initiatives, Nordic co-operation continued among the electrical utilities for many years. Transmission links between the countries are a visible result of this co-operation. Enabling use of generating reserves, the links have reduced the total need for power plant construction.

[1] its first chairman was Ingvar Wivstad from the Swedish State Power Board (Vattenfall) with Per-Eric Ahlström as secretary. They were followed by IVO's Kalevi Numminen assisted by Anders Palmgren

3.7 Documentation

In December 1968 the *Committee* took up the question of dealing with the onrush of computerising information on nuclear science and technology. At this time, the US AEC sought partners to enter into agreements to exchange datorised information in this field. The following January, the three national nuclear research institutes' libraries, with Helsinki University of Technology[1], decided to form a 'Nordic Atomic Libraries, Joint Secretariat' (*NALJS*). The secretariat was placed at the Risø library under Eva Pedersen. The co-operation was formalised and a Memorandum of Understanding with the US AEC was subsequently signed in January 1970. This was one of the first occasions where the Nordic countries could act as a *Nordic group* to sign an international agreement.

Partners of *NALJS* also joined the IAEA's International Nuclear Information System (INIS) as it became operational in April 1970. Here *NALJS* acted as a decentralised centre to help the new computerised indexing system to get under way. This ensured that all Nordic publications in the nuclear field were registered - and could be found - in an international documentation system.

Co-operation among the Nordic libraries has continued for many years. When in 1978, the area was broadened from nuclear documentation to cover general energy research, *NALJS* encompassed this area also. In 1980 a Nordic Energy Index (NEI) was created. This embraced all energy-related literature. The following year, a new Nordic Advisory Board for energy information (NAB) signed an agreement - with what was now the US DOE. NAB was a joint body with ministry representatives from the four Nordic countries. Future registration of literature in each country was extended to cover the entire energy field.

Later, from 1982 to 1989 *NALJS* worked under contract to the Energy *Officials* of the *Ministers*, editing catalogues of Nordic research in the energy field. Ultimately, in January 1988, *NALJS* changed its name to SNEIL (Secretariat of the Nordic Energy Information Libraries).

Co-operation among the Nordic libraries has enabled working routines to be rationalised and kept free of competition. It is doubtful if each country on its own could have benefited from the information available from abroad.

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[1] much at the initiative of the latter's Nordic-oriented director Elin Törnudd who had previously been head of secretariat of the Nordic Co-operative Organisation for Applied Research (NORDFORSK) in Copenhagen

Now they shared their know-how, profiting, for example, from Studsvik's ability in the early days to run the American tapes. The original *Committee* initiative has provided a long lasting forum for new incentives to be discussed prior to international meetings on documentation policy.

3.8 Continued contacts through the *Kontaktorgan*

The two main themes for the *Kontaktorgan* during the 1960s continued to be international co-operation and Nordic topics. In 1970, the *Kontaktorgan* identified the need for a small *Contact Group* between the ministries in the Nordic countries. This would deal with questions outside the technical scope of the *Committee*. The members of this group (Note 3.8) would liaise in the periods between the *Kontaktorgan* meetings. They were also to facilitate the work of the *Nordic Secretary*, who became a member of the *Contact Group* in 1973 and was simultaneously appointed Secretary-general of the *Kontaktorgan*.

When for the first time, the Nordic Secretary presented the Nordic nuclear co-operation internationally, he appeared as a Finnish delegate to the fourth Geneva Conference in 1971, where he distributed a reprint with the four flags of the countries working together in the Committee.

IAEA and safeguards

IAEA questions were always discussed at *Kontaktorgan* meetings. For many years the Nordic countries continued to alternate on a seat of the IAEA Board of Governors. In the early days IAEA Board meetings were long and sometimes lasted for several weeks. The country currently occupying the 'Nordic' seat frequently consulted other Nordic countries to represent their viewpoints at Board meetings. Iceland did not participate because it would have required a substantial commitment. Nevertheless, Magnús Magnússon attended practically every General Conference from 1957 through to the 1990s. On one occasion in 1978, he was absent when an important vote was to be taken. His Nordic colleagues called him urgently, so he immediately hurried to Vienna for the ballot and saved the situation for the industrialised member states' representation in IAEA's Board.

Safeguarding nuclear material was frequently discussed in the *Kontaktorgan*. In the early days personalities from the Nordic countries such as Gunnar Randers - and later Sigvard Eklund as IAEA director - were active in making the IAEA the leading organisation to safeguard nuclear material. Norway was the first country to have a reactor inspected by IAEA's safeguards inspectors when they assessed the NORA plant in 1961. Danish support to develop IAEA safeguards was personified by H.H. Koch and Per Frederiksen. Their influences resulted in early agreements with Denmark in 1965 and 1968 and further Danish participation in the revision of safeguards systems.

In 1968 the 'nuclear super powers' had reached an agreement to open the nuclear markets to countries submitting their nuclear material to IAEA's safeguards control. This marked a significant change in the relations between the grand powers. It was the fruition of a lengthy process to develop a policy aimed at avoiding the disasters of atomic warfare. The detrimental consequences to Nordic countries of such a conflict were increasingly recognised. Sweden was the only Nordic country to participate in the ENDC (Eighteen Nations) group that negotiated the advent of the NPT.

According to the 1970 Treaty on Non-Proliferation of Nuclear Weapons (NPT), rules and techniques in IAEA safeguards were to be replaced. Now all 'non-nuclear weapon states' such as the Nordic countries needed special safeguard agreements. These were to be complemented with specific 'attachments' for each individual nuclear facility. Finland had already negotiated transferring to the IAEA safeguards control rights of the Soviet Union, UK and the USA. The draft worked out between Finland and the IAEA therefore formed the basis for subsequent NPT-safeguards agreements. Finland was the first country to sign such an agreement and make subsidiary arrangements.

Nuclear Energy Agency and Euratom

In January 1972, when ENEA's (page 39) future activities were to be discussed, a meeting with the four Nordic countries and ENEA was organised in Copenhagen. Harmonising policies and developing safety criteria were among the topics proposed for the Agency's future activities. Similar consultations with other countries led to the enlargement of ENEA and its transformation into NEA, the Nuclear Energy Agency of the OECD.

The consequences of Danish and Norwegian membership of Euratom was discussed in the *Kontaktorgan* and taken up in the *Committee* in the early 1970s. Background information assembled by the *Nordic Secretary* was discussed in the *Committee*. When finally only Denmark decided to join the Common Market and Euratom from 1973, it maintained its commitment to Nordic ventures.

Relations to the Nordic Council

The *Kontaktorgan* reported to the Nordic Council annually. Later, when the Nordic Council of Ministers (the *Ministers*) and its Energy *Officials* came into being in 1973, the *Nordic Secretary* forwarded the reports through the new Nordic secretariat in Oslo.

Its committees prepared the work of the Nordic Council. Nuclear questions were addressed initially by its Economic Committee and later, by its Social-/Environmental Committee. During the annual sessions of the Nordic Council, questions of high national importance raised by the participating politicians were considered in a Nordic context. This was noticeable in the years during which the opposition to nuclear power was growing.

The Nordic Council routinely consulted with the *Kontaktorgan* as a competent group when its members, the parliamentarians, raised issues that might lead the Council to formulate recommendations to the Nordic governments. The first issue discussed in 1967 concerned radioactive waste and the back-end of the fuel cycle. The *Nordic Secretary* twice represented the Nordic Council at hearings in the Council of Europe. The first in September 1984 in Stockholm, related to waste management. His report impressed the secretariat, although members of the Nordic Council were less approving. In general, they were critical of nuclear matters. The second hearing in January 1987 on nuclear accidents followed the Chernobyl accident.

The Nordic Council continued the practice of using the Nordic expert groups as its competent advisers. The *Kontaktorgan* received all proposals relevant to its field of work, which members of the Nordic Council put forward, for comment. After the *Kontaktorgan* wound up, some of its functions were taken over by the Nordic Committee for Nuclear Safety Research (*NKS*), who then dealt with such questions. This practice was abandoned in 1994 (page 238).

Development in the Nordic countries up to 1973

The *Kontaktorgan* discussed possible Nordic ventures against the background of the current situation in the individual Nordic countries.

In 1972, Denmark took the first steps to secure sites for future nuclear power plants. With 1980 as the target date, the two Danish utility groups investigated different reactor types. In view of the similar situation in Norway, the ELSAM utility established contacts with the Norwegian State Electricity Board (NVE).

For Norway, 1982 was the target date for the first nuclear power reactor planned by NVE. However, as time passed, this date steadily moved backward. To make commercial use of Norwegian expertise a new firm, Scandpower was created in June 1971 on the initiative of Henrik Ager-Hanssen from IFA. The new company was an off-spring from IFA, with active participation by Norwegian industry. It was a logical follow-up from the NORDEK negotiations (page 61) which had provided an intimate contact between industry and the research institute. In certain aspects Scandpower was a competitor to Studsvik although they also attempted to co-operate. This competition was welcomed by ASEA-Atom because it prevented a monopoly from developing in the Swedish market

Waste management was first taken up at the *Kontaktorgan* level in September 1972, at a meeting at Lysebu in Oslo, held to assess the situation in the various countries. The *Kontaktorgan* decided to concentrate initially on policy questions related to waste of lower radioactivity content (low and medium level waste). This was the category of immediate interest to all countries. The second NKA-seminar in 1974, held at Lidingö close to Stockholm, also dealt with waste[1].

[1] It was planned with Bo Lindell, the head of the Swedish Institute for Radiation Protection (SSI)

Following an initiative from the Swedish Ministry of Industry to co-ordinate the purchase of uranium and enrichment services, the Swedish utilities in mid-1972 formed the Swedish Fuel Supply Company (SKBF) to handle their affairs in fuel supply and waste management[1]. At the outset its main activities were in the 'front-end' of the fuel cycle. With the changes in political conditions for nuclear power in the 1970s however, its main thrust was directed towards the back-end. SKBF became a partner to many Nordic initiatives in the waste field.

[1] Jonas Norrby from Vattenfall was appointed chairman

4. The energy crisis 1973 and the start of NKS

The oil embargo in the latter part of 1973 led to a sudden change of lifestyle as oil prices escalated. In the Nordic countries, as elsewhere, it was manifested by restrictions in automobile use etc. It had a major impact on views of nuclear power. Concerns about its safety were now balanced by fears about energy shortages and dependence on vulnerable energy supplies from abroad. At the time, North Sea oil and gas fields discovered first in Norway and then in Denmark, had yet to be exploited on a large scale.

4.1 The *Ministers'* reactions on the first energy crisis

The energy crisis forced governments to review their energy supply systems. Views on energy questions changed in several ways. The Nordic Industry *Ministers* requested a report on future Nordic co-operation in the energy field. They declared that nuclear power could increase, provided its safety was assured. They also gave a high priority to developing renewable energy sources. Issued in 1974, the report was produced by the *Officials* for Industry and Energy ('EK-E' or 'ÄK-E'), with contributions from the *Kontaktorgan*.

The meeting of the Industry *Ministers* at Gothenburg in January 1975 was combined with a visit to the Ringhals nuclear power plant site. At this and subsequent meetings, the *Nordic Secretary* observed that discussions were conducted in an atmosphere of good-will for increased R&D on nuclear safety. The *Ministers* instructed the *Officials* and the *Kontaktorgan* to investigate the scope for enlarged co-operation in the safety field.

Simultaneously, in January 1975 an ad hoc working party[1] was set up to identify possible Nordic projects in the energy field. Nuclear questions were not included, but the report referred to the *Committee*'s interest to engage in energy research programmes, including heat-only producing reactors. The *Contact Group* organised a reference team with national representatives, to supply material to the

[1] under Ivar Haahr from the Danish National Agency of Technology seconded by Rut Bäcklund Larsson, the secretary of the new Nordic Fund for Technology and Industrial Development that had come into existence in 1973

working party[1]. The report was issued in 1975 and indicated areas to be promoted at the Nordic level following the energy crisis. This was the first step towards organising a parallel Nordic activity to that developed by the *Kontaktorgan* since 1957.

Discussions about this report laid the basic framework on which a new nuclear safety research programme was built, as described below.

4.2 Effects on the *Kontaktorgan* and the *Committee*

Both the *Kontaktorgan* and the *Committee* modified their working programme following the energy crisis.

The *Kontaktorgan*

During the 1970s, rapidly increasing demands for uranium drove prices sky-high. Securing adequate supply therefore, became a major concern. One possibility considered was to accelerate uranium production at the Swedish Ranstad mine. The *Kontaktorgan* discussed the fuel cycle, even including Swedish ideas for an enrichment plant based on ultra-centrifugation.

Thoughts on heavy water production were resurrected since it appeared that Canadian production was insufficient to meet the predicted demand for CANDU reactors.

The *Kontaktorgan* devoted its meeting in September 1974 to reactor safety. At the meeting, Jan Døderlein from IFA gave a lecture that also catalogued reactor safety projects in each of the Nordic countries.

During the following years administrative changes in Nordic countries influenced the work of the *Kontaktorgan*. Denmark abolished the Atomic Energy Commission in 1976. Risø became a national research institute with its own Board reporting directly to the ministry[2]. The new Environmental Protection Agency absorbed the Danish Nuclear Inspectorate. In Sweden, a new investigation[3] examined the future of AE. In 1975 a new SKI Board for reactor safety started to fund research projects.

[1] among others Jon Berg and Veikko Palva
[2] Erik Ib Schmidt, who had succeeded H.H. Koch, became chairman of its new board
[3] under Mats Lemne

From 1976, Finnish participation in OECD's Nuclear Energy Agency (NEA) led the *Kontaktorgan* to discuss international representation. It questioned if Nordic countries could be jointly represented on NEA working groups or those of the International Energy Agency (IEA), created by the OECD in 1974 after the energy crisis.

It soon became clear that countries would not benefit by giving up their own representation. Nordic co-operation might be helpful however, in discussions of matters coming up. The *Kontaktorgan* felt that such co-operation should not impinge on the national image and should not compromise either international representation, nor the independence of safety authorities and their advisory bodies.

Joint elaboration of background information was seen as a constructive way to provide input to individual authorities and arrive at a common understanding. This was a strong argument for joint project work. Radiation protection authorities already adopted this procedure when dealing with the practical application of international recommendations (page 79). Through working together on current issues, countries' representatives became orientated towards common attitudes in international discussions.

The research institutes

A survey made early in 1975 at the initiative of the *Contact Group* highlighted areas of possible Nordic co-operation related to reactor safety and waste management. These were fields in which Nordic countries could benefit from rationalisation of efforts. Such co-operation might also lead the countries to adopt similar basic rules. It was argued that this, in turn, would facilitate industrial applications in the Nordic area - desirable from a utility point of view - and influence international development. This was something in which Nordic governments were interested, since it could build on the positive reception enjoyed by the *NARS* recommendations.

New proposals were discussed in the *Committee*[1] (Note 4.1). Some non-nuclear energy questions were also taken up although the *Committee* decided to keep its activities mainly within the nuclear field. In this period the work of the research institutes became more commercially oriented. In its discussions, the *Committee* acknowledged that theoretical, non-commercial issues, would have the best probability of success in joint project work.

[1] since 1974 Veikko Palva had followed Gunnar Holte as its chairman, with Pekka Silvennoinen as contact person

The research institutes increasingly looked at options for work on alternative energy issues. As usual, official Swedish investigations were under way concerning areas of work at Studsvik. Questions related to more efficient use of available energy and heat sources were included. Commercial ventures were proposed, especially in the new fields of energy production and conservation. Studsvik moved quickly in this direction. Peter Margen - who had been a member of the *Committee* - became an expert on heating systems, including district heating, energy storage and heat pumps. A new division for energy techniques was created at Studsvik in 1976.

VTT carried out a similar survey and started collaborating with Studsvik on energy conservation and district heating schemes. Meanwhile Risø, supported by the European Commission (CEC), became actively engaged in fusion research. Sweden also joined this CEC programme. Gunnar Holte expended a lot of energy in attempting to prevent Swedish research budgets being absorbed by the European fusion programme to pay the ‘entrance fee’ for Swedish participation.

The group of institute *Directors*[1] discussed the broad lines of action. The new ‘fashion’ of talking about research strategy also came up in the institutes. VTT quickly worked out a foresighted priority action list. At a meeting of the *Directors*, people from the other institutes were confounded. They asked for clarification when the Finns mentioned that *microelectronics* would be an important field of future research.

In the mid-1970s joint project work among the four countries, related to nuclear energy, reached a turning point. Its annual turnover including manpower, approximated 10 million Kroner (ECU 1.5 million). Most of the nuclear areas at IFA were already related to Nordic work: Halden, Scanuk, NORHAV and waste management. The same was true, although to a lesser extent at Risø where nuclear issues were a smaller part of total activities. Around 1975 it became more difficult for these two research institutes to finance work related to nuclear power. The situation was different in Finland and Sweden where utilities and authorities needed research results.

In 1975, many international ventures were raised in the newly formed nuclear safety group of the IEA. The Nordic countries combined their efforts to rationalise Nordic participation, in particular to the new IEA projects proposed by the US Nuclear Regulatory Commission (NRC). These were discussed in the meetings of the *Committee* and also in the *Kontaktorgan*.

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[1] under its new chairman Pekka Jauho

Long negotiations followed. First between the Nordic parties at meetings at Risø, organised by its technical director Niels W. Holm and then in meetings which generally took place at the Arlanda airport, led by AE technical director Ragnar Nilsson. To satisfy the need to enhance reviews of safety evaluations, the USA NRC needed a complete set of programmes to predict events following a loss-of-coolant accident. NRC had experienced problems with the interface between individual calculation programmes it was using. Its staff was familiar with the NORHAV work (page 73) and appreciated its quality. Nordic participation in LOFT however, required an extension of the NORHAV agreement and the appointment of a single Nordic project leader. NRC's interest was so strong that the date to sign a new Nordic agreement was brought forward. The 'Arlanda group' then became known as the *Nordic group* under Ragnar Nilsson who officially acted as the Nordic project leader.

Nilsson had a personal fashion of abstract talking, which may have impressed the Americans. On behalf of the *Nordic group* he traded in Nordic results and a substantial manpower commitment (initially 5-6 people/year) against participation in LOFT[1]. Joining this programme gave the Nordic countries firsthand insight into its many activities. This enabled them and their industry - above all ASEA-Atom - to make rapid use of the results.

The original Nordic/LOFT agreement was signed in October 1976. The *Nordic group* was asked to present its first result - a code that would model not only the cooling of dry fuel elements but also the sequences following injection of emergency cooling water - after six months. Having hastily prepared the code they then spent another two years rectifying it so that it could actually be used.

In 1980 the NORHAV agreement was extended by a further two years, using the new NKS/SÄK projects (page 161) as partial 'in-kind' payment. During this period, the Nordic manpower commitment was reduced to 3 persons each year. The smaller input was balanced by handing results from later phases of the Marviken experiments to the NRC. Studsvik now preferred to use manpower from Risø, against payment, for its part of the LOFT obligations. However, at the same time Risø and VTT paid Studsvik to compensate for the delivery of Marviken results to the NRC as part of the Nordic input. The same problem area was later dealt with in successive NKS programmes (SÄK, SIK, RAK) from 1980 (page 161, 232, 243).

[1] Aksel Olsen from Risø became technical co-ordinator

When later, the Nordic parties contemplated participating in the new IEA ventures on materials research (HSST) and fuel behaviour (PBF), their suggested involvement seemed inadequate as compensation, at least at the outset.

Dispersion of radioactive material to the atmosphere following a theoretical accident was a further initiative[1], resulting in a series of meetings starting in May 1975. These were called SNODAS, an acronym for Nordic Dosis and Dispersion Models' Comparison. The impacts of radioactive releases from an accident were still being investigated and included calculations of possible effects of events in neighbouring countries. Nordic contacts had started in the early 1960s, with dispersion experiments performed at Studsvik, complementing theoretical work at Risø. The new SNODAS initiative was a follow-up from the comparison of the Swedish Urban Siting Study and the WASH-1400 report in 1974/75 (page 74). These showed that models currently in use gave diverging results. Participants were to apply their models for atmospheric dispersion to the same case and compare the outcomes. Also, calculations of population doses from a radioactive cloud were to be compared.

The SNODAS meetings contributed to a better understanding among the research institutes' meteorology sections and led to improved models. The national meteorological institutes weres however, more prudent, they did not share models that they wished to exploit commercially. From 1980 the SNODAS work was co-ordinated with the upcoming NKS radioecology programme (page 112). Consequently, specialists in radioecology participated in the SNODAS meetings. After its twelfth meeting in October 1984, SNODAS' activities continued within the framework of the Third NKS programme's AKTU programme (page 174). The knowledge acquired was invaluable in relation to the Chernobyl accident in 1986 (page 194).

More nuclear power?

In *Denmark* the ELSAM utility group accelerated its work on nuclear power, reinforcing its nuclear staff[2]. In 1975 protagonists still believed that a first nuclear power reactor could be in operation by 1983. Risø increased work on nuclear technology for the utilities. High quality basic research had to continue however, so that expertise would be available to help solve non-nuclear problems. Danish fuel element fabrication was developed, in anticipation of a Danish decision on

[1] by Niels Busch from Risø and AE's Stig Bergström

[2] which had been under Gunnar Lund-Jensen since 1972

nuclear power by 1975. A government proposal in 1976 even envisaged constructing six nuclear power plants for the period 1985-1995.

The economics of nuclear power and its environmental effects became essential issues in the debate. In 1976, a *Finnish* study on plans for a new power plant at the Kopparnäs site favoured nuclear over a conventional plant in both these aspects. Also other reactors were suggested, such as a 1000 MW combined heat and power generating plant close to Helsinki with a proposed start in 1982. A project for two additional reactors at the Loviisa site in the late 1980s was also discussed.

In *Norway* the State Power Board established its own department[1] for nuclear power. Investigations into suitable sites for nuclear power plants on the West coast continued. The plants were required as a reserve for years without rainfall. However, the need for large amounts of cooling water and the respect for the beauty of the fjord landscape led to local protests. These projects were later abandoned, partly due to technical reasons and partly because of the increasing scepticism against nuclear power in general and its possible environmental impact. The official date for the first nuclear power plant was now set beyond 1985.

Discussions on nuclear reactors also covered their ‘unconventional’ use. A novel *Swedish* design[2] for a safe, heat-only reactor SECURE was the object of detailed Finnish-Swedish design efforts in the mid-1970s. Juhani Kuusi led the Finnish team at Finnatom and Olli Tiainen tried, without result, to provide a site for a 100 MW prototype of this design with the Helsinki City Electricity Board. An attempt to secure financing from the Nordic Industrial Fund was unsuccessful. Given external financing, all four countries might have participated in this project, but now only a Finnish-Swedish consortium - including VTT and AE - could be formed in 1976.

Opposition to nuclear power

The energy crisis failed to sway public opinion sufficiently to counter its fear of nuclear power. The ‘China syndrome’ was perceived as a real threat. Opposition against nuclear power became an issue for the *Kontaktorgan* from 1974. Debates in the national parliaments on energy supply, including the role of nuclear power, were taking place in all the countries in 1975. Key words in the debate were reactor safety, waste, transportation, effects of radiation, and misuse of plutonium.

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[1] which came under Ingvald Haga

[2] by Kåre Hannerz of ASEA-Atom

In *Denmark*, a public information campaign to address energy questions was launched. The nuclear debate was coloured by political - antinuclear - opinions. The Barsebäck plant, 20 kilometres from the centre of Copenhagen, became a syndrome in the Danish debate. When the first site, at Gyllinge Næs in Jutland was identified, it led to strong protests. The anti-nuclear association OOA, founded in 1974, requested a three-year moratorium on nuclear power in Denmark. In 1976 the government shifted position and decided to delay a decision on nuclear power until questions of safety and waste disposal were evaluated.

In *Sweden*, nuclear power became an important item of discussion between Thorbjörn Fälldin - since 1976 the new anti-nuclear Prime Minister, influenced by Hannes Alfvén - and Olof Palme, who still supported nuclear. An information drive was subsequently launched by means of local study groups.

In *Finland*, local resistance arose against plans for nuclear plants in or near Helsinki. A *Norwegian* Nuclear Power Commission *kjernekraftutvalget*[1] constituted in 1976 comprised parliamentarians and experts, including members of the group ‘action against nuclear power’. The commission had two years to examine the safety implications of nuclear power in Norway. The *kjernekraftutvalget* became a forum for lively discussions between adversaries and adherents.

In 1975 the *Committee*’s contact group for environmental information issued a collection of articles about risk, radiation effects, plutonium etc. When shown this publication at a meeting of the *Committee*, the directors expressed concern that the names of the research institutes were on its front page. They feared that the publication would be seen as a defence for nuclear power rather than neutral information.

Nuclear societies

The nuclear societies in Denmark, Finland, Norway and Sweden acted as focal points for scientists and engineers active in the nuclear field. The *Nordic Secretary* attempted to co-ordinate work in the four national societies, for example by letting the same lecturer from abroad visit several nuclear societies in the same round. There were also joint study tours, and once at a much later date in 1990, the head of the Danish Nuclear Inspectorate made his first visit to Russian plants on a tour with a team of the Finnish nuclear society.

In 1973 an initiative from Switzerland proposed creating a European Nuclear Society (later the ENS), to mark Europe’s growing maturity and its independence

[1] under Leif Granli

from the USA with its American Nuclear Society. To co-ordinate Nordic participation, a Nordic meeting was organised[1] in November 1974 at the Copenhagen airport with the ENS initiator Alain Colomb who came up from Geneva. Finland and Sweden decided to join ENS and participated in the inauguration ceremony in Paris in April 1975. Jacques Chirac opened the meeting and everything was in French. When the time came to sign the funding ENS charter and “la sociétée nucléaire Finlandaise” was called upon, nobody moved, until the *Nordic Secretary* discretely raised and pointed at Erkki Vaara, the chairman of the Finnish ATS who then understood that it was his turn to come to the podium to sign.

Over the years a number of initiatives were taken to encourage joint Nordic use of ENS’ activities. Denmark joined in 1983 and Norway had not decided before it abandoned nuclear power and wound up its nuclear society.

Materials properties

The long-term behaviour of materials used in nuclear power reactors became an important safety issue. A *Committee* contact group[2] had reviewed steel for reactor vessels since the early 1970s. VTT in particular pushed to widen the original co-operation in materials study. Up to now, investigations dealt mainly with zirconium alloys (Scanuk).

In Finland more knowledge on fuel for the planned Loviisa reactors was required, and Jarl Forstén therefore prepared a new programme in 1975.

Hilding Mogard in Studsvik raised the question of how to avoid damage to fuel elements subjected to higher *burn-up*[3] in a power reactor. He launched several consecutive projects in which irradiated fuel was rapidly exposed to further irradiation in so-called ramp tests. Called a variety of names such as Interramp, Over-ramp, Demoramp, Transramp etc., the tests started in 1975. The purpose was to study the interaction between the fuel pellets and the surrounding metallic cladding. The three other Nordic countries joined the programme, which attracted wide international participation. Rather than being in competition with the Halden programme it was seen as a complement, since much higher *burn-up* was possible in the powerful R2 reactor at Studsvik.

The Nordic countries joined in a similar programme organised by the US firm Batelle, where they were known as the *Nordic group* although they each had an

[1] following a proposal by Tapani Graae from Finnatom

[2] headed by Studsvik's C.G. Österlundh

[3] i.e. remaining within the reactor for longer periods to use more of its fission energy

individual contract with Batelle. Based on this experience, Per Knudsen at Risø launched a fission gas project with Nordic and international participation. Carried through in three phases from 1980 through 1990, it led to improved understanding of the physics involved and of the codes used to calculate the behaviour of fission gas generated inside the fuel elements.

By the time these different projects ended in the late 1980s, knowledge gained allowed much higher *burn-up* to be achieved without damage to the fuel.

Waste

From being considered a purely technical problem that would be solved in due time, waste management became a central issue in the public debate. Opponents to nuclear power found that if it could be argued that there was no solution to the long-term management of radioactive waste, then nuclear power would be halted. Waste questions therefore received much more attention. The *Kontaktorgan* seminar on waste at Lidingö in May 1974 (page 91), attended by more than 100 participants, laid the ground for numerous Nordic initiatives in this field.

A need for more precise regulations and better methods of waste disposal was clearly identified at the seminar. Therefore, in September 1974, the *Kontaktorgan* set up an ad hoc waste group to formulate proposals on low and medium level waste. This group became an example of how constructive co-operation could be achieved between research institutes and authorities. In its report to the *Kontaktorgan* in 1975 the group recommended that a comprehensive Nordic waste programme be organised by a waste group comprising members from authorities and research organisations in the Nordic countries. The programme would include practical work in the field of low and medium level waste.

In practice, the *Committee* waste group (page 72) took over this task. The group[1] worked out a proposal for an integrated handling scheme for low and medium level waste (the NIPA project). This encompassed all aspects from its generation through to disposal. An agreement, similar to the one on NORHAV (page 73) was drawn up and signed by the four research organisations in the summer of 1975. Nordic participants subsequently started practical work, such as in Bonnevie-Svendsen's solidification laboratory at Kjeller. Solidification of low and medium level waste was discussed with operators from the nuclear power plants.

[1] headed by Per Linder from Studsvik

Disposal of high level waste was of immediate concern in Denmark and Sweden because it was considered a prerequisite for nuclear power. In Finland a group[1] was charged by the ministry to specify arrangements for waste management. Finland planned to export spent fuel from Loviisa to the Soviet Union while fuel from Olkiluoto was to be stored.

In Denmark salt domes were under consideration as a repository for waste. Following an evaluation in 1975 of their suitability for storing high level waste from a Danish nuclear power programme, a detailed project was started in 1977.

In 1972 a Swedish waste study (the Aka project) was organised[2], initially concentrating only on questions of high level waste. Its chairman was the governor (*landshövding*) of the Malmöhus county, Gösta Netzén. The Aka study group visited the other Nordic countries in the following year. According to Aka, the main alternative for spent fuel would still be reprocessing so that use could be made of the plutonium. Following its recommendations, a Programme Council with funds for research on radioactive waste (PRAV) was established in Sweden in 1975.

A Nordic Aka meeting was organised with the *Kontaktorgan* in Malmö in September 1975. At the conference dinner, the *Contact Group*'s Norwegian member Knut Solem revealed his second character - besides being responsible for nuclear questions at the ministry, he also appeared on shows at the Oslo night club Chat Noir. He captivated the assembly with a witty after-dinner talk, up staging Gösta Netzén, the arranged speaker.

Questions on waste, raised internationally were also discussed at the Nordic level. For example, the *Committee* although not persuaded, considered partitioning[3]. In August 1976 the *Committee* established a group to deal with the back-end of the fuel cycle, with main emphasis on fuel storage, transportation and geologic disposal. This group followed the development and prepared a report (page 129), but the research institutes were not able to take major steps in this field on their own. The *Kontaktorgan* also raised the question of protecting nuclear material against theft ('physical protection'). The Nordic transport group later pursued this, page 111.

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[1] led by Pekka Jauho

[2] on the initiative of Alf Larsson who since 1971 was employed at the ministry

[3] separation of transuranic elements from high level waste

4.3 Preparations for a nuclear safety research programme

During 1975 the *Contact Group* discussed various initiatives for extended co-operation in nuclear safety. It proposed that the *Kontaktorgan* should establish a committee or an ad hoc group to define joint perennial projects and to carry them through. Made up of specialists from research organisations, competent authorities and utilities, it could be assisted by a secretariat financed by the *Ministers* and located at one of the participating organisations.

The members of the *Contact Group* went into great detail in planning a future programme. Alf Larsson dealt with plutonium, while Mäkipentti and Solem looked at organisational questions. Various forms suggested for the new committee or group included adopting the principles of the earlier *NARS* agreement or even running it as a direct continuation of *NARS* (page 81).

The *Committee* thoroughly debated the proposed content of a future safety programme. K.P. Lien at IFA produced a comprehensive package of background material as a basis for discussions on areas that might be covered by a Nordic programme.

In its report in October 1975, the *Kontaktorgan* described the prospects for joint Nordic work. It stressed the need to see it in the perspective of the international studies being carried out simultaneously. Three areas were singled out as particularly relevant to the safety issues that should be addressed to facilitate the introduction of additional nuclear power: management of low and medium level waste; specified norms for construction and operation of nuclear power reactors, and safety in handling plutonium. While existing Nordic organisational frames would be adequate to carry out a new programme, special financing would be required. In November 1975 upon receipt of this report, the *Ministers* formally requested the *Kontaktorgan* to produce a report, now with concrete proposals for joint projects to enhance nuclear safety.

Already in September the *Kontaktorgan* had decided to establish an ad hoc group for nuclear safety research, taking the acronym *NKS* (Note 4.3). The group was to propose a first joint programme by 1976. It should combine those project areas that were of highest current interest, such as quality assurance, waste, and tasks for safety authorities including plutonium, and perhaps radioecology. Due regard was to be given to international co-operation in the safety field.

NKS met for the first time in November 1975 in Helsinki, the day after a meeting of the *Committee*, many members serving on both groups. Veikko Palva, the *Committee* chairman, was quite upset when he heard from the *Nordic Secretary* that no chairman had been appointed for *NKS* and refused to take over this post himself. During dinner it was decided to nominate Thomas Eckered, assistant SKI director, who was not member of the *Committee* and arrived by a later plane. The NKS work was then to be co-ordinated by its *bureau* consisting of Eckered, Heikki Reijonen from VTT, and Marcus.

Lengthy discussions in various circles followed regarding content, organisation and financing of a programme. The *Kontaktorgan* and the *Committee* initiated various activities to support the programme, and groups prepared issues to be managed under the *NKS* initiative. At this point the fields for investigation included quality assurance, waste management, authority queries and control room issues.

The theme chosen for the third *Kontaktorgan* seminar, arranged jointly with NORDEL at Helsingør in December 1975, was Quality Assurance (QA). Here the different parties including utilities, manufacturers, authorities and research organisations presented their opinions. Peter A. Morris from Scandpower brought the latest news from the USA and in the evening he impressed participants with his gallon bottle of Bourbon whisky with incorporated handle.

The main recommendation from the seminar was to examine existing US standards and adapt them to Nordic conditions. The goal was targeted at achieving harmonised rules, procedures and requirements. Embracing people from utilities and research organisations, the organising committee subsequently changed to an ad hoc group which advised *NKS* on a future QA programme[1]. In view of coming reactor projects, this research field was judged to be so urgent that work started in 1976 - before any decision on financing of the NKS programme.

NKS consulted the *Committee*'s waste group to make proposals for project work in waste management[2]. In a parallel move, the *Kontaktorgan*'s ad hoc waste group worked out thoughts of more fundamental character. This resulted in a recommendation for a programme furthering a common attitude to principles governing the management of low and medium level waste. It should ensure that no matter where - in the Nordic region - waste would be disposed, an equal safety level would be attained.

Common Nordic principles for waste management accorded with a parliamentary proposal raised in the Nordic Council in October 1975. The *Kontaktorgan*'s views were presented for the Industry *Ministers* in November 1975. In February

[1] Ingvald Haga from the Norwegian State Power Board acted as *NKS*' contact person in this group

[2] Its ideas were presented to *NKS* by Studsvik's Lars Carlbom

1978, an ad hoc group recommended that a future waste programme should concentrate on a system for management of reactor waste and analysis of the risks involved.

Thomas Eckered dealt with relevant authority related questions. They included plutonium and transport, emergency preparedness and similar items, but there was some doubt about the role which NKS projects could play in questions where the authorities' regulatory functions were concerned. Studsvik's Pehr Blomberg and Jens Rasmussen from Risø arranged a meeting on layout of reactor control rooms and subsequently submitted a proposal for a research programme.

To an increasing extent, the new Nordic *Officials* controlled the *Ministers*' budgets, under the administration of the Nordic secretariat located in Oslo since mid-1973. Therefore the *Kontaktorgan* would apply to the secretariat for support for the research programme planned by *NKS*. The *Nordic Secretary* made the first contacts with this new secretariat[1] in late 1973 and later regularly participated in the meetings of the Industry/Energy *Officials*.

There were signs of empire building from this new secretariat. A paper written in April 1976 listed a string of Nordic organisations - starting with the *Kontaktorgan* - that could be placed under the secretariat. This prompted strong protest from many quarters, after which the plans were scrapped.

When in September 1976 *NKS* presented its first proposal to the *Kontaktorgan*, some of the nuclear research institutes expressed fear that any separate financing of such work would ultimately be taken from their own budgets. A new programme would only complicate the administration and reduce their freedom of action. Others, such as VTT, saw an advantage since additional grants could be expected from the Finnish ministry. These would compensate for the national input which was to be contributed by organisations participating in the new Nordic programme.

The *Nordic Secretary* presented the proposal to the *Ministers* in August and in November 1976. Olof Johansson, the Swedish Minister of Industry - although essentially antinuclear - showed distinct interest in its contents. The proposal included 35 projects, originally at a total cost of FIM 14 million (ECU 3 million), spread over a period of 3 years. This was a hitherto unheard amount for the secretariat of the *Ministers*. Therefore, it was no surprise that discussions about financing were intense.

[1] first with Gudmund Saxrud and then his new director, Olli Bergmann

4.4 The First NKS programme 1977-80

The final proposal for the NKS programme prioritised four programme areas. Quality Assurance (**QA**) became the first area where work was already underway on the terminology to be used. Waste management (**AO**), with the largest budget, was the second. Control room design (**KRU**) became the third and authority related questions (**MY**) the fourth (see Note 4.4.A). Other areas proposed by NKS, including radioecology (**RA**) and plutonium issues, needed further evaluation. Radioecology was to be the subject of a Nordic seminar, prepared by a Nordic contact group, set up to follow ongoing international studies.

At their meeting in November 1976 the *Ministers* accepted that 1977 would be a trial period for the new programme. In June the Nordic contribution was finally set at only NOK 0.8 million Kroner (ECU 0.1 million). During this year, therefore, much of the work was in the form of pilot projects. The main programme period was consequently extended to include 1980.

Initially it was easy to obtain grants from the Nordic budget. Few organisations were geared to working out comprehensive project proposals, and there was therefore a surplus of funds. The *Ministers*' total Nordic project budget for 1978 amounted to NOK 29 million, whereof the NKS programme received the highest single contribution of 2.1 million. Once, during an early year when there was a need for more finance, the *Nordic Secretary* invited the *Ministers*' Secretary-general to lunch and gently prised the required funds from him.

For 1979 the budget was specified as NOK 5.7 million, but this time the *Ministers*' secretariat was more reticent and proposed 2.7. After lengthy discussions a NOK 4 million budget was agreed. The following year the secretariat allocated NOK 4.6 million. In total therefore, the *Ministers*' allocated sum of NOK 11.6 million was reasonably close to the original NKS proposal of FIM 14 million. The total cost of this programme, including national contributions, was NOK 27 million (ECU 3.5 million). Although a large sum, it was divided into many projects, each with participants from several countries. The amount of money received by single research groups was therefore small.

In its original proposal *NKS* suggested that existing Nordic groups carry through the new projects: the *Committee* would work in technological areas and *NARS* on authority-oriented work. However, once the proposal for the first 3-year programme was ready, it was the *Kontaktorgan* that assumed general responsibility for the project work by nominating steering groups, project leaders and host organisations. The *Nordic Secretary* co-ordinated the programme and became the link between the actual project work and the secretariat of the *Ministers* who controlled the finance.

The *Contact Group* established a system in which a responsible host organisation was appointed for each project. Letters, to be signed by the respective institute management, were drafted and an arrangement made for annual revisions by the respective national auditors. *NKS* converted to an ad hoc group to advise the *Kontaktorgan* and temporarily changed its name to *NGS*.

Financial administration now became time consuming, so in mid-1978 Bjørn Thorlaksen from Risø was employed on a half time basis to help the *Nordic Secretary*. Henny Frederiksen had worked for the *Nordic Secretary* since 1974, and the addition of the new part-time member created a team that eventually became the NKS central project administration, partly financed through NKS project funds.

Steering groups, one for each programme area, were responsible for project work. Leaders appointed to each of the 30 projects (the KRU programme alone had 13 projects) were chosen to ensure that a Nordic balance was maintained between the projects (see Note 4.4-A). Following decisions by the steering groups, project funds were transferred annually to the organisations doing the work. A letter of authorisation from the *Nordic Secretary* to the *Ministers*' secretariat triggered each transfer. At the end of each year the NKS secretariat received invoiced for work performed by participating organisations, but not surprisingly, they usually corresponded to the sums already transferred.

While the concept of at least equal contributions by each country - to be added to the Nordic finance - was accepted at the outset, its documentation created problems. The value of in-kind contributions was calculated on the basis of NOK 300,000 (ECU 50,000) per person-year (later changed to NOK 250,000) despite the fact that the true cost varied considerably among the participating organisations.

Once, the Danish national auditors came down heavily on the Risø technical director Niels W. Holm, to make him prove that the man-hours indicated in the NKS annual report were actually provided by Risø.

Therefore, in 1981, the wording on equal national contribution to the Nordic project work was changed to, "by experience it turns out that participating organisations contribute at least equal amounts". However, *NKS* still required contributions - through direct financing or in-kind performance - to be equal to the Nordic funding, when averaged over several projects.

This requirement was considered fulfilled for the Danish participants through work on complementary Euratom projects. A similar situation existed in Sweden where related work was frequently financed through R&D budgets coming up from time to time in areas of actuality. Norway also, was able to make arrangements by involving parts of IFA's Halden work. In Finland, the ministry reserved money for participants in NKS projects to make up for their 'national' contributions.

Quality assurance (QA)

Although during 1977, only NOK 0.25 million was made available for QA work, participation by the utilities ensured a swift start to the programme. The programme comprised 13 projects, devising QA systems for all phases of planning, building and operation. It also included organisation of feedback, documentation and contractor evaluation. In long sessions the steering group[1] worked hard to draw upon US experience and adapt systems to conditions prevailing in the Nordic countries. This work was particularly relevant to Finnish and Swedish nuclear power plants and for the manufacturing industry, especially in Sweden.

QA manuals and documentation were produced for use during nuclear power plant construction and operation. Utilities actively helped this work while industries in other fields were kept up to date through existing national QA societies. However, to some extent these societies felt bypassed by the rapid developments within the nuclear industry which even attempted to modernise traditional QA nomenclature.

Waste management (AO)

The waste programme, dealing with risk analyses for low and medium level waste, aimed to establish a link between repository characteristics and required specifications for waste to be disposed of. A pilot project was worked out at IFA in 1977[2]. The *Committee* waste group, supplemented by utility representatives, was changed to a steering group with a project leader from Studsvik. Five subproject leaders were involved, necessitating a significant co-ordination effort. The project leader's work load increased rapidly as other national tasks were added to his duties, the *Nordic Secretary* therefore, took over his function, helped by a coordinator[3].

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[1] under Jarl Forstén's, chairmanship
[2] with Kjell Neset as project leader
[3] Heikki Reijonen from VTT

Being a theoretical study, the project, although interesting to those participating, was of less practical value than a parallel study on the first Swedish waste repository. Known as the ALMA project, it could adopt a more realistic approach. It was financed by PRAV (page 103) and headed by Nils Rydell who also served on the AO steering group. It was therefore possible for some national work to be taken over by the NKS project. On the other hand, some competition for resources was unavoidable since not all waste specialists engaged in national work were available to assist in the Nordic programme which in any case lacked the economic strength of the utilities.

The project included experiments, tests and developing calculation methods. Spectacular fire tests on steel drums filled with waste and solidified in bitumen were performed at VTT. Simultaneously, Risø and Kjeller tested solidified waste for leaching of radionuclides. Specialist gatherings were organised to discuss solidification, migration from repositories, transport risks, waste combustion, etc. The study resulted in evaluations of factors to be considered when assessing the safety of the entire system comprising waste handling, transportation and disposal. Besides leaching, mechanical strength and resistance to fire and freezing were shown to be highly significant properties of solidified waste when considering its handling and final disposal.

The final report was sent to interested bodies in the Nordic countries for comments. This ensured that it was widely studied and made available to those - mainly in Finland and Sweden - engaged in actual projects for repositories.

Control room design (KRU)

With the availability of process computers for automated operation, control room operators needed to adapt to a new working environment. To study the impact of this and to identify training requirements, a pilot project[1] started late in 1976. This work therefore started before the TMI accident in 1979 and the subsequent analysis of operator actions during the accident. Nordic work therefore turned out to be timely when new concepts were developed after TMI.

A formal agreement was concluded between Risø, IFA, Studsvik and VTT in April 1978, and the Nordic grants were divided equally between them[2]. The idea was to combine the advanced theoretical concepts on models of human performance developed by Jens Rasmussen at Risø, with experiments in Halden and work

[1] led by Studsvik's Pehr Blomberg

[2] Jens Rasmussen led the main project from Risø

on actual control rooms in Finland and Sweden. However, the complicated language used in Jens Rasmussens concepts posed problems for the participants. Therefore, to maintain a coherent approach, plenum meetings attended by many project participants became a necessity. Experiments were prepared at Halden to examine the value of novel control panels. Work on man-machine interaction, subsequently a major item on the programme of the international Halden project, was thus partly inspired by the KRU programme.

A sudden change in existing control rooms was not intended, rather a gradual approach to arrive at a more user-friendly representation of important plant information. An effect on actual control room design would be expected within a time span of, say, five years. This turned out to be the case.

One immediate result was a description of skills required from plant operators, and guidelines for training. This information was particularly useful to the new Finnish nuclear power stations. Other project results were more difficult to convey to nuclear power plant staff because of the sophisticated language - the *slang,* introduced by Rasmussen.

Authority related projects (MY)

Although discussed, no Authority oriented projects were actually started by *NKS*. This was because authorities' representatives found that the proposed themes did not fit well into the NKS framework. Their own co-operative scheme was better suited to questions of joint interest. Later, they also found that acting as a steering group for the NKS system was outside their terms of reference. Their Nordic working groups took up some questions, such as emergency preparedness, while a new Nordic transport group was suggested to address questions related to movement of radioactive material.

The fourth *Kontaktorgan* seminar in Aulanko in November 1976 dealt with transport of nuclear material[1]. Following recommendations from the seminar, the Nordic transport group was formed and met in December 1977[2]. At the outset, three working parties were set up: Standardisation of Certificates, Physical Protection, and Transport by Mail. Their recommendations were issued in 1981 and subsequently led to simplification in the work of both applicants and authorities.

Since transport questions were part of the First NKS programme, the activities of the group were financed through the MY programme. Later the transport group

[1] Olli Paakkola put in a lot of hard work to prepare this seminar

[2] under the chairmanship of SKI's Paul Ek

dealt with the IAEA transport regulations, emergency questions and licensing of large transport containers. The group also worked on joint Nordic viewpoints when the IAEA transport regulations were up for revision. Such viewpoints had a greater impact because they were forwarded by more than one country. Sometimes one of the group's members represented the other Nordic countries in Agency transport group meetings. IAEA's *Intertram* project was triggered by proposals originally discussed in the Nordic group.

The Nordic transport group was later taken over by the radiation protection authorities and transferred to their own Nordic scheme[1]. Bengt G. Pettersson submitted a description of its activities to the *Annerberg group* in 1987 (page 198).

Radioecology (RA)

The earlier series of Nordic seminars, the RIS (*Radioactivity in Scandinavia*) meetings (page 44), were abandoned in 1969 because of the dwindling levels of man-made radioactivity in the environment. However, by 1974 several power reactors were operating and concern over possible effects of releases led to a proposal to resume Nordic work on radioecology. Joint projects in this field were also viewed in anticipation of mutual assistance in case of accidents.

Following a NKS recommendation, the first of a new series of Nordic seminars on radioecology took place in Norrköping in November 1976. After the seminar, the organising committee[2] was asked to investigate possible joint projects.

NKS needed to thoroughly discuss the fundamentals of a radioecology programme before it could be launched. SSI's Jan Olof Snihs pushed hard, but received little help from the Finnish members. Veikko Palva favoured work related to nuclear installations, also because the Finnish financial contribution to the NKS work came from the Ministry for Trade and Industry that was not responsible for environmental matters. There was also criticism from STUK which felt that project funds should go to essential projects rather than to certain experts.

Despite these problems, nine projects were agreed, covering a variety of areas. The first project started late in 1977[3]. It covered so-called bioindicators, that help to detect normal as well as exceptional releases of radioactive material to the environment. Devices to sample seabed sediments were tested and inter-calibrated

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[1] Successive chairmen were Bengt G. Pettersson and Leif Hannibal

[2] with Studsvik's P.O. Agnedal as secretary

[3] J.O. Snihs was chairman of the new steering group

near Barsebäck, and related analytical results from different laboratories were compared.

Future project work was discussed at the second of the new series of radio-ecology seminars, held at Helsingør in May 1979, where project plans were outlined for the coming period: Anneli Salo, Olli Paakkola, Marcus and Ragnar Boge

Elis Holm organised a Nordic course in sampling and analysis at Lund in April 1980. At a planning meeting for projects related to large nuclear accidents held at Lysebu in May 1980, a control programme for releases from a nuclear power station was designed.

End of the First NKS programme

This first round of NKS projects was terminated in 1981. Seminars attended by representatives from related fields of activities were important to disseminate the results from this First programme. In line with this, KRU together with the Halden project held a presentation seminar in June 1982 at Frederiksstad.

A QA seminar was organised in Helsinki in August 1980 at the newly built Ramada hotel. Participants from the offshore oil and gas production field were invited in an attempt to convey the results to another risk-prone area of high relevance. The conference dinner took place in the *Four Seasons* restaurant. Jarl Forstén held an exquisitely witty talk, mixing names and facts from the project work with the name of the restaurant.

The AO work was presented at a waste seminar in September 1981, organised by the *Kontaktorgan* with SKBF in Kungälv and opened by Gösta Netzén. The social programme included a visit to the Bohus fortification on the old Danish-Swedish border. Here Bertil Persson from Vattenfall improvised to become a perfect guide and toastmaster.

In February 1979 the *Kontaktorgan* again called upon its ad hoc group - *N**G**S* - (here for simplification also denominated *N**K**S*) to outline the contents of a follow-up programme based on experience from the First programme, which they were also asked to evaluate. When searching for an evaluation methodology, *NKS* was unable to find a suitable system and attempted to develop one of its own with criteria proposed by Veikko Palva (see Note 4.4-B). NKS wanted to illustrate the added value of Nordic engagement in project work. What was the main advantage? Was it that common questions were dealt with in a broader circle; was it simply that cross-border relations were established, or was there added value through pooling forces and competencies?

NKS discussed the evaluation procedure at its meeting in June 1982 in which the director from the CEC Joint Research Centre, J.P. Contzen participated. Instead of the CEC practice of establishing a panel, NKS decided to carry out the evaluation through some of its own members who would each concentrate on an individual programme area (Note 4.4-C).

The evaluation, which ended later in 1982, showed that concrete results were produced in the QA field. In other areas, experts from various circles had worked together towards a common target and established a common knowledge base. This was considered an important achievement.

One general conclusion was that at an early stage a project's objective must be defined: whether it is to provide a generic pool of competence, or to resolve technical issues.

The steering groups had acted rather as a forum for discussion than as a driving force for project management. Long meetings with detailed technical discussions had not been particularly effective. The participation of project leaders - some of which were employed as consultants interested in obtaining Nordic financing - was questioned.

For projects aimed at building competence, the present set-up for steering groups might be adequate, but an improved format was needed for other types of project. Those with influence over national funds' allocation should be on the steering groups. Similarly, organisations needing the results, such as government agencies and industry, should also be represented.

It was recommended that no project should be smaller than one person-year annually, otherwise the organisational and administrative efforts would get out of proportion.

Certain areas such as QA had been mostly financed through national funds. The NKS framework however, had made it possible to co-ordinate national efforts with only a small amount of Nordic financing. The Nordic funds had been used to “grease the wheels”, as the people of the *Minister*’s secretariat liked to say. Other areas had required more extensive financing.

The evaluation report of the First NKS programme was the first of its kind in this area. It was widely distributed, and it was discussed with the president of the Nordic Science Policy Council, Elisabeth Helander, in view of its use for similar Nordic programmes.

Apart from the official evaluation, it appeared that each participating country benefited from the NKS programme. For Finland and Sweden it meant that a broader knowledge base was available. The projects had drawn upon many years of development work at IFA and upon the high scientific and theoretical knowledge at Risø. Denmark and Norway had reinforced their bank of knowledge in applied nuclear technology. This would be needed regardless of the introduction of nuclear power. The project work also promoted an inflow of information to the Nordic countries from their joint participation in international ventures.

5. Changing conditions for co-operation

In 1977, when the First NKS programme started, the three research institutes mainly concentrated on nuclear issues. However, research into non-nuclear energy steadily increased. The fourth (VTT) had always carried out research over a much wider field. At the time, all countries experienced opposition against nuclear power and concerns over radioactive waste. Nordic networks, established as a result of the *Kontaktorgan*'s activities, were useful in providing additional knowledge when possible adverse effects of nuclear power were to be analysed.

5.1 The research institutes

In 1977 the *Directors* reviewed the collaboration scheme among the research organisations. Their own meetings had provided opportunities to informally exchange views. This forum raised many relevant issues for joint work that were referred to the *Committee* for further action. However, the *Directors* did not have an established follow-up mechanism, and their intentions were not always conveyed to the staffs in a convincing manner.

Reorganisation of the *Committee* work

The *Directors*' summer meeting that year was to be held in Denmark. Erik Ib Schmidt (page 94) wanted to attend and suggested that the meeting be combined with a week-long 'study tour' to the uranium and zirconium deposits in Greenland. At the last moment V.O. Eriksen cancelled his participation and called Nils Godtfred Aamodt from holiday to take his place.

This meeting discussed the continued collaboration among the four research organisations in the light of the NKS programme now progressing. The prospect for *Committee* work was now significantly reduced. There was also competition from commercial ventures and nationally sponsored tasks. In Sweden for example, new committees, changing from time to time, were set up to finance work within the country. National tasks would normally take priority over Nordic ones. A proposal raised in the *Committee* to share tasks under the Swedish KBS study (page 129) was eventually rejected as being not practical. On the other hand, the *Committee*'s flexible organisation permitted new groups to be set up at short notice and without formalities.

By mid-1977 the co-operation arrangements comprised many permanent groups and projects (see table Below).

***Committee* groups and projects 1977**

- ∗ Reactor physics (page 94)
- ∗ Environmental effects (page 76)
- ∗ Reliability (page 85)
- ∗ Post irradiation examination (page 71)
- ∗ Marviken experiments (page 74)
- ∗ Interramp, Overramp (page 101)
- ∗ NORHAV (page 73)
- ∗ NIPA (page 102)
- ∗ Scanuk (page 101)
- ∗ SNODAS (page 98)

Other collaborative ventures included the largely independent library (*NALJS*) scheme (page 87) and the groups preparing NKS ventures on control rooms and waste. At the same time, participation in the international HSST and PBF programmes (page 98) was being prepared. Finland and Sweden also shared work on models for district heating and heat-only reactors (page 99).

Adapting to new priorities, the *Directors* decided to reorganise the work of the *Committee* with *area groups* covering now relevant fields. Priority was given to joint project work in three areas:

- Nuclear safety,
- Energy R&D,
- Back-end of the fuel cycle.

The *Directors* decided to appoint the chairman of the *Committee* from one of the institute managing directors[1]. Some *Committee* members (shown in Note 5.1) were also members of NKS. Although new terms of reference were drafted, the *Committee* did not feel it necessary to ratify them. In 1978, the meeting frequency was reduced to three times per year. However, it was still considered essential to maintain the *Committee*'s work separate to that of the *Directors*' group which was to deal with strategic and policy questions.

[1] Niels W. Holm was the first, followed by V.O. Eriksen in 1979

The *Committee* secretariat transferred from Studsvik to Risø and was now to replace the functions of the contact people (page 66). Marcus' new assistant Bjørn Thorlaksen was charged with the routine work for the *Committee*. Its members turned down a proposal that each institute would reserve 50,000 Kroner for *Committee* related activities.

The arrangement to exchange information in the *Committee*'s environmental information group (page 77) resulted in several investigations, study trips and publications. Among other things, a leaflet on the transportation of radioactive materials was issued. Following the *Directors*' 1977 review, the environmental information group was suspended and replaced by a list of contact persons in the four countries.

These people[1] did not hold meetings but the contacts established through this and other *Committee* initiatives proved valuable for many years. An incident at a much later period illustrates the usefulness of these contacts: In March 1992 news reached the outside world of an accident at the Leningrad nuclear power plant at Sosnovy Bor. This was portrayed by the media as threatening to turn into a major Chernobyl-like catastrophe. At the time one of the contact persons was sitting in a Nordic specialist meeting. When information of the incident was conveyed to the Finnish meeting participants by a telephone call, the contact person asked participants to immediately inform their personal contact networks. Various Nordic authorities therefore, were quickly able to pass authoritative information about the true extent of the accident to the media. This action prevented a false media alarm.

In 1984 the Studsvik R2 reactor, which originally commenced operation in 1960, was closed down to replace its reactor tank. Part of the isotope production was taken over by Norway. After this shut down, and as commercial interests for use of the research reactor gained importance, Studsvik reduced its radioisotope production. Favourable terms of supply were consequently negotiated with IFE. The harsh financial climate at Studsvik therefore, in some way benefited the old plan for joint Nordic production.

[1] Evelin Sokolowski from Studsvik, VTT's Seppo Vuori, Ole Walmod-Larsen from Risø, and IFA's Per I. Wethe

Energy research

In the autumn of 1977 the *Committee* established an energy group[1] (see Note 5.2) to promote collaboration among the research institutes and investigate the possibilities of obtaining grants from the Nordic Industrial Fund. After working for many hours at the group's winter meeting, which took place at the Norwegian skiing resort Geilo, Salminen spurted uphill on his cross-country skis, while Dietrich slalomed downhill.

The Nordic Fund accepted three proposals promoted by the group covering heat storage and distribution, but rejected a large project, Energy System Study for the Nordic Region. Work on a Nordic analysis of energy systems was nevertheless continued[2] and included plans for a Nordic seminar. In October 1978 it became clear that the Swedish Delegation for Energy Research[3] was also planning a Nordic seminar on this subject. Even the Nordic Prime Ministers, at one of their meetings, discussed the possibility of assessing energy systems for the Nordic countries. However, a Nordic seminar on this subject was not held until 1980 (page 133).

In 1978 the *Committee* energy group started to compare the environmental effects of different kinds of energy production. This was highly relevant, for instance in relation to the Swedish Energy Commission, whose report was due later the same year. It is notable that as early as 1979 the Swedish Government decided that external effects of energy production were to be minimised. A Nordic working party established by the *Committee* energy group drafted proposals for methodologies and for case studies. This was a genuine attempt to apply knowledge from the nuclear field, where methods for the evaluation of impacts on the environment were well developed. While the hope was that the Nordic Fund would finance the work, the *Kontaktorgan* at its meeting in Reykjavik in September 1978 felt that it would be unfortunate if a committee only representing the 'nuclear' institutes would undertake this work. A better solution would be to discuss this matter in a Nordic seminar with broad representation. To deal with this question, IFA agreed to host the next *Kontaktorgan* seminar in 1979 (page 143).

The energy group examined the use of metal hydrides to store hydrogen (in effect, energy storage). Although, following a Swedish initiative, methanol production

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[1] Thorlaksen acted as a secretary also for this group. Ove Dietrich from Risø was chairman up to 1979 when VTT's Pekka Salminen replaced him

[2] co-ordinated by Kjell Solberg at IFA

[3] under Sigfrid Wennerberg at the ministry

was also considered, it turned out that a group of interested parties already existed. This group was more suited and included Norway and Sweden. 'Fluidised bed' combustion was another interesting field for all the countries. However, joint initiatives were hampered by the fact that individual institutes already had national industrial partners, who did not plan to collaborate.

These examples illustrate the difficulties encountered by those attempting to organise joint development work beyond the pre-commercial stage. They also highlight the limitations to co-operation among the four independent national research organisations.

Safety related work

The four countries continued to work together on the Marviken safety experiments (page 74), with the Danish and Norwegian contributions now being in the form of manpower delegated to the site organisation.

Ragnar Nilsson from Studsvik continued to represent the *Nordic group* in negotiations with the US NRC. In 1979, on behalf of the Danish, Finnish and Swedish he signed agreements on participation in the PBF and HSST programmes (page 118). A number of other advantages were identified in support of acting as a *Nordic group*. Thus, it would indirectly market the services of the increasingly commercial research institutes. Also, it could increase national interest and therefore trigger additional research grants. Perhaps also, it would result in orders from neighbouring countries.

The *Committee* discussed, with some scepticism, the forthcoming Second NKS programme (page 155). Some members urged the *Committee* to make its voice heard on the programme content since it would after all mainly involve the research institutes. Studsvik who had not been given a seat in *NKS* by the Swedish members of the *Kontaktorgan* especially made this point. The reason perhaps, was because several other Swedish organisations were viewed as being closer to the relevant safety issues. The *Committee* also disapproved of the idea that countries should yield national work of similar volume to that financed from Nordic funds; this was thought to impinge on the individual institutes' freedom to set their own priorities.

The *Committee* wished to ensure that the content of the coming NKS programme coincided with the institutes' priorities. Therefore, in 1979 it activated its ad hoc safety *area group*[1]. This group was to give the institutes' view on the contents of

[1] headed by Bjarne Micheelsen from Risø

the Second NKS programme. To avoid a conflict of interests, *NKS* chose to use this *area group* to help identify future reactor safety projects and review the existing organisation for the entire Nordic safety work. Matti Hannus, who was charged by NKS (Palva) to prepare the second NKS proposal also acted as secretary for this *area group*. It identified a long list of relevant joint projects and concluded the work by submitting its report to the *Committee*.

Diversification from nuclear research

Risø changed its name to 'National Laboratory' after the AEK wound up in 1976, and from 1981 slowly diverted its activities from the nuclear field. In 1985 nuclear power was taken out of Danish energy planning. Risø's nuclear activities were further reduced and more emphasis placed on environmental matters and energy issues. In 1986 Risø modified its objects clause and confirmed its designation as 'National Laboratory'.

In February 1978 the Swedish Aktiebolaget Atomenergi (AE) changed its name to Studsvik Energiteknik AB, **Studsvik**. In February 1980 the Institutt for Atomenergi IFA changed its name to Institutt for Energiteknikk **IFE**, since now only one third of its activities were nuclear and most of these were related to the international Halden project. At VTT nuclear activities were already confined to just a few of its many departments, mainly that of *nuclear technology*. Activities such as materials research and human behaviour belonged to other VTT departments that were not solely dealing with nuclear questions.

As AE was now 'Studsvik Energiteknik' and IFA was to become IFE, even the *Committee* (NAK) considered changing its name. In view of the institutes' changing roles, in 1979 its name changed from N**A**K to N**E**K, replacing '**A**tom' by '**E**nergy'. Even if the official name was now NEK, the new designation never achieved general use. The NAK idiom had been consolidated.

Once it became clear that there would be no nuclear power in Denmark and Norway it was important to adapt the knowledge to other fields. The requirement for the research institutes to become more self-sustaining increased. Studsvik and VTT had long since taken a commercial attitude. Risø also now experienced economic difficulties and undertook projects with external financing (20% of the turnover in 1980). In the same year, only 10% of IFE's activities were related to nuclear power (35% when Halden was included), while the more commercial offshore oil and gas sector played an increasing role.

Knowledge gained in the nuclear field was above all applicable to the offshore industry in areas such as modelling of fluid flow and reservoirs. Also energy savings, materials, use of isotopes, and simulators for training could benefit from past nuclear related studies. These fields were important for the research institutes adapting to non-nuclear work. Their efforts however, were mainly directed towards national users and less fit for co-operation.

The Norwegian example shows how knowledge gained in the nuclear field could be used in other areas while also maintaining Nordic co-operation. The Halden project was still a focal point for international and Nordic co-operation. The interplay between operators and modern computerised control rooms remained a central issue both for Halden and for future NKS programmes. At the same time the Halden project provided IFE with links to the reactor industry.

Scandpower could market some of IFE's reactor knowledge, offering services such as quality assurance and fuel management to the international market. But its service was also frequently used in the other Nordic countries, for ELSAM for example, and for SKI during the technical review of the waste disposal concept (KBS) submitted by SKBF in 1977 - as an answer to the Stipulation Law (page 129). Here Scandpower made use of several Danish and Norwegian consultants. In 1978 Scandpower performed an evaluation of electricity generating costs in Sweden.

After the TMI accident in 1979 (page 143), the need for all national institutes to continue research into nuclear safety was evident. In addition, Chernobyl (page 190) highlighted the obligation to keep a level of knowledge available in case of reactor accidents in neighbouring countries. This provided a continuing basis for co-operation on nuclear matters.

5.2 The *Kontaktorgan*

From the outset, the *Kontaktorgan* worked on political, international, technical and economic aspects of nuclear energy. Now the NKS programme, its financing and the associated requirement for contacts with the *Ministers* added to the issues on its agenda.

The policy of maintaining and enlarging the *Kontaktorgan*'s co-operative ventures depended on a small number of key people. From the outset, it came from those in a central position to build up their country's nuclear expertise. Later, policy was formulated at the ministerial level of nuclear advisers. Fortunately for the *Kontaktorgan* these people also represented their countries in the *Contact Group*.

The contact people sometimes suggested national projects to be included in a Nordic scheme. This was more to do with the farsighted desire for mutual understanding and common opinions in the Nordic region than to the added input that could be expected. This strive for mutual goodwill was subsequently taken over by the leaders of the *NKS* team and from 1990 by the Consortium group (page 217).

The *Contact Group* now came to play a central role planning joint activities. It met frequently, in 1977 for example, nine meetings were held. Björn Palmén assisted Mäkipentti in 1975 and from time to time deputised for him in the group. Palmén joined many *Kontaktorgan* meetings and frequently used the piano to give the evening reception a solemn touch. This was also the case in 1984 when ambassador Nord was the host in the Norwegian Government's building for receptions at the well-known address Parkveien 45. When the secretariat of the *Contact Group* moved to Finland for three years in 1980, Björn Palmén took over from Eva Elbæk Jørgensen who had been its secretary since 1976. From 1980 until its dissolution, the secretariat was located in Denmark[1].

In March 1977 the first Loviisa reactor was inaugurated with the appearance of the presidents Kekkonen and Kosygin, who for the occasion acted as reactor operators. Many Nordic guests attended the ceremony including the *Nordic Secretary*, to whom at lunch, Russian participants talked of their desire to enter the Nordic nuclear co-operation. Sadly, they were interrupted when Kosygin, having been served first and finished his desert even before the others were served, rose and left the luncheon, taking them with him. "Now we can have a moment of leisure" said the Vattenfall director Jonas Norrby who stood up and offered a portrait of Queen Louisa to the Finnish hosts.

A Nordic reporting system organised by the *Contact Group* sent daily news reports by telex to the Nordic countries from the UN conference on nuclear fuel and its fuel cycle, this time not held in Geneva but - thanks to Kurt Waldheim who now headed the UN - in Salzburg during September 1977. At the NUCLEX fair in Basle in 1978, a joint Nordic stand NUCLEAR SCANDINAVIA exhibited as in 1969, 1972 and 1975, however on this occasion Norway did not participate.

[1] In the *Contact Group* Alf Larsson was replaced, first by Bo Johanson and thereafter by Gösta Lindh. In 1978 Gadegaard replaced von Bülow.

Kontaktorgan or *Officials*?

In 1977, diverging views on the role of the *Kontaktorgan* emerged. Already throughout 1975 proposals to transform the *Kontaktorgan* to a committee of Atom *Officials* were discussed. It would be a complement to the *Officials* committee for Industry and Energy. This idea originated at the Swedish ministry in the early 1970s.

Accordingly, a proposal was put forward to convert the *Kontaktorgan* NK**A** (A for Atomenergi) to NK**E** (E for Energi). At this time there was no other Nordic group with members appointed by the governments that covered the whole energy field. Furthermore it was the nuclear research institutes who were first involved in energy conservation and new energy forms. This research even included long-term perspectives, such as fusion and magnetohydrodynamics. In the *Kontaktorgan*, Finland's and Sweden's representatives argued for a change to NKE, since in these countries the same ministries were responsible for all aspects of energy, including research.

On one hand it was considered logical to use the *Kontaktorgan* framework to address emerging energy issues and environmental effects, so that technical questions could be dealt with by the *Committee*. Nordic contacts already existed through the work of the *Kontaktorgan* whereas new Nordic groups would need to create a network of contacts.

On the other hand, the rapidly developing energy sector would soon outgrow the nuclear area. If the *Kontaktorgan* were to become a player in the wider energy field, it would also need new contacts and more members. Other Nordic countries expressed doubts about enlarging the *Kontaktorgan*'s mandate since in this period so many nuclear questions were up for debate. Some of them were within the jurisdiction of the Foreign Ministries who were also main participants in the *Kontaktorgan*. Finally, seen in a bigger Nordic context, it might be useful to create new frameworks for co-operation.

It was the Norwegians who put a spoke in that wheel. After the oil and gas discoveries, the organisation in Norway was being modified, in preparation for a new Ministry for Petroleum and Energy. Until they settled this issue, the Norwegians refused any discussion on the Nordic level. In the *Contact Group*, Knut Solem vigorously defended the Norwegian position.

The new Norwegian Ministry was inaugurated in January 1978. Meanwhile, the *Ministers* started several initiatives on the energy front. A Danish Energy Ministry was created in 1980. The Swedish Ministry of Industry was converted to include energy in 1982.

In the present situation the ministries were increasingly engaged in the *Officials* committees. Here they had more control than in the *Kontaktorgan* with its more independent thoughts, traditions and participants and perhaps, it's dedicated *Contact Group* and *Nordic Secretary*.

The future organisation of Nordic co-operative research was described in a report[1] from the Nordic Cultural secretariat in Copenhagen in 1980. While the national budgets for energy research in the Nordic countries were in the order of one billion Kroner (ECU 150 million), big discussions were needed to make a few million available for joint projects. The *Kontaktorgan* commented on the report draft, and in a letter to the *Officials* in July 1980 the *Nordic Secretary* reviewed the experience from organising Nordic projects.

Important requirements when organising Nordic project work

(July 1980)

- Close contacts must be arranged at the planning stage between the different authorities in charge of national programmes.
- Personal and economic incentives must exist for those involved in joint actions, to be provided either by the Nordic project in question, or nationally.
- A thorough and continuous follow-up is needed, and prospective areas for further joint action must be systematically examined.
- Co-operation in pre-competitive areas is preferable. Projects close to the needs of authorities are easier to arrange, while industrial involvement usually complicates this type of ventures.

In 1981 the *Kontaktorgan* renewed discussions on its future and it became clear that its scope should remain in the nuclear area. Its members also wished to keep it free from the bureaucracy of the *Ministers*' organisation and its secretariat.

Once energy ministries had emerged in Denmark, Norway and Sweden, the *Officials* for Industry and Energy was *de facto* separated into two independent com-

[1] worked out by Bertel Ståhle

mittees in 1981. Several representatives in the new Energy *Officials* were also *Kontaktorgan* members[1].

Although keeping a distance from the organisation of the *Ministers*, the *Kontaktorgan* wished to maintain good relations. The *Contact Group*, after its meeting in Oslo in June 1980, was invited for dinner at the home of Hans Kühne, the new Secretary-general of the Nordic secretariat[2]. The *Kontaktorgan* reciprocated, for example by inviting the *Ministers*' Secretary-general to its 25 years meeting at Lysebu near Oslo in February 1982. The *Nordic Secretary* joined in the Energy *Officials* meetings until 1989.

In the circles of the *Minister*'s secretariat, the *Kontaktorgan* was considered to be one of the best-organised Nordic assemblies. With a well-established system for project management, it was seen as well worthy of receiving important economic support for its safety programme.

In 1982 the new Energy *Officials* established a Nordic Contact Group for Energy Research[3]. In the following *Kontaktorgan* meeting it was made clear that research questions in non-nuclear energy fields should now be referred to this Contact Group. However, since the research institutes tried to increase participation in Nordic energy research, initially such energy questions were inevitably raised in the *Kontaktorgan*. This was especially so because the *Directors* also attended the *Kontaktorgan*'s meetings.

Safety authorities and *Kontaktorgan*

As safety questions predominated and waste management became an important issue, it was important for the *Kontaktorgan* to involve both established and fledgling nuclear safety authorities in its activities. During the 1970s the authorities were reinforced in all countries. In Sweden, nine new posts were created at SKI between 1974 and 1976, and the Institute for Radiation Protection assumed responsibility for all research in its field. In Finland the total sum for nuclear safety research and authorities was increased and amounted to FIM 18 million (almost ECU 4 million). Six senior staff members from Risø were taken over by the Danish Nuclear Inspectorate at its creation in 1973.

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[1] such as Gunnar Vatten from the new Norwegian ministry

[2] together with Rutger Croneborg who dealt with *Kontaktorgan* matters at the secretariat

[3] headed by Morten Lange

In cases of need the nuclear inspectorates could call upon additional manpower which was available at the research institutes - with or without payment. Many of those involved would make use of their Nordic relations in their work. Thus, expertise from Risø was also available to the Danish Environmental Agency when it evaluated projects on reactor safety and waste disposal.

The radiation protection authorities continued their annual meetings and invited the *Nordic Secretary* to attend. The combined meeting of the *Chiefs* group of radiation protection and reactor safety authorities in Denmark during October 1978 dealt with consequences of large reactor accidents. In the 1979 meeting emergency preparedness, physical protection and waste questions were taken up.

Personal relations between the directors of the radiation protection authorities were excellent. At one occasion at the end of a meeting at Forsmark, the SKI director Lars Nordström before leaving his job in 1983 invited the combined group of *Chiefs* to his private castle in Penningby, located at the East Coast where Russian invaders had been a threat a few centuries ago.

The radiation protection authorities had a network of working groups and contact groups, originating from the work with the Nordic Flag-Books (page 79). Then however, the work extended to other fields, some of which were common with NKS related project groups.

The leaders of the authorities now participated in the *Kontaktorgan* meetings, but often gave the impression of being on guard to preserve their domain as independent authorities. There was a traditional scepticism between the radiation protection chiefs, under the leadership of Bo Lindell, and other participants in the *Kontaktorgan* meetings, most of which were related to the Ministries of Industry or Energy. The authorities preferred to keep a distance to underline their independence. This antagonism is said to originate from a discussion between the Danish physician Juul Henningsen and Niels Bohr who refused to divulge his politically sensitive knowledge, and to Rolf Sievert who was jealous of the large sums available in Sweden for the reactor programme.

5.3 Waste: reprocessing or direct disposal

In 1977 waste questions came up everywhere. NORDEL put waste management on its agenda. The *Kontaktorgan* devoted its 1977 February meeting to waste questions, inviting chairman Netzén of the Swedish Aka committee (page 103) to assist. A report on the back-end of the fuel cycle was prepared in a group[1] (page 103), and here possible future areas of collaboration were indicated.

All Nordic countries except Iceland participated in the International Nuclear Fuel Cycle Evaluation[2] (INFCE) initiated in 1977 by the USA president Jimmy Carter. The US hoped that by avoiding spent fuel reprocessing, plutonium would be removed from the fuel cycle. This was at a time when some Finnish and Swedish utilities had contracts for take-back or reprocessing with Soviet and UK organisations. Also the research reactors in Denmark and Sweden sent their fuel abroad for reprocessing.

The waste picture was dominated by the fact that the new Swedish government under Thorbjörn Fälldin (page 100) had issued the so-called Stipulation Law in 1977. This determined that no reactors could be licensed unless an *absolutely* safe waste management scheme could be shown to be available. The scheme could be based on either, direct disposal of spent fuel elements, or on reprocessing - provided that a contract existed. The latter was the case for only a small amount of Swedish power reactor fuel. Swedish utilities reacted strongly by creating, in December 1976, the project 'fuel cycle safety' (KBS)[3]. The *Committee* discussed whether some of the KBS work could be delegated from Studsvik to the other countries (page 117), but this could not be arranged in the time available. However, the Swedish Nuclear Inspectorate used several advisors from other Nordic countries - particularly from Norway - in consecutive reviews of KBS' applications.

[1] with Göran Carleson from Studsvik as author

[2] Of the three co-chairmen in the INFCE waste group, Silvennoinen came from Finland and Eckered from Sweden

[3] headed by Ingvar Wivstad

Waste was among the questions taken up by NORDEL's Nuclear Power Committee in 1978, here visiting the site at Eidefjord in Norway for a large underground hydroelectric power plant. From left to right: Marcus, Magnus von Bonsdorff, Anders Palmgren, Søren Mehlsen (photo: Per-Eric Ahlström)

A Nordic KBS meeting was organised in Stockholm in December 1977. Arranged in conjunction with NORDEL's Nuclear Power Committee, it became the *Kontaktorgan* seminar for that year. It dealt with vitrified high level waste from spent fuel reprocessing. This was SKBF's first attempt to answer the requirement of an *absolutely* safe waste management system. The issues were discussed in groups formed from more than 300 seminar participants. Netzén gave the after dinner speech in the well-known Stockholm restaurant Operakällaren. In his talk he mentioned - with a cunning smile - that the ministry sponsored the dinner, which was true but embarrassed the person who flouted official ministry rules to help the organisation committee.

It was at this seminar that Pekka Jauho in an informal meeting with the chairman of PRAV Ove Norell (page 103), Studsvik's L.-Å. Nöjd and the *Nordic Secretary* put forward the idea of a Finnish-Swedish waste group. The group would co-ordinate work on reactor waste between the two countries. This complied with the *Ministers*' recent concept of a Nordic 'co-operative body'. The group which first met in May 1978, included several of the participants from the new NKS project AO (page 109), but it was more closely tuned to the utilities' needs. Nils Rydell, in charge of the Swedish ALMA project was chairman. Officially this group met until 1981, but the relations established laid the grounds for contacts between the utilities for many years. This indirectly resulted in Finnish installations of similar design to those in Sweden. Their intermediate storage facilities for spent fuel as well as underground repositories for low and medium level waste, were amongst the first in the world to be built.

A follow-up Nordic KBS seminar was organised in Stockholm in September 1978 and thus also became that years' *Kontaktorgan* seminar. Here the Swedish industry presented its reply to the second alternative of the Stipulation Law: direct disposal of spent fuel elements.

The Swedish authorities and government accepted the first KBS scheme, for geological disposal of high level waste, in March 1979 on the night before the TMI accident. A similar scheme for spent fuel was approved in 1984. With the waste management condition satisfied, work could continue on the six Swedish reactors that were still to be put in operation.

This waste management scheme represented a major change in policy: it was clear that the Swedish nuclear programme would be of limited duration, therefore there was no point in reprocessing the fuel to recover the plutonium for recycling. Swedish waste policy therefore, became the precursor for direct disposal of spent fuel.

This solution was not evident for Danish and Finnish waste management plans. In 1978, the Finnish power companies established a nuclear waste commission (YJT) the members of which participated in Nordic waste projects.

In Denmark the first project phase of the utilities' investigation in 1978 (page 103) indicated that underground salt domes in Denmark were suitable for high level waste disposal. The work was followed up with deep geological investigations in three of the domes[1]. Contacts were established with the KBS project, to discuss a range of issues, including safety concepts. Scenarios describing the consequences of a theoretical future intrusion into a waste repository were compared. It transpired that for the salt dome concept, more severe assumptions could be tolerated than for the Swedish bed rock repository.

Also in 1978, the parliamentarians of the Nordic Council made a proposal about radioactive waste. The *Kontaktorgan* offered to act as the competent Nordic body and instructed its *Contact Group* to work out details.

In spite of international thoughts about the advantages of joint installations in the fuel cycle - the IAEA report on Regional Fuel Cycle Centres was issued in 1977 - the Nordic countries made no attempt to create joint repositories for their relatively small quantities of radioactive waste. Norway tried to solve the question of the small amount of waste remaining from the pilot reprocessing plant at Kjeller (page 46). Denmark made informal approaches to several countries, including the

[1] these Danish waste evaluations were under Søren Mehlsen at ELSAM

USA, to get rid of waste from a future nuclear power programme, the public acceptance of which seemed to be mainly threatened by the waste question.

On the contrary, in the light of growing opposition there was a push, mainly from Sweden, towards developing an international policy requiring each country to take care of its ‘own’ waste, regardless of whether its geological conditions were suitable for an underground repository.

5.4 Changed relations between the research institutes

Once *NKS* had taken over project work in nuclear safety, the *Committee*’s field of action was reduced. It now centred on general energy questions, safety projects at Marviken, the NORHAV project, discussions on the back-end of the fuel cycle, and the large post-TMI projects of the International Energy Agency.

The end of the *Committee*

In 1979 the *Committee* considered the cost of the activities (meetings etc.) it initiated. Although recognising the value of Nordic contacts for individuals from the research institutes, the *Committee* felt that its efforts should be limited to fewer, large joint projects.

The most promising area for collaboration appeared to be in new energy fields. However, the situation differed among the four organisations.

Studsvik worked hard to develop expertise in new fields such as coal combustion techniques and ‘energy wood’ products. Bertil Sjöholm was in charge of the new energy department and participated in the *Directors*’ meetings. VTT examined alternative fuels, particularly peat.

Directors of former nuclear research institutes discussing peat for energy production in Finland in 1979. From left to right: V.O. Eriksen, Marcus, Kjell Håkansson, Niels W. Holm, Veikko Palva, Pekka Jauho.

In 1978, while in Holland for an EAES (page 42) meeting, the *Directors* had discussed widening the work of the research institutes to take account of the new energy fields. Should they form a joint venture? In January 1980, the *Directors* under the chairmanship of V.O. Eriksen, issued a letter of the type ‘to whom it may concern’, principally directed at Energy Ministries and those responsible for future Nordic energy ventures. The letter underlined that the four institutes, with a total of 3500 employees, represented the largest coordinated research body in the Nordic region.

Representatives from ministries who sat on the Energy *Officials* were somewhat sceptical towards preferential involvement in the new energy projects by the ‘nuclear institutes’. They preferred to mobilise other circles to engage in activities relating to the emerging energy research field and started by organising seminars to discuss future Nordic ventures. The *Committee* tried to occupy an important seat on the 1980 seminar on energy system studies (page 120), the prospect of which appeared promising.

The ‘nuclear institutes’ participated in the Nordic Council’s seminar ‘Energy in the Nordic Countries - Economy, Environment and Security of Supply’ at Södertälje in November 1981. Through their lectures they tried to demonstrate their qualifications for participation in coming ventures. There was also a *Kontaktorgan* poster.

Following this seminar, the *Committee* energy group proposed a large energy system study for the Nordic countries, but the *Committee* members were hesitant. They felt that, in its present form, such a Nordic approach might interfere with national energy plans. Therefore, they agreed to check the study’s content with each country’s ministry. IFE prepared an outline of related project proposals for the *Officials*.

However, the large study was never carried out. It would have been both extensive and expensive, and perhaps, the members of the *Officials* had no political desire. They would be reluctant to disclose possible advantages in optimising the distribution of gas, coal, hydro and nuclear power across the Nordic borders.

The collaboration among the institutes had been limited in the latter years, partly because of increasing commercialisation, and partly because the focus had shifted away from nuclear tasks. A new approach was therefore warranted. In January 1982 the *Directors* decided to dissolve the *Committee* after 13 years of existence and replace it by their own *NIS* group of institute directors.

Apart from the energy group, the existing groups working with atmospheric dispersion (SNODAS), documentation (*NALJS*) and NORHAV were to continue. On one hand the *Committee* secretariat was to be taken over by the institute organising the following NIS meeting, on the other hand the *Nordic Secretary* was to continue his co-ordinating function.

Continued contacts among the *Directors*

The *Directors* now attempted to draw up a scheme where the institutes complemented each other and specialised in selected areas of interest to the new Nordic energy ventures. They set up two working groups to evaluate perspectives for future collaboration: an energy group and a nuclear group. Both were headed by assistant directors from Studsvik, Bertil Sjöholm and Stig Bergström. Although the *Directors* would have preferred future work to be independent of the now obsolete *Committee* working patterns, it was again the *Nordic Secretary* who had to push the two new people in charge.

Bertil Sjöholm managed to visit both Kjeller and Risø on the same day and discuss his concept: to determine individual profiles for the four institutes. Institutes would refer work to each other according to their specialist fields of research: wind power at Risø, offshore technology at IFE, and combustion technology to be shared between Studsvik and VTT.

When the Directors *met at VTT in November 1982 they proposed to establish individual profiles of activities for the four countries' research institutes. From left to right: Niels Busch, Nils Godtfred Aamodt, Lars Kolind, Kjell Håkansson, Veikko Palva, Hans Bjerrum Møller, Pekka Jauho, Stig Bergström, Marcus, Ingvard Rasmussen, Jon Berg, Lars-Åke Nöjd.*

In late 1982, resulting from Sjöholm's investigations the *Committee* energy group was replaced by a *Directors* 'programme' group. The group's tasks were to identify commercial ventures such as energy conservation, energy storage, and environmental impact.

Each institute was to name a project leader to form a Nordic specialists group with the task of finding a Nordic market for its field of expertise. To fund this work each institute would make 100,000 Kroner available.

This proposal might have achieved closer co-operation between the research organisations than that attempted by the *Committee* when it was established in 1969. It would permit a gradual move towards specialisation by each of the four parties. It soon transpired however, that the individual institutes wanted to keep their domestic customers and utilise professional staff beyond the specialist fields attributed to them. It was surprising that the sums actually made available for the 'programme groups' investigations were hardly touched.

When the institutes jointly proposed the Nordic energy system study, the Sjöholm group approached the *Officials*' Contact Group for Energy Research through its president Morten Lange and secretary Christian Mosgaard (page 155), who rejected the idea. This discouraging outcome gave no hope to the four research organisations for a preferential position.

A new strategy was tried when the Bergström group on nuclear power was instructed to work out an agreement between the institutes to launch joint commercial ventures. The group investigated two areas: commercial irradiation services, in particular the irradiation of silicium for use in TV and VDU screens, and probabilistic safety analyses. However, none were attractive as collaborative ventures for the institutes, which had already established independent commercial relations.

After these two attempts, ambitions for joint ventures were practically abandoned by 1984, but questions of importance to the institutions' future strategies continued to be discussed openly. The *Directors*' meetings continued for years and were useful platforms to exchange current thinking. These meetings were those of colleagues who came together to discuss common problems. In this respect the meetings may be seen as a more intimate Nordic edition of the EAES activities (page 42). EAES meetings hardly allowed similar discussions on sensitive questions of institute management.

At one *Directors* meeting a visit to the Finnish peat industry was organised by Jauho. On another occasion, Kjell Håkansson presented a new Studsvik brochure with the title 'Sell Studsvik' urging staff to seek new commercial opportunities. A retort came promptly from Niels Busch: "Sell Studsvik, buy Risø".

In 1989, the *Directors* made a last attempt to organise joint work between Risø, Studsvik and VTT on combustion technology. They hoped to obtain financing from the Nordic Energy Research Programme under the *Ministers*. A proposal was produced for cleaner and more efficient combustion processes, but the *Officials*' programme had other priorities such as energy saving and environmental impacts.

Meetings among the *Directors* continued on an informal basis into the 1990s although they gradually became less frequent as the need for commercial survival of individual institutes became paramount.

The termination of organised collaboration between the research organisations by no means implied an end to the numerous working contacts and groups at the professional level. These were maintained and therefore Nordic relations continued. After 1982 the role of the *Committee* was to a certain extent taken over by *NKS*. How *NKS* extended its field of action in the 1980s is described in the following chapter.

5.5 Some reflections on the *Committee* period

The Nordic research institutes were as brothers and sisters: they helped each other, learned from each other, but there could also be competition and mistrust. In the early days, thanks to the desire for Nordic contacts, it was easy for members of staff from research institutes to obtain permission to visit sister organisations in other Nordic countries. This was seen as an evident benefit for the work. Specialists could derive great professional satisfaction from simply contacting opposite numbers in another Nordic country. Such contacts often resulted in a direct outcome which was more effective than that achieved from attending big international conferences for example.

Possibilities and limitations of the *Committee*

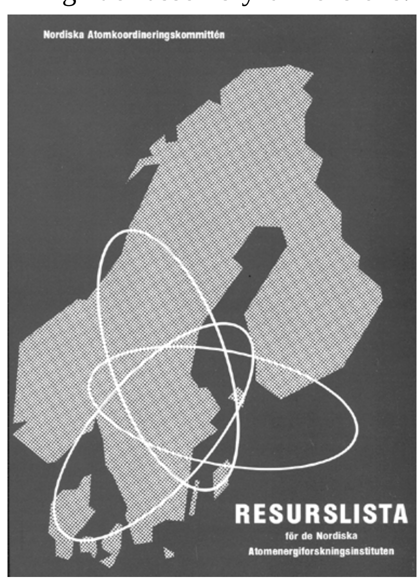
When in the mid 1960s some of the institutes queried with the utilities whether future reactors should be heavy or light water, they arranged for a closer collaboration by establishing the *Committee*. That however, was as far as they went, they did not want further integration, so the *Committee* was only given a co-ordinating function. The institutes therefore maintained their sovereignty. Collaboration had to work in spite of existing differences.

It soon became obvious, that as an administrative body, the *Committee* could not achieve co-operation in fields related to research. Scientists after all, had greater knowledge of the people and countries with which they wished to make contact. The *Committee* found that in technological areas, such as when the goal was to develop a mathematical tool, the prospects should be better.

In the early days, there were few problems obtaining finance at nuclear research centres, and personal ambitions of the staff together with national prestige often weighed heavier than arguments about rationalisation and joining forces with Nordic colleagues. Therefore, it was not always easy to convince individual staff members of the benefits of joint Nordic ventures.

Since participation in joint Nordic ventures was left open to each institute, Nordic projects had to compete with others, in particular those related to high profile national developments. The *Committee* had no way of enforcing agreements and no financial resources of its own. For the *Committee*'s contact people it could be a harsh experience coming home from a Nordic meeting where certain decisions had been made, only to find that their own organisation was not prepared to follow the advice. Therefore Nordic meetings often dealt with project surveys, enumerating possible joint actions which were successively more difficult to carry through.

At the outset, there had been no restrictions on flow of information from the research centres. The freedom of information that originated from the Atoms for Peace concept in 1955 had gradually been replaced by commercial limitations, such as in reactor core calculation or in determining fuel assembly dimensions. Therefore, questions related to intellectual property and patents were taken up by the *Committee*.



Around 1970, much effort was deployed to pave the way for collaboration among the research organisations even on commercial terms: price lists for services, rules for commercial use of results, income from patent rights, use of non-patentable results, know-how etc. Lists were prepared with commercial products (services, codes etc.) available at each organisation, specifying the degree of freedom to use such products in a commercial Nordic venture. Rules for the use of patents were worked out so that they could be included in future agreements. A 'clearing house' concept discussed by the Committee would facilitate the use of services such as manpower and results from other institutes. The conditions that permitted AE to exploit results from the joint development of a code in the Scandinavian fuel channel (SDS) project (page 68) in 1973, give a positive example of application of these rules.

Value of broad contacts

In this type of voluntary collaboration it is the people themselves who must see the advantages and be motivated to become part of a joint venture. The *Committee* attempted to stimulate interest by bringing staff at all levels in the institutes, into contact with their opposite numbers through Nordic ventures. The directors had their own committee, the group leaders and the specialists had contact groups at their respective levels. Even the operators of research reactors met to discuss common problems, as did people from the administrative departments.

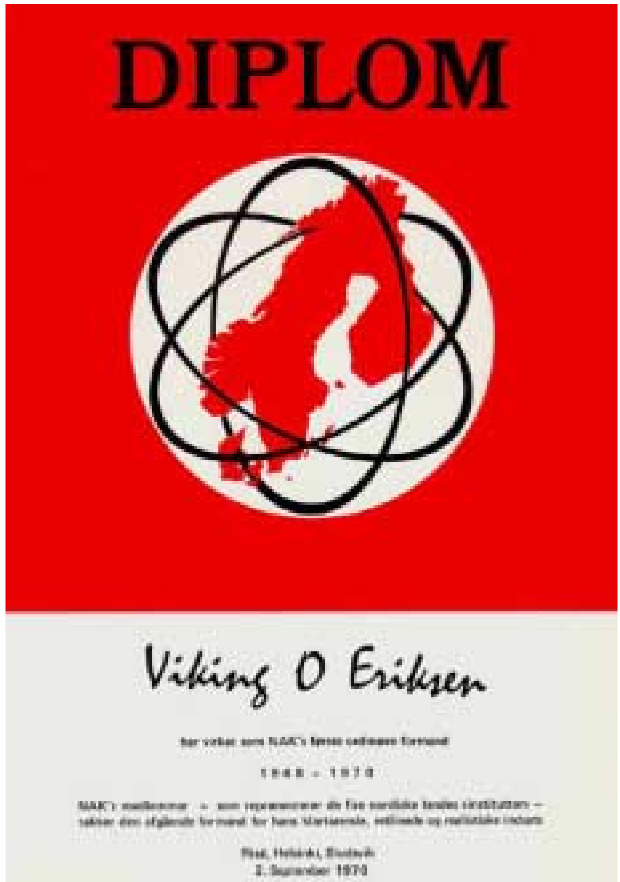
Efforts to make staffs feel directly involved extended through not only joint projects, but also contact groups, seminars and other arrangements. The success of collaboration goes beyond measuring the number of projects and reports completed. It is also judged by the willingness of specialists in one country to pick up a phone and consult colleagues in another country when the need arises in their daily work.

Such success was reasonably achieved in the *Committee* period. Those involved in many of the joint ventures consulted freely, although knowledge of the Nordic set-up outside their circles was quite limited. Those not involved in Nordic groups or taking initiatives were reluctant. The Scandinavian Reactor Physics Meeting (page 47) is an example: it had its own co-operative arrangement and saw the *Committee* as newcomers to the field. In the subsequent NKS period from 1977 (chapter 4), although areas of joint work were limited, Nordic networks were excellent, but now encompassing a reduced number of disciplines.

For some participants, although the Nordic projects themselves were of minor importance, they derived real benefits through resulting informal contacts. In some cases these contacts paved the way for future commercial ventures.

Another condition satisfied was that corresponding contacts existed at a higher administrative level: the *Kontaktorgan* was an excellent example of this - especially after its *Contact Group* came into existence in 1970 (page 88). In some way the later NKS reference groups (page 217) were designated to have the same function.

The atmosphere in the Committee was positive and even amiable; outgoing chairmen received a diploma, and when the Nordic Secretary returned from Thailand in 1976, rewarded by the SAS airline for his great number of air voyages between the Nordic countries, he distributed silk ties to the Committee members saying, "it is thanks to you that I could go on this trip".



Decentralised administration

A further reason for the *Committee* success may be the absence of a central administrative unit and the tendency to empire building. Decentralised administration thus can be useful, but its success depends on responsible people in decentralised positions to respect their tasks and maintain initiative.

The concept of employing and sharing the costs of a joint member to act as a permanent initiator, proved to be effective and cost efficient. By allowing him to be regular member of the different groups he obtained direct contact with staff and directors at all the institutions involved. This helped to further goodwill and a commitment to joint working. Whenever a joint venture was launched, one of the participating organisations assumed the secretariat and assigned a member of its staff to deal with secretarial questions. The system with national contact people facilitated the daily work, both of the *Committee* and the *Kontaktorgan*. For many of those who took the job as contact persons this later turned out to be a step in their career[1].

The *Nordic Secretary* was therefore assisted by local secretaries[2] - often selected within the various working groups - who would be his discussion partners when planning future initiatives. They would organise meetings, write minutes, and help to published and disseminate results.

Competition or co-operation

Co-operation between the four parties (or five, counting Iceland who joined the *Kontaktorgan* but not the *Committee*) was necessarily governed by the differing ambitions of the institutions involved. However, in an international perspective they all felt the advantage of working together. Combined projects, such as the early concrete reactor tank and the later NORHAV and Marviken MX groups, were sufficiently potent to attract international interest.

The particular field dealt with here however, confirms that national endeavours usually dominate the behaviour in international relations. Thus, collaboration was often complicated by initiatives taken at different times by individual countries. Examples of national initiatives that countered Nordic ventures can be found in all of the countries.

In some fields competition - sometimes in contrast to agreed procedures - could not be avoided, such as for example, in the fields of isotopes and reactor physics. Problems of this type usually arose between Norway and Sweden who needed to

[1] Thus, Aksel Olsen was appointed technical director at Risø, Pekka Silvennoinen became director of the nuclear technology department at VTT, Alf Larsson became head of the waste department at SKI, Jon Berg managing director of IFE, just to mention some of them.

[2] the *Committee* had its secretariat at Studsvik from 1973 through 1977 with Pehr Blomberg as contact person, later followed by Göran Carleson. The *Kontaktorgan*'s *Contact Group* had its secretariat at the Atomic Energy Commission in Copenhagen from 1973 with Niels Gadegaard as secretary, and the first NKS secretariat was with Heikki Reijonen at VTT in 1975.

cover part of the research institutes' income by commercial ventures. This only became necessary in Denmark much later. In Finland, VTT's target was to earn half of its turnover from commercial customers.

On the social side also, there were contacts which had an indirect effect on the official co-operation. One example is the Scandinavian Atomiades which started in 1966 following an initiative from Studsvik. The Atomiades rotated between the three countries having a nuclear research centre. Many contacts made were also useful professionally in joint Nordic work. In 1985 the Atomiades changed name to Scand Sport, following the general development away from nuclear issues at the research centres. Pictured here is a volley ball game from Scand Sport 1987. It shows that there was no sexual discrimination in Scandinavian Atomiades.

When it was clear that of the five countries, only two started a nuclear power programme, this complicated the co-operation issue since it meant that the national research institutes were at different phases of development work. The scope for collaboration in areas of genuine common interest was accordingly reduced. For Finland and Sweden, the Nordic scheme gave them access to expertise and manpower from other countries that wanted to keep in touch with the 'real' nuclear power world. It could also add to a participants' credibility for future national and international work, to refer to a Nordic background.

Different countries took the lead in Nordic projects. During the 1950s many initiatives came from Norway. In the 1960s, skills were evenly distributed among research institutes and many ventures were proposed. These included developing mathematical methods, put forward from Denmark, and projects in reactor technology proposed from Sweden. Later, thanks to the foresight of a small number of individuals, several Swedish projects were included as part of a Nordic programme, first in the *Committee* period and later in NKS programmes. Not only were such Nordic projects relevant, but they mobilised new interest in the 'non-nuclear' countries Denmark, Iceland and Norway. At the same time they raised these projects' profile, which benefited the Swedish participants.

As each of the institutes - starting in Sweden and soon followed in Norway - was forced away from its initial privileged stand and had to approach a more commercial position, the fields of co-operation became more restricted. For the staff, at Studsvik in particular, a conflict could arise between interest in Nordic ventures and the need for income from its own activities. Already by 1971 staff members at the institutes found it hard to join Nordic projects unless there was a policy decision for each particular item.

In Sweden, following the creation of ASEA-Atom, AE was obliged to provide results without being able to market them. An example is in reactor physics, where AE made experiments for ASEA-Atom to verify codes to predict the behaviour of fuel elements. In Norway, IFA worked with the new Norwegian firm Scandpower (page 91) to produce a set of codes for the entire reactor core. The Norwegian and Swedish efforts seemed to be complementary which indicated prospects for joint marketing. The *Committee* attempted to combine them, starting by establishing surveys of existing codes with a view to organise joint work on their verification. Negotiations between AE and IFA were arranged at top-level. Perhaps a genuine will was lacking, or their national loyalties took precedence. Each of them have since made successful use of their code packages, although some co-operation has taken place amongst them from time to time.

In the safety field there was less commercial interest. The institutes saw their role as consultants for the safety authorities, without experiencing a conflict of interest even if they also used their knowledge to advise industry.

With only two of the five countries opting for nuclear power and work at the research institutes reoriented accordingly, it was logical to wind up the *Committee*. The directors however, continued to meet and explore other means of collaboration, either in actual project work, in sharing of tasks, or just to learn from shared experience.

6. From TMI to Chernobyl

At the end of the 1970s nuclear power was well established with four reactors operating in Finland and six in Sweden. Utilities in Denmark and Norway were actively planning their own nuclear power programme. At the same time, opposition against nuclear technologies continued to rise. The *Kontaktorgan*, with its members from ministries, research institutes and authorities, exchanged information and promoted joint endeavours in fields of current national and international interest, provided that a Nordic approach was feasible seen from the individual countries' point of view.

6.1 The Three Mile Island accident

The accident at the TMI-2 reactor in Harrisburg was the first accident in a civilian nuclear reactor. It was caused by human error, and although no member of the public received a radiation dose, it raised fears of nuclear safety around the world and strengthened resistance against nuclear power.

Rumours in the Norwegian mountains

The seventh *Kontaktorgan* seminar took place at Røros in the Norwegian mountains on 2.-4. April 1979. It dealt with environmental effects from various forms of energy production. Organised with NORDEL, there was broad participation from the evolving environmental authorities in the Nordic countries. One purpose was to identify areas for Nordic project work. The project on quantification of environmental effects produced by the *Committee* energy group (page 120) was presented by Studsvik's Lennart Devell. The audience was entertained at the dinner, not only by being introduced to the strange Norwegian *rømme* sour cream, but also by Egil Storbekken, the authentic flute player from Norway's mountains.

The practical organisation was in the hands of Rolf Lingjærde from IFA. He was also President of the Norwegian Atomic Energy Society and had many international contacts. Soon after the start of the seminar he was called to the telephone, to hear news which completely overshadowed the conference. A pressurised water reactor at Harrisburg, USA had experienced a loss-of-coolant accident. From this point onwards the latest rumours were relayed to the audience. The accident was at Three Mile Island (TMI): now a hydrogen bubble was forming, possible explosions, and so on. There were also news about the hesitating response from various authorities, and the evacuation.

Effects in the Nordic countries

The accident created a wave of public opposition in all the Nordic countries. Olof Palme, the Swedish Prime Minister had up to now favoured nuclear power and reprocessing. Shortly after the accident, he appeared on television and declared his total opposition.

Immediately after the accident the government announced a referendum on the future of nuclear power in Sweden. It was held in March 1980. It was perhaps a calculated sophistication that three alternative questions were formulated. Two of them were positive for nuclear power in that either 12 or 6 reactors would remain for some time. As a result, refusal of nuclear power was avoided, and two rectors still not having a licence, plus four under construction could be taken into operation provided that they satisfied the requirements of the Stipulation Law (page 129).

While the referendum was only consultative, the Swedish parliament ruled that all reactors were to be taken out of operation by the year 2010, at which time the most recent ones would have reached the age of 25 years. This was the life time used to calculate depreciation.

Two Swedish committees were set up to examine reactor safety and to assess the consequences of phasing out the nuclear programme. The first investigation started in 1979[1]. It examined the possibility of accidents similar to TMI occurring in Sweden and recommended safety improvements. Finnish and Swedish authorities also carried out safety reviews on their nuclear power plants and proposed both short and long term safety improvement programmes. Extensive safety enhancement programmes, which were subsequently launched, provided valuable inputs into later NKS projects on reactor safety.

Several other Swedish investigations followed, such as ‘energy-and-environment’ and ‘coal-health-environment’. A White Paper on more efficient emergency planning was also issued.

In 1979, a joint Danish-Swedish committee[2] studied safety at the Barsebäck nuclear power plant. Its terms of reference also included examining the environmental effects of other energy production sources such as coal burning in Denmark. This in particular annoyed the Swedes because of the prevailing winds from the west. The susceptibility of the Barsebäck reactors to failures similar to those which led to the TMI accident was also investigated. Building on the lessons of

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[1] with Lars Högberg as secretary

[2] under Jens Kampmann and Gösta Netzén

TMI, new proposals put forward included improving information flow in the event of an accident. Plans were to consolidate already established contacts and to co-ordinate information activities. The Danish emergency plan for an accident at the Barsebäck plant was revised in October 1981.

A Danish decision on nuclear power was postponed in 1981. The Energy Ministry maintained that nuclear power was an option, subject to a positive outcome from the Environmental Protection Agency's evaluation of safety and waste questions. Completion of this work was scheduled for 1982. It was to be 1984 however, before the Agency terminated its review of the reports from the utilities covering safety, waste and location of nuclear plants. The outcome was positive, although subject to confirmation that spent fuel could be safely disposed in Danish salt formations. Those opposed to nuclear power however, now dominated parliament.

The Norwegian *kjernekraftutvalget* (page 100) issued its report *Nuclear Power and Safety* in October 1978. In preparing its content, information made available through Nordic sources was of great help, and the report represented a comprehensive state-of-the-art description. Within the Commission there were strong differences of opinion among the members, perhaps reflecting the different views evolving among the Norwegian population. Most members found nuclear power acceptable provided that strict safety requirements were satisfied. However, when the Norwegian parliament in October 1980 dealt with Norway's future energy situation, the proper conclusions of the report were hardly discussed. Parliament stated that Norway would not need nuclear power in the twentieth century.

In December 1979, as part of the First NKS programme, a seminar on the authorities' regulation of operating reactors was organised[1]. This provided an opportunity to discuss the TMI accident and to see whether Nordic authorities should improve their analysis of plant operations.

Following the Swedish evaluation of reactor safety in 1981 mentioned above and the subsequent FILTRA research project, a filter tower - to provide additional safety against radioactive releases in case of an accident - was added at the Barsebäck site and put into operation in 1985. Other Swedish reactors were also to be supplied with devices to further reduce the amount of radioactive material that could be released in the event of an accident, thereby mitigating any off-site consequences.

In July 1982 it was decided that another Danish-Swedish committee would be established to review the existing safety evaluations of the Barsebäck plant. After

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[1] by SKI consultant Lars Andermo

some delay its members were appointed, with a Norwegian ex-minister as chairman[1]. Its report, published in March 1985, recommended closer contacts between Danish and Swedish authorities. Accordingly, an agreement was signed in April of that year between government representatives from both countries, to exchange information on reactor safety and emergencies. In case of an accident, information would be passed directly from the Swedish Nuclear Inspectorate (SKI) to the Danish contact person.

Although these contacts were quite effective, Danish politicians still demanded that the Barsebäck plant be closed. Several heated discussions took place in the Nordic Council in 1985. The Danish antinuclear politician Margrete Auken continued her attacks against the *Kontaktorgan* and in 1986 raised the question of its missing statutes (page 204).

In Finland Jorma Routti became secretary of the Atomic Energy Commission in 1976, replacing Pekka Jauho as its chairman in 1988.

The Finnish utility TVO in 1981 decided to construct an intermediate storage facility (KPA) for spent fuel located above ground, along the same lines as the underground Swedish CLAB store at the Oskarshamn site that was planned to house all spent fuel from Swedish reactors for an extended time period. In 1984 construction work started at the site of the TVO reactors. The store was to be operational in 1987.

Safety and radiation protection authorities

The Swedish Nuclear Inspectorate SKI was reorganised and expanded in 1981. It now expended a large budget for nuclear safety research which included the funds for the Swedish contribution to NKS. In 1983 a new section was established within the SSI to inspect nuclear power plants. In 1984, at the Finnish Centre for Radiation Safety (STUK), the functions of radiation protection and nuclear inspection under Antti Vuorinen were redefined with enhanced emphasis on reactor safety.

A new Swedish waste authority (the NAK commission for spent fuel, later transformed to the Board for Spent Nuclear Fuel, SKN) was put in place in 1981 to survey R&D and calculate amounts to be paid by the utilities into a waste fund. The fund was to cover all future costs of decommissioning and perpetual waste care. This meant that in many cases three official Swedish representatives participated in Nordic waste meetings, the two others being SKI and SSI.

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[1] Trygve Bratteli followed by Rolf Hansen

The Swedish Stipulation Law from 1977 (page 129) was replaced in 1984 by a new nuclear law. The last two large reactors at Forsmark and Oskarshamn were to be licensed according to the new law, which also required that satisfactory schemes for waste management were in place. A new nuclear law was presented in Finland in 1985 according to which building of any new nuclear power plant required parliament's consent.

The co-operative scheme among radiation protection authorities was well developed, with several working groups (a total of 14 in 1984), including the Nordic Transport Group and, typically, a group on radon in dwellings. This Nordic background helped the national authorities in their international matters. For example, it gave the Danish authorities a firmer stand in discussions about Euratom's new basic norms for radiation protection. The Nordic authorities exchanged information on external threats, such as those posed to the Nordic area by falling Soviet COSMOS satellites in 1978, 1983 and 1988. In 1988 the authorities even exchanged calculations on the satellite's expected trajectory and possible consequences of a fall on Nordic territories.

The *Committee*, still in existence at this time, considered that the TMI accident did not warrant a change of priorities to existing projects on reactor safety among the institutes. In 1980, the group of Nordic reactor safety authorities recommended work on probabilistic safety analysis and suggested a sum of 150,000 Kroner to be allotted for this purpose. But the *Committee* in turn recommended that this question be taken up by *NKS*. Progress had already been made in related questions, such as the use of fault trees (in the *NARS* period, page 82), in NORHAV and in the Marviken experiments (page 75).

Kontaktorgan activities

After the TMI accident the *Kontaktorgan* discussed the necessity of new safety criteria and whether the still existing *NARS* framework (page 83) was suitable for such work. Its *Contact Group* was therefore instructed to investigate any necessary initiatives. J.A. Firing from Halden evaluated required actions but found that current and planned NKS programmes already covered the most important questions.

The *Kontaktorgan* also planned a Nordic contribution to the IAEA conference on nuclear safety during October 1980 in Stockholm. The paper introduced ideas on the need for enhanced international efforts to arrive at nuclear safety standards, something, which was realised in the 1990s through the work by the IAEA.

The theme of the 1980 *Kontaktorgan* seminar was ‘The nuclear fuel cycle in a Nordic perspective’. At this time, the need to assure that raw material and services such as enrichment, would be available in the future, was a major concern. A Finnish-Swedish system for mutual assistance in this field was suggested. The seminar was held at Ebeltoft on Jutland’s East Coast and included an evening walk through the old town where, during the tourist season, the watchman sings every night hour.

Another question dealt with by the seminar related to the back-end of the fuel cycle. Although it was never openly stated, some doubted that it was necessary for each country to develop its own system of waste repositories. They wanted to test whether the question of waste disposal could be dealt with in common. What was evident was that certain conditions needed to be satisfied if the Nordic countries were to co-operate in back-end operations of the fuel cycle. These included such questions as responsibilities, insurance, and safety requirements. The seminar discussed these issues which were also put forward by the Nordic Council. The Council wished to consider ways for joint action on waste management, including non-technical aspects.

As a follow-up, the Finnish ministry in January 1981 called a Nordic meeting to discuss requirements to facilitate co-operation in back-end of fuel cycle work. Factors to be taken account of included international agreements, safeguards and physical protection. It was recommended that non-technical obstacles, such as laws regulating the transfer of ‘material’ between countries, should be reviewed to permit closer Nordic interaction in this field. Although not specified, it was understood that ‘material’ in this connection meant waste.

In February 1981, the *Kontaktorgan* started an evaluation of these questions. A group[1] produced a report in 1983. It recognised that while few problems would exist for such joint Nordic ventures, it would be advisable to solve certain administrative questions through agreements - including norms, procedures and requirements - prior to any actual transfer of ‘material’ between the countries. In particular, safeguards and accountability questions regarding fissile material of different origin would have to be considered.

The report was subsequently translated into English and given a wide international distribution, but there was no political drive to permit the ideas to be further pursued.

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[1] with Staffan Laurén from the Swedish ministry as author

The time to decommission some nuclear installations approached. Several small plants, such as the first research reactors in Denmark, Norway and Sweden had already been taken out of operation, and in 1983 a Nordic meeting on this theme was arranged. Organised[1] in Visby on the island of Gotland, the meeting was co-sponsored by the *Kontaktorgan*. Subsequently, a reference group continued contacts and was active in planning decontamination projects in the coming NKS programme.

The 1983 *Kontaktorgan* seminar at Lidingö near Stockholm also dealt with waste. With participation from the utilities it reviewed projects for handling highly active waste and options for its disposal. The quality of the Danish salt domes was new for the majority of participants, and the sophisticated safety analyses carried out in the Swedish KBS project aroused strong interest. The IAEA director Hans Blix sent a telex from Vienna to explain his position: it would be better for the environment, for economies, and for non-proliferation if countries with large nuclear programmes took over the waste from small programmes in repositories which they planned to build.

The 1982 *Kontaktorgan* seminar at Leangkollen outside Oslo dealt with Technology, Society and Communication. It was prompted by the rising recognition that information previously released - about radiation, nuclear power and risks - was insufficient. The seminar was arranged by the Norwegian Council for Scientific and Industrial Research (NTNF)[2], with the Nordic Journalist School and the Nordic Culture Secretariat. This identified a need for more comprehensive public information so that people could form their own opinions about the risks of new technologies. The seminar also revealed the need for direct information to improve the politicians' base for decision making.

Members of the *Kontaktorgan* received the seminar's findings enthusiastically and recommended a number of actions, which the *Nordic Secretary* attempted to put into effect. They included the provision of an improved basis for complicated decisions and methods to incorporate subjective viewpoints. However, there was no Nordic body to handle such questions and the circles he contacted - mainly educational institutions - were not in a position to advocate the conclusions. None of the initiatives on a Nordic level led to a result, but similar questions were later dealt with in the Third and Fourth NKS programmes: RAS-490 and BER-3 (pages 180 and 223).

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[1] by SSI's Ragnar Boge and Curt Bergman
[2] and its dedicated secretary Liv Linde

At its meeting in Oslo in February 1984, the *Kontaktorgan* discussed different aspects of Nordic co-operation. Pekka Jauho spoke about safety research in risk prone industries and Anders Palmgren about the favourable conditions for nuclear collaboration in the Nordic countries: the absence of competition made both NORDEL's and NKS' work efficient. Ragnar Sohlman, the Secretary-general of the *Ministers*' secretariat, explained how Nordic financing was intended to promote 'concerted actions' by combining national resources.

The 1984 *Kontaktorgan* seminar at Jönköping was arranged with the new Swedish NAK commission referred to above. It dealt with alternative choices for waste[1] disposal. Alvin Weinberg from Oak Ridge was an inspiring contributor to discussions about mainly Finnish and Swedish plans for underground disposal of spent fuel. Opposition groups also actively participated in the talks.

A review of the Nordic-IAEA agreement, on mutual assistance (page 49) started in 1985[2]. Relationships established amongst those working on this review (Note 6.1) were later to prove useful during the Chernobyl accident and in Nordic working groups on information and emergency preparedness.

The original 1963 Nordic agreement had remained intact for many years. Finally it only needed updating to indicate those authorities now responsible and to specify actual contact points. Iceland, who had only declared its adherence to the spirit of the original agreement by letter, was now included in the list of contact points.

In 1982 on the initiative of Björn Palmén, the *Contact Group* proposed an exchange scheme for people working at the Nordic authorities who were engaged with nuclear questions. Years later, Palmén himself was one of the few people to take this opportunity when he spent several months at the information department of SKI.

The waste contact forum

In 1982 a new platform for contacts in the waste field was invented: The Nordic *waste contact forum*. Here, everyone involved with waste projects was given the chance to briefly summarise their work. Each person was given 5 or, exceptionally, 10 minutes for a presentation. The chairman (the *Nordic Secretary*) made himself rather unpopular by making each speaker stick exactly to the agreed time limit. In this way the whole waste area was covered in just one day, instead of the

[1] The organisation was in the hand of J.O. Liljenzin from Chalmers University of Technology at Gothenburg. Rolf Annerberg from the Swedish ministry opened the meeting.

[2] with STUK's Anneli Salo in the leading role

several days which would normally be required by such a large group of specialists.

The *waste contact forum* was a permanent organisation for several years, and in practice replaced both the earlier NIPA project among the research institutes (page 102), and the Finnish-Swedish waste group (page 130). The first meeting took place at the SSI in October 1982[1]. This was the first meeting to be held in the courtroom of SSI's new Haga headquarters. Four years later, this large room was occupied night and day by staff manning hastily erected telephone lines, attempting to advise the Swedish population on the impact of the Chernobyl fallout.

The first meeting of the *waste contact forum* was a success and was quickly followed by a second meeting at VTT in September 1983[2]. The list of participants, of which more than half presented their own paper, proved to be a useful tool for Nordic contacts in the waste field.

The second *waste contact forum* had revealed that work on criteria was advancing independently in the various countries. In 1983 the Norwegian Nuclear Power Inspectorate[3] emphasised the need for guidelines and criteria to cover waste disposal documentation. A proposal was made in the *Kontaktorgan* in 1983 to use the *NARS* framework (page 83) for work on documentation for waste installations. The *NARS* agreement was still in force and a small part of its budget remained, but in spite of several attempts in the following years it was never used again.

The third meeting of the *waste contact forum* was at Risø in March 1985 and was combined with a Nordic bitumen day, also featuring Hubert Eschrich from Eurochemic, to discuss waste solidification in bitumen. Knud Brodersen invited everybody to his puppet show about the waste expert who spends his time travelling between countries to attend international waste conferences (see next page).

The fourth *waste contact forum* at Kjeller[4] in October 1987 was attended by 66 participants. These included the director of the Swedish Nuclear Fuel and Waste Management Company SKB (previously SKBF, page 92) Sten Bjurström, who was delighted to meet so many of the Nordic specialists working in his field.

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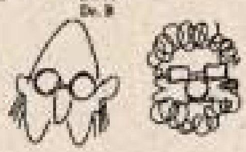
[1] after preparatory work by Curt Bergman

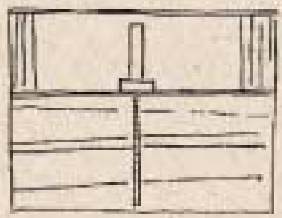
[2] organised this time by Margit Snellman

[3] under Kåre Øfjord since 1982

[4] organised with Olaf Kleveland

Cast: Dr. A
Dr. B





Curtain.
Dr. A and dr. B enter from opposite sides

B: Oh, pleased to meet you, Dr. A.

A: How are you, Dr. B. How are you - -
Let me see, when did we meet last, - was it yesterday ?
- or the day before yesterday ? - or just possibly the day
before the day before yesterday ??

B: Well, the Planning Commitee meeting at - -

A: And the conference on comparative assessment and evaluation

B: And the review meeting on program progression -

A: And the ad hoc group on program funding -

B: No, that is next week. What you are thinking about is no
doubt the ad hoc group on program budgets -

A: Well, well, anyway, pleased to meet you again, Dr. B.
I am looking forward to the presentation of your interesting
work - -
(Aside)
God knows how many times he now has presented the same results

6.2 The Second NKS programme 1981-85

The First NKS programme had provided a forum for effective project work in fields which were of joint interest. These partly dealt with safety issues of new or existing nuclear power plants, partly with assessing possible environmental impacts due to their exploitation. Towards the end of the First programme it was obvious that this form of co-operation should be continued, especially in view of the availability of finance from the Nordic budget. Therefore, in March 1979 the *NKS ad hoc group* with representatives from research organisations and authorities or industry which needed the results was again called upon (see Note 6.2-A). Thomas Eckered again acted as chairman and again the Finnish participants offered to provide the secretariat[1].

The background for a new NKS programme was the need to evaluate the risks involved in continued - and perhaps extended – use of nuclear power. One quarter of the generating capacity on the Nordic electricity supply network was now nuclear and there was a strong desire to be less reliant on energy imports.

Planning activities

As its first action, NKS consulted with the four existing steering groups from the First programme (page 107). In addition, the group that had been in charge of the seminar on environmental effects of energy production (page 143), the *Røros group*, was to propose subjects for inclusion in a new programme. The Røros group, consisting of key people from the seminar - mainly from Environmental Protection Agencies - was pulled together by the *Nordic Secretary*. By August 1979 it had worked out a proposal that included five projects for a **MIL** programme on environmental implications of energy production.

The TMI accident and its aftermath influenced the choice of programme areas. A clearer definition of fields that needed improvement had appeared and therefore a comprehensive programme on reactor safety (**SÄK**) was included. Calculations related to the reactor core could build upon expertise previously engaged in the large *Committee* programmes and in the NORHAV project. The work on control rooms in the First NKS programme was now directed towards human reliability (the **LIT** programme). Previous work on quality assurance was to be followed up by a new programme (**KVA**) in an attempt to apply the results to other industrial sectors. Two of the former programme areas were to be continued: waste management (**AVF**) and radioecology (**REK**).

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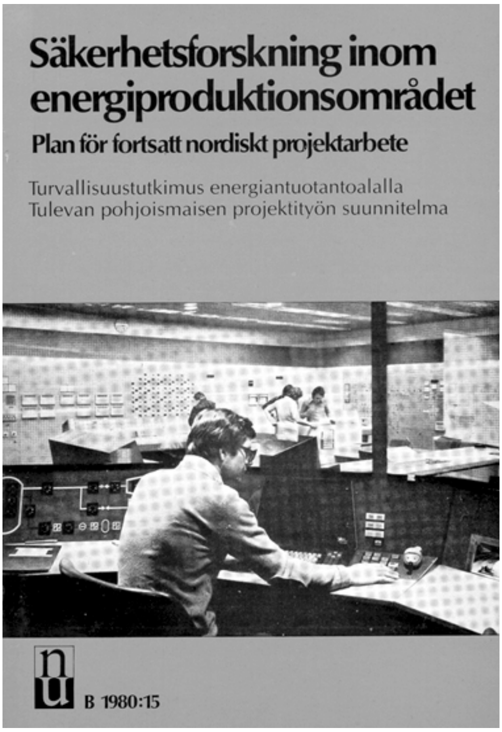
[1] now represented by Matti Hannus from VTT



An outline which included five main areas comprising 14 projects, was worked out by September 1979. Its title: Safety Research in the Energy Production Field, reflects that research related to the nuclear field might also be useful in other energy production areas. This also coincided with the policy of the Ministers who wanted to broaden the field of research to other areas than nuclear. The programme proposal was widely distributed and known as 'the blue book' according to the colour of its cover.

Several *Officials* (page 93) now discussed *Kontaktorgan* matters. The Environment *Officials* felt responsible for the **MIL** project area while the Energy *Officials* were responsible according to the *Ministers*' hierarchy for the *Kontaktorgan*/NKS programme and its financing. To avoid a competitive situation among the two *Officials*, a meeting was arranged between the *Nordic Secretary* and the Swedish members[1] of the two committees.

The *Kontaktorgan* decided to leave the MIL programme to the Environment *Officials*. It was reviewed by what later became the MIL steering group[2]. The *Nordic Secretary* presented the proposal to these *Officials* during a meeting in one of the beautiful castles at Sjælland used by the Environmental Agency. He later continued to contribute to meetings of the steering group of the MIL programme in rooms filled with smoke from the pipes and cigarettes of environment officials. All originally proposed MIL projects were followed up in the Second NKS programme with one exception: the one attempting to compare environmental effects

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[1] Valfred Poulsson and Lars Hjorth
[2] chaired by Peter von Boguslawsky from the Academy of Finland

of various energy production methods, using similar methodologies. The *Committee* energy group therefore pursued this project for some time.

The *Committee* proposed that its *area group* for safety (page 114) - with some alteration - might act as steering group for the SÄK programme.

The programme was updated and revised in 1980. At this time Eckered had left SKI and was replaced by Møller-Madsen. He now headed the Danish Nuclear Inspectorate, which was located at the boarding house for foreign scientists opposite of the Risø site. In May of that year, during a Swedish strike, a telephone conference was held in *NKS* for the first time. Møller-Madsen started by explaining the rules: nobody could interject without asking him - but with the disciplined and modest Nordic participants there was no risk of congestion on the line.

The *Contact Group* appointed leaders of the new steering groups (Note 6.2-B).

To assure contacts with one important group of project results users, utilities were asked to join the LIT steering group. In this manner, contact persons from the NORDEL circle, even though not formally its representative, would keep fully up to date. A similar arrangement was made for the SÄK programme.

Economy

The *Kontaktorgan* applied for finance from the *Ministers* and obtained NOK 5.1 million (ECU 0.8 million) for 1980. The corresponding sum set aside for the new MIL-projects was NOK 2 million. The allowance for 1982 of NOK 5.8 million for the NKS programme was the biggest sum on the Nordic project budget. NKS would have preferred a framework budget for the entire four-year period, but this was not possible with the complicated approval mechanisms of the *Ministers*.

NKS distributed the Nordic funds for 1982 among the five programme areas but kept 0.5 million as a reserve for proposals coming up during the year. In fact, three additional project proposals were accepted. Although *NKS* considered that the Nordic Transport Group did not fit into any of the programme areas, financial support was made available for its activities from the common NKS project funds. In 1983, 5.7 million were apportioned to NKS.

During 1980 there were few other Nordic projects in the energy sector. Funding for non-nuclear projects discussed by the *Officials* were of the order of NOK 0.2 million. When they established a proper project organisation for energy related work in 1981, a full time professional, Christian Mosgaard was engaged. His headquarters were located at the Danish Energy Agency in Copenhagen. Although Mosgaard's proposals were initially criticised for missing substance, in time they led to a real battle for Nordic financing.

As the years passed, the *Kontaktorgan* found it increasingly difficult to obtain support for its NKS programme. This was partially due to the fact that *Officials* members adhered to national instructions, in several cases directed against what was supposed to be 'nuclear research', although the NKS programmes in fact dealt with only safety related questions.

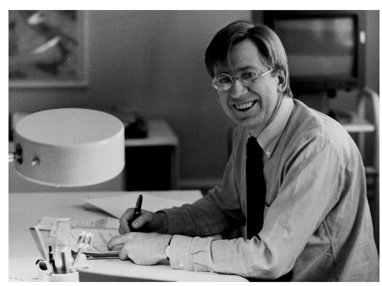
The total sum from the *Ministers* for this Second NKS programme, excluding the MIL programme, was NOK 25.6 million (ECU 4 million). This sum was matched with national input corresponding to 35 million.

The 'new' NKS

Up to 1981, *NKS* had worked during two periods to prepare the First and Second programmes, respectively. It now appeared that a rolling plan was needed to keep the programme updated. Another task would be to periodically review the project work and recommend modifications to the *Kontaktorgan*.

It was therefore given a more permanent role, although still called an 'ad hoc' committee. The abbreviation *NKS* was intended to cover two different notions: (1) the Nordic nuclear safety programme and (2) the committee charged to carry it through[1]. This created some confusion, but the double sense was maintained until 1997 when the NKS committee was designated as its Board.

The members of NKS were re-appointed by the Kontaktorgan in February 1981[2].



Thomas Eckered, now with Swedish utilities (RKS), came back as chairman.

From mid-1981 the accounts were kept by Risø's H.C. Sørensen, who was charged with NKS' administrative tasks while Henny Frederiksen continued to provide a firm basis for the mostly travelling *Nordic Secretary*. In 1982 NKS established a secretariat at SKI with Sören Norrby acting. Anders Palmgren from Imatran Voima Oy followed Eckered as chairman in early 1983. Thus the NKS *bureau* (consisting of chairman, secretary and the *Nordic Secretary*) again included three different Nordic nationalities. NKS had two annual meetings, but its *bureau* met quite frequently to keep the work running.

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[1] here written as *NKS* (italics)

[2] However Niels E. Busch replaced Aksel Olsen, Poul Emmersen replaced Møller-Madsen, and Lars Högberg replaced Gräslund.

The *NKS* meetings were held at different locations. Thanks to Eckered's good relations with Swedish utilities one meeting was at Forsmark with an overnight stay at the manor beautifully restored by Vattenfall. The October 1982 meeting at Järavallen included a visit to the nearby Barsebäck plant. At this meeting different forms of co-operation were examined: large nationally financed projects could be combined into a common frame (such as NORHAV), but could then live their own life without necessarily being included in the NKS programme. On the other hand there were small Nordic projects mainly aimed at exchanging knowledge and summarising the state-of-the-art. Such projects were dependent on Nordic financing.

Disseminating results

It was the 'new' NKS that evaluated the First programme as referred to on page 114. One finding was that the participating organisations had not been sufficiently active in disseminating results from the project work.

It was recognised that reading reports was not as effective as hands-on project experience to understand the results. In fact, during the First NKS programme, practically everyone engaged in nuclear related quality assurance in the Nordic countries was involved in the QA project. The evaluation also made another point: it criticised that direct results of the KRU projects could not be observed in nuclear power plant control rooms.

The question of results disclosure was also taken up by the *Kontaktorgan*. Subsequently, the *Contact Group* in a letter to *NKS* underpinned the importance of improved dissemination of future results. The steering groups should assume this task.

NKS devoted several discussions to information activities and concluded that these should be made part of the tasks of steering groups. Each group should define its target groups and report progress to *NKS*. This led to discussions and a written procedure with excellent ideas, however it was not easy to follow in practice. It was recognised that technical information from the projects should primarily be spread through seminars and publications, but information should also be conveyed to ministries and persons influencing decision makers.

An information pamphlet describing the NKS programme was issued in 1983. At the end of the period, in 1985, NKS decided to issue a more substantial folder about its project activities to help make its work known. The *bureau* was charged with this, but it took much effort and several meetings with the somewhat wilful consultant at Malmö to arrive at a result - a colour brochure, in Scandinavian, Finnish and English versions. It was to be the fall of 1986 before its publication, so that some of the findings of the Chernobyl accident investigations could be included. In hindsight it can be questioned whether these and other brochures had an impact and how much they helped to inform about NKS.

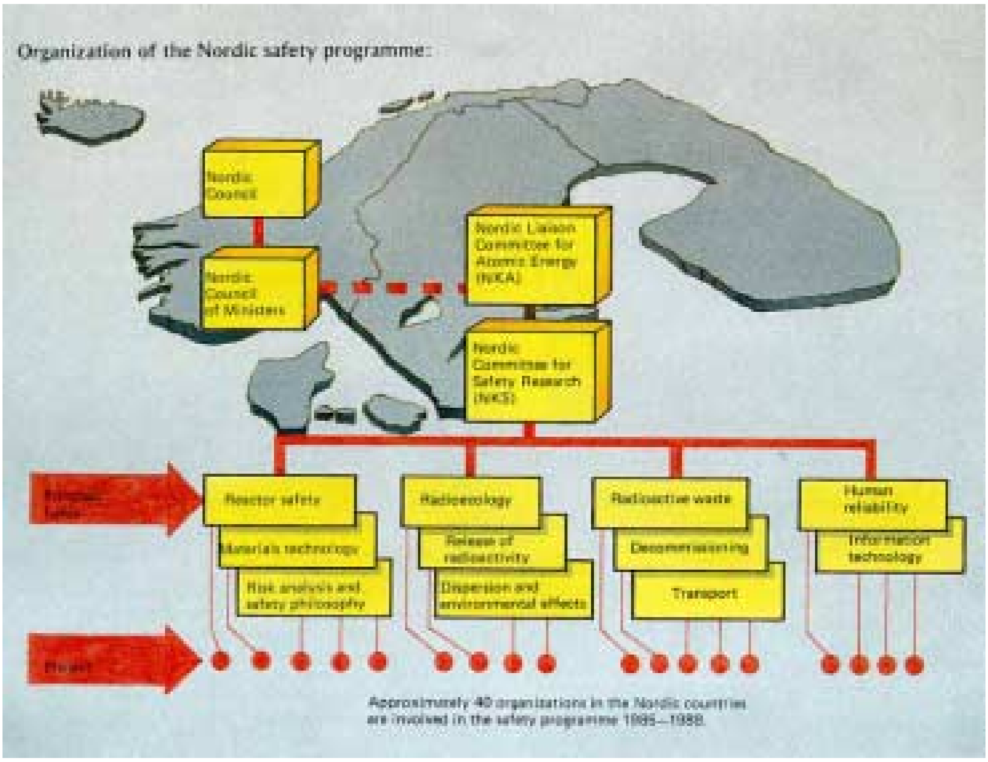

Diagram from the NKS brochure planned 1985. When presented to the Kontaktorgan it was discovered that there was a solid line showing the relation to the Ministers. This caused some excitement since it was essential to the Kontaktorgan members that they did not depend on the much younger Ministers' organisation, so the solid line had to be dotted in the final edition 1986.

NKS decided that each of the projects would have to issue a final report in English, written for a competent, external readership.

In order to allow project leaders to consider their conclusions from the four-year period, a mid-term 'hearing' was convened at Stockholm in August 1983. Here the project leaders presented a 'test report' indicating the planned outcome. The project leaders first protested, but the hearing turned out to provide a useful discussion forum among the nine attending project leaders and *NKS*' members. Few of the projects had considered disseminating results and some of the presentations were pitched at a far too high level.

The hearing was a necessary step on a long course towards well-prepared final reports. Following this experience, mid-way seminars were also held in all the following programmes.

The final reports from the Second NKS programme were to be edited in the publication series of the *Ministers*. All Nordic reports were edited[1] at the secretariat of the Nordic Council located in its beautiful residence among embassies in central Stockholm. All types of Nordic publications were routinely distributed from the secretariat according to a fixed distribution list.

The *Nordic Secretary*, when told to make use of these lists for the recent brochure on NKS, discovered that dissemination of Nordic publications was largely restricted to people who themselves participated in one or the other Nordic group, regardless of their professional field of interest. Helped by the *Contact Group*, he therefore undertook the laborious task of compiling a catalogue of people in the Nordic countries who would be - or ought to be - interested in various publications on NKS work. For each person identified, he produced a profile of expected interests, so that coming publications could be distributed to the proper target group.

It was suggested that this could be a useful tool for the Nordic secretariats and other Nordic organisations. However, there was no follow-up, because authors of other reports were unconcerned about this problem. It is a fact that people show more interest in writing reports than to ascertain their distribution.

One obvious target group for information from NKS was the utilities. From 1980 the responsible NORDEL body was its Thermal Heat Committee, the successor of its Nuclear Power Committee[2] (page 86). This committee was regularly informed of the NKS programme through the *Nordic Secretary* who attended its meetings.

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[1] by Åke Edwall

[2] Its first chairman was Gunnar Lund-Jensen from ELSAM with Jørgen Pedersen acting as secretary

Reactor safety (SÄK)

The objectives that were of common interest in the field of reactor safety were, to develop methods for safety analysis, to produce common knowledge, and to reach a consensus on reactor safety in general.

All four nuclear research organisations were involved in this programme which was influenced by the aftermath of TMI. Some of the SÄK projects would necessarily be out of Nordic balance because of the greater interest within the two countries with nuclear power programmes. The Nordic budget was small when compared with the large national programmes, consequently, NKS' work was a minor component in these countries. However, it was attractive enough for safety authorities and utilities in Finland and Sweden to want to participate.

At the time, the extent to which probabilistic methods could be used in licensing was unclear. A pilot project started early in 1980, following a recommendation by the licensing authorities (page 147). This aimed to formulate the basis for work on risk analysis and licensing, using probabilistic methods. It led to a vast project on probabilistic risk analysis, PRA.

As nuclear power plants in the Nordic countries had specific differences from those in the USA it was necessary to determine the most suitable methods to use. In the Nordic countries, various teams actively examined the availability of methods and data to calculate selected sequences, thereby uncovering needs for further improvements to PRA techniques. Several methods were under development, and the SÄK-1 project was to investigate their relative merits. Concurrently with the project work, actual PRA studies of nuclear power plants were started in Finland and Sweden.

This **SÄK-1** project, under Tuomas Mankamo from VTT became a link between the earlier NORDEL-related work on component reliability (page 85) and later projects such as AKTI (page 173) and SIK-1 (page 232). The project involved theoretical work from Risø, collection of component data from Finland and Sweden, and development work on statistics by Kurt Pörn at Studsvik. The SÄK-1 work was helpful to those simultaneously drafting the Swedish 'T-Book' which contained reliability data on components from Finnish and Swedish nuclear power plants.

The project work concluded that available PRS techniques were a useful tool which could help licensing authorities evaluate the safety of nuclear power plants. It was primarily the Finns who, after some years, insisted that the term should be P**S**A (Probabilistic ***S****afety* Analysis), not P**R**A, to avoid the word Risk. To day the term PSA is widely used.

In addition to the final SÄK-1 report and information folder, an attempt was made to communicate the results to the non-nuclear field through a separate report. This outlined the merits of PSA: to identify weak points, to select between alternatives, and to evaluate proposed changes.

After the TMI accident it became clear that even small breaks in the primary cooling circuit could lead to serious reactor accidents. Such sequences now needed to be investigated and so two projects were started under Risø's Aksel Olsen.

Thus project **SÄK-3** dealt with computer codes that could be used to describe the trend of events during small breaks (LOCAs). Rather than developing a new code the participants evaluated existing ones, including those favoured by individual organisations who had selected them for their own use. The project provided people involved with the state-of-the-art knowledge in a field where further development continued for many years.

The calculations were compared with results from large-scale tests performed under the LOFT project (page 97) and to corresponding experiments at Ispra (LOBI) and at Studsvik (FIX2). The project highlighted that models for calculation of small breaks are complicated, expensive in use and require a high level of competence. This area of research was pursued for many years, as part of the NKS work also. Relations with NORHAV were close as three of the countries (after 1980 without Norway) continued to work with LOFT.

The related **SÄK-5** project investigated heat transfer to the steam/water mixture surrounding the fuel. It included model work and comparison with experiments. This knowledge is essential to prevent situations leading to the release of radioactive material from fuel elements within the reactor core. It turned out - not surprisingly - that in certain, specified aspects improved modelling programmes were necessary.

The most serious problem in boiling water reactors, the type manufactured by ASEA-Atom, was so-called intergranual stress corrosion. A project on corrosion of reactor material, **SÄK-4**, started in 1982, initially with VTT's Hannu Hänninen as project leader. Then, the problems in Nordic reactors were smaller than elsewhere, but this type of corrosion appeared a few years later in several of the reactors.

Much SÄK-4 work concentrated on questions related to seawater corrosion. This attracted participants from a wide circle. During the four-year period many other results produced were equally relevant to non-nuclear applications.

Human reliability (LIT)

One of the findings from the KRU work (page 110) during the First NKS programme, was that human aspects play an important role both in the design and in the operation of complicated industrial plants. The TMI accident dramatically demonstrated the importance of human reliability in the operation of nuclear power reactors. The LIT programme was based on the premise that human errors may be reduced through improvements in organisation and operator support. Jens Rasmussen proposed Björn Wahlström as leader of the LIT steering group. Wahlström, although somewhat embarrassed at the confidence shown in him, accepted the task.

Means to reduce human failures during maintenance were studied in the LIT-1 project under Roger Hagafors from SKI. This identified and analysed typical errors. Procedures were examined to determine if for example, mistakes made during maintenance would be detected at the next inspection. The work also attempted to determine optimum frequencies for tests performed as part of a maintenance scheme. It turned out that error-reporting systems needed to be improved and lessons learned recorded on a database.

Another project (**LIT-2**) examined how a utility's organisation could influence safety. Whereas after an accident it is normal practice to analyse technical and human factors, the influence of the organisation is frequently neglected. John Lindqvist, who was appointed by the NORDEL Thermal Heat Committee, made a personal crusade of making this project at least easily accessible to the utilities. With Vattenfall director Lars Gustafsson, he worked intensively towards achieving this objective.

The third project (**LIT-3**) dealt with the use of computers to improve the design process of control rooms and to assist operators. This project addressed some fundamental questions, such as the division of tasks between operator and computer, and the impact of signals on operator decisions. It was thought that expert systems might be devised to assist operators in abnormal situations. L.P. Goodstein developed a theoretical basis at Risø, while experimental validation at Halden was prepared by Magnus Øvreeide as a continuation of the tests from the KRU programme (page 110). This question was later pursued in the CAMS projects as part of the Fourth and Fifth NKS programmes (pages 233 and 243).

Another project, **LIT-4**, started in 1982 under Jens Rasmussen, assessed how training simulators can be used to collect information on human reactions.

Quality assurance (KVA)

The incentive for this work came up during the QA seminar in Helsinki in August 1980 (page 113). It was an attempt to transfer methods for quality assurance to other industries related to energy production. Börje Ahlnäs from ASEA accepted - with some reluctance - to chair the steering group.

There was some competition between people on this programme and individual consultants who made their living from courses on industrial quality assurance. Occasionally, there was conflict over the nomenclature used in the nuclear field that was not entirely identical with the conventional one.

Work suffered from the fact that manpower and finance provided by participants - who were small manufacturing enterprises - was minimal. This demonstrated the different attitudes and working environments between nuclear and other industries. A request for support from the Nordic Industrial Fund, to help introduce feedback from quality assurance systems in industry, was rejected. Difficulties were also experienced in identifying authorities to be responsible for quality assurance in conventional industry. One project group attempted to specify the qualifications required for so-called QA *system auditors*, which resulted in input to national courses. However, another attempt, to produce guidelines for a manufacturer's introduction of a QA system was abandoned due to lack of finance.

The KVA programme terminated in 1983. The most significant result from this work was a survey of Nordic literature in the field.

Radioactive waste (AVF)

Once the former waste management programme was wound up in mid 1981 it required a significant effort to launch a new one. Finally, seven projects were adopted to form a new programme collection, to start in September of that year. The programme's steering group included representatives from industries, authorities and research institutes engaged in waste management.

Alf Larsson, who was now head of SKI's waste department, was an eager participant. He led a project dealing with the management of waste arising from a postulated small reactor accident (**AVF-1**). This was prior to the Chernobyl accident and it required a lot of persuasion before the consultant, ASEA-Atom could agree to work on a scenario describing the consequences of an accident that appeared unthinkable. When the calculations were finally made it was evident that dealing with the waste from such a minor accident, although manageable, would present a major task.

The second project, **AVF-2**, dealt with long-term behaviour of solidified reactor waste. This was a question cherished by Risø where similar work was simultaneously performed for a project of the European Commission. Several waste plants in the Nordic countries used bitumen as a matrix to incorporate waste of relative low radioactivity content. The behaviour was examined in a number of minor contributions to the project work. For example, Finnish research demonstrated the changing characteristics of the waste that may occur with time.

Already prior to project AVF-2, the Nordic countries had carried out a considerable amount of work on solidification of 'reactor waste' and the characteristics of the products, in line with work carried out since 1975 under the NIPA project (page 102). In 1982 it was decided to issue a catalogue of all related projects in the Nordic countries with IFE's Moj Bonnevie-Svendsen as co-ordinator. This **AVF-4** project coincided with plans to publish the first IAEA book of Waste Management Research Abstracts, and here the Nordic project provided a timely input to the IAEA.

Alf Larsson started a new drive for an international comparison of models used to predict the behaviour of waste disposed in repositories. Such a project called 'Hydrocoin' had just been proposed. Its purpose was similar to a previous SKI project ('Intracoin') where mathematical models describing transport of radionuclides in geologic media were compared.

In 1982, a pilot scheme for the Hydrocoin project was made part of the AVF programme. The purpose was to use models and computer codes to assess the flow of ground water flow around a waste repository in crystalline rock. Questions to be addressed included the accuracy of the codes and their ability to describe real situations and to determine the impact of various parameters on the result. With their planned repositories, Finnish and Swedish organisations were active partners in these projects. Other countries however, were less interested and only listened to oral reports in the steering group.

Under the Third NKS programme 1985-85 a further project of the same type was added: the 'Intraval' project (page 175). All three were attempts to compare and, to a certain degree, 'validate' calculation programmes intended to predict the performance in the long term related to effects within an underground waste repository.

On one hand these international projects benefited from NKS' reputation and its funding. An example of this was NKS' help in the starting phase of the Hydrocoin secretariat in Sweden and in contributions to its financing. On the other hand their results became available in Denmark and Norway where the only interest was, however, in Hydrocoin.

In 1983 following a seminar in Gotland (page 149), a new project on decommissioning (**AVF-6**) was planned[1]. At this time experience was already accumulated from decommissioning operations on reactors at Risø, Kjeller and Stockholm. Pilot projects on transport needs and radionuclide inventories were launched together with SSI. These were to prepare a decommission follow-up project in the Third NKS programme.

Radioecology (REK)

This programme was a direct continuation of the RA-work in the First NKS programme (page 112). It dealt with pathways of radionuclides released from normal operation of a reactor or following an accident. The results would be available to calculate for example, radiation doses to the population. In case of accidents the information would help decisions on countermeasures to be taken. In this respect the REK programme already contained elements of the emergency preparedness programme (BER) introduced after the Chernobyl accident in the Fourth NKS programme (page 222).

The meetings in the steering group were complicated by long discussions about distribution of Nordic funds, under Jan Olof Snihs' patient guidance. Research institutes needed income for their work, but economic conditions differed. At Studsvik, where the secretary of the group was employed, the economic situation was harsh and a substantial amount of project money was therefore diverted in this direction.

A series of one and two day 'mini-seminars' and workshops introduced by the radioecology group proved to be effective fora for co-operation. Each event focused on a distinct issue and was attended by not more than two participants from each country.

The **REK-1** project under IFE's Ulf Tveten, was a foresighted attempt to accumulate essential information needed to evaluate environmental effects of a large reactor accident. Until now the only available information came from the fallout after bomb tests, and there was little knowledge on which to base calculations of population dose following a reactor accident. Ironically, this knowledge only became available after the Chernobyl accident and once the contaminated sites in the former Soviet Union became accessible for research.

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[1] with SSI's Ragnar Boge

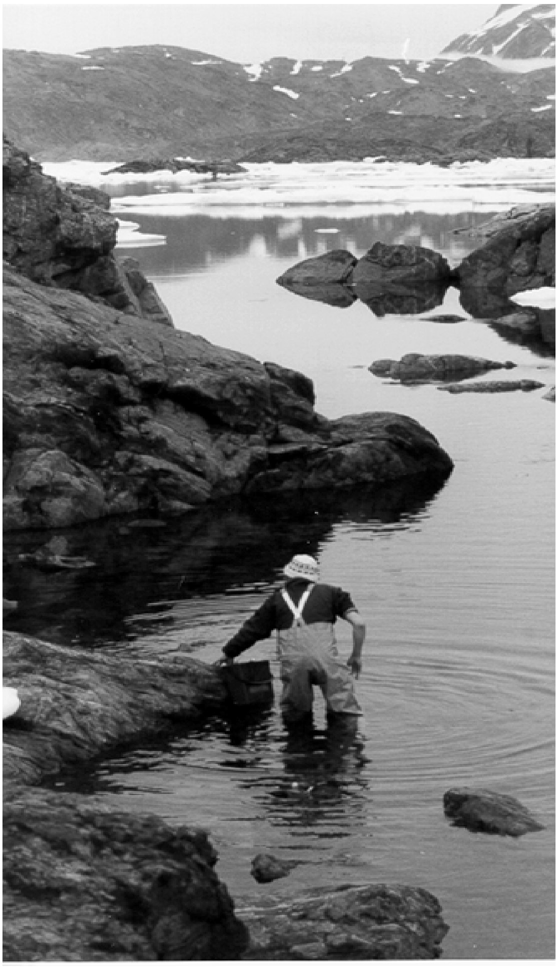
In the second project under Ulf Grimås from the Swedish Environmental Protection Agency and STUK's Anneli Salo (**REK-2**) the intention was to investigate the behaviour of radionuclides released to the marine environment. It was considered important to evaluate how radioactive materials would be bound to sediments.

The Biotest Basin, artificially created in the Baltic Sea near the Forsmark site - by connecting some of the archipelago islands - was to be used as a test site. Ulf Grimås was a fierce advocate for experiments here, but there was a fundamental disagreement between the operators of the Forsmark reactors and the scientists. The former were striving to keep releases down to a minimum, the latter required sufficient radionuclides for experiments. Thus, planned tests were difficult to realise. Finally, the most useful NKS contribution was to employ a part-time local scientist to carry out experiments so that at least a few results could be obtained.

The third Nordic radiocology seminar took place at Hyvinkää in May 1982, and here participant brought their rather voluminous air sampling equipment for calibration. This intercalibration exercise was made at nearby Nurmijärvi, while instruments used for background radiation were compared at Helsinki.

The study of bioindicators (page 112) in different regions of the seas surrounding the Nordic countries continued in project **REK-3** under Asker Aarkrog. Seaweed and certain mussels were selected and their accumulation of radionuclides determined. Their characteristics were 'calibrated' so that they would be available to investigate releases to the marine environment following an accident. This technique proved to be highly sensitive enabling small routine releases from a nuclear power plant to be traced up to 100 kilometres away. The outcome of this project was used in conjunction with a European Commission project to map the radioactive contamination of the entire North Atlantic to determine the effect of releases from reprocessing plants in England and France.

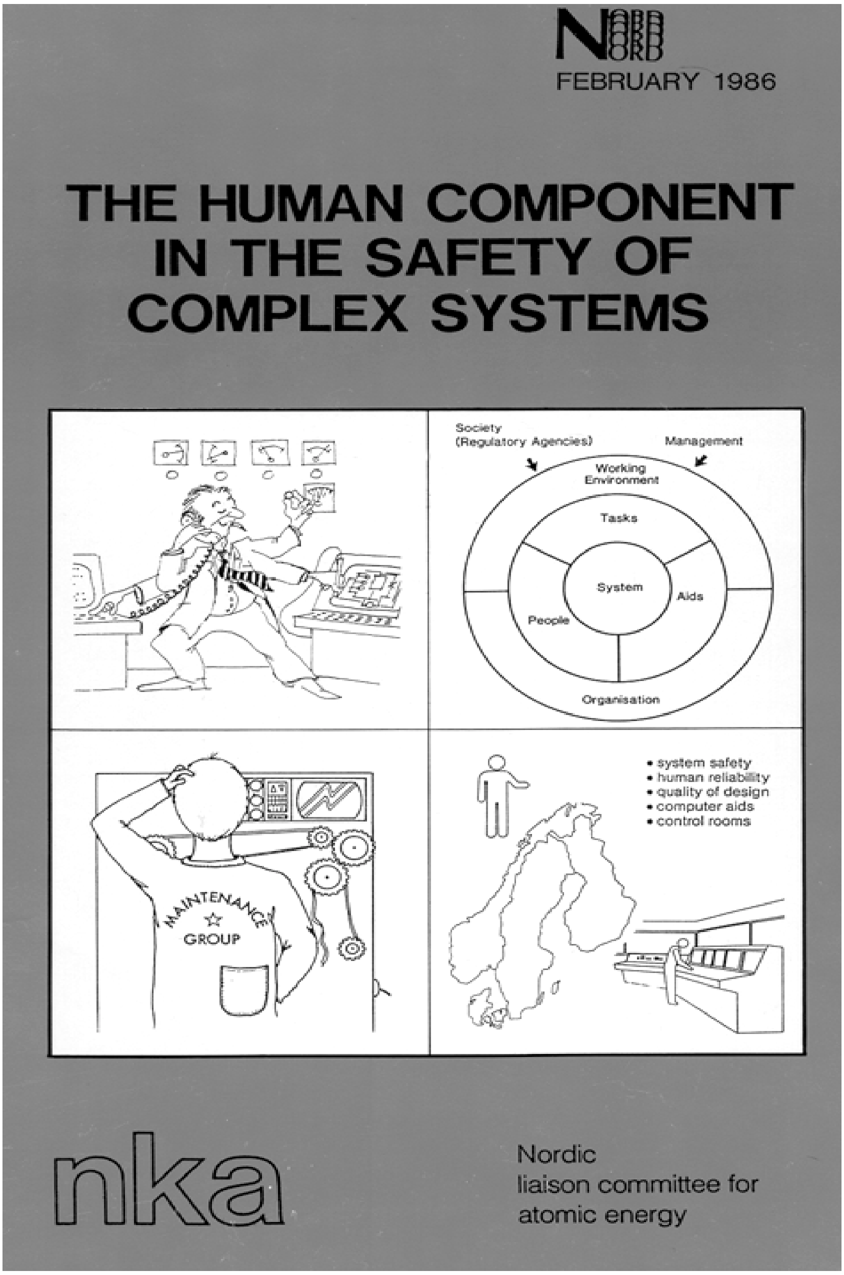
Releases to the Baltic Sea were also made part of the REK programme. It simultaneously constituted a Nordic contribution to the work of IAEA's programme *Monitoring of Radioactive Substances in the Baltic Sea* (MORS) which was taken over by the Helsinki based Baltic Sea Commission in 1984.



Bioindicators were found to trace radioactive releases at very long distances. Here Risø's Henning Dahlgaard sampling seaweed at Ammassalik in East Greenland 10,000 kilometres from Sellafield, during the REK project. Photo: Asker Aarkrog

Another project (**REK-4**) dealt with radionuclides released from the combustion of coal and peat and the radiological consequences of using 'fly ash' as an additive in building materials. The released activity is comparable to routine releases from nuclear reactors. However, this project was not seen as defending small environmental doses from nuclear power, but as a desire to calculate even negligible doses from all types of electricity generating plant.

Many scientific publications resulted from work related to the REK programme, including three Ph.D. theses.



Several areas of expertise including human behaviour were combined in the LIT project. Front page of summary report by Björn Wahlström 1986

Ending and evaluating the Second programme

The programme period was extended until mid-1985 to cover the reporting period. This meant that funding continued to make up for reduced annual finance from the *Ministers* during the latter years. It was also hoped that this prolongation would result in timely completion of final reports. In fact, 17 reports were issued, while one never came out. Three summary reports[1] were widely distributed, see list of NKS reports (page 277).

Evaluation of the programme started early in 1985. This time the procedure was available, and six evaluators (Note 6.2-D) offered to review the programme. *NKS* asked Lennart Hammar and Pekka Silvennoinen to summarise the findings in a general overview, and this was completed in 1986. They stated that technical projects in the safety field were well suited for Nordic co-operative ventures, especially when different expertise from participating countries is available to the projects. They also pointed out that NKS should concentrate on a few, relevant topics, restricted to areas where a firm basis can be provided by national institutions that have a genuine interest in that particular field.

In the evaluation of the Second NKS programme it was felt important that results should be equally useful in non-nuclear fields, such as in the case for probabilistic risk assessment methods. This followed the spirit of the *Ministers*' (the principal sponsors') wishes.

It was in this sense that a seminar on corrosion in seawater and in power plants was arranged at IFE in August 1985 to discuss results from the SÄK-4 project. A follow-up study was made by Liv Lunde at IFE together with the Statoil Company in an attempt to transfer knowledge from this NKS project to the offshore oil and gas industry. In the same sense, Risø's Kurt E. Petersen wrote a report on the use of risk analysis and techniques in the non-nuclear field.

One conclusion from the evaluation was that many of the individual projects dealt with rather detailed questions that did not necessarily contribute to the overall goals. This may have been due to the influential role of the research institutes who were sometimes more interested in their own research than in overriding Nordic goals. There was also criticism of the too frequent changes among leading project staff - which can be explained by the relatively small economic compensation from the Nordic funds.

[1] Reactor safety (by Bjarne Micheelsen), Human factors (by Björn Wahlström) and Radioecology (by Jan Olof Snihs)

The evaluation noted that the LIT programme combined different national goals under one integrated title, without succeeding to combine highly theoretical studies with practical applications. The LIT results were presented in the first *Mariehamn symposium* in April 1986, attended by data experts, psychologists, researchers, users, and authorities. Björn Palmén opened the symposium, Thomas Eckered introduced and Franz Marcus chaired the final discussion. This centred on what the distinctive Nordic mark signified in this field and concluded that it was a positive working environment with good relations between employer and employee. This would be favourable for the introduction of new technology in control rooms. The return from the symposium was complicated by another strike among the ferry lines between the Åland Islands and Sweden, but the meeting participant Emil Bachofner helped out by flying busy people to Sweden by private plane.

Other seminars were also held to present the results. The fourth Nordic radioecology seminar took place at Gol in the Norwegian Mountains in February 1985 (page 195). A waste seminar was combined with the third *waste contact forum* at Risø in March of the same year with special emphasis on waste solidified in a bitumen matrix.

Normally all final results from the NKS programmes were open for interested parties. In 1985 the right of foreign organisations to obtain preliminary results, working documents etc. of NKS projects, was questioned. This was prompted by the fact that the USA utility organisation Electric Power Research Institute (EPRI) was interested in a particular LIT project. NKS decided that non-confidential information could be freely exchanged, but that information received in return should be made available for all organisations involved in the NKS work.

6.3 The Third NKS programme 1985-89

Already when the Second NKS programme had been running for three years it was clear that the work should continue for a further period in a new programme. By this time the *Committee* had ceased its activities (page 133) and major collaboration among the research institutes was through NKS. Safety authorities and some utilities were involved in the projects. A somewhat cumbersome routine was established to procure economic support from the *Ministers*, and the responsible national ministries, through their participation in the *Kontaktorgan*, favoured this very tangible form of Nordic co-operation.

An important objective of a Third NKS programme was to provide decision-makers in the Nordic countries with authoritative, uniform background information. This would help them to realistically judge the impact of nuclear power and the steps required to maintain its safety. A large amount of information was available from the sixteen operating reactors in Finland and Sweden which were now well on their way towards maturity. Answers also needed to be found to the steady stream of waste questions raised. The programme should thus contribute to a uniform view on safety in several kinds of nuclear activities, including reactor operation, waste management and environmental impact.

Another endeavour aimed to transfer some knowledge from the nuclear field to other areas. Areas with high safety and reliability requirements could make good use of advanced methods of risk analysis and information technology.

The programme was planned by *NKS* in 1983 under its chairman Anders Palmgren. For the third time VTT offered to serve as secretariat[1]. Some of the *NKS* members (shown in Note 6.3-A) were in central positions as 'customers' for the results. Others were themselves directing national programmes in related fields, or in research organisations. A hearing on the needs of a future programme had been held with the project leaders of the Second NKS programme in 1983, at the same meeting where they had presented their ideas about final reports in that programme (page 158).

Jarl Forstén and Niels Hansen outlined a programme in materials research. A need for greater knowledge of ageing and long-term behaviour was argued as a reason to again include materials studies in the programme. Pilot projects were carried through into late 1984, with the main initiative coming from VTT. An input also came from Gustaf Östberg, formerly at Studsvik and now professor at

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[1] this time with VTT's Björn Wahlström acting

Lund, who expressed doubts about the reliability of calculations on the risk of catastrophic failures of pressure vessels.

Waste management was still a controversial issue to address. This was important both in public debate and to certify that planned methods would be applicable in practice.

After the TMI accident a probabilistic approach was initiated to identify additional accident causes (e.g. the RAMA project in Sweden and the Finnish VARA project). Studies of severe accident sequences were under way, and in Finland and Sweden the first probabilistic analyses of the nuclear power plants were being completed. This would be an obvious field for joint research.

The plan for the Third NKS programme was published as the ‘Red Book’ in October 1984. It contained a total of 32 projects in five programme areas. Several planning groups were formed and project proposals evaluated against a number of criteria, similar to the NKS evaluation criteria (Note 4.4-B). Pilot projects were started in mid-1985.

When the *Kontaktorgan* first discussed the new programme in 1984, STUK’s Antti Vuorinen recommended that it should be flexible enough to adapt to changing needs. This flexibility turned out to be important after the Chernobyl accident.

During earlier programmes, responsibilities within the steering groups were unclear. The groups comprised both requesting/financing parties and executing bodies (project leaders). From now on only the former would be members. To ensure closer contact between project work and the now (for all practical purposes) permanent *NKS*, chairmen of the five steering groups were nominated from *NKS*’ own members. For the first time each programme area was to have a co-ordinator who would also act as secretary in his steering group (see Note 6.3-B). The organisations to which the co-ordinators belonged would be responsible for accountancy for individual programme areas.

Initially in 1985, thirty project leaders were appointed, but during the four-year period this figure increased to 54. Although project leaders were no longer steering group members, they could be invited to participate in their meetings.

The new co-ordinators met for the first time in May 1985 to discuss their tasks and responsibilities. Rules for organisation, management and economics were accepted by *NKS* in June and approved by the *Kontaktorgan* in 1986. Every year *NKS* determined budgets for each of the five programme areas while the steering groups distributed the funds amongst individual projects. H.C. Sørensen provided book-keeping and some assistance for the project leaders from the central NKS secretariat at Risø.

In spite of increasing complications in obtaining Nordic funding, financing from the *Ministers* for this Third programme exceeded that of the two earlier ones. NKS was still the biggest item on the Energy *Ministers*‘ project budget. Its share amounted to 71% in 1986, 58% in 1987, and around 50% the last two years. The national input to the project work was calculated at twice as much as the Nordic financing.

Radioactive releases, dispersion and environmental impact (AKT)

The AKT programme was divided into two quite separate parts, the first dealing with phenomena within the reactor containment (**AKTI**), the second with those in the surroundings (**AKTU**). Per-Eric Ahlström, originally reactor physicist and now at SKB, was chairman of the steering group. In view of the wide field of activity it was difficult to find members for the steering group with expertise in both fields. In the event, most of them specialised in the AKTI area. The project leaders worked quite independently - and frequently complained of heavy work loads and low budgets.

The two sections of AKT were to be linked by the *source term*, i.e. the theoretical radioactive release from a reactor containment following a hypothetical accident. This would provide input to calculations of dispersion, uptake and doses in the environment. However, the AKTI group could not devise a *source term* that would yield sufficient fission products for AKTU calculations. Lennart Hammar from SKI argued that the desired magnitude of *source term* would be unrealistic because it would exceed the safety goals set by the Swedish government. These goals were attained by the accident limitation systems installed in the Swedish reactors after the TMI accident, and being installed in Finland. If unrealistic *source terms* were assumed in accident assessments in a Nordic research programme, it would unnecessarily raise questions about the adequacy of safety requirements.

The AKTI ‘programme’, initially led by Arne Pedersen from ELSAM, formed a working group (**AKTI-110**) to review events within the reactor containment following a fuel burst. Codes available for calculating accident sequences were compared in separate projects. While there would otherwise be no Norwegian AKTI participation, this became possible when J.O. Liljenzin moved from Gothenburg to a university chair at Oslo. Here he joined a Nordic team working to develop a new code to describe hitherto unknown chemistry factors during a sequence leading to fuel meltdown. The dissipation of radioactive material in the form of aerosols, both within and possibly out of the reactor containment was also studied.

Knowledge of codes was important in view of new requirements from the authorities following the TMI accident. They now required analyses of accident sequences, a task which was particularly complicated in Finland, where VTT had to adapt the codes to Soviet type VVER reactors.

In 1987 Klaus Kilpi took over the AKTI group. The former project leader had found a decrease in financing unacceptable, although this had become necessary for all NKS projects that year. Kilpi managed to keep the project together but had difficulties in summarising its contents, so that the final AKTI report was never published. However its results were used in the SIK-programme of the following NKS period (page 233).

Results for two Ph.D. degrees were produced in the AKTI area.

The AKTU 'programme' with Ulf Tveten consisted of a large number of individual projects, some of them related to SNODAS (page 98), others to radioecology. The purpose was to improve predictions of health effects and economic consequences following releases to the environment in case of a reactor accident. Tveten himself investigated the influence of winter conditions: natural and man-made decontamination of snow covered roofs and roads. But he was unlucky because the first winters of the project period were unusually mild and no snow fell in the Kjeller region.

The AKTU work turned out to be closely related to important sequences occurring during the Chernobyl accident. Those people involved in the fourteen AKTI projects made good use of their contacts in the days and weeks following the accident. Tveten tried to include actual post-Chernobyl measurements from the Nordic area in a database being created in one AKTU project. However, it turned out to be practically impossible to get hold of such data, especially where measurements had not been verified.

The final AKTU report provided a comprehensive picture of the impacts of Chernobyl releases in Nordic environments. The results were equally interesting in all Nordic countries.

Nuclear waste management (KAV)

It was recognised that the available Nordic financing was insufficient for large projects on waste management. Such projects were already under way in Finland and Sweden where there was an urgent need to present actual solutions. Therefore, the intent was to engage in projects that complemented national work and broadened knowledge in relevant areas. As a result, the new waste programme was composed of several separate projects in a similar manner to the second NKS waste programme AFV (page 163). Some projects were in fact follow-up's from earlier Nordic activities.

Thus, the Hydrocoin work[1] continued and the Intraval project (page 164) started.

A similar venture was launched from SSI[2]. The goal was to improve models predicting consequences of radioactive releases in terrestrial and aquatic environments, and to validate the models. The intention was to verify that calculated values correspond to those actually measured. Initial work started in 1984 with pilot studies[3] and was followed by a pilot project financed by the KAV programme in 1985. The project confirmed that organisations in Denmark, Finland and Sweden and in many foreign countries wished to participate. This led to the international Biomovs project, mainly financed by SSI. To some extent it replaced Nordic radioecology activities in this period.

After Chernobyl, the project attained a high profile. The October 1986 Biomovs meeting held in Vienna provided an opportunity to discuss how the accident could provide information for improved validation studies. Data from post-Chernobyl measurements were subsequently used in the project.

Some financial support for these international projects to strengthen their Swedish secretariats came from the KAV programme. The real project work however, was performed strictly by those countries - including Finland - that participated in the international Hydrocoin and Biomovs groups.

NKS pointed out that models used to describe the transport and accumulation of radionuclides in the biosphere would be equally important for non-radioactive pollutants. This was one guiding thought behind the Swedish efforts to promote a uniform view on risks from all so-called *genotoxic* matters, described below in the RAS programme.

Geological research, **KAV-330** was a new item in NKS. Large programmes were under way in Finland and Sweden, but by adding small items through a joint Nordic project the contacts between geological research organisations was promoted. This was a useful outcome from the project. While the final report[4] answered some geological questions related to disposal in crystalline rock formations, it was

[1] with Alf Larsson and Kjell Andersson
[2] by Ragnar Boge and Gunnar Johansson
[3] by Ilkka Savolainen from VTT and Studsvik's Ulla Bergström and Christina Gyllander
[4] by Alf Björklund from the Academy of Turku

difficult to see its direct relevance to ongoing work for repositories in the countries.

Once the hiatus following the Chernobyl accident subsided, Curt Bergman tried to identify selected aspects of decommissioning for project **KAV-350**. It was difficult however, to identify salient questions to be addressed years before power reactors were to be decommissioned. Work was therefore limited to identifying radionuclides important for decommissioning, waste management, and to assessing the availability of plant history information, which would have a bearing on its decommissioning strategy.

Project **KAV-360** dealt with transportation. SKB's Bo Gustafsson was surprised to note the difference between his role as a project leader in his own industrial undertaking and in a Nordic project. In the latter, individual contributions often depended on the goodwill of participants. A comprehensive survey of waste volume and transportation needs in the Nordic countries was nevertheless compiled. One recommendation was that the IAEA transport regulations be developed to take account of the transport system's contribution to overall safety. This was the case in the Swedish system with SKB's specially designed seagoing vessel *Sigyn*[1].

The waste situation resulting from major core damage to a BWR was taken up in **KAV-390** as a continuation of the previous study in the Second NKS programme (page 163). ASEA-Atom was again employed as single consultant to estimate waste quantities resulting from such an accident. An important question to be answered was whether existing waste facilities at the plants could handle the situation. Studies indicated that an accident would result in large volumes of waste. Waste treatment equipment that generally existed at all BWR reactors in the Nordic countries could handle the cleanup but the operation would take several years.

Individual members of the steering committee had somewhat different attitudes to the various projects. On one hand interest in waste questions had declined both in Denmark and Norway, on the other hand the KAV projects were small in relation to ongoing programmes in Finland and Sweden. They did however, include questions of considerable interest such as those on transportation and waste resulting from an accident.

[1] in the Nordic mythology, *Sigyn* is Loke's spouse, evil's foe

Risk analysis and safety philosophy (RAS)

This programme was to arrive at fundamental principles to evaluate risks. The principles would be applied to radiation protection, technical nuclear safety, and in similar non-nuclear fields.

Lennart Hammar, chairman of the steering committee achieved a scoop by enlisting Gunnar Bengtsson, the boss of SSI, to head one project and act as co-ordinator for the entire RAS programme. During the Chernobyl crisis however, he was forced to hand over his co-ordinating role to another person[1].

The work was divided into five projects, the goals of which were subsequently adjusted in a continued effort to bring them into a common frame.

Project **RAS-410** examined the extent of steps taken to optimise radiation protection for personnel in a nuclear power plant. STUK's Olli Vilkamo used contractors, such as ASEA-Atom to investigate procedures at different sites. It appeared that real optimisation was a complicated process and not done in practice. Utilities preferred to on be the safe side instead of only optimising doses to as low as 'reasonably achievable'.

In this connection the question of the cost for an averted radiation damage ('the cost of a *manrem*') was touched upon. This figure is used to consider what should be invested to avoid a certain radiation dose. The Nordic group of radiation protection authorities had discussed this issue earlier and proposed a figure of USD 200 per avoided *manrem* (USD 20,000 per averted *mansievert*). This related to nuclear power and was not relevant to medical uses of radiation (diagnosis, treatment). In the BER-3 project (page 223) figures five times higher were discussed while in the RAS-410 optimisation project the cost of collective doses was shown to vary depending on the doses received by individuals. The authorities in relation to their work with nuclear power plants later adopted the higher figure.

Radiation protection in nuclear plants was discussed at a meeting of the Nordic Society for Radiation Protection. Organised at Öland in October 1985[2], it was attended by representatives of utilities and research establishments. The meeting was told of an agreement, made in 1984 between Finland and Sweden, to exchange dosimetry data. This meant that total doses received by personnel working in both countries were now registered at the authority in the operator's home country.

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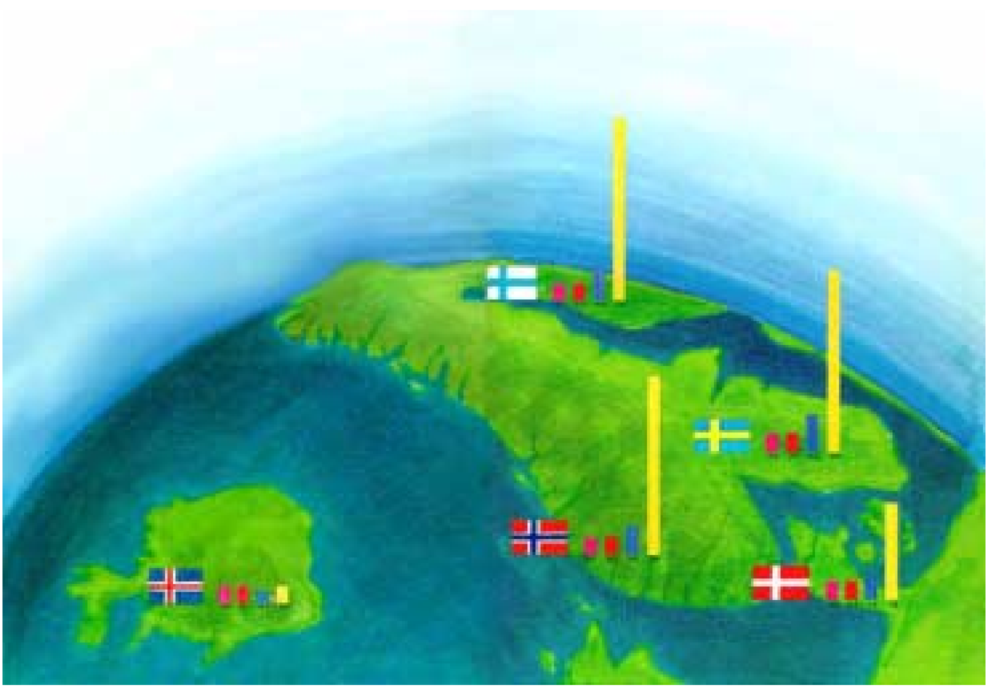
[1] at the outset to Gunnar Johansson from his institute and to Bo Liwång from SKI

[2] by Viki Lindblad and Torsten Eng from the Swedish State Power Board

Variations in natural background radiation throughout the Nordic area were examined in project **RAS-430**. Terje Christensen from the Norwegian Institute for Radiation Hygiene also tried to compare radiation risks with chemical risks and with radiation from non-nuclear generation methods. This work stimulated efforts to expand the project to include information on radiation risks. An offspring of this attempt is the work on a comprehensive pamphlet about radiation, mentioned below on page 192.

Results from the project indicated enormous variations in background radiation levels in the Nordic area. They also illustrated the contributions from nuclear power, other energy sources and from energy conservation measures such as additional home insulation. This was judged to be of interest to a wider circle and led to the publication of an easily understandable pamphlet in several languages.



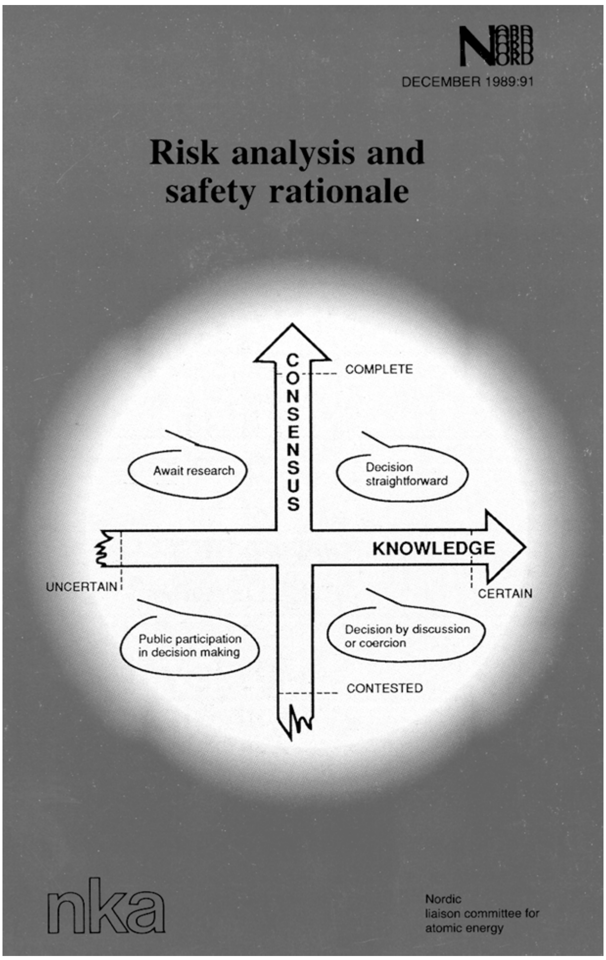
The natural background radiation varies considerably between the Nordic countries and is highest in Finland and Sweden due to radon gas from the subsoil.

Main issues in the Third NKS programme.
From brochure 1986 (see picture page 158)

Kari Laakso at VTT continued his studies on probabilistic safety analysis (PSA), mainly with colleagues from VTT and ASEA-Atom. This was for project **RAS-450** that dealt with technical specifications for nuclear power plants. In the Nordic countries, technical specifications for reactor operation, designed to provide a high degree of safety, are prepared by operating organisations and approved by the regulatory authority. In this essentially Finnish-Swedish project, improvements proposed included specifications to determine optimum test intervals for equipment. These took account of economy, equipment availability, and the consequences of breakdown or failure based on probabilistic assessment methods.

Uncertainties in probabilistic assessments were investigated in project **RAS-470**. The fora provided by annual seminars and project meetings stimulated a healthy discussions which allowed people to voice their scepticism over the justification of PSA methods in safety assessments. It was clear that PSA was a useful tool in design and safety evaluation. However, it was difficult to take account of human error or common mode failures not considered in the analysis, such as flooding of the entire plant.

Gunnar Bengtsson put considerable effort into project **RAS-490**. It attempted to combine information from many sources in an analysis of decisions related to risks. The project also aimed to promote an understanding of areas in which society should increase safety. One initiative was the attempt to use equal principles for all *genotoxic* materials regardless of whether of nuclear origin or not. The RAS-490 group had a mix of expertise, with Risø's H.L. Gjørup following certain lines of thought while VTT's Björn Wahlström tried to pursue his ideas from the INF programme (below). Scandpower's Odd Vesterhaug was an active counterpart in the discussions.



Decisions on questions involving large risks must take the public perception into account. Front page of RAS-490 report 1989 by Gunnar Bengtsson.

Materials research (MAT)

Four project areas were selected to improve methods used to control construction in nuclear power plants and avoid corrosion and failures due to cracking. Two projects dealt with *corrosion*, the others with *fracture mechanics*.

The first project on corrosion in seawater **MAT-510** was co-sponsored by the Swedish 'Värmeforsk' programme and included experiments in Stavanger with water from the North Sea. Different methods were devised to avoid detrimental effects of seawater coming in contact with reactor material and offshore constructions.

The second project **MAT-530** looked at methods to identify intergranual corrosion in piping material of a type used in nuclear power reactors. It involved a 'round-robin' exercise in which six laboratories in and beyond the Nordic countries tested the same welded specimen. Different analytical techniques were available and the results compared.

The first project on fracture mechanics **MAT-550** was to provide additional knowledge of cracks that could lead to catastrophic failures. To measure crack propagation, three methods were tested at IFE, Risø and VTT respectively and evaluated at SKI. A substantial part of Nordic research in this area was co-ordinated through the project.

The second project on resistance against fracture **MAT-570** dealt with methods to determine whether cracks in pressurised components would develop further - with possible catastrophic failures - or would stop. If a detectable leak occurs prior to break, failure can be avoided. The project included experiments and calculations. Two tests were performed at VTT with large steel vessels to compare analytical results with measured values.

Although this was the second time, it was unusual for materials research to be included in a NKS programme. Materials researchers in the Nordic countries already co-operated in many other projects both in a Nordic context and on the wider international scene. It was difficult for the steering committee, chaired by Søren Mehlsen, to co-ordinate the NKS projects with national work where projects received greater financial support.

Advanced information technology (INF)

An emergency situation in a complicated industrial plant such as a nuclear power reactor would involve many decision-makers: the local staff, local and central authorities, and technical support organisations located elsewhere. The INF programme was designed to provide all bodies with the same information through computerised systems. In addition, the system would provide predictions of the developing situation and indicate available countermeasures. Thus, decision making would be improved and conflicting instructions avoided.

Risø's Knud Møllenbach was active in formulating the strategy, which continued earlier more theoretical programmes (KRU, page 110 and LIT, page 162). He soon left Risø, to be replaced as co-ordinator by Verner Andersen in 1987.

The computerised system was perceived as a useful aid to shared decision making. However, this proved to be an over-ambitious goal and instead, a computer-based information system was developed. A reminder function was introduced to record events and suggest countermeasures. Current actions were also recorded.

Several different interest groups were combined in the programme. Halden and VTT worked on development and maintenance of an expert system, while experiments on human reactions were in the hands of Berndt Brehmer at Uppsala University. A description of information needed by those dealing with an emergency and their different tasks was to be produced by a Swedish consultant. Unfortunately this work was delayed and when finally produced, it did not reflect the actual information needed. This matter created tensions in the project because SKI, who financed the Swedish input, resented the consultant's high costs and engaged two other consultants instead.

The steering committee under Jon Berg and with Verner Andersen experienced difficulty in co-ordinating joint efforts due to the fact that they had little control over individual tasks' finance. The final outcome was a system to handle and record messages received during an emergency. A test at the Loviisa site confirmed the applicability of the system, but the experienced operators were equally successful in managing the situation with conventional, non computer-based means.

A session about the INF programme was organised in conjunction with one of the Halden project meetings in May 1988. Held in spectacular surroundings at Loen on the Norwegian west coast, arriving delegates could only hope that the small aeroplane bringing them could be made to stop before the runway ended as abruptly as it had started. Some of the meeting participants raised doubts as to the viability of the INF concept presented by Verner Andersen, but at the same time the Danish national plant for Management of Hazardous Waste 'Kommunekemi' declared its interest, something which turned out to be useful in the follow-up phase after the INF programme.

Jens Tarstrup, the Danish member of the steering group, was helpful in organising a presentation in Brussels. This meant that the work could be subsequently followed up in the second ESPRIT programme of the CEC which started in 1989. An integrated information system to support decision-making was to be demonstrated and tested in an emergency drill. At the end of this project, Verner Andersen continued working for a similar EUREKA project in 1993. The work was later followed up in another venture, with Finnish and Norwegian participants, to develop the practical application of computer-based emergency support systems.

Communication of results

The project leaders prepared final reports that were again edited in the NORD series of the *Ministers* (page 159)**.** In total 24 reports plus one overview report were due, but one of them was never produced. Distribution of the final reports remained a problem. *NKS* ruled that the steering groups should take this responsibility, but this failed to improve the result. Their distribution was therefore planned in conjunction with the central NKS project secretariat, using individual distribution lists for each report.

The NORDEL Thermal Power Committee showed continued interest in the NKS programme and at its meeting in April 1986 decided to establish its own follow-up group. This group, with members from the four Nordic countries and all nuclear utilities met annually from 1987. Its meeting were convened by the *Nordic Secretary* so that they could discuss NKS' project work. This was one way to encourage utilities to apply its results. Members of the group regularly attended NKS seminars. This group therefore formed an important link between the programme and those using its results.

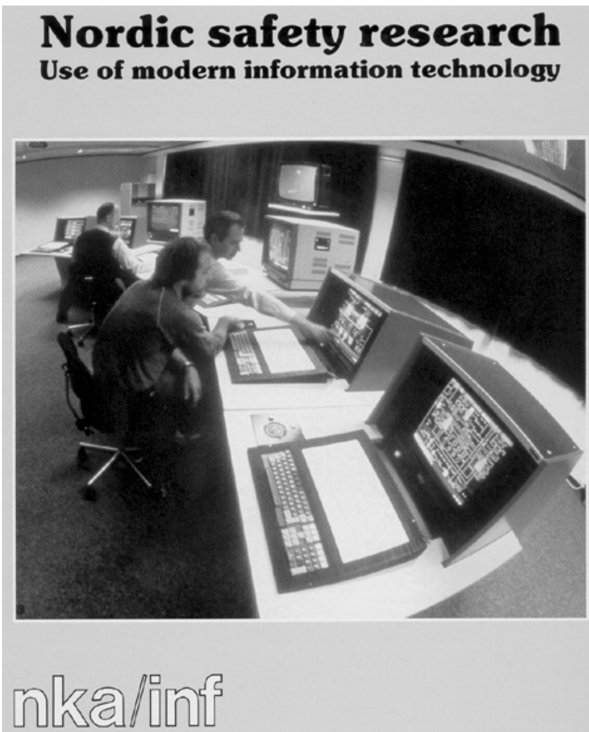
This arrangement was made while the NORDEL Thermal Power Committee was under Lars Gustafsson from Vattenfall[1], chairman since 1983. The contacts continued when the Thermal Power Committee converted to a committee dealing with environmental questions. With time however, the view on nuclear power in the NORDEL circle changed. In 1990, when the *Nordic Secretary* again asked for comments from the follow-up group, Carl-Erik Lundgren, the new chairman of the committee - now called Environment and Generation - replied, “we do not have such a nuclear group in NORDEL!” Nevertheless, members of the follow-up group continued their interest and held a last meeting in May 1990.

Mid-term seminars were arranged in all five programme areas during the second part of 1987. The waste seminar was combined with the fourth *waste contact forum* (page 151) at Kjeller in October. The AKT seminar was organised at Risø. An evening get-together was held in the canteen and here Bjarne Micheelsen gave a memorable speech recalling Nordic collaboration in reactor physics and safety. He mentioned all the people who had played an important role over the years, and described their particular characters.

[1] with Morgan Andersson as secretary

A lecturer from the HSST programme at the Oak Ridge National Laboratory was invited to the MAT seminar at Risø.

The last meeting of the RAS steering group in Sweden during the spring of 1989 was enriched by the unexpected piano playing of Thorstein Bøhler, director of Scandpower.



An English brochure about the INF project was issued in 1987 and distributed for the mid-term INF-seminar at Kjeller in November.

The final AKT seminar took place at Leangkollen near Oslo in June 1989. Ulf Tveten organised it, and the boat trip on the Oslo Fjord this warm summer evening will be remembered, as will his own quintet of wind instruments playing at the end of the seminar.

A Nordic waste seminar was organised with SKB at the Nordic Cultural Centre at Hässelby Castle in Stockholm during March 1990. Its objective was to update waste management situations in the Nordic countries. Thus, it was seen that the Finnish and Swedish work on highly active waste followed the same trend, although the Swedish investment was considerably higher. Provisions set aside by the utilities to cover the cost of final disposal and decommissioning were also comparable (SEK 0.019/FIM 0.017, equivalent to slightly above ECU 0.003 per kilowatt-hour generated).

An international Biomovs symposium held in Stockholm in October 1990 marked the end of the first phase of this international venture. A number of young radioecologists from the Nordic countries participated. There was an apparent interest in continued work on modelling, to reduce the uncertainties that were still apparent in predictions of radionuclide movement through the biosphere. A new Biomovs project was subsequently launched.

The final RAS seminar was held at Tamsvik north of Stockholm in May 1990. To stimulate discussion, five Scandinavian 'opponents'[1] introduced their critical remarks on the projects, which resulted in a lively discussion.

An international workshop[2] in June 1988 compared principles for the disposal of radioactive and other hazardous waste. Here the SSI director Gunnar Bengtsson attempted to devise a uniform way of considering radioactive waste in line with other substances that have similar environmental effects. This workshop can be considered a precursor for the international seminar on *genotoxic* substances co-sponsored by the RAS programme.

This *Genotox* seminar was held in Stockholm in October of the same year. Besides SSI, several agencies[3] helped to organise the event. It was an attempt to explore the possibility of developing a unified approach to protection against risks associated with different types of genotoxic agents. Among others, the Swedish professor Torbjörn Westermark argued that the damage to humans from genotoxic substances could be expressed in an equivalent manner to damage from radiation. This hypothesis would make it easier for the authorities to maintain equivalent safety standards in various fields of pollution and perhaps reduce the gap between radiological and chemical safety. It was surprising that participation from other Nordic countries was low. Inspired by discussions on risk communication, the first ideas for a future NKS research project on information began to crystallise.

In 1991, SSI followed the same line of thought by organising an international symposium on the environmental consequences of hazardous waste disposal. The

[1] Jørgen Firing now at Statoil, Palle Haastrup from Ispra, Stefan Hirschberg now at the IAEA, Christer Viktorsson at this time at the NEA, IVO's Björn Wahlström now at the International Institute for Applied Systems Analysis near Vienna.

[2] organised at the initiative of SSI's Ragnar Boge

[3] including the Environmental Protection Agency and the Swedish Chemicals Inspector ate

Danish speaker at the meeting was from the Environmental Agency and he bluntly stated that no waste should be generated if it remained hazardous beyond 100 years.

A session on the use of probabilistic methods was arranged at the annual meeting of the Scandinavian Chapter of the Society of Reliability Engineers (SRE) at Otaniemi in October 1986. This became the annual *Kontaktorgan* seminar, co-sponsored with the NORDEL Thermal Power Committee. Various uses and limitations of PSA analyses were discussed. The discussions also revealed the differences between ‘classical’ industry with safety goals limited to the plant itself and ‘new’ industries (nuclear and off-shore oil/gas) where risks to the outside are calculated.

Presentations of the MAT results were made in special sessions at two international seminars: The two projects on corrosion occupied a session at the Nordic Corrosion Seminar in Stavanger in June 1989. During the same period, the projects on fracture mechanics were presented with a NORDTEST project at a ‘state-of-the-art’ seminar in Trondheim.

The second *Mariehamn symposium* (cf. page 170) was organised in May 1989 with the title ‘Man in Complex Systems’. Although the LIT programme as such did not fit directly and was not presented, most of its participants took part in the symposium. Here, future trends in control of technical installations were outlined, with a view to reducing safety risks and economic losses, while improving the working environment.

Administrative matters

A second meeting with the co-ordinators and the secretariat was organised at Tamsvik near Stockholm in August 1987, this time to discuss reporting, simplification of accounting and dissemination of results. The co-ordinators criticised the steering groups of being too passive and complained about the requirement for six-monthly progress reports. *NKS* could not agree on this point.

The Nordic bureaucracy became increasingly complicated throughout the 1980s: Seventeen *Officials* were in action to evaluate suggested Nordic programmes before the annual budget proposal could be presented to the Nordic Council. In 1984, almost 300 projects were financed by the Nordic budget, for which only NOK 90 million (ECU 15 million) was available. An annual contribution to the NKS programme of 5-6 million thus amounted to a large proportion. The *Ministers* in charge of the entire Nordic budget had difficult choices to make such as: nuclear safety or welfare of blind children?

For the entire Third NKS programme 30 million Kroner had been granted from the *Ministers* (first they were in NOK, and from 1987 in DKK when the *Ministers*' secretariat moved from Oslo to Copenhagen, equivalent roughly to ECU 4.5 million). The corresponding national contributions to the programme were estimated at 72 million Kroner.

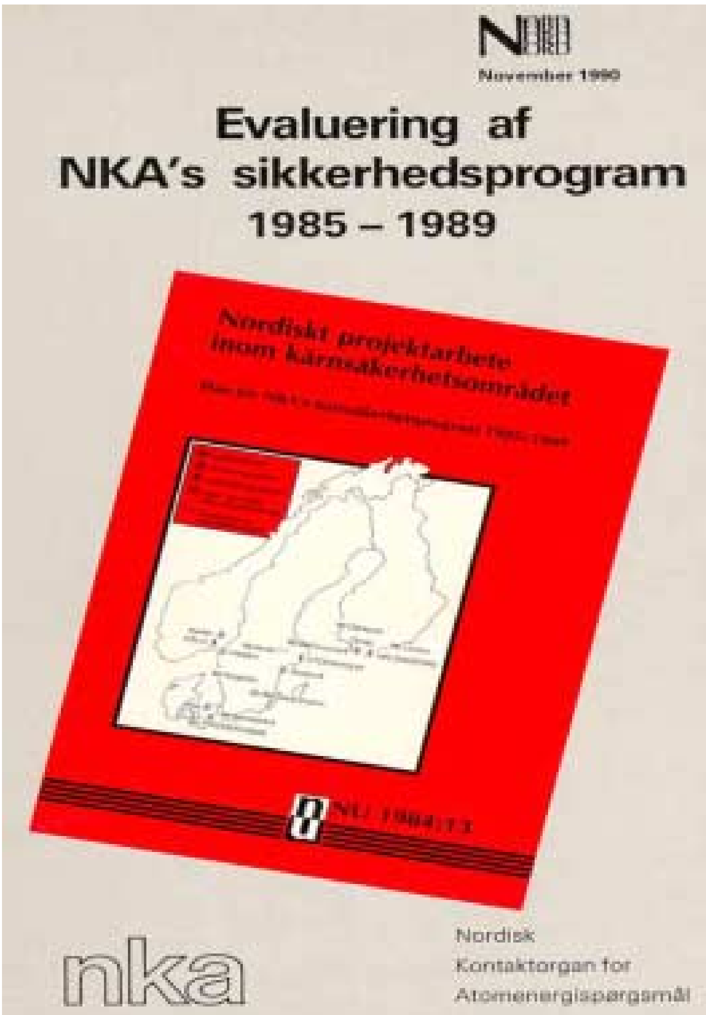
There was great ignorance among different sectors of the Nordic organisations. The Nordic Council nominated 1988 as the Nordic Year of Technology. NKS was only informed by chance and had no possibility - and finally disinclined - to participate.

The search for a new NKS chairman after Anders Palmgren was explained by the *Nordic Secretary* at a meeting in the NORDEL Thermal Power Committee. In the traditional Sauna after the meeting, one of the Swedish members, Leif Josefsson, mentioned that the Swedish Nuclear Training and Safety Centre (KSU) was getting a new director. “That should be your man” he said. Thus, Svante Nyman became the third NKS chairman in March 1987. He was well acquainted with Nordic work, having been in charge of Marviken test operations in 1967, where Nordic engineers participated.

Meanwhile, the NKS secretariat shifted from Sweden to Finland according to the principle of distributing tasks between the countries. Hitherto the secretariat had been with a safety authority, and STUK’s Tapio Eurola informed NKS that STUK would take over, but for practical reasons it was Bjarne Regnell who would do the job. Regnell worked independently from the line organisation of IVO. He had previous experience as evaluator in the Second NKS programme and as member of the AKTI group and was therefore familiar with NKS.

Evaluating the Third NKS programme

Five people were selected to evaluate the programme in 1990 (Note 6.3-C), using the same criteria as in the proceeding programmes (Note 4.4-B).



The evaluators found the choice of programmes justified because of the need to improve the basic understanding of safety in a wide sense. Contrary to conventional industry where the main concern is to protect the installation itself and the people working there, in nuclear plants the safety is extended to protecting both the general public and the environment. This justified the broad scope of the programme.

The evaluators stressed that project results should be presented in a form suitable for safety assessment. The number of parties participating in a project should depend on its goal; thus if the work should lead to new findings, a small number of participants would be preferable, while more should be involved when summarising the state-of-the-art.

While it was agreed that Nordic ventures ought to be co-ordinated with national or even international projects, Nordic financing should not support true international projects.

Co-ordinators were recognised as useful to keep project work on track, but should confirm that they are able to devote sufficient time and effort for this purpose.

Outlook for continued NKS activities

After the two large NKS programmes in the 1980s there was no doubt that this form of Nordic collaboration fulfilled an important mission. NKS had become the *Kontaktorgan*'s dominating activity replacing the earlier activities of the *Committee*. The authorities dealing with reactor safety and radiation protection participated actively, and a number of utilities and related technical organisations took part in the project work.

The administrative organisation functioned well and the programme areas were continuously adapted to the actual changing needs in the countries. Through publications and communications in international meetings the NKS activities had become well known abroad.

But the outlook for continued NKS activities after the Third programme looked bleak, firstly because of changed attitudes following the Chernobyl accident, secondly because of other priorities in those Nordic circles that influenced the use of the Nordic project budget.

6.4 The Chernobyl accident

The accident at the Chernobyl reactor number 4 in the vicinity of Kiev occurred in the night between Friday 25 and Saturday 26 April 1986. This catastrophic failure of the Soviet type RBMK reactor came as a shock for the entire world. It was due to a combination of design shortcomings, operator errors, bad co-ordination and missing information from central Soviet authorities to the plant staff describing previous incidents, and the absence of what was from now on to be termed *safety culture*.

The release of radioactive products continued for several days. During this time nuclear specialists everywhere attempted to find detailed information on the RBMK reactor design so that they could decide on what could be done to mitigate the situation. Resulting from the accident, public perception world-wide, swung strongly against nuclear power.

First observations and reactions

Forsmark nuclear power station north of Stockholm was the first to detect radio-active fallout on the following Monday. By coincidence, the NORDEL Thermal Power Committee held its meeting at Forsmark on Friday the 25th. Guided by its chairman Lars Gustafsson, committee members strolled around the site on Saturday.

When the *Nordic Secretary* arrived from Forsmark to his meeting at SSI in Stockholm on Monday 28 April, some put forward the theory that the fallout could be the first indications of a submarine accident in the Baltic Sea. At SKI, the director Olof Hörmander asked his staff to use its network of personal contacts within the next hour to try and find an explanation. He then said, “and in the meantime I shall contact my Nordic colleagues”.

It was not until Monday night however, when the brief official Soviet message about the accident was made. The announcement was probably triggered by Swedish requests in Moscow for information. It had thus taken almost two days to get any information from the Soviet Union. This was partly because their experts were not authorised to give information and partly because officials in Moscow did not actually know what had happened at Chernobyl. Information on movements of pollution over other countries was limited. Some dispute at ministerial level between Finland and Sweden over transfer of early information could not be avoided. Such was the tension that even Finnish President Koivisto entered the discussion.

The official inauguration of CLAB, the Swedish underground storage plant for spent fuel at the Oskarshamn site took place the next day, 29 April. Birgitta Dahl, the Minister of Energy, gave the inauguration speech and at lunch talked about “this male dominated working environment”. During the afternoon visits to the plant and the transport vessel for spent fuel *Sigyn* it started raining. However, it was news and not the weather that abruptly interrupted the visits. Ministry officials hastily returned to their offices in Stockholm following reports of new fallout from Chernobyl.

Nordic activities

During and after the accident, the Nordic networks among specialists worked very efficiently. This demonstrated beyond doubt the effectiveness of joint Nordic contacts developed over many years. As an example, at noon on Monday, the Swedish Barsebäck contact person notified his Danish colleague - who was at a meeting in the DDR to discuss rapid exchange of information in case of accidents – adding, “if you hear rumours about releases from a Swedish nuclear plant, it doesn’t come from us!” This led the Risø people to contact the Finns who had also measured increased background radiation levels.

Radiation protection authorities introduced countermeasures and set limits, based on national considerations. In some respects this confused the populations, since action levels differed between the Nordic countries. As, during the days of the accident, people watched TV from other Nordic countries and saw conflicting advice, they doubted the credibility of the authorities. On Swedish TV, SSI’s Gunnar Bengtsson in his knitted pullovers was followed by viewers from all over Scandinavia. He had agreed with the Swedish minister on a prudent approach, which differed somewhat from that of other countries. Misunderstandings were frequent and not well explained, such as whether limits for the radioactivity content of a certain foodstuff were absolute or depended on the amount ingested.

Anneli Salo from STUK, who was then in charge of the radiation protection section at the IAEA in Vienna, produced copies of a report from the First NKS programme. Dealing with techniques for taking environmental samples and measuring them for radioactivity, it was given wide international distribution. It was Olli Paakkola’s team at STUK which first published data measured after the fallout occurred.

Those people who were knowledgeable about reactor accidents, radiation protection and emergency questions were linked up through provisionally arranged telephone services in the various countries. Thus they were able to talk to and inform anxious members of the public. This activity went on for weeks.

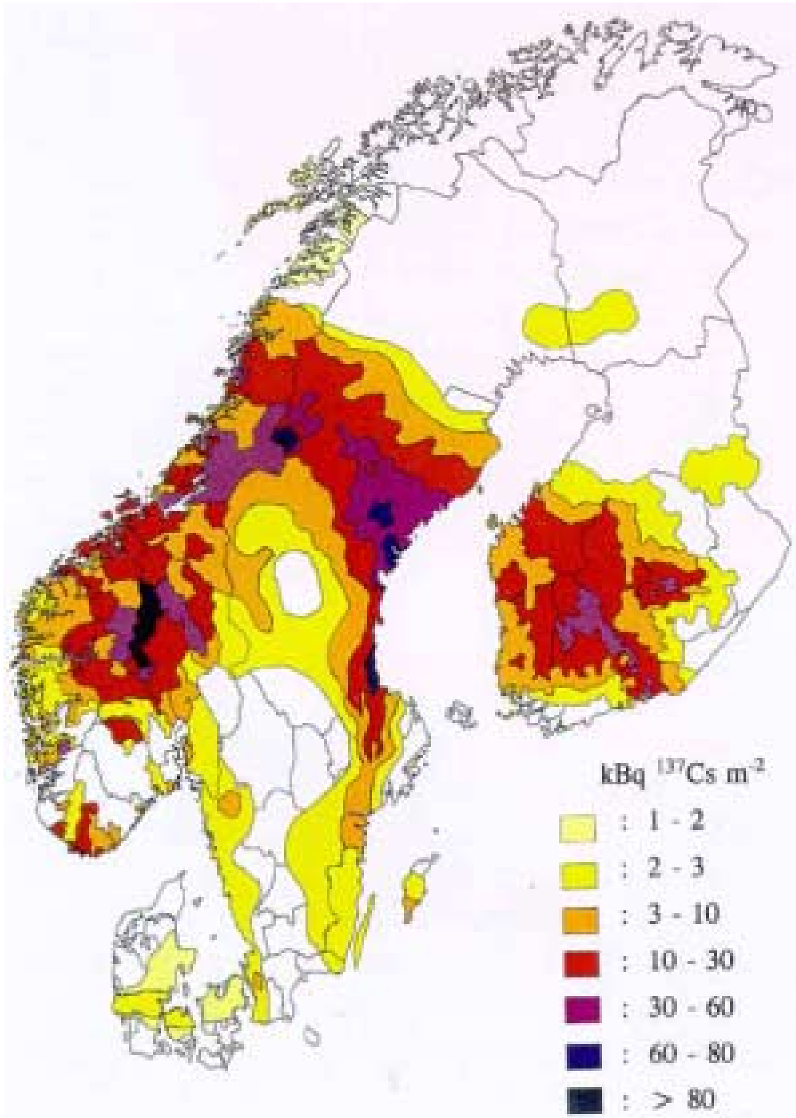
During this phase there was no time for normal tasks, let alone Nordic project work, because of the heavy workload.

After some time, when measures for the future were to be decided, different government services and ministries who had not previously been involved with nuclear issues appeared on the official scene. The *Ministers* in various shapes - environmental, agricultural, social - held Nordic meetings and issued press releases. Limits for radioactivity in foodstuffs were discussed in a group, which was later to work out a Nordic proposal for reference levels (page 223).

Studsvik's Lennart Devell provided daily samples from Crete and Munich and detected many *hot particles* in the fallout. He published an early article in the magazine *Nature* and later joined in a comprehensive review of the fallout situation in the Nordic area, published in the ENS magazine *Nuclear Europe* in November.

In 1985, prior to the Chernobyl accident, as a follow-up of the work on radiation risks under to the RAS-430 project, an information folder 'Radioactivity in the Nordic countries' was being compiled. It was a comprehensive explanation of natural radioactivity levels, of units such as Becquerel and Sievert, accidents, radiation risks to a Nordic public, and related issues. The author, Gordon Christensen at IFE worked on this in agreement with the *Nordic Secretary*. Its preparation was at an advanced stage, a journalist had reviewed the text and a designer completed the illustrations.

Approval by the competent authorities however, was slow - this was not considered a matter of high priority. SSI protested, because they could not accept some of the phraseology. When the Chernobyl accident occurred, none of the countries had ready-made information material at their disposal - and nobody at the authorities remembered the Nordic draft hidden in their drawer. Everyone had to start from square one again to quickly produce written material for the general public.



There was a wide variation in fallout from Chernobyl between the Nordic countries. Iceland,not shown here, was in the lowest category. From Dahlgaard: Nordic Radioecology, Elsevier 1994

Proposals for follow-up actions

After the accident several proposals materialised to extend the scope of the on-going NKS programme. *NKS* held a special meeting in August 1986 to discuss four possible additional tasks. Some of them were not taken up again until the next NKS period, such as information about reactors in neighbouring countries. Others were dealt with in the following months.

At an extraordinary meeting held in the SNODAS group (page 98) during September, Ulf Tveten proposed a project to verify models - used to predict atmospheric dispersion of Chernobyl releases over long distances - against actual measurements following the accident. This TRANSAM project on Transfrontier Atmospheric Models was conceived as a Nordic project with wide international participation. A pilot project was worked out together with Helen ApSimon from Imperial College and the director of the Norwegian meteorological institute Anton Eliassen, who was also active in the World Meteorological Organisation (WMO). This attempted to combine a Nordic project with a large number of countries through the Commission of the European Communities (CEC) research programme. However, since basic financing could not be obtained from the *Ministers*, the project was abandoned.

Later in 1986, the IAEA, the WMO and the CEC used the TRANSAM concept and launched it as a joint research programme. The Nordic work on atmospheric dispersion was later followed up by NKS in its Fourth programme (page 222) and replicated in the ETEX project of OECD's Nuclear Energy Agency in the mid 1990s.

NKS decided to extend the AKTU programme by collating radioactivity measurements from the accident on a Nordic database. The radioecologists also proposed to use the Chernobyl fallout to identify critical paths for radionuclides. Ulf Tveten managed to collect a wide range of information related to the effects of the Chernobyl accident and its fallout in the Nordic area and include it in the AKTU programme (page 174).

Following the SNODAS discussions, another initiative was taken with VTT's Björn Wahlström as central figure. A pilot project was initiated to investigate whether an advanced information system could be designed to aid information transfer between existing national detection systems for airborne radionuclides. The plan aimed to introduce an automised detection system for airborne radionuclides and computerised displays of radiation values, to be available in the case of an emergency - the so-called VAR project. It was discussed in November 1986 and in the INF programme (page 182), but no Nordic financing could be obtained.

This issue was then pursued nationally in each country but it was to be much later - after the BER programme (page 222) – before any Nordic agreements were made. In fact, detection systems were further developed in the individual countries and not through joint project work.

A request for additional grants from the *Ministers*' budget reserve was made by NKS early in 1987. A sum of DKK 8.3 million (slightly above ECU 1 million) over 3 years was needed for the proposed new projects on radioecology (see below), transfrontier atmospheric pollution and a Nordic detection system. However, neither the *Officials* for Environment or for Energy felt that this was important to their own work. Therefore, at their meeting in June 1987 the *Ministers* saw no possibility of increasing the NKS grants.

Radioecology

Up to 1985, in its two first programmes *NKS* had justified including radioecology with the argument that, citing Bo Lindell, "in case of a big reactor accident, large areas might be contaminated". The *Contact Group* in its discussions about the Third NKS programme had opposed a continuation of work in this field, arguing that enough measurements had been made. Radioecologists were in fact, still measuring remaining fallout from bomb tests more than 20 years ago. In *NKS* Jan Olof Snihs had argued for a continuation of the now well-established collaboration, but without success.

The radioecologists were furious. After the fourth Nordic radioecology seminar in Gol in February 1985 (page 170), following discussions between Johan Baarli, director of the Norwegian Institute of Radiation Hygiene and the *Nordic Secretary*, the latter wrote to the *Ministers*. The letter suggested that in future the Environment *Officials* should finance Nordic work in this area. However, they were interested only in those activities that contributed directly to environmental control. On its part, the radioecology group was not prepared to propose such projects.

After the accident the incensed radioecologists repeated that, "they have measured enough". The *Contact Group* sought to procure small financial contributions from each of the national radiation protection institutes and were successful to the extent that a modest budget was made available from different national sources.

While in June, a first telephone conference was held to discuss Nordic cooperation in radioecology after the accident, a meeting with wide representation could not be organised until October. *NKS* wished for a new radioecology programme and recognised the importance of involving the numerous researchers who worked in this field since the Chernobyl accident, especially in Norway. Many of them had not been given time to study available experience, and had therefore neglected to invite some of the knowledgeable people to join new groups.

Gustav Tham from Studsvik put together a proposal for a new Nordic programme and in April 1987 Henning Dahlgaard from Risø contacted 20 institutions in the Nordic area to work out details of this programme. When no Nordic funds could be found it was planned to use the limited national financing available to further discuss coming activities through a number of mini-seminars. These were finally combined into the fifth Nordic radioecology seminar at Rättvik in 1988 (page 230).

Contacts through the *Kontaktorgan*

The *Kontaktorgan* as such was not involved in the official contacts between the countries in the period after the accident, but its members made use of their Nordic relations. In fact these personal relations were the only valid information channels in the first few days.

The *Kontaktorgan* used its meeting in Reykjavik in September 1986 for a thorough discussion about the accident and its consequences. In discussions with Nordic safety authorities attending the meeting, it was found that the accident was of a unique character. It had no implications for the safety of nuclear plants in the Nordic countries that were of an entirely different design. Therefore, the ongoing NKS programme would require only minor modifications.

At their meeting the following day the radiation protection *Chiefs* established two new groups, one on emergency provisions and one on detection systems for airborne radioactivity. In November 1986 another new working group of the *Chiefs* took up the question of transferring measured values of airborne radioactivity among the countries.

During the following months, individual Nordic countries entered into bilateral agreements with neighbouring countries from where information was considered to be of value. These were countries where an accident in a nuclear plant might pose a risk, or from where information could be obtained on effects of accidents in neighbouring states.

The IAEA had used the Nordic agreement existing since 1963 (page 49) in its guide for mutual assistance published in 1984. Now, after the accident, an international convention on mutual assistance was drafted by the IAEA with active participation by the Nordic countries. They also pressed for a new IAEA convention on early notification of a nuclear accident, which was ready in 1986.

The Nordic Chernobyl expert seminar

In spite of reluctance from those ministries and other quarters who had put the accident on their own agendas - "so many Nordic Chernobyl meetings have been arranged" - the *Contact Group* in May discussed to organise a Nordic expert meeting. After some hesitation on the part of different authorities concerned, the *Nordic Secretary* was asked to organise this seminar, specifically on behalf of the Nordic authorities in the fields of environmental and radiation protection.

This was held at Skokloster north of Stockholm on 3-4 November. Almost 100 participants attended and felt that it made a very worthwhile contribution to their efforts to improve emergency preparedness in their respective countries. Risto Tienari from the *Ministers*' secretariat was impressed and exclaimed, "but this is excellent". SKI's information officer Gunilla Wünsche had arranged for the well-known TV journalist Bengt Orup to give an after-dinner *causerie* on people's anxiety, the small Becquerels and the big Sieverts.

In discussions during the seminar a long list of proposals was put together, specifying desirable future actions as shown in the Table.

Proposals from the Nordic Chernobyl seminar

* Limits for radioactive content in foodstuff should be reconsidered, including exceptions in emergency situations, and they should be made easier for the public to understand.
* Sampling procedures and measurement of radioactivity should be standardised, and equipment intercalibrated. Measured data should be made available throughout the Nordic area. Future R&D should include radioecology.
* Nordic countries should consider systems to exchange data on airborne radioactivity.
* Nordic contacts among those responsible in emergency situations need improvement and joint exercises should be carried out.
* An information policy and information material was missing. Contact lists of people responsible for emergency measures should be established and kept updated.

Distrust in the *Kontaktorgan* activities?

Following heated discussions in the Nordic Council, the Environment *Ministers* in October 1986, asked the *Ministers*' secretariat to organise a working party on nuclear accidents and radioactive contamination. This was also to include research and other questions that had arisen since Chernobyl. The working party was to report to the Environment *Officials*. This can be seen as a move of non-confidence in *Kontaktorgan* activities in this field.

With the unofficial name the *Annerberg group*, the working group[1] met for the first time in February 1987 (see Note 6.4). The *Nordic Secretary* was invited to several of its meetings, including the one in which financing questions came up.

The *Ministers*' secretariat, when refusing to finance the post-Chernobyl projects proposed by NKS, pointed to the Annerberg group. Here, however, the request was in turn referred to a coming NKS programme. Here, also an idea came from the Finnish member: the funds available for Nordic safety projects could simply be given to the *Chiefs* who would well know how to use them.

The Annerberg report was ready in February 1988. It was dealt with at a meeting of the Environment *Ministers* who simply forwarded it to the Energy *Ministers*. One conclusion was that the existing collaboration through the *Kontaktorgan* and among the authorities had been instrumental in establishing direct contacts that had proved useful after the Chernobyl accident. The report supported ongoing and future NKS work that should now include safety in nuclear installations, emergency preparedness, radioecology, and waste management.

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[1] Per I. Wethe acted as secretary and Risto Tienari represented the *Ministers*' secretariat

7. End of the *Kontaktorgan*

While organising joint projects, mainly through the *Committee*, was an important task for the *Kontaktorgan* in the 1970s, its activities during the 1980s were concentrated to three areas: discussion of international nuclear matters, information exchange through seminars and working groups, and management of the safety research programmes. The latter was partly financed by the *Ministers*.

The members of the *Contact Group* changed with time[1]. Over the years its secretariat had been located partly in Denmark, partly in Finland. This secretariat had been of great help to the *Nordic Secretary* in providing discussion partners from the ministries, when contemplating future initiatives in the entire field of action related to the *Kontaktorgan*. From 1986 the secretariat functions were taken over by the *Nordic Secretary*, in conjunction with the contact person from the country hosting the next meeting.

7.1 Complications for the *Kontaktorgan*

The Energy *Officials* met for the first time in 1982, at a time when Ministries of Energy were created everywhere. This gave these ministries a more comprehensive view of Nordic activities. Nordic co-operation was now one of their regular tasks. The *Kontaktorgan* was viewed with some scepticism, perhaps even envy. Here was a long-standing, quite independent committee with its own working pattern and traditions. It had an executive Secretary-general with access to contacts at all levels in the Nordic countries and a programme that received the largest single contributions from the *Ministers*' Nordic funds. Some circles considered the *Kontaktorgan* as ‘a state within the state’.

Many of the questions discussed earlier by the *Kontaktorgan* were now less relevant. The Norwegian Parliament had abandoned nuclear power (page 145) back in 1980. Danish interests in nuclear questions were reoriented when Parliament, in March 1985 decided - with a marginal majority - to exclude nuclear power

[1] Some of their names are René Rothman and Niels Christensen from Denmark who both acted as secretaries for the *Contact Group*; they were followed by Suzan Lange and Terkel T. Nielsen; Sakari Immonen from Finland; Per Strangert and Gudrun Schöllin from Sweden followed by Ingvar Persson; Kristin Brobakke and Knut Mansika from Norway, followed by Hans Jacob Holden.

from Danish energy plans indefinitely (page 122). This decision was influenced more by the negative stand of parliamentarians than by hard knowledge. After all, evaluations on reactor location, safety and waste disposal had been positive.

Once nuclear power strategies were clear in the countries, with only Finland and Sweden operating power reactors, the main area for co-operation was in the field of safety. The supply of fuel cycle services was mainly relevant only to Finland and Sweden. All countries had a common interest to develop further knowledge in safety work, and the NKS programme took care of this rather independently.

On the other hand the *Kontaktorgan* meetings still gave the participants valuable advance information. Members were not bound by decisions and could freely exchange views on questions which were to be discussed in various international fora.

At this time Nordic countries did not always adopt a common position in international negotiations. One example is the *London Dumping Convention*. Initially, when it was recommended to terminate sea dumping of low-level radioactive waste, there was a joint Nordic stand. Later however, internal Danish fights over policy resulted in positions opposite of those of other Nordic countries regarding minute releases to the sea. As to IAEA issues, the tradition of a shared Nordic seat ended in 1977. Sweden tried to get a more permanent seat on the Board at the time when the IAEA Board of Governors increased and modified its composition. Now for the first time more than one country was on the Board and in 1986 Nordic countries occupied three seats simultaneously.

In 1982 Birgitta Dahl became Minister of Energy - later of Energy & Environment - in the new Swedish government led by Olof Palme. It was in her period that Sweden raised doubts over the value of semi-annual *Kontaktorgan* meetings and to the set-up with its *Contact Group* and its *Nordic Secretary*.

This was clearly felt during the meetings. Critical voices were raised from Suzanne Frigren in the *Kontaktorgan* and Gudrun Schöllin who acted in the *Contact Group*.

An attempt was made to change the original provision, still in force in some countries. This was that the *Kontaktorgan* was under the Ministries of Foreign Affairs and that its members were appointed by the governments (even by the President of the Republic in Finland). It was the Ministries of Energy who now wanted to be in charge. The situation was complicated by the fact that the *Kontaktorgan* had always had members from several ministries to cover the entire nuclear field.

Also on the political front the *Kontaktorgan* with its large consumption of Nordic funds for nuclear safety research was observed. From 1985 onwards, nuclear power's adversaries took up questions about the *Kontaktorgan* openly in the Nordic Council.

Those ministries responsible for the *Kontaktorgan* wanted to make sure that there was no flaw in the organisation of a committee that received project allowances from the *Ministers*, and they consequently adopted a defensive position. This appeared as directed against the *Kontaktorgan* itself, and perhaps this also was the case.

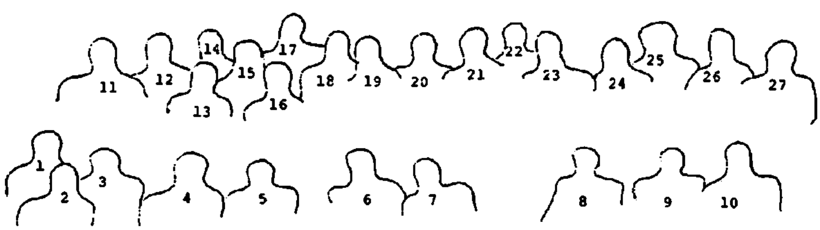
Arrangements that had up to now been made in a correct, but less bureaucratic manner were now to be formalised. Thus, members of *NKS* were to be formally appointed by the *Kontaktorgan* and not by the *Contact Group* and their tenure was for a limited duration. The position of the *Nordic Secretary* in relation to *NKS* was to be clarified: he was not a member but represented the *Kontaktorgan*.

The *Kontaktorgan* meetings had become not only formal but also difficult to manage with many participants from several ministries, research organisations, safety authorities, etc. Therefore, the *Contact Group* sought to reduce the themes and perhaps change the order of the two annual meetings. In 1984 the *Contact Group* evaluated the meetings and concluded that more time should be made available for actual discussions. It also suggested that the number of participants could be reduced. In 1985 the *Kontaktorgan* attempted to put these recommendations into practice. Its February meeting in Helsinki was spread over two days. On the first day, international questions were discussed separately by a smaller group. This procedure was followed in some of the following meetings and also in a number of enlarged *Contact Group* meetings dealing with international issues. However, reaction to this latter arrangement came quickly and the *Contact Group* was told to involve representatives from the Foreign Ministries as soon as any international question was dealt with.

The weather was perfect at the Kontaktorgan *meeting at Risø in September 1985. The names of the participants are given below*

11. Poul Emmersen (Civilingeniør) TNA
12. Antti Vuorinen (Överdirektör) SSI
13. Gudrun Schöllin (Departementssekr.) Industridep.
14. Kari-Veikko Salonen (Sektionschef) Utrikesmin.
15. Ilkka Mäkipentti (Industriråd) HIM
16. Susanne Frigren (Departementsråd) Industridep.
17. Hans von Bülow (Direktør) ENS
18. Bengt Olofsson (Departementssekr.) Utrikesdep.
19. Sten Bjurström (Direktør) SKB
20. Johan Baarli (Direktør) SIS

21. Per Suhr (Overingeniør) Miljøstyr.
22. Harald Midttun (Generalkonsul) Utenriksdep.
23. Franz Marcus (Eksekutivsekr.) NKA
24. B. Bastrup-Birk (Kontorchef) ENS
25. Niels Christensen (Sekretær) EM
26. Knut Mansika (Konsulent) Olje- & E.dep
27. Björn Palmén (Diplomingeniør) KIM



1. Kaare Øfjord (Kontorchef) SA
2. Haakon Storhaug Førstekonsulent) Utenr.dep.
3. Klaus Singer (Underdirektør) Risø
4. Niels-Godtfred Aamodt (Adm. direktør) IFE
5. Olof Hörmander (Generaldirektør) SKI

6. TorbenSimonsen (Fuldmægtig) UM
7. Stig Bergström (Direktør) Studsvik
8. Pekka Silvennoinen (Professor) VTT
9. Tore Tønne (Underdirektør) Olje- & energidep.
10. Terkel T. Nielsen (Kontorchef) EM

Deltagerne i NKA-mødet den 16. august 1985 på Risø

Although Iceland had been a founder member of the *Kontaktorgan* its participation - in the more nuclear power oriented activities - was limited. In 1985 however, Sigurður Magnússon arrived on the scene and requested information, initially about the safety programme.

For the *Kontaktorgan*, funding its NKS programme was becoming a growing problem. The Energy *Officials* had increasing needs for other projects and the NKS budgets were a steady item on the *Kontaktorgan* agenda. In fact, the NKS programmes still consumed more than half of the budget available for the Energy *Officials*.

The Secretary-general of the *Ministers*, Ragnar Sohlman returned the 1986 application for the NKS programme. It contained little detail and merely referred to the previously submitted four-year plan. Separate applications for each of the five programme areas were demanded by the *Ministers*' secretariat. The secretariat also conveyed a desire from the Energy *Officials* for better contact with the work at project level. They wanted to avoid any criticism given the fact that a large part of their budget was allocated to the NKS programme. The secretariat also raised the question of missing statutes for the *Kontaktorgan*.

When it was known that the *Ministers*' secretariat contemplated a professional evaluation of the *Kontaktorgan*, a counter-movement was launched. It proposed that activities of the Energy *Officials* should also be included in the evaluation. The *Kontaktorgan* reacted quickly and in 1987 took the initiative by arranging its own external evaluation of future needs and of the content of a new safety research programme. Finn Lied, former Norwegian Minister of Industry and chairman of the IFE Board was chosen as an independent high-level consultant to investigate the necessity of such a programme. As for the *Ministers*' energy research programme, it was evaluated by Ove Dietrich, now director of a Danish electricity utility.

In his report in September 1987, Finn Lied recommended continued close cooperation on nuclear safety questions of current interest to the authorities in all the Nordic countries. It should be related to possible risks in nuclear installations, covering all aspects from the technological level to accidents and their consequences for man and environment. The Annerberg group (page 198) acted on the report's recommendations and they were later used as input to the Fourth NKS programme (page 215).

7.2 The end of the *Kontaktorgan* 1989

The fight against the *Kontaktorgan* went on throughout the 1980s.

Statutes for the *Kontaktorgan*

Already in 1981 the *Nordic Secretary* had been asked by the Nordic Council's secretariat about the statutes for the *Kontaktorgan*. He answered, "there are written working regulations for its NKS programme but no detailed statutes". This was one area in which the *Kontaktorgan* was vulnerable to attack.

In 1984 the Nordic Council recommended that Nordic projects be more efficiently controlled, including evaluation of their effectiveness and productivity. This recommendation came a year after *NKS* published its first - widely distributed - evaluation report (page 115). Research work results related to safety questions was apparently of little interest to politicians or political organisations on the distribution list. The contents were probably too technical.

The request for true statutes continued. In 1985, the *Contact Group* formulated a set of rules on procedure from existing documents describing the work of the *Kontaktorgan*. Questions, such as voting rules that had never occurred in practice were now included. It was also decided to invite the person responsible for energy questions at the *Ministers*' secretariat, Niels Pettersen-Haag, to future *Kontaktorgan* meetings.

In this connection, the administrative rules for NKS had to be revised. Its members were to be appointed for periods of two years. *NKS* must now be a permanent group, so its 'ad hoc' designation must be removed.

After lengthy preparations and after a last minute Danish attempt to modify its content, a text with statutes for the *Kontaktorgan* was forwarded to the *Ministers* in June 1986. It was approved in January 1987, presented to the Nordic Council and finally adopted by the Energy *Ministers* in June 1987, thirty years after the foundation of the *Kontaktorgan*.

The final battle

According to the Nordic hierarchy, from 1987 the *Kontaktorgan* was a specialised body under the *Ministers*, reporting through the Energy *Officials*.

In 1987, the chairman of the *Officials*, Tore Tønne, requested that the status of the *Nordic Secretary*, whose costs had been shared by four of the Nordic countries since 1967, be clarified. He also suggested that the *Kontaktorgan* have a permanent chairman, instead of letting the host country of each meeting hold the chair. This was apparently an attempt to give the members of the *Officials* a more pronounced role, something which reminds of the question who represents the European Union - the Council or the Commission?

In 1988 it was decided that the person due to chair the next *Kontaktorgan* meeting would assume the role even in the period before the meeting. The frequency of the *Kontaktorgan* meetings was reduced to one per year. Nils Godtfred Aamodt, followed by Suzanne Frigren and finally Ilkka Mäkipentti acted in this position.

Now it was the chairman who represented the *Kontaktorgan* in meetings of the *Officials* and the *Ministers*. Also meetings of the *Contact Group* came under the leadership of the *Kontaktorgan* chairman.

The perennial Nordic plan for energy research, in the hand of the Energy *Officials*, expired in 1988. A new plan was under preparation to be presented to the Nordic Council in 1989. At this point, the *Ministers*' secretariat suddenly terminated the employment of the project secretary in this field, Christian Mosgaard (page 155) by a letter, which for some unknown reason was widely circulated. Instead several part-time project secretaries were employed, apparently to give the *Officials* a firmer control.

A report describing future *Kontaktorgan* activities was produced in May 1988 and presented by its chairman Aamodt and NKS chairman Svante Nyman in a meeting of the *Officials*. The *Contact Group* prepared an outline of the new NKS programme - the Fourth - for the meeting of the *Officials* in July, based on the reports by Finn Lied (page 203) and the Annerberg group (page 198). The Danish representative Terkel Nielsen was instructed to reject it, since his ministry, under Jens Bilgrav-Nielsen, had other uses for Nordic funds than for nuclear safety research.

In 1988 several proposals came up in the Nordic Council: that future appropriations for the *Kontaktorgan* must first be submitted to the Nordic Council itself, and that all nuclear power plants in the Nordic countries be closed.

The fate of the proposed Fourth NKS programme was to be decided at the Energy *Ministers*' meeting at the Faroe Islands in July 1988. Here it became clear that Denmark was willing to accept only half of the proposed 6 million for NKS' activities. The Danish stand was that a yearly balance should be made between Nordic project proposals related to the 1987 Brundtland Report *Our Common Future* advocating sustainable development, and the NKS programme. The other countries recognised the importance of a firm financial commitment as a precondition for embarking on a new four-year programme.

An attempt to compromise, at around 4.5 million, was unsuccessful and the decision was postponed until a later *Ministers* meeting. The visit to the Faroe Islands will be remembered for the abundant ration of alcoholic beverages and their effect on distinguished civil servants, and for the century old folk dances and songs enjoyed by all the meeting participants at the Nordic house in Tórshavn.

At the subsequent *Ministers* meeting in October 1988 the Swedish representatives, supported by the three other countries, proposed a reduced programme with 4.8 million annually. They warned however, that the alternative could be to entirely remove the safety programme from the *Ministers*‘ Nordic budget. The Danish representatives could still not accept the proposed level.

Therefore, at their meeting in June 1989, the *Ministers* finally decided to “eliminate the *Kontaktorgan* from the budget of the *Ministers*”. This decision would have consequences not only for the practical work of the *Kontaktorgan* but, as announced by its Swedish members, but also for the tasks of the *Nordic Secretary*. Both these questions were dealt with at the following meeting of the Energy *Ministers* in November 1989.

Here, the Swedish representatives proposed to abolish the formal set-up of the *Kontaktorgan*, including its statutes. The co-operation could then be replaced by more informal contacts. The *Ministers*’ secretariat argued that removal of the statutes would also avoid future debates in the Nordic Council. The other countries would have preferred that a competent group under the *Ministers* remain. They made clear that the services of the *Nordic Secretary* should be preserved, especially in view of the coming NKS Fourth safety programme. Obviously there was still a need for contacts. The Nordic Council for example, had just raised the question of airborne transport of nuclear material over the Arctic region.

It was thus in November 1989, after having been in force for two and a half years, that the Energy *Ministers* decided to abolish the *Kontaktorgan* statutes. Following a Swedish proposal continued NKS activities would be based on an agreement - the future Consortium agreement - that should be worked out among the national authorities.

7.3 Final *Kontaktorgan* related activities 1990–1991

As a follow-up to the Nordic Chernobyl expert seminar (page 197), the *Contact Group* established two working groups. These were discussed at another *Kontaktorgan* meeting held in September 1989.

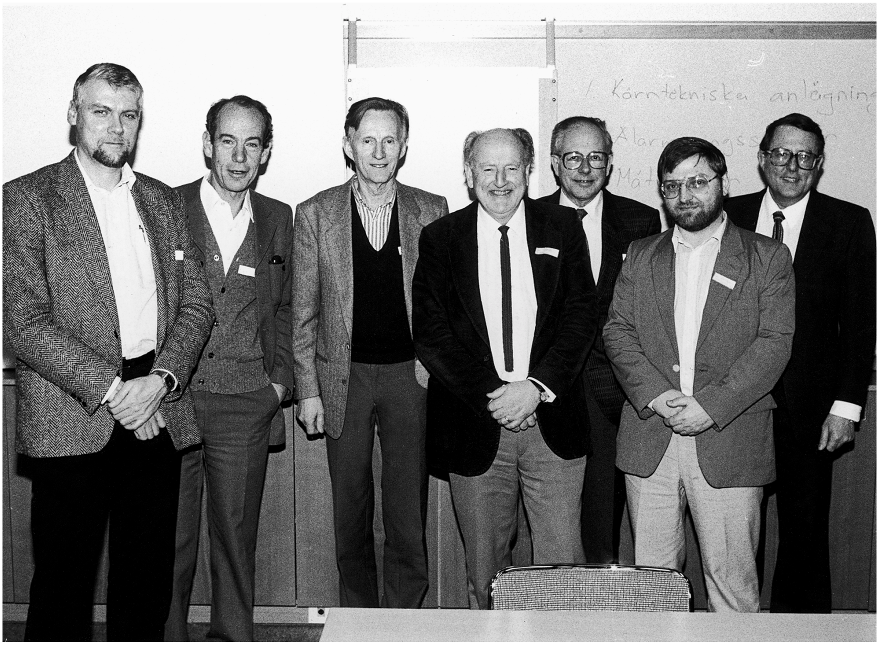
The first group, on information, was under the chairmanship of Hans Jacob Holden (page 238) from the Norwegian Ministry of Petroleum and Energy. A seminar was held in October 1988 at Vikersund in Norway[1]. It was recognised that if similar information were to be given to the different Nordic populations in a nuclear emergency, it would require intimate contacts among information officers of national emergency organisations. A Nordic forum should be established, involving both staff from national authorities responsible for information in nuclear emergencies and people with similar tasks in utilities and research organisations. A working group, to report to the *Kontaktorgan*, was charged with establishing such a forum. Another task was to create contact lists and keep them updated and to discuss coming emergency exercises. This was later carried on in the *Nordic Information Contact Forum*, page 238.

The second working group, on competence, was organised[2] with the Norwegian professor Per Oftedal as principal advisor. It was to be the 1989 - and the last - *Kontaktorgan* seminar, held at Studsvik in January. Here it was recognised that expertise is needed not only in countries with nuclear power but also elsewhere so that international obligations can be fulfilled and knowledge made available in case of nuclear incidents or accidents.

Around 1990 people who had been involved in the nuclear field since its beginning were rapidly approaching retirement. Much of the intellectual expertise risked being lost before being passed over to the next generation. At the seminar the SKI director Olof Hörmander proposed that the future NKS programme should redress this. At the end of the programme a large Nordic emergency drill would test competencies in many areas.

[1] prepared with SSI's Sven Löfveberg and his Swedish colleagues

[2] initially under one of the SKI directors



The organisation committee of the 1989 Kontaktorgan seminar on competence where it was recognised that a new generation of experts should take over. From left to right: Hans Ehdwall, Marcus, Tormod Riste, Per Oftedal, Klaus Singer, Bjørn Thorlaksen, Lennart Devell.

At the end of 1989, an attempt was also made to identify other, non-energy matters that could be taken up by the *Kontaktorgan* under its original terms of reference. However, there was no real interest in activities such as nuclear techniques in medicine and industry, or nuclear law, although a Nordic contact group[1] existed to discuss issues related to the International Nuclear Law Association.

Following the decisions by the Energy *Ministers* at the end of 1989, the Swedish Minister of Energy Birgitta Dahl in April 1990 notified the other Nordic countries that the Swedish government had decided to withdraw from the *Kontaktorgan* from July 1990.

Ilkka Mäkipentti who was now acting as chairman of the *Kontaktorgan*, following a proposal from Suzanne Frigren, explored the possibility of keeping a contact group among the ministries. Such a group might act as a competent body in relation to the *Ministers*, or it could be informal. But the official stand was negative.

[1] at the initiative of IVO's Juhani Santaholma

Also, close personal relations existed which permitted individual contacts to be made as needed.

The next meeting of the *Kontaktorgan*, its 68th, was postponed until October 1990 when it included a visit to the Loviisa site. Matti Komsi from IVO discussed the safety of Soviet-designed reactors at the meeting, led by Svante Nyman. This was the last meeting and it was held without Swedish participation. It was decided to advise the *Ministers* to revoke the *Kontaktorgan* since it made no sense to continue without Sweden, in spite of the fact that the last meetings had demonstrated its value.

Hans von Bülow - who had been present at the very first meeting in June 1957 - was asked to act as ‘liquidator’ during the final period to dissolve remaining activities.

One final arrangement related to the *Kontaktorgan* was organised in Copenhagen in October 1991 and it dealt with questions about Euratom. All the Nordic countries came to the meeting where the Danish representatives gave a detailed picture of how nuclear issues were dealt with according to the Euratom Treaty. This was at a moment when other Nordic countries were seriously considering joining the European Union.

The Swedish ministry attempted to continue informal contacts about matters similar to those previously dealt with by the *Kontaktorgan* in an organised manner. Ingvar Persson called a first meeting, and later another meeting of the same kind took place in Oslo, but this initiative also died away. The Energy or Foreign Ministries were not sufficiently interested.

7.4 Some recollections from the *Kontaktorgan* period

The meetings in the original *Kontaktorgan* were characterised by the personalities of the leaders from the four or five countries. Most of them had important roles during the war. They had their opinions and were foresighted. These *grand old men* had been instrumental in creating the national policies and the research activities. The meetings of the *old Kontaktorgan* with these dominating personalities were inspiring with fresh ideas put on the table. However, the conclusions were often missing, which could led to a feeling of frustrating after the meeting.

There was always a ‘working lunch’, often of the highest quality, and a dinner at the end of the day where useful information was exchanged. This custom of joint dinners was taken up by the *Nordic Secretary* who introduced the tradition of having a get-together on the night before the meeting, without ever using project money from the *Ministers* for this purpose. These arrangements not only made sure that everybody was there for the next morning, but also enabled people to exchange views - and perhaps find solutions, before the meeting. Only the Finns frequently arrived in the morning - with their time difference they could be at a 9.30 meeting in any Nordic capital. They saved hotel costs but had to get up at 5 o'clock. Even today the dinner is important, but great care is needed to organise it to provide ample opportunities for individual talk without distraction due to background noise or long periods of being seated in fixed positions.

Later the *Kontaktorgan* meetings became more formal. Participants changed more often to be replaced with people who at that time happened to be employed at the ministry and who tended to be more bureaucratic and less inspiring. Instead of creating initiatives the *Kontaktorgan* now became a forum for information exchange and an umbrella for other initiatives, mainly generated by *NKS*. As the directors of the safety authorities joined, an atmosphere of precaution built up.

Finally, in the course of the 1970s the most effective results came not from the *Kontaktorgan* itself but from its *Contact Group*, where the participants were active and positive. This enthusiastic approach continued until the moment the Swedish representation changed in the 1980s and mistrust was injected into the group.

Some of the individuals who were involved with the *Kontaktorgan* over the whole period are mentioned in this paper. An example is Magnús Magnússon, who was also Iceland's IAEA representative from the outset in 1957. By some he was called *Mr. Heavy water* because of Iceland's particular interest in this field.

The traditional competition between the Nordic countries could not be completely avoided. The *big brother* attitude of the Swedes was to a certain extent justified in the field of reactor technology, but at the outset it was the Norwegians who came first, and they were well conscious of this. The Norwegians had a way of simplifying their participation. When other delegations came to a meeting with several people, the Norwegians sent just one person who managed everything. An example of this was Jan Døderlein who, alone, dominated the meeting, or Jon Berg who, at the time when he was the Norwegian representative in the *Committee* declared that he needed no contact person like the three others - and then fulfilled his task at least as efficiently as they. The Icelanders played a minor role up to the time when Sigurður Magnússon entered the scene. He rapidly caught up with the others, he managed to sit on Nordic committees of the highest level and his word was respected in the *NKS*.

It was fortunate perhaps that the original *Nordic Secretary* was not Swedish. This might have created a feeling of Swedish dominance in this co-operative venture. Now he was Danish, had one of his offices in Sweden, previously worked in Norway and made sure that also the Finns understood what he was saying. This arrangement helped to avoid the feeling that one party was dominant. The new *Nordic Secretary* from Sweden, active from 1994 was also an outspoken ‘Nordist’ and never appeared in the *big brother* role, in spite of his imposing height of 2.02 meters.

The position as a *Nordic Secretary* turned out to be a useful bridge between the politically oriented environment of the ministries, the practical work of the research organisations, and later of the safety authorities. Its function was essential to pursue goals in practice. This often meant overcoming resistance caused by politically oriented desires within the *Kontaktorgan*. The structure, with an executive member participating in the various groups, employed jointly by the Nordic countries, was a novelty in 1967. Then only true organisations such as NORDFORSK or NORDITA had employees with a Nordic salary.

As a general rule Scandinavian tongues were always used in the meetings, but sometimes it was difficult to understand each other. Many Danes had little regard for the difficulties of others that were trying to grasp their rapid succession of indistinct words. This was especially complicated for the Finns - the young Mäkipentti was frequently placed next to Stevenius Nielsen at dinner in the *old Kontaktorgan* and hardly understood his conversation. Nielsen went on talking anyhow and expected no comments. Then H.H. Koch was better, he spoke little but when he did his words were clear. At one dinner his welcome words at the first course of soup, were simply “velbekomme”. As a ‘réplique’ the versed dinner speaker Jens Chr. Hauge in his thank you speech at the end of the meal thanked Koch for his “warm welcome”. Everybody laughed. Erkki Laurila, on the other hand, always had a cigar lighted and hardly spoke without it in his mouth. Difficult to follow his often complicated thoughts. Bo Aler never raised his thin voice, so people had to prick up their ears to the utmost. Only the Norwegians talked clearly and loved to say, “I’m thinking loud”.

In spite of what is said above, a fundamental advantage of Nordic over other international co-operation is that everybody - with the exception of some Finns and some Icelanders - can use the nuances of their own mother tongue. This avoids some of the unfairness that can be felt by people participating in international meetings where they are limited in expression while others are better mastering the common language. In spite of some difficulties in grasping the usually floppy Danish pronunciation, this worked well, especially in groups such as the *Contact*

Group. On other occasions it was more difficult. Björn Palmén - on the only occasion that he headed the Finnish delegation at a *Kontaktorgan* meeting - had so much trouble understanding a pipe-smoking Danish participant that he started speaking Finnish himself. This reminded the others of the efforts required to understand them.

8. Free from political directives

There had certainly been reasons for terminating first the *Committee* and then the *Kontaktorgan*. *NKS* had taken over most of the safety work, and here the - former nuclear - research institutes were major participants. In the vast field of energy research the institutes were too different to work together, or they were tied up nationally. For quite some time they had difficulties in making themselves known as energy research institutes, and it took time for the different national organisations who sponsored energy R&D to forget that three of them had for many years been devoted to the nuclear field.

The countries' official attitudes sometimes differed when they met in international fora, such as in the *London Dumping Convention*. The *Kontaktorgan* members now had many other occasions to meet in connection with their international work and they did not have the same tradition for personal relations as earlier.

However, there was a desire in all the countries to continue the co-operation in the framework of NKS with its practical approach, dealing with questions of actual relevance in the form of joint project work.

8.1 A new financial basis

When it became apparent that NKS' funding by the *Ministers* would cease in 1989, it was clear that countries wishing to join a new NKS programme would need to provide their own assets.

In June 1989, the Swedish government instructed SKI to plan a new safety programme. SKI was to work with SSI and other organisations active in NKS, the Swedish Board for Spent Nuclear Fuel being specially referred to. This programme was to deal with research in nuclear safety, radiation protection and related fields and should be carried out in Nordic co-operation. The Swedish share of the earlier NKS budgets had always been transferred through the SKI research budget, which was in turn provided by the utilities as a sort of tax.

Also the Finnish system was well geared for such a set-up, since it was the Ministry of Trade and Industry that controlled the funds for the NKS work. These included funds previously channelled through the *Ministers* and those allocated to Finnish organisations participating in Nordic project work to make up for their national complement.

In Norway, Hans Jacob Holden managed to introduce a new budget item to the Ministry of Petroleum and Energy’s budget, to cover Norwegian expenses for NKS work.

In 1988, the Danish Nuclear Inspectorate was transferred to the Civil Defence organisation, later reshaped as the Danish Emergency Management Agency under the Ministry of the Interior. Bjørn Thorlaksen became the new leader of the Inspectorate and by July 1989 funds corresponding to the Norwegian share were found in Denmark also.

In informal discussions, the *Nordic Secretary* suggested that two thirds of these Danish and Norwegian appropriations could be used as national contributions to the basic budget of the new NKS programme, while the remainder could be reserved for financing national activities related to the programme.

Sigurður Magnússon arranged for a contribution corresponding to Iceland’s share.

It was a new approach to invite other organisations to co-sponsor the programme through a relatively small annual contribution. During 1990 contributions were secured from nine such co-sponsors (Note 8.1).

8.2 The Fourth NKS programme 1990-93

In 1987 national organisations participating in the activities of the *Kontaktorgan* and NKS were asked to give their views on the value of this form of co-operation. The replies from the four Norwegian parties in the *Kontaktorgan* (Foreign Ministry, IFE, the Nuclear Power Inspectorate and the Institute of Radiation Hygiene) were typical. They stated that the main benefit, besides offering a forum for discussing international ventures, was the shared knowledge, in particular through NKS’ safety programmes.

Planning activities

Finn Lied, in his report in 1987 (page 203) had proposed issues to be included in a new NKS programme, strongly influenced by the Chernobyl accident. Following these recommendations, NKS under its chairman Svante Nyman formulated its views on the contents of a Fourth programme, first in a working group in August 1987 and then through NKS discussions in November.

It was argued that active work was needed to preserve knowledge in fields of safety and the environment to honour the Nordic countries’ obligations according to international conventions. This concerned all five Nordic countries.

Svante Nyman arranged special planning meetings at his KSU Stockholm office, sometimes in the wine cellar of the old office building, to discuss the contents of a new programme. Norway pushed heavily for radioecology. At the meetings its representative, Tor Gunnerød, spoke for long periods on the need to include projects in this field. In fact, a radioecology programme had already been planned following the work on fallout from Chernobyl (page 196).

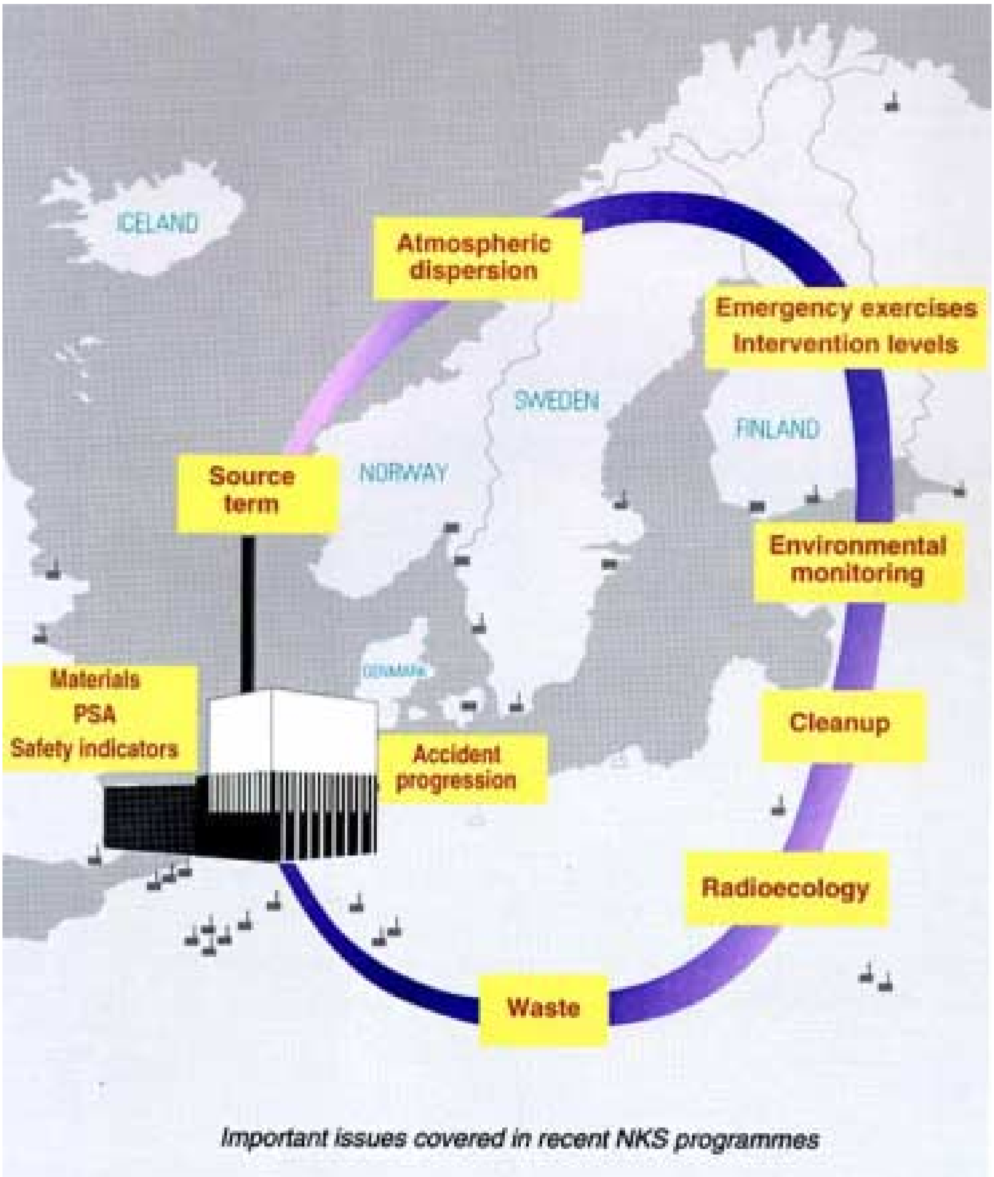
At the end of 1988 three planning groups were established to prepare the contents of new programme areas, *emergency preparedness*, *waste management*, and *reactor safety*.

In conjunction with the discussions with the *Ministers* about financing (page 205), *NKS* attempted to accommodate the demands for a reduced programme. One suggestion was to combine the waste and safety programmes into one. Later, Arne Hedgran, now professor of reactor safety at the Stockholm Royal Institute of Technology, was consulted in this matter and argued for four separate programmes. NKS had also considered a possible alternative in case sufficient funds were not forthcoming from the *Ministers*. Joint work could then be based exclusively on safety projects financed by Finnish and Swedish safety authorities.

The recommendations from the Nordic Chernobyl seminar (page 197) provided direct input to the new programme. Also proposals formulated by NKS after Chernobyl, although not acted upon, were now reviewed. In particular the creation of a knowledge base comprising reactors in the surroundings of the Nordic countries, and a Nordic network between measuring stations for airborne radioactivity were considered.

IFE's Per I. Wethe drafted an outline of the new programme in 1989. It referred to the investigations made by Finn Lied, the Annerberg group and the Brundtland report. The overall goal was defined as providing a joint Nordic view on nuclear safety and radiation protection and to further develop competence so that important decisions taken in one country would be well understood in the neighbouring countries. Essential issues such as emergency preparedness were to be included for the benefit of authorities and utilities, and the programme would also strengthen the countries' position in international discussions.

At the outset the radiation protection authorities were critical of the new programme. Although they appreciated the personal contacts obtained through earlier programmes, some of them thought that NKS had too much administration relative to the limited funds. They even considered whether they could themselves obtain grants directly from the *Ministers*.



The Chernobyl accident strongly influenced the choice of project areas in the Fourth NKS programme 1990-93. From article in Nuclear Europe Worldscan 9/10 1995 by Marcus & Nyman.

Thus, the earlier organisational set-up of NKS had been criticised because it included groups on so many different levels. In 1988 a working group[1] reviewed the organisation and administration of a coming programme. The organisation should reflect the main purposes of the programme, which included dissemination of knowledge, promotion of uniform views, and establishing personal contacts across borders. With this in view it was found advantageous for relevant people at several levels to remain involved.

Increased commitment by *NKS* members was recommended, one obligation being to continuously review the ongoing project work. There was long discussion over whether steering groups should be maintained. The alternative was for *NKS* itself to act as a steering group for the entire programme while competent reference groups would be attached to each of the programme areas. The latter solution was selected, combined with the function of co-ordinators who would also act as central figures in each their reference group. The reference groups would help to review plans and disseminate results.

NKS would itself distribute funds among the projects while each project leader would place orders or distribute Nordic finance to the participants. In practice, it was the co-ordinator who came to play an important role in this aspect.

Since the new programme would be financed by the national authorities instead of, as previously, from a Nordic account assigned to the *Kontaktorgan*, a new formal structure had to be created. The SKI director Olof Hörmander discussed the issue with the *Nordic Secretary* during early 1989 and SKI’s Lennart Hammar edited the text for the agreement. A Consortium group would be created, comprising national authorities that provided the basic joint finance.

The *Nordic Secretary* would continue his part-time position in NKS, but the related costs would be born by the national organisations, as in the past. In this way they would not be charged to the project budget.

The new programme would be free-standing in relation to the activities of the Nordic authorities’ joint group (the *Chiefs*), but people from the authorities would be involved at different levels in the NKS system.

The new Consortium (Note 8.2-A) was constituted at a meeting in Copenhagen in December 1989.

[1] under VTT's Pekka Silvennoinen

Parties to the agreement about the Fourth NKS programme

- The Danish Emergency Management Agency,
- The Finnish Ministry of Trade and Industry,
- Iceland's Radiation Protection Authority,
- The Norwegian Nuclear Power Inspectorate, later replaced by the new Norwegian Radiation Protection Authority,
- The Swedish Nuclear Power Inspectorate, representing Swedish authorities

Members of the new *NKS* and its chairman were appointed at the same meeting, see Note 8.2-B[1].

A new team of 19 project leaders/co-ordinators and 28 reference group members was put together in January 1990 at the first meeting in the Fourth NKS programme. Of the people nominated, 17 project leaders and 20 reference group members actually carried on until the end of the programme in 1994. Project descriptions were worked out in 1989[2].

Following agreement with the Swedish Consortium Party, the central secretariat with H.C. Sørensen remained at Risø and was resourced to handle report editing and the publication of information material. Meanwhile, Henny Frederiksen continued to take care of running matters for Franz Marcus.

A sophisticated accountancy system

Once NKS financing passed from the *Ministers* to the Consortium group in 1990, additional losses due to currency exchange could be expected. They were avoided by allowing the new Parties' contributions to remain in their individual countries.

Since the central secretariat was located in Denmark, where accountancy control also took place, the NKS budget had to be in Danish Kroner (DKK). In 1990 and

[1] Svante Nyman was again chairman, Bjarne Regnell secretary, and Franz Marcus Secretary-general

[2] Odd Vesterhaug from Scandpower worked on emergency questions, Risø's Henning Dahlgaard on radioecology, VTT's Kari Laakso on reactor safety, the three Swedish organisations simultaneously engaged in the waste field shared the planning (Johan Andersson, Ragnar Boge and Rolf Sjöblom)

1991 NKS established its own bank accounts in Denmark, Finland, Norway and Sweden. Payment of bills was triggered from the central secretariat, where the actual accounts were kept in DKK, FIM, NOK and SEK, respectively.

Establishing this accounting system required great skill because of many complicating factors. These included the fact that no Value Added Tax (*moms*) was due for services billed to another country (this became less frequent once Finland and Sweden joined the EU in 1995) nor when services were paid through accounts from another country.

Fluctuations in rates of exchange would make the central accounts almost impossible to keep, therefore rates between the currencies were maintained at the same level for one year at a time. On one occasion, at the end of 1992, the Swedish Kroner (SEK) dropped sharply, and because the major contribution to the NKS funds came from Sweden, all project allowances for the following year had to be reduced.

H.C. Sørensen arranged and continuously improved the system, although the project leaders complained that his surveys did not always match the accounts kept by them. At the end of the period Lennart Hammar proposed improvements to make it easier for the project leaders to overlook the actual economic status.

In 1991 the Danish national auditors, having been alerted by their Norwegian colleagues, visited the *Nordic Secretary*'s office at Risø. Instead of going into depth with the accounting system they were quite helpful and showed a surprising interest when they were told about, for example, background radiation levels in Denmark. The risks of nuclear power were put into perspective for them and they were given information on current Nordic project work. The auditors stated that NKS' annual accounts should be approved in writing by the Consortium Parties and then included in Risø's accounts, since the NKS secretarial function was located there.

The new organisation in action

The job as co-ordinator turned out to be more time consuming than foreseen. In practice co-ordinators were project leaders at a higher level. As a rule, each co-ordinator annually attended an NKS meeting. A first meeting with the central secretariat and the co-ordinators was held at Risø in August 1990, a second meeting took place at Voksenkollen in February 1992.

NKS discussed the necessity of establishing project groups with national participants to assist each project leader in his task and provide more direct contacts to the organisations involved. Although this was not a requirement, it was quite natural for most of the project leaders to establish such a group.

In principle, follow-up of professional quality was delegated to the reference groups. For *NKS*' meeting in Iceland in September 1991 - this was the first time that *NKS* members brought their spouses - the NKS *bureau* worked out a list of quality criteria. It was intended that *NKS* would grade the success of individual projects on a scale of 1 to 3. At the meeting, however, the reference group chairmen - who were members of *NKS* - were reluctant to give low grades to some of 'their' projects. Only a few projects were identified as needing special follow-up. Instead it was decided to let the reference groups use these criteria for their running survey of project work.

NKS obtained a favourable offer to subscribe to *NucNet*, the new international nuclear news service. After a trial period in 1991 the subscription was made quasi permanent. An arrangement was made with Risø to immediately fax NucNet information on accidents anywhere in the world and other important news to individual members of *NKS*, enabling them to respond to concerns and counter rumours.

15 years' NKS celebration

Taught by the experience of earlier programmes, a large mid-term meeting was planned to give the project leaders the opportunity to discuss the expected outcome of work due to be included in their final reports at the end of 1993.

This was to be combined with NKS' summer meeting in 1992, which became a major Nordic conference and also marked the first 15 years of NKS programmes. To make the conference attractive, four outstanding speakers from Britain, France, Russia and the USA were invited to give overview presentations related to the main areas of the NKS programme. It had taken some time to persuade *NKS* of the value of such a big event but finally, the idea was approved. Organised by a reinforced NKS secretariat at Risø, the event was held in early September at the Scanticon hotel near Helsingør.

The meeting was preceded by a seminar on reactor safety in neighbouring eastern countries. Representatives from the Baltic States were invited to the meeting. At this time, Nordic countries were trying to assist the Baltic States through projects to improve nuclear safety. There was an obvious political will, but it was clear that considerable economic resources were necessary.

NKS chairman Svante Nyman opened the meeting, here together with the Nordic Secretary

IAEA director Hans Blix had carefully prepared his introductory lecture while on vacation in Sweden, in telephone contact with the *Nordic Secretary*. In summer sunshine, delegates enjoyed an excursion to the Louisiana art museum, prior to the conference dinner, with Henny Frederiksen improvising as a guide. When passing an old wooden windmill she exclaimed, “and here you see the result of Risø’s wind power research”. Mikael Neumann, the Danish/Swedish artist appeared after dinner and sang about small probabilities, human errors and the Nordic summer. He composed the words on the basis of background material on nuclear problem areas and surprised everybody with his understanding of the issues.

Many users of NKS programme results were present. Everyone joined in group discussions intended to provide a basis for the following NKS programme, the Fifth. One spokesperson for each of the running programmes summarised the discussions about future issues and many constructive proposals were put forward. Only the waste spokesman used this occasion to politicise. He declared that the next NKS programme would get no Swedish support unless it again encompassed a waste programme. This was a subject against which the *Nordic Secretary* had put a question mark after the difficulties in the three past NKS programmes, of formulating coherent waste programmes of general Nordic interest.

The following year, in 1993 the summer meeting took place during September in Lappeenranta from where an excursion to the former Finnish town Vyborg in Russia was organised by Bjarne Regnell.

Emergency preparedness (BER)

International conventions on early notification, assistance and corresponding bilateral agreements in which individual Nordic countries had engaged after the Chernobyl accident required the presence of qualified people in all the countries. This was one background for this programme[1].

In project **BER-1**, Ulf Tveten investigated the trustworthiness of models used for the prediction of atmospheric dispersion over long distances. In addition Studsvik was to work out a computerised handbook to provide easily accessible information to serve in case of land contamination. Unfortunately, it was primarily the computer programme that kept the project people busy. The data should have come mostly from the RAD-programme, but this was not geared to furnish such information. Finally, only limited data was fed into the system. In hindsight it can be seen that individual national authorities will use information systems tailored to their own needs. Much of the research people's more sophisticated model work is too complicated to use in emergency situations.

Two exercises to predict atmospheric dispersion after a simulated release of radioactive material to the atmosphere were organised by Tveten. The first was held in January 1992, a second in June 1993. Many observations made could later be used in the more comprehensive exercises of project BER-5 (see below). Debriefings, with all participants including the meteorological institutes, were useful to show participants areas in which their models needed improvement.

The **BER-2** project examined options to rapidly transfer radiation data from environmental monitoring systems in Nordic countries. The radiation protection authorities had already established a Nordic working group in 1986. Its purpose was to consider mutual information (page 194), but practical and organisational problems had yet to be resolved.

In the project a test arrangement was set up to transfer measured data between Finland and some of the other countries. However, real transfer of data was not part of the project, since this would be a matter to decide for national authorities responsible for emergency preparedness.

Part of this project, led by Janne Koivukoski from the Finnish Ministry of the Interior, was to describe the many and varied measuring devices for airborne ra-

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[1] Anneli Salo from STUK was originally chairperson of the reference group, with Erling Stranden as co-ordinator. Leif Blomqvist followed her, and when also he left STUK it was arranged that he could continue his chairmanship even if he now held a quite different position in Finland and was not a member of *NKS*

dionuclides that existed in the Nordic area. Torkel Bennerstedt who acted as a consultant to the project leader worked out a comprehensive report. Another part of the project dealt with measurements made from aeroplanes in case of a sudden fallout situation.

In a nuclear emergency situation the decision-maker must consider many aspects of radiological, economic and psychological order. This problem area had appeared in the days of the Chernobyl accident and was now dealt with in project **BER-3** under Risø's Ole Walmod-Larsen. It included the question on intervention levels, i.e. at which point of radiological threat certain countermeasures should be introduced.

Various theories for decision making were investigated. In December 1992 the first Nordic *decision conference* was arranged at the Danish Emergency Management Agency's school near Helsingør. Directors of Nordic emergency organisations participated. The 'facilitator' engaged for the conference had also been active in similar conferences in the Soviet Union after Chernobyl. Although the conference demonstrated that group decisions could lead to clashes of opinion, the participants finally found that decision conferencing is a useful tool for complicated emergency situations.

When deciding corrective actions after a radiation accident, the financial cost of an averted radiation dose is needed. This had already been discussed in the RAS-410 project (page 177). In the BER-3 project the 'willingness to pay' method was tested. A pilot study carried out in Denmark recommended an average value of DKK 50,000 (ECU 7000), as the sum interviewees would be willing to spend for one additional year of life. This figure was used as an input to suggest a set of harmonised Nordic intervention levels. However, the project work advanced in parallel with similar studies both in some of the Nordic countries and internationally. The time was not ripe for the national authorities to accept the harmonisation proposed by the project team.

The *Officials* for Food Issues took another Nordic initiative in 1988. The fact that different intervention levels for foodstuffs had been decided in the Nordic area caused concern, as this might impair the credibility of the authorities. The levels had been fixed after Chernobyl and were in part due to different dietary habits, but mainly due to a different approach. A working group[1] had been established to prepare a proposal for Nordic reference levels. This would be in the form of a Nordic model for national response. When by chance, some members of the BER programme saw the draft report they were offended not to have been consulted.

[1] under Ole Harbitz

They identified several areas where the proposal failed to take account of the latest findings on radiation protection. However, through a diplomatically worded comment, drawing attention to the expected result of the BER programme and its impact on the proposal, the Nordic peace was reinstated.

The **BER-4** information project had some difficulties in defining its research, and long discussions were needed to plan truly project-oriented work. Since the project group under SSI's Sven Carlsson consisted of information officers, the trend was rather to promote contacts with media. The group incorporated most of the people who met in the *Information Contact Forum*'s (page 239) working group, so the two tasks were dealt with simultaneously and confounded.

The group arranged a second seminar of the Nordic Information Contact Forum at the Oskarshamn site in October 1991. Named 'Boundless Information', it was a first Nordic attempt to invite representatives from the media together with the authorities and their information officers. A Norwegian consultant planned an emergency scenario, in which the media would be present during a nuclear emergency situation managed by the directors of the emergency agencies. However, it was not a success (and rather expensive), since the drill was too artificial to provide a realistic example.

A third seminar of the Information Contact Forum was arranged at the Finnish-Swedish cultural foundation *Hanasaari* in Helsinki in October 1993. Information activities in international organisations were presented, as well as relevant projects in the NKS programme. There were many occasions for contacts - including a dance radiantly introduced by Sven Carlsson. One of the most important outcomes was the contact established among participants from the same country, including the media, who perhaps met here for the first time.

Seen from left: NRPA's Ole Harbitz with SKI's Gunilla Wünsche, SSI's Jack Valentin and on the right, DEMA's Vibeke Hein

The main activities of BER-4 were related to information culture in the Nordic countries. The project resulted in a brief policy on information, a short strategy to cover its implementation and a survey of existing information material in various countries. It was stressed that information given out in each country should be based on a common factual basis. Therefore an information package containing facts about radioactivity and countermeasures was prepared on which national information activities could be based. As a result, the national authorities have prepared uniform information for the public. Exercises to test the efficiency of Nordic contacts in a stressful situation were also made part of the Nordic exercises in project BER-5.

The BER-4 project also arranged a week-long seminar for journalists in October 1992. Lectures were given first at the Swedish Forsmark site (photograph) and then on the boat sailing to Saint Petersburg for a visit to the Sosnovy Bor reactors. The speakers included SSI's Jack Valentin who's contribution helped to make the difference in dealing with basic safety obvious to the participants. The seminar was a success, although at a considerable cost. However, participating journalists were from minor newspapers and their attendance had little effect on changing media attitudes. In 1997, a similar excursion was arranged to Murmansk and the Kola nuclear power plant, and this time a certain effect on the media could be noted

At the outset, during the 1989 *Kontaktorgan* seminar on competence, Olof Hörmander had proposed a large Nordic emergency exercise (page 207). This was carefully planned as project **BER-5** by a team led by BER co-ordinator Erling Stranden, with Torkel Bennerstedt acting as exercise co-ordinator. The main purpose was to test whether the authorities throughout the Nordic countries would react to a threat in a similar way and the ability to establish contacts between them. No regional exercises had been carried out on such large scale before. At the same time the Nuclear Energy Agency of the OECD was planning the first international off-site emergency exercise (INEX 91), although on a more modest scale. This provided an opportunity to exchange information on the planning phase between the two exercises.

The exercise was first discussed at a BER seminar at Voksenåsen near Oslo in November 1990. It was to be divided in two parts and thoroughly planned over a long period. Consultants wrote the scenario and produced simulated input to national emergency teams.

The first exercise (NORA) was held in January 1993. A complicated scenario involving two damaged nuclear vessels travelling in different directions, ensured that all Nordic countries were subject to possible consequences. NORA was useful at the national level but during the hours following the emergency, very few Nordic contacts were utilised to verify that countermeasures taken were similar to those decided by neighbouring countries. IAEA and NEA each sent a staff member of Nordic nationality who could observe the exercise without needing translation.

The second phase (ODIN), picturing the situation a week after a serious accident, was exercised in November 1993. This time authorities received information on the situation from Nordic contacts, but decisions were still taken nationally. A separate Nordic team headed by Anneli Salo evaluated both phases.

The project also issued an overview of the emergency organisation in each of the five Nordic countries including contact numbers for rapid responses.

In 1991 SSI's Judith Melin proposed an additional BER project to provide an overview of factors to be considered prior to cleanup operations after a nuclear accident. These included cost, radiation burden and socio-psychological questions. There was some doubt in NKS whether a new project should be started at such a late stage. This was perhaps also due to the fact that the programme already had preponderance on emergency and radiation protection. However, it was eventually accepted as project **BER-6** and made rapid progress. A preliminary report was prepared during working sessions in 1993 and in October of that year the study was presented for an international forum where it aroused considerable interest in countries close to Chernobyl. However, the project leader changed job and was followed by Per Strand who was already heavily engaged with project RAD-3. The final report was not issued until the end of 1997.

Waste and decommissioning (KAN)

The waste programme[1] once more combined a somewhat heterogeneous choice of non-related projects.

[1] Kaare Ulbak was chairman of the reference group with Johan Andersson as co-ordinator

STUK's Esko Ruokola was both project leader and practically sole contributor to an investigation regarding low-active waste (project **KAN-1.1**). It dealt with waste the radioactivity of which was so low that it might be 'cleared' of regulatory control. He presented his views in a seminar in December 1993 where it was discussed whether to use 'best estimates' or conservative values. Depending on the method used, amounts cleared could be so small that the management costs would increase unreasonably. The questions were seen as important to waste handling when nuclear plants are decommissioned.

In view of international consultations taking place simultaneously, the KAN reference group insisted that specific exemption limits should not be proposed but guidance notes should be prepared for clearance applications. Also, recommendations were made on the use of 'scaling factors' to take account of radionuclides that are difficult to measure in the presence of other, more dominating nuclides.

The reprocessing pilot plant at Kjeller (page 46) was in its final state of decommissioning and project **KAN-1.2** under John Erling Lundby aimed to accumulate the experience gained. There was little Nordic participation in this project although a seminar was held at Kjeller in December 1990 with fervent discussions about decommissioning and waste categories that should be exempt from control. Studies to reduce waste volume created plenty of interest. This actual decommissioning operation demonstrated the importance of preserving information on the original plant design. In his final report Lundby emphasised the psychological aspects and the emotions of former operators when they have to dismantle their own plant.

The most spectacular of the waste projects dealt with conserving information for future generations (**KAN-1.3**). High level waste remains radioactive for a long time and certain related information needs to be retained. Mikael Jensen, the project leader from SSI, showed great imagination by launching two studies on historic archives. One looked at how the Vatican preserved its archives over time and another examined German State archives in the twentieth century. The question of intrusion into waste repositories had just been taken up as an issue internationally, and the project team was called to join in these discussions.

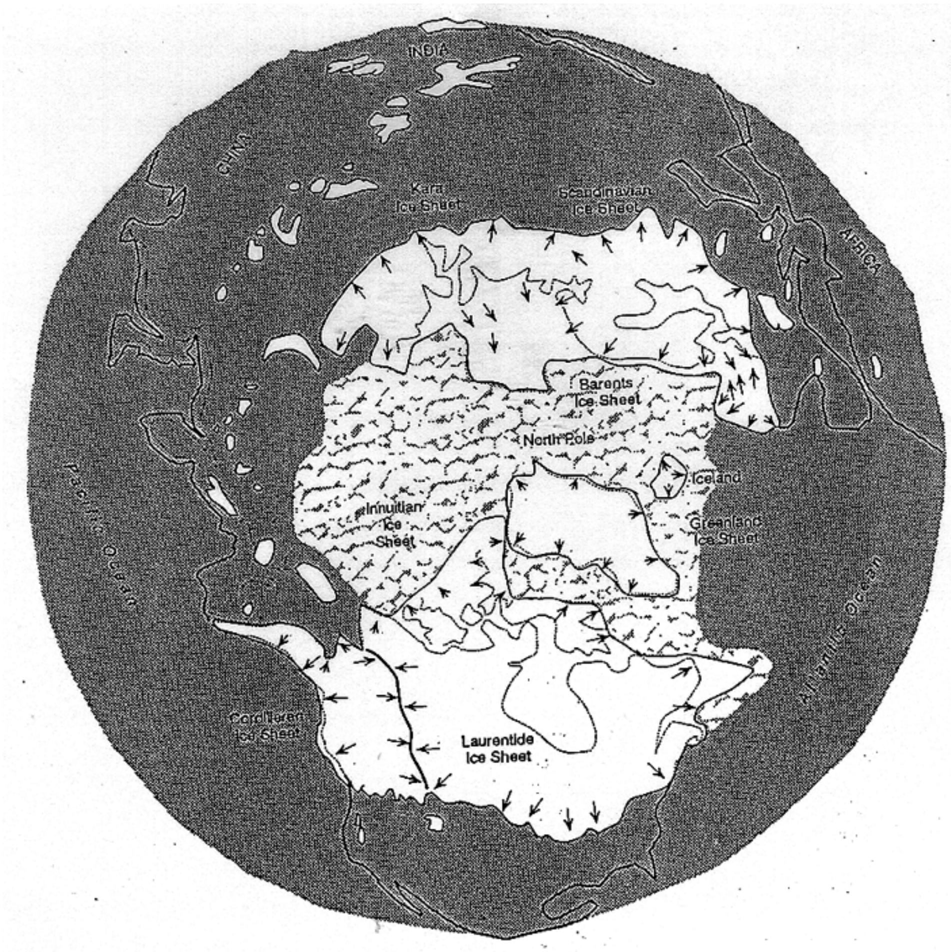
The Swedish National Archive participated actively in this project but it was impossible to mobilise interest from Denmark. Norwegian historians contributed by reflecting methods to convey understandable information over long time periods. *Markers* placed on the site with signs explaining the matter can be misinterpreted, as seen from the example of runic inscriptions in Scandinavia.

The durability of various archive media was explored in the KAN-1.3 project. Perhaps surprisingly, paper in combination with archive ink turned out to be better than modern computerised methods, which are rapidly outdated, the data becoming illegible. Here is a fragment of a document made in China in the third century A.D. From the Museum of Ethnography, Stockholm

Another waste project, related to radioecology and emergency preparedness, studied management of the large waste amounts arising from cleanup of contaminated areas following a nuclear accident (**KAN-2**). Jukka Lehto from the University of Helsinki headed the project. Cost-benefit analyses were made for various cleanup measures, depending on the possibilities available for waste disposal.

This project produced some original work into the extent to which forests can be decontaminated. There was also experimental work in Norway to test methods to remove surface layer of the ground from contaminated areas.

The last waste project attempted to summarise knowledge generated in the Nordic countries and elsewhere on climatic evolution including ice ages and its possible impact on waste repositories (**KAN-3**). Fritz Kautsky organised a seminar for geologists in Stockholm in October 1992, which even included participants from Iceland and Norway. He also arranged a discussion at the Nordic Geological Winter Meeting in Luleå in 1994. However, he did not succeed in finalising the report from the project.



SKI's Fritz Kautsky managed to pull together a great amount of information, for example on the glaciated regions of the Northern Hemisphere during the last ice age. The world sea level was around 100 m below the present one (from Skinner and Porter 1987)

Radioecology (RAD)

The renewal of Nordic radioecology programmes was welcomed in the countries, where many new people were now involved, especially in Norway. Interest in radioecology at this time can be seen as a special feature of more general Norwegian environmental concern. It went so far that in 1992, a proposal was made to establish an international research institute for radioecology in Norway. In the event the idea was never realised. Concern over releases from nuclear installations in the neighbouring regions, especially in the Kara Sea, also influenced radioecological work.

For NKS it was important to reconnect research to already existing results. The fifth Nordic radioecology seminar had been organised by Jan Olof Snihs in his home region in a typical Dalecarlia setting at Rättvik in 1988. Here the 140 participants discussed detailed plans for a coming programme. Its theme was a quantitative description of the path of radionuclides through various Nordic ecosystems.

Erik-Anders Westerlund, recently returned to Norway from a post at the IAEA was chairman of the RAD reference group with Risø's Henning Dahlgaard as coordinator. In spite of his sarcastic remarks about the Nordic bureaucracy, Dahlgaard managed to keep together work by four project leaders in different areas of the radioecology field. During this period, important findings were made, resulting from the many measurements taken of the Chernobyl fallout.

NKS intended that results from the RAD programme should be used for emergency preparedness. An attempt was therefore made to establish a link with the BER programme[1]. However, radioecologists and emergency people were not on the same wavelength and little understanding was achieved.

As part of the programme, **RAD-1** included inter-calibrations to train and test various laboratories in the countries. Grants were also made available for young scientists to train in other Nordic radioecology laboratories.

Elis Holm from the University of Lund planned a new course in radioecology, similar to the first course in 1980 (page 113). At the Nordic Society for Radiation Protection's meeting at Ronneby in August 1990, programme managers from the European Commission participated. At this occasion, an attempt was made to combine the Nordic course with the ongoing CEC programme. A written request sent to Brussels received a negative response. Such a Nordic course was perhaps seen as being in competition with a similar project organised in Mol as part of the CEC programme. When the Nordic course eventually took place in Lund during April 1991, twenty-eight students attended - with twenty-six lecturers. This was one move to transfer knowledge to the new generation. A textbook with lectures from the course was finally issued in 1994.

The database for radionuclide measurements established after the Chernobyl accident (page 194) became a subject for discussion. If the database was to be usable, then somebody should control data and feed it into the system. Lena Carlson spent some time at Risø to write a user manual, but the database's creator was continuously changing the system itself. Scientists unwilling to put their data into

[1] through the participation of VTT's Seppo Vuori

the system created another obstacle. They were reluctant to include data before it was published in their own scientific papers, which resulted in a significant delay. The database was finally abandoned.

Through the RAD programme it was possible to collect samples in highly contaminated areas of the Southern Urals. NKS helped to start joint Nordic-Russian research in this field that was subsequently carried on in programmes of the EU.

The high content of radionuclides persisting in fish from freshwater lakes was taken up in project **RAD-2** led by Manuela Notter from the Swedish Environmental Protection Agency. While the main attention in this post-Chernobyl period was on factors that influence caesium contents in fish, there was no room to include strontium in the research, even though experience from the bomb test fallout had shown its importance.

The collective dose received by Nordic populations from contaminated foodstuff after Chernobyl was dominated by agricultural products. The transfer of caesium from soil to plants and animals was a major concern. In project **RAD-3** large variations were observed between different Nordic regions. In this project there was an early shift of leader. An attempt was made to co-ordinate the work with the computerised handbook in project BER-1 mentioned above, but the two projects continued along separate paths.

The surprisingly high concentration of radionuclides observed in forests, game animals, reindeer and mushrooms were examined in project **RAD-4** with STUK's Aino Rantavaara. The work attempted to establish a 'budget' for caesium from fallout, but the project leader experienced difficulty in obtaining the agreed contributions, particularly from some of the Norwegian professors engaged in the studies.

Risø's Asker Aarkrog used the results of projects on aquatic and terrestrial radioecology to make a survey of the sensibility of various Nordic environments to radioactive fallout. Analysis of the doses to the Nordic populations after the Chernobyl accident provided a basis on which to predict population doses following the event of any future contamination of individual Nordic environments.

The sixth Nordic radioecology seminar took place in the Faroe Islands in June 1992 and included a visit to the lawn where the Faroe's national team were knocked out of the European football championship that same evening. Several seminars co-sponsored by the RAD programme included a symposium at Bergen in June 1991 where Britt Salbu spoke on her cherished field of *hot particles*. Another meeting on environmental radioactivity in the Arctic and Antarctic, was held at Kirkenes, close to the Russian border in August 1993. Here the support from NKS made participation by several Russian experts possible.

Instead of issuing final reports from each of the four RAD projects, the whole programme outcome was published as a book in the environmental science series of the editor Elsevier in 1994. Although plagued by many delays, the book was a major achievement due to the efforts of the co-ordinator Dahlgaard.

Reactor safety (SIK)

In the planning phase[1] there had been some discussion between the Danish and Finnish *NKS* members about how far the projects should go into detail on so-called 'living' probabilistic safety assessment and severe accident sequences. These required professional skills that were mainly available in countries with power reactors. It was therefore decided to reconsider the SIK project proposals with people from the nuclear inspectorates.

An introductory phase in 1990 permitted interested parties to formulate detailed project plans. This provided an opportunity to resolve differing views between Danish and Finnish participants. Motivated by the need for knowledge to tackle future cross-border safety problems, the final version of the SIK programme was subtitled *knowledge acquisition for preparedness*.

In the project on probabilistic methods and safety indicators (**SIK-1**) led by VTT's Kari Laakso, large meetings were necessary at the outset to involve all those working on ongoing national projects. These were mostly Finnish and Swedish ones and included those of the utilities. The intent was to extend the - now conventional PSA analyses, to make them plant specific and give operators an instantaneous picture of the current plant status. The goal was to arrive at results that were applicable by the utilities. Although utilities were represented in the SIK reference group, it was recognised that introducing new systems takes time and that results need to be presented to management in a convincing way.

Another project goal was to identify a group of indicators to predict changes in safety related functions so that early corrective action could be taken. Performance indicators, derived by combining results from the project's two parts might then provide input to the information presented to operators about the plant safety level.

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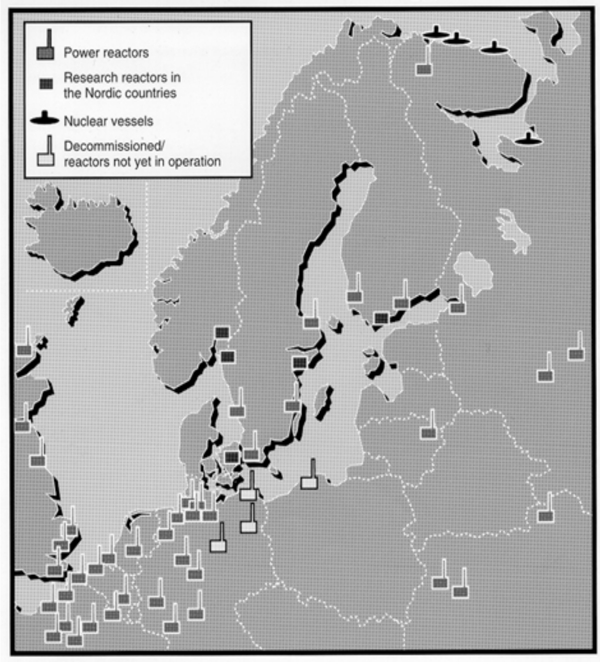
[1] Lennart Hammar was an inspiring chairman of the reference group with VTT's Risto Sairanen as co-ordinator

SKI's Wiktor Frid led a project (**SIK-2**) where various phenomena were analysed which would have to be considered in calculating accident sequences. The project started at a time where an agreement on exchange of information was being drawn up between SKI and VTT. This covered severe accidents and large related experimental programmes, which were organised internationally. The SIK-2 project was a follow-up of the AKTI work (page 113) and involved comparison of various computer programmes available for use in the Nordic countries. It aimed to establish greater control of accident management through an understanding of the processes involved in a reactor accident. It included evaluation of chemical effects and the function of aerosols in transferring radioactive material through the reactor containment. However, comparing and verifying codes seems to be an endless task since codes can be continuously refined.

The *CAMS* project, part of SIK-2, was conceived to examine a system for computerised assistance to plant operators in case of an accident. A workshop organised within the Halden project in November 1992 recognised that in the present NKS programme, CAMS could only lead to a prototype. This work was then organised at Halden utilising a simulator from the Swedish Forsmark plant.

There were different interests in project **SIK-3** led by Erik Nonbøl: Risø wanted to collect information on reactors in neighbouring countries, particularly those to the east and south, for background information in case of an accident. However, the Norwegians and Knut Gussgard in particular, were interested in nuclear seagoing vessels moving around in the North and Barents Seas. The project was also therefore, to include information on nuclear powered submarines.



It was difficult to get project SIK-3 on track and the *Nordic Secretary* decided to invite the project group to a summer dinner to ease relations and create a positive attitude to the work. The only available venue was the expensive Ulriksdals värdshus in the Stockholm region, but the initiative was worthwhile in spite of the sky-high prices. Although less interested, the Finnish and Swedish participants now at least contributed by describing plants in their own neighbourhood. Information about reactors was sometimes difficult to obtain, especially for those in Germany, in spite of promises on confidentiality since NKS restricted it for use in its own circle and by reactor safety authorities.

In view of past difficulties with editing final overview reports in time (e.g. in AKTI) it was decided in 1992 to engage an external consultant to write a summary report of the entire SIK programme. This was a wise decision, because one of the three final reports - the SIK-2 - was never finalised. In 1993, Bengt Pershagen, ex-Studsvik, was engaged as a consultant to write this summary report. He managed to give an all-round picture of reactor safety in general and of the understanding that had been achieved through the SIK-programme. This covered three important areas: the inherent characteristics of different reactor types; the safety features provided by their design, and the way they are operated.

Termination and dissemination of results

In the two previous NKS programmes financed by the *Ministers*, final reports had been published free of charge as part of the NORD series of the Nordic Council, by its Stockholm secretariat who had been most helpful. The *Nordic Secretary* arranged that a similar arrangement could be made for the Fourth NKS programme, this time however against payment. Now all publication went through the Copenhagen office of the *Ministers*. New rules for publication had just been issued, so the reports were in the less fashionable series called 'Nordic seminar and working reports'.

It turned out to be a complicated affair with long delays in printing. The main problem however, was to get the authors to express themselves in a language understandable to non-specialists. The *Nordic Secretary* put a lot of effort into working with authors to produce summaries, explaining results of their projects to lay readers. Many project leaders also needed help to produce lists of relevant readers to whom the report in question was to be distributed.

Out of the 15 final reports to be issued, two were never finalised by their authors. Two additional short summaries were produced however, one compiled by Leif Blomqvist, covering the BER programme and the second, on KAN was written by Johan Andersson.

Final seminars were planned in three of the programme areas for the first half of 1994. They were an attempt to present the NKS conclusions in conjunction with results from other work performed in the Nordic countries. The seminars were organised by the *old crew*, but marked the take-over by the new generation.

The first was a **waste** seminar, organised in Helsinki together with the Finnish utilities' Waste Commission (YJT) during April[1]. In his keynote speech, Curt Bergman from SSI but currently working with IAEA mentioned that the principles now worked out by the IAEA for waste management were strongly supported by the Nordic countries.

A seminar on **reactor safety** research in Nordic countries was held at Saltsjöbaden in April[2]. This also offered an occasion to summarise the individual Nordic countries' assistance programmes to the neighbouring regions in the east. Here the creation of a safety conscious atmosphere, motivation of personnel and its alertness to identify weak points were underlined by STUK's Jukka Laaksonen.

During the seminar, working groups discussed the complications for utilities in applying research results to practical applications, in particular the advanced PSA methods.

A new Nordic initiative on reactor safety was described during the seminar, the Nordic utilities' *Council for reactor safety*. It was formed by the directors of the Swedish and Finnish utilities which owned BWR reactors, following an incident at the Barsebäck plant in 1992 which led to the temporary shut down at five Swedish reactors. One purpose was to ensure feedback of information, including information from the reactor vendor ABB Atom (formerly ASEA-Atom).

A seminar on **emergency preparedness** was organised with the Norwegian Radiation Protection Authority at Sundvolden in May[3]. This seminar satisfied a request made at the start of the Fourth NKS programme by the radiation protection *Chiefs* to arrange a Nordic meeting on strategies, intervention levels and issues related to emergency situations.

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[1] STUK's Olli Vilkamo was the local organiser, helped by Torsten Eng from SKB

[2] It was organised together with Ingmar Tirén of the Swedish Nuclear Technology Centre at the Royal Institute of Technology

[3] with Eldri Naadland acting

The new and the old Nordic Secretary at the 1994 Saltsjöbaden reactor safety seminar: Franz Marcus who had worked with this Nordic co-operation since 1967 and Torkel Bennerstedt who took over during the Fifth NKS programme

Risø's Per Hedemann Jensen described international trends in setting intervention levels. The basic concepts still being discussed, no Nordic harmonisation was achieved in spite of many discussions and the BER-3 project. Therefore preparation of a Nordic Flag-Book (page 79) had not yet started.

In all three seminars the participation by both researchers and authority representatives, a characteristic feature of the NKS programme, made discussions attractive for the participants. The seminars were also used to present the next NKS programme and to allow the new *Nordic Secretary* to be introduced.

Evaluation of the Fourth NKS programme

The programme was evaluated in 1994 in the same manner as earlier four-year programmes with one evaluator for each programme area (Note 8.2-D) In addition, a separate person evaluated the waste project dealing with the influence of climate (KAN-3). The total direct financing amounted to DKK 28 million (ECU 4 million) of which DKK 3 million were from the nine external co-sponsoring organisations. In addition, approximately 200 project participants and their organisations had invested much time and effort into the work.

Some evaluators dealt with rather detailed matters; others only looked at overall issues. Many results identified had practical applications such as those related to emergency exercises, radioactivity in foods, and maintenance routines in nuclear power plants. A meeting, to allow evaluators to arrive at joint conclusions, recommended ways to improve dissemination of results to target groups. The outgoing *Nordic Secretary* summarised the findings so that the team now embarking on the Fifth programme could use them.

NKS had discussed the usefulness of the reference groups on several occasions. The evaluators found that their importance depended on their chairman, on how far the members engaged themselves and on the co-ordinator. Some reference groups (such as SIK and KAN) were important for the project work, influencing its direction during the period. Others found it more difficult to first formulate and then impose their viewpoints.

It was recommended that before entering into commitments for future programmes, project participants and their organisations should carefully evaluate the amount of time they would need to devote. Each project leader must ensure that the various sub-projects are coordinated into a unified project. To ensure that time scales are met, project leaders should, if necessary, apply economic pressure.

The evaluators also emphasised that NKS should establish a policy aiming at enhanced information about its projects. Final reports should contain conclusions and recommendations that can be followed up. The directors of the competent authorities in individual Nordic countries should be formally requested to give their views on these recommendations.

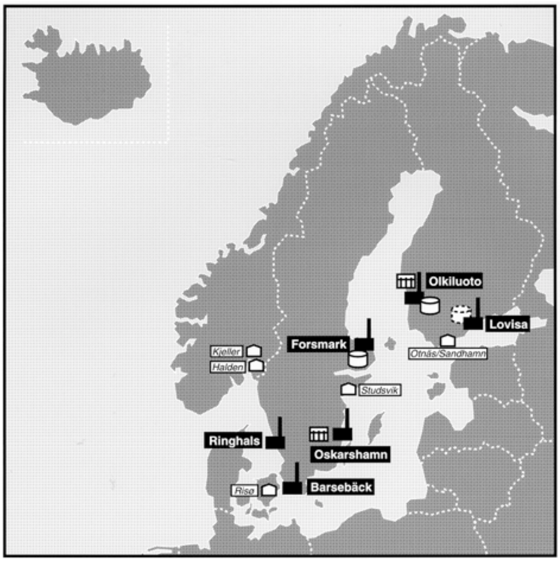
8.3 Related Nordic activities

All the Nordic countries supported the protocol from the Rio conference on environment and development, signed the 1992 Climate Convention and worked actively for the reduction of carbon dioxide emissions. But this did not change their views on nuclear power. Several attempts to obtain consent for a fifth nuclear power plant in Finland - to provide additional base-load electricity - failed in 1993. Despite increasing public acceptance of Sweden's nuclear power plants, the government made several consecutive decisions to close at least one of the Barsebäck reactors. Closure of the first unit was first set at 1995 but was later changed to 1998.

Several Nordic activities continued in the nuclear field. Although not directly related to the NKS programme, close liaison between these and NKS' activities was maintained through personal contacts.

Final relations to the Nordic Council

After the *Kontaktorgan* disappeared, *NKS* took action when nuclear-related questions were raised in the Nordic Council. In 1993 the question of safety related to radioactive waste came up. In response the *Nordic Secretary*, helped by the KAN reference group and the organising committee for the 1994 waste seminar (page 235), compiled a survey. A report by SKI's Rolf Sjöblom on waste management in the Nordic countries was also forwarded. However, there was no reaction from the Nordic Council.



The last expert survey for the Nordic Council was made by NKS in 1994 and dealt with the situation in the waste field.

When the Fourth NKS programme ended and the Fifth was planned in 1994, the practice of giving advice to the Nordic Council was abandoned at the request of the Swedish representatives in *NKS*. They argued that now, *NKS* was purely a committee directing a research programme. Thus, after 37 years of official partnership, liaison with the Nordic Council ended.

There was now no competent Nordic body to give advice. Therefore in March 1994, the Environment *Ministers* and the authorities dealing with nuclear safety appointed contact people to form a Nordic network. This would deal with issues to be raised such as those concerning nuclear safety in the surroundings of the Nordic area and Nordic countries' assistance programmes. Several of NKS' members became members of the network. The contact people, however, only met in the beginning. It was found that the *Chiefs* group (see below) could better deal with Nordic policy issues of this type.

The Information Contact Forum

Following the Vikersund seminar (page 207) a working group of the *Information Contact Forum* under Hans Jacob Holden started to develop a routine for contacts among those information officers at the Nordic authorities that would be involved in the event of a nuclear emergency. This definition complicated Swedish participation, as three different authorities felt that it was their responsibility. All three participated in the work, which was subsequently integrated into the activities of the projects BER-4 and BER-5 (page 225).

In the working group, Hans Ryder from the Danish Emergency Management Agency proposed a layout for contact lists, which were produced in 1990. These have since been used frequently by the information officers. An example is when SKI's Gunilla Wünsche was travelling home by train in June 1990, listened to the news and heard a rumour about a radioactive cloud approaching Northern Scandinavia from the Kola Peninsula. By quickly using her Nordic contacts she was able to dismiss the ploy and head off the inevitable avalanche of media interest.

The group carefully planned a seminar for the directors of the authorities responsible in emergency cases. However, the directors did not attach a great deal of importance to the proposal and it was finally replaced by the meeting at the Oskarshamn site as part of the BER-4 project (page 224).

The working group achieved its purpose by establishing excellent relations. Members maintained contact if the unexpected occurred and they exchanged information during Nordic emergency drills.

Safeguards

In the field of safeguards the Nordic countries have similar policies. Direct Nordic contacts continued among those people, mostly at Ministries of Foreign Affairs engaged in international safeguards questions, mainly to prevent nuclear material from being diverted to nuclear weapons. They held a few meetings after the *Kontaktorgan* was abolished, but thereafter contacts were taken during meetings at the IAEA. Here, in Vienna, the traditional Nordic dinners provided a useful forum to exchange viewpoints. In some way therefore, the *Kontaktorgan*'s traditions lived on. Even when it came to relations with the EU they felt the benefit of established but informal Nordic contacts.

On the initiative of SKI's Paul Ek an attempt was made in 1990 to create a Nordic *Society for Safeguards*. The first seminar was held at Eskilstuna in April 1991. One purpose was to improve the understanding among those who routinely take part in international political discussions on non-proliferation - and who might be far away from practical day-to-day safeguard aspects, and those who work full time updating safeguards accounts or carrying out safeguards research. Thus, technical as well as political questions were discussed. Unfortunately, some busy participants from Foreign Ministries had little time to stay and attend to the many and complicated issues added to the daily work by the necessities of the international regime. The significant differences between Euratom safeguards in force in Denmark and the IAEA regime in the other Nordic countries were highlighted.

A second seminar took place in Copenhagen in February 1994. Here it was concurred that the 'Society' should cover a large area of subjects, including transportation of fissile material and its physical protection. It was not felt convenient however, to follow SKI's proposal to use the Society for joint action, such as the forthcoming discussions with the EU. One reason was that safeguards implementation would be negotiated directly with individual installations and national authorities.

A third seminar in Oslo in October 1996 examined the question of illicit trafficking of nuclear material. This can pose health risk and constitute a threat of proliferation. The problem how to deal with the great amounts of material coming 'on the market' in connection with the dismantling of arms was discussed, including the Nordic countries' possible actions in this respect.

Common market - Euratom

From time to time NKS discussed possible relations between its Nordic programme and similar activities in the Framework programmes of the European Communities/European Union. Frequently the same questions were raised in both Nordic countries and in the Framework programmes. In September 1987 the *Nordic Secretary* together with IFE's Ulf Tveten outlined the NKS programme in Brussels to co-ordinators responsible for similar work in the Commission. The same year, an NKS group[1] considered possible ways to relate Nordic and European programmes dealing with the same issues.

NKS also discussed how its future programmes could align with those of the EU. Fundamentally NKS needed to explore the extent to which it needed to continue its programmes if more Nordic countries became EU members. The general opinion was that each of the individual Nordic countries was too small to make its voice heard in the large group of EU member countries. Therefore, it should find a constructive approach to co-operation between NKS and EU activities. In 1992, NKS attempted to combine some of the SIK programmes in its Fourth programme (page 233) with the Commission's planned 'reinforced concerted action' programme on reactor safety. However, it was unsuccessful in introducing the Nordic institutes as a combined group to the EU programme.

A new chapter of relations with EU started in 1995 when three of the Nordic countries were members (page 246).

[1] with Jon Berg, Lennart Hammar and Pekka Silvennoinen

Baltic Sea States

When working contacts with the Baltic countries became possible during the early 1990s, the door opened for a certain degree of Nordic co-operation. With the foundation of the Council of the Baltic Sea States and its working group on Nuclear and Radiation Safety in 1992, the Nordic countries shared efforts to upgrade nuclear safety and radiation protection in the Baltic area.

At the last *Kontaktorgan* meeting in October 1990 (page 209) it became evident that assistant programmes were prepared independently from individual Nordic countries. Occasional Nordic meetings, initially involving the Foreign Ministries, led to a certain measure of Nordic co-ordination. Each Nordic country had its particular area of interest and therefore contributed part of the tasks in its national assistance programme. In the reactor safety area, Finland and Sweden strove for leading positions. Finland became the main partner for supporting the Sosnovy Bor site near Saint Petersburg and Sweden for the Ignalina reactors in Lithuania. Norway was especially active in the Barents Sea and the Murmansk area, while Denmark mainly dealt with emergency management including advanced air monitoring and Iceland with help to Estonia. In 1995, SSI started annual information meetings 'NORDSAM ÖST' where opportunities for co-ordination were discussed.

The authority *Chiefs* group

Once the *Kontaktorgan* ceased its activities and *NKS* concentrated on its priority research areas, the group of directors of Nordic safety and radiation protection authorities (page 128) discussed many of the items previously taken up by the *Kontaktorgan*. The existing networks were maintained and new working groups established as need arose. Interest in NKS work increased as members participated in both groups. From 1995 the new *Nordic Secretary*'s co-ordinating role was recognised when he was again invited to the *Chiefs*' annual meetings. This action also confirmed their interest in NKS' work.

The Nordic Transport Group continued its activities as one out of half a dozen authority working groups.

The countries made common efforts in the mid-1990s to push the new IAEA conventions on nuclear safety and waste management.

There were close contacts in the radiation protection field in the preparation of the new basic safety norms that were issued in May 1996. These constituted a binding Directive from the European Commission.

Co-operation between the Finnish and Swedish authorities was particularly close related to inspections of nuclear power plants. This was achieved in ways such as exchanging reactor inspectors. There was also a permanent representative from STUK on the advisory SKI safety board.

8.4 The Fifth NKS programme 1994–97

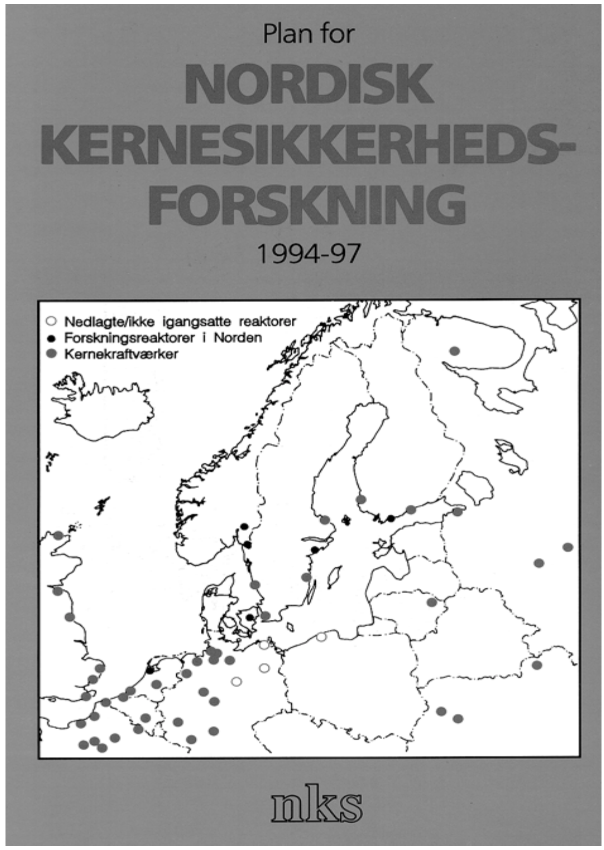
Preparations for a new four-year programme started at the end of 1992 and were accepted in principle by the Consortium group in February 1993.

In the first draft for the new programme in 1992, alternative use of the Nordic funds had been discussed. One possibility would be to employ several young people full time, to promote co-operation in specific areas. They would co-ordinate work taking place in the individual countries. A 'future-group' comprising an *NKS* member from each country produced a paper proposing a simplified programme covering only two areas.

More intensive planning efforts started in November 1993.

Again it was difficult to define a waste programme of interest for all parties. Per-Eric Ahlström from SKB helped by suggesting that efforts should focus on low and medium active waste containing long-lived radionuclides. Consequently, four people including SKI's Sören Norrby, who were strongly motivated for a programme to continue Nordic waste work, attempted to detail the project plans.

Early suggestions favoured fewer single projects. This would mean that a greater proportion of Nordic funds would be available for each project, and also the organisation structure would be simplified. These ideas were not new, they had been put forward before the start of each new NKS period.



The contents of each project was described in a plan for the new four-year programme, included in the 'green' book, which was issued in April 1993. It shows the nuclear installations in the surroundings, a concern for the Nordic countries and a background for the Fifth NKS programme.

A rejuvenated NKS

At this time it was clear that a new generation should take over the roles in the NKS system. The *Nordic Secretary*, active in his role since 1967, started a year-long search for a new chairman and for his own successor. For each position he sought to identify at least one candidate name from each Nordic country.

In October 1993, the Consortium group appointed Magnus von Bonsdorff, at that time managing director of the Finnish TVO Company, to become NKS' fourth chairman. In November 1993 the group, together with the coming chairman, engaged Torkel Bennerstedt as the future *Nordic Secretary* with the title of Secretary-general. Bennerstedt was previously employed by SSI, but now acted as consultant to NKS' current BER programme. At the same meeting a new four-year agreement was signed by the five members of the Consortium group.

The Finnish Ministry of the Interior and the Norwegian Ministry of Environment became new co-sponsors in the Fifth NKS programme (Note 8.1).

Seven projects were initially defined for the new programme. These covered areas of *reactor safety* (**RAK**), *waste management* (**AFA**) and environmental effects (**EKO**), the latter comprising *radioecology* and *emergency preparedness* (Note 8.4-A).

The leaders of the two emergency preparedness projects were from the Danish and Norwegian emergency authorities, which made co-ordination with the emergency group of the *Chiefs* easier.

An eighth project on information was contemplated but not included from the outset. It was again taken up in 1996.

A ninth project was originally proposed to deal with work related to neighbouring countries in the East. All the Nordic countries were in some way engaged in supporting their eastern neighbouring countries with safety improvement programmes aimed at reducing the threat from earlier Soviet-designed reactors and to help in cleanup processes (page 241). Ways in which the new programme could assist this process were discussed. Inviting participants from the Baltic region might be one such way, but it became clear that language would be a barrier. The advantage of using Scandinavian languages would be lost and also other complications would be introduced in the well functioning Nordic system. Instead it was decided to keep the options open to involve Baltic participants in certain suitable activities.

Another reason that the NKS programme did not include co-operative ventures in support of safety improvement work on Eastern European plants was that individual Nordic countries had different priorities (page 241). In any case a Nordic endeavour would have no special advantage over national schemes.

Previously, Iceland's contribution to Nordic project work had been small in view of its limited interest in questions related to reactor safety and the small resources in the country. This position changed after Chernobyl when it was recognised that rumours of contamination could threaten the fish exports on which Iceland's economy depended. In the Fifth NKS programme therefore, there was active participation, arranged between Sigurður Magnússon and the new *Nordic Secretary*.

The new NKS in action

The 'new' NKS (Note 8.4-B), held its first meeting at Bolkesjø in the Norwegian mountains in February 1994, together with the resigning members. Seven young project leaders, four of them female, were proposed for the new programme. Prior to the meeting some of the participants had the occasion to visit the oppressive valley where heavy water had been produced at Rjukan. During the Second World War, sabotage and bomb attacks prevented it from falling into the hands of Germany. It was the remainder of this stock that had been instrumental in Norway's and Sweden's early entry into the atomic age (page 32).

The first part of 1994 was considered a pilot phase. NKS and the Consortium group approved final project plans in June 1994. Plans were detailed for the first two years while the remaining period would be discussed after mid-term. The starting point for the work was marked by a seminar in Stockholm during September 1995, where the new project leaders presented their working plans.

NKS retained reference groups for each programme area, but combined radioecology and emergency preparedness reference people in one group. This was another attempt to enhance the understanding of related functions, but it again proved to be a miscalculation. The group grew too large and those from one field did not participate in the discussions about the other.

The NKS secretariat remained at Risø. At the outset this was an attempt from the outgoing *Nordic Secretary* to make sure that there would be a reasonable Nordic distribution of NKS tasks, with a Finnish chairman, a Norwegian secretary (participant of the *bureau*), while the *Nordic Secretary* was Swedish. Utilising the Risø infrastructure proved to be a fortuitous choice. Two people from Risø (Finn Physant and Annette Lemmens taking over H.C. Sørensen's functions) were dedicated to provide part-time support to NKS. In practice their services extended well beyond their specified duties of keeping accounts and printing reports.

The new team effectively went into the Internet age with Home Pages, e-mail and portable telephones. Issuing reports on CD-ROM was also planned.

Financed by the Swedish Rescue Services Board, a fifth EKO project to pre-plan early cleanup operations, was included in the programme from 1996.

Information was recognised as being of such importance that a new project on overriding information issues was started directly under the *Nordic Secretary*.

When the NKS Consortium was formed in 1990, it included one organisation from each of the five countries although the Swedish party, SKI, also represented other Swedish authorities. After the abolition of the Board for Spent Nuclear Fuel, the new *Nordic Secretary* arranged for the Radiation Protection Institute (SSI) to join the Consortium group. This helped relations and resulted in a more positive attitude among the Institute's staff, towards joining the project work.

The members of the Consortium group were now invited to join *NKS*' regular meetings. This simplified the organisation since their own meetings were reduced to short formal get-togethers, which were held once per year. The *NKS* group was now called the NKS Board.

The outgoing *Nordic Secretary* continued in an advisory role. Henny Frederiksen, his long-standing secretary, retired in 1995.

In 1997, Antti Vuorinen who had recently retired from his job as director of STUK, was employed as a single evaluator for the entire Fourth programme.

Contacts with the European Commission

From 1995 Finland and Sweden were members of the European Union - twenty two years after Denmark's membership, and Norway participated in several EU activities related to nuclear questions. The former *Nordic Secretary* had for several years updated his survey of groups according to the Euratom Treaty, first presented at the 1991 Copenhagen meeting (page 209) and now helped to inform the new members about the complicated picture.

NKS continued discussions how an approach between its Nordic activities and related EU projects could be established[1]. Could the Nordic countries perform pilot projects on a small scale that would then serve as input to larger Euratom projects?

Another approach would be if NKS could work on specific questions for the related Commission services. Combined EU research grants and NKS research funding would have advantages for all the parties involved.

Informal scouting activities took place in Brussels starting in 1995 with the purpose of establishing an understanding of similarities between the large EU Framework programmes and the, in comparison, rather modest project work in NKS. A first informal meeting about Nordic participation in various EU activities was arranged in December 1995. Representatives from the Commission staff were also invited to a seminar organised at STUK's Helsinki office at the mid-term seminar of the Fifth NKS programme, prior to the NKS meeting in January 1996.

Two concerted actions in the Fourth EU Framework programme, involving participants of the Fifth NKS programme, were planned in 1997. The first was a repeat of the comparison of different mobile monitoring systems (RESUME-95) which had been tried out in Finland in August 1995 in one of the EKO projects.

[1] This approach was formally in accordance with a joint declaration on Nordic co-operation which was issued in June 1994 and which indicates that Nordic countries newly members of the EU intend to continue, in full compliance with Community law, Nordic co-operation among themselves as well as with other countries and territories

Here a Finnish journalist is seen interviewing the EKO-3 project leader from DEMA, Jens Hovgaard with a French participant, Christian Bourgeois listening. RESUME was to be followed up in 1998 by a similar exercise with participation throughout Europe, this time with another project leader under EU sponsorship.

The second concerted action was the development of integrated safety analysis to combine various disciplines into an overall approach, inspired by NKS' RAK programme. It started in 1997 and the working group included participants from three Nordic countries.

9. Looking back: How could all this happen?

Half a century of co-operation, of meetings, projects and journeys, of disappointments and successes, was it worthwhile? What did it all result in? How did this collaboration survive so long? Why was the interest and commitment to questions of nuclear energy and safety maintained for so many years? Was it because of the ever-changing potential of its applications, or the fear of its perceived risks, or was it also related to the manner in which this particular co-operation was conceived and managed? What, if anything, makes this co-operation different from the hundreds of other cases of Nordic enterprises, working groups and institutions?

The co-operation was complex, and so are the answers to these questions. They are not only to be found in the subject of the co-operation itself - the nuclear area - and how it was related to external events in the international political and economic environment during these fifty years. They are also to be found in a number of specific conditions prevailing in the Nordic countries and in the presence of personalities who played key roles during that period. Some of the early and continuing successes also gave the collaboration continued impetus. The whole story can probably best be explained by understanding the way in which it was managed.

The following is an attempt to draw out some of the lessons from these various factors, as they appeared during the two main phases of co-operation: that during which the *Kontaktorgan* was in operation (1957 - 1989), and the more recent phase of the *NKS* (1977 - 1997 and onwards).

Special conditions favouring Nordic collaboration

It is well known that there are special facilitating circumstances peculiar to collaboration among the Nordic countries. These are factors which naturally lie behind all Nordic co-operation: closeness of the countries both geographically and politically, the ‘Nordic tradition’ and easy understanding between people from countries of similar cultural background, common use of Scandinavian languages, shared physical environment and a history of common problems with some of their neighbouring countries. Perhaps their relatively small size and the satisfaction from being part of a larger group also plays a role.

Two factors of more political nature have been of fundamental importance for the continuity of the work in the specific field dealt with here.

Firstly, in the struggle to rebuild Nordic ties after the War, the Nordic Council was created in 1952. This provided a mechanism for initiatives on essential issues and a forum for continued follow-up of Nordic activities. It was through the Nordic Council that the original initiative for a permanent *Kontaktorgan* in the nuclear field was taken.

Secondly, as a consequence of a general political desire for an extended Nordic co-operation, the Nordic Council of Ministers was founded in the early 1970s. This was essential to the initiation of *NKS* and funding for its project work on nuclear safety from a common Nordic budget.

The *Kontaktorgan* for Nordic nuclear collaboration

After the War, the scientific and industrial potential of atomic energy clearly called for international co-operation, if it was to be properly managed. Nordic collaboration in this area offered several attractive prospects: political independence from the restrictions imposed by larger and more powerful international blocs; the promise of cheap and practically unlimited energy production, and the development and modernisation of industry. Although the Nordic countries were at different stages of development in the 1940s and had different ambitions, it was relevant to consider what they could gain through joint actions.

As a consequence, political leaders in the Nordic countries established the *Kontaktorgan* in 1957. Its mandate was to follow the development and planning of nuclear energy in the Nordic countries and to watch for - or promote - any ensuing opportunities for co-operation, including those for industrial development.

This political decision was one of the most important factors, which helped to keep co-operation active in the early period and for many years. Nordic governments and parliaments closely followed the work of the *Kontaktorgan* and the activities it gave rise to.

During the *Kontaktorgan*'s two first decades, the public perceived nuclear energy as a promising new type of electricity generation. International questions dealt with by the *Kontaktorgan* during this time, therefore, were dominated by the need to secure the supply of nuclear materials to enable such energy production. The lessons of the War also added another important theme to the political agenda.

This was international co-operation to prevent the misuse of nuclear materials. Each of the Nordic countries had great ambitions in this respect.

In the 1960s, individual Nordic countries participated in international collaboration, and many scientific and technical issues were raised in the countries. This stimulated great interest and brought together responsible ministries and scientists in the meetings of the *Kontaktorgan*. During this period, the national nuclear research organisations became focal points for developing knowledge needed to practically apply nuclear techniques. They formed a strong basis for Nordic co-operation on technical issues.

A number of external events also kept the issue of nuclear energy in the public eye and characterised the work of the *Kontaktorgan*. First the oil crisis and then the two nuclear plant accidents that contributed to the rising resistance to nuclear energy.

The case for project work on nuclear safety: *NKS*

The risks related to nuclear power had been recognised from the outset. Public interest in nuclear safety however, became focused when the 1973 energy crisis raised the prospect of an accelerated nuclear programme. These concerns were also heightened by doubts raised by opponents and the emerging anti-nuclear movement.

The Nordic Council of Ministers' new project budget provided a source of finance for project work and was the basis for a new era of dedicated joint actions on nuclear safety research. *NKS* was established on the initiative of the *Kontaktorgan* in 1977.

Five NKS programmes each lasting four years were carried out from 1977 until late 1997. The programmes' centre of gravity changed over time. In the first decade they concentrated on methods to ensure safety related to reactor operation and waste management. After the TMI accident in 1979 however, the emphasis switched to analyses and prevention of accidents.

In 1986, Chernobyl highlighted risks from nuclear installations outside the Nordic area and created a new basis for joint actions. Nordic countries have common concerns caused by their geographic position, specific nature, and threats of radioactive pollution from surrounding countries. This became the motivation for NKS' project work in the 1990s, which called for an enhanced understanding of accident sequences, effects of radioactive releases to the environment, and emergency measures.

The organisation and management of co-operation

One of the main reasons for the sustainability of co-operation was the philosophy which guided it, and the management style which characterised it.

Firstly, the goals of the collaboration, which were defined at its inception, were so comprehensive that they remained adequate and sufficiently flexible for many years. The form of the co-operation was therefore able to develop with time and its focus could be adapted to the evolution of events both within the Nordic countries and in the international arena. The particular management style of the co-operation enabled full advantage to be taken of the flexibility afforded by these broad goals. Perhaps one of the main reasons for its achievements was the subtle manner in which the co-operation was continuously tuned to the challenges of changing circumstances within the Nordic countries and internationally.

Secondly, the philosophy behind the co-operation contributed to this flexibility through its non-threatening, non-coercive approach. This certainly strengthened the collaboration. The *Kontaktorgan* provided a forum where all kinds of, sometimes sensitive issues could be discussed and opinions formed. There was however, no attempt to force joint decisions. Each country could act independently and join activities, which it agreed with or was interested in, and refrain from others. The non-binding nature of the co-operation - according to the *à la carte* principle - has made it easier for countries to participate whenever the proposed initiatives were of interest. They collaborated when they perceive it to be in their own interest. It was not necessary to provide additional inducements for them to participate.

Care was taken to make sure that Nordic efforts did not become a competitor to national work, but a complement to it. Co-operation centred on areas where each country could participate without inhibiting its national freedom of action. This tacit acceptance of differing national interests created a co-operative environment, which was strengthened by its freedom of choice. It ensured that when two or more countries worked together they did so through clearly self-identified interest.

In a parallel set-up, Nordic utilities effectively transferred both knowledge and electricity. However, a true political drive to introduce nuclear power on the Nordic supply net was never created. When only two of the five countries adopted nuclear power they worked closely together in a number of fields. Simultaneously, they continued to use the broader Nordic frame to develop their knowledge.

The *Kontaktorgan* played a particularly important role, especially during the first decades of collaboration. Although there was no attempt to reach common decisions, its meetings provided a mechanism for those involved in national decision-making to jointly discuss their problems. Members held high office and occupied key positions in their various countries. *Kontaktorgan* meetings therefore, helped to influence both national and international policies. The latter because of keen participation by members attending international fora. Indeed, throughout the whole period, the co-operation placed the Nordic countries in a better position to meet external challenges.

The *Kontaktorgan* did not examine specialised technical issues in detail, instead it recommended specialist joint bodies to be set-up as needed. All the Nordic investigations and joint bodies such as the *Committee*, *NARS*, *NKS* were initiated by the *Kontaktorgan*. The direct industrial co-operation achieved, mainly between Finland and Sweden, was also an indirect consequence of the common ground laid by the *Kontaktorgan*.

This meant that joint activities were organised in a systematic manner, with the *Kontaktorgan* retaining an overview, until the time when the focus of co-operation shifted to the *NKS* in the 1980s. As this history shows, many joint projects were organised such as those of the research institutes' *Committee* in the 1970s.

Although the concept of collaboration thus had considerable flexibility, its actual *modus operandi* was more tightly managed. In the interest of efficiency when joint project work was undertaken, there were and are binding agreements and strict rules for management with well defined responsibilities, recurrent evaluations and periodical reviews of goals.

The latter is particularly important and relates to the constant attempt to keep the co-operation relevant to changing circumstances and emerging needs. For each new four-year NKS period there is a new reflection period, a repeated 'starting from scratch'.

A continuous attempt was made to ensure clarity in pinpointing the clients or target groups for actual project work. Thus, those using the results from joint activities were always identified. In the 1950s these were largely the ministries and politicians; in the 1960s industry; in the 1970s research organisations; in the 1980s safety authorities, and in the 1990s those responsible for emergency provisions.

While co-operation satisfied the needs of different interest groups as time varied, its management concept reduced bureaucracy. This was achieved by clearly defined responsibilities and by delegating major administrative tasks to participating organisations. Except for the three first NKS periods in the 1980s this work was independent of the more bureaucratic management of official Nordic institutions.

These institutional mechanisms were driving forces behind the co-operation and helped it to the survive for so many years. There was however, another specific management instrument that continuously nursed the collaboration. This took the form of a *Nordic Secretary* who was jointly employed by the Nordic countries from 1967. The *Kontaktorgan*'s activities could be intensified through the efforts of the *Nordic Secretary*. As a discussion partner for all the concerned parties, the *Nordic Secretary* was highly mobile. Much of his time was spent to motivate key people in each country. During both *Committee* and *NKS* periods, he activated participants for new Nordic ventures through planning and consulting, and secured follow-up of decisions. Projects were never initiated without prior discussion, frequently on a face-to-face basis, with those who would implement them. This process secured wholehearted participation from the outset.

At any particular period prospective client groups were made aware of collaborative work by directly involving those interested in making Nordic contacts. At the outset, these included people behind national programmes and in research organisations, followed by those within ministries who formulated policy, and finally the authorities in charge of safety, radiation protection and emergency provisions. Goodwill was maintained by involving people at several levels in the countries so that those associated with joint projects did not feel isolated in their organisations. Information was also permanently exchanged with utility groups concerned.

These direct contacts, established with a broad range of people, permitted a dynamic style of management which could adapt quickly to change. Through this large pool of personal contacts, the *Nordic Secretary* was quickly able to create new Nordic groups as the occasion required, without obstruction from formal barriers. The function of *Nordic Secretary* thus, was instrumental in transforming the co-operation between ministries during the *Kontaktorgan* period into a cooperative activity between safety authorities after the *Kontaktorgan* had ceased to exist.

By avoiding setting up a central bureaucracy, this management structure proved to be both rational and economic. National administration costs have always been low, and the costs of the *Nordic Secretary* were shared among the countries that participated, first in the *Committee* and later in *NKS*. Countries paid in proportion to their contribution to the IAEA.

Availability of funds for individual projects greatly facilitated the organisation of joint work. During the *Committee* period of the 1970s the research institutes financed projects with an annual turnover of ECU 2 million. This was possible because Nordic projects were in areas that had priority nationally and because there were agreements covering commercial use of results. During the 1980s and 1990s

NKS disposed of similar sums of money, first from the Nordic Council of Ministers and then from those authorities that were directly interested in its projects. Although the amounts were small compared to national budgets for similar work, their impact was greater due to the synergistic effects of the collaboration.

The role of key personalities

Some engaged in the co-operation found it so rewarding that they remained committed over many years, even through several changes of patterns for collaboration in the international field. The perseverance of key people who organised and kept various parts of the co-operation alive created an atmosphere of comradeship. This collegiality has been a major factor in motivating individuals to participate over several decades. Their continued involvement ensured that there was always a colleague at the end of the phone in another Nordic country to give advice or to share pressing problems.

Although most of the Nordic groups had a limited life span, some, started several decades ago such as the one dealing with energy documentation, still function today. This is probably due to the personal relations created between various partners and to an absence of competition.

Many playing leading roles on the international scene gained their basic knowledge from Nordic groups where new ideas could be developed. Many of the concepts developed in the Nordic countries and tested in the Nordic sphere have had a decisive impact on the international development both in terms of policies, technical issues, research and science.

Synergistic effect of early successes

The prospects for collaboration were apparent already in the 1950s, when the benefits for long-term commitment were recognised. For example, when in the 1960s the national nuclear research organisations became focal points to develop practical nuclear knowledge, it formed a basis for Nordic co-operation on more technical issues of common interest.

The *Kontaktorgan* initiatives also helped the Nordic countries to improve their contacts with the outside world. They were able to refer in international gatherings to a considerable knowledge base, created through their exchange of experience. As a group they had a stronger voice in the international arena. This was reinforced in certain formal international bodies by an arrangement that ensured the successive presence of a representative from one of the Nordic countries. This guaranteed a continuous Nordic voice, which sought to present a common Nordic position.

In many cases, Nordic agreements were precursors for international conventions: on mutual assistance, on reactors in neighbouring countries, and lately on exchange of monitoring data for airborne radionuclides. Nordic opinions presented in the IAEA, or in the OEEC/OECD are examples of this. It can be seen through active support of European projects, first in the framework of the OEEC, lately in relation to Euratom.

As a *Nordic group*, the countries have attained international recognition in fields of documentation for example, or as participants in experimental projects such as those of the US NRC. For many years NUCLEAR SCANDINAVIA was a well-known trade mark of Nordic exhibitions at international nuclear fairs.

Such results gave witness to a recognisable international impact and encouraged continued Nordic collaboration.

Some results obtained in the nuclear field

The decision to collaborate not only on essential political and conceptual levels, but also to carry out practical joint work has resulted in visible achievements. Drawing on the best expertise available in each country has meant that there have been visible, concrete results from joint research projects. A few examples of outstanding professional results illustrate how the Nordic countries put themselves in the forefront of nuclear development: from the *Committee* period the calculation of accident sequences (NORHAV), experimental verifications (FRIGG), and large test facilities (Halden, Marviken). In the NKS period the radioecological knowledge and the regional set-up of emergency measures.

Some of the themes dealt with in the early 1970s have continued to develop during NKS' project work over several decades, continuously adapted to new needs. Many of them have helped a whole generation of new consultants to enter the market. The following are examples of some of these results:

- Modern control room development is influenced by NKS projects which have evolved from control room design, over human behaviour, towards emergency management and computerised support in accident management.
- Techniques for probabilistic safety evaluation have been stimulated by concepts developed in Nordic projects, starting from determining equipment reliability, development of 'fault trees' and finally, leading towards 'living' probabilistic analyses.

- Improved insight in the evolution of reactor accidents has been achieved through joint work on accident analysis, development of codes and their verification in large experiments.
- National concepts for radioactive waste management were stimulated by Nordic contacts and projects on management of low and medium active waste, waste repository safety, and its possible environmental impact.
- Methods for environmental control of radioactive pollution and prediction of its effects were developed through NKS' radioecology programmes with projects on measurement of radionuclides and determination of 'transfer factors' leading to their concentration, and calculation of possible population doses.
- Nordic input through mutual information contacts, development of public information policies and contact networks influenced systems for emergency preparedness and information policies. The determination of intervention levels and principles for decision making during emergencies are based on concepts of risk philosophy developed in joint programmes.

The value of the collaboration for other fields

As some of the above examples indicate, the readiness to reassess in the light of emerging needs and to pick up on new issues, meant that the results from joint projects were seen to be beneficial in other fields also. In some cases, the results of work in the field of nuclear energy can be said to have led to a break-through and to have influenced thinking in other quite unrelated fields.

Thus, during the Second and Third NKS programmes of the 1980s there was a push to transfer knowledge from the nuclear field to other risk prone industries. Researchers attempted to apply knowledge from radioecology to other pollutants such as heavy metals. They also endeavoured to promote a common international view on all *genotoxic* substances.

Diversifying the focus of the national institutes' research started on a large scale during the early 1980s. Probabilistic safety analyses, which had been developed in the nuclear energy field, could now be used in other industries. The studies carried out on human reliability were useful for other energy production utilities such as offshore oil fields. General knowledge of two-phase flow, quality assurance and materials' properties obtained through NKS projects could also be used in the offshore industry, where Norway's IFE was especially successful.

When viewed in total therefore, the investment in nuclear technology has paid off for the individual countries, both in terms of the expertise developed in the area of immediate interest and the applications in other fields.

Effects of recent results

The goals for NKS' work from 1990 included the development of joint views both on the technological side e.g. how to judge abnormal situations in operating reactors, and for environmental aspects, e.g. how to interpret enhanced radioactivity in certain foodstuffs. New projects were formulated in accordance with the interest of authorities for nuclear safety, radiation protection and emergency preparedness. Many of these projects have provided overall surveys and material for handbooks used by these circles.

The build-up of expertise is another recent NKS goal achieved through direct involvement in actual project work. Through the NKS projects, professional understanding in the three countries without nuclear power has been increased, so that they are able to provide knowledgeable counterparts to discuss and evaluate safety related matters.

Many projects deal with issues which concern the public. Therefore, dissemination of results and informing about NKS has become an important challenge in the 1990s. Information about the project work may demonstrate that sensitive questions are being dealt with conscientiously.

Publication of results from Nordic projects also helps to illustrate the level of knowledge available, thus reinforcing the Nordic countries' position in relation to international matters. This is useful for the links being woven between the NKS programme and the EU. The individual Nordic countries use results from NKS' projects in the fields of nuclear safety and emergency provisions in their assistance programmes for the new republics around the Baltic Sea.

Outcome of a more general character

As a result of the co-operation, an enormous amount of information has been exchanged between the Nordic countries. In spite of the differences in attitude to nuclear questions that have emerged, the creation of multiple networks on several levels has resulted in a common understanding in essential areas such as non-proliferation, safety, and emergency preparedness.

For individual scientists the most important outcome of joint actions may not be the production of final reports but rather the less definable benefits such as inspiration that follows from the close personal relations among individual scientists and with other research teams that have common interests, taking advantage of the broader knowledge base that becomes available. Through the co-operation more scope is available for their publications, which has resulted in many academic degrees being awarded over the years.

For Finland, Nordic co-operation was particularly important especially at the start when the country had little in the way of research facilities. The networks facilitated information transfer, persons involved in projects received specialist training, and the availability of results helped during a period when conditions within the country were difficult.

Both Finland and Sweden benefited from the quality and capacity of research available in Denmark and Norway in numerous fields related to a nuclear power programme and its safety issues. Conversely, the other countries and in particular Denmark and Norway could keep in touch with the 'real' nuclear power world through the co-operation.

Iceland has developed its own expertise in the post-Chernobyl era to ensure its emergency preparedness for a nuclear accident should it occur somewhere in the region.

Learning from the past

In spite of the generally positive outcome of so many years of co-operation, there have been times when the collaboration has appeared to falter or has not achieved what was hoped. It is important not only to build on the successes, but to see what lessons can be learnt from the disappointments.

Exchange of information was essential for the success of the *Kontaktorgan* in the first decades, but it turned out to be insufficient as a basis for extensive Nordic co-operation. This requires actual contacts on the working level. Thanks to project work within a well-defined framework the co-operation attained a higher quality and intensity, first in the *Committee* period from 1969 and then through the NKS programmes since 1977.

Co-operation has been particularly successful in fields where knowledge is needed by the authorities as a basis for their evaluation of nuclear activities and for establishing rules.

Co-operation is harder when it involves industrial interests. In 1969 an attempt was made to integrate all available Nordic industrial and research capacities in the nuclear field. Such a move would have realised many benefits in terms of joint service functions and infrastructure. The perspectives of a Nordic frame however, were not sufficiently attractive for such a grand effort.

Although in the 1970s co-operation among the large research organisations was quite intensive, repeated attempts for a true integration of their essential functions were unsuccessful. The goals of the institutes remained focused on national interests and these were not always identical. As the research institutes' field of action was enlarged in the 1980s to encompass a broader spectrum, they steadily moved away from nuclear issues. The common denominator therefore, disappeared and co-operation practically ceased although it could then be replaced by the contacts provided by NKS' programmes.

In the future the goals of *NKS* will naturally be modified to meet new challenges. Access to information and ease of communication afforded by the Internet for example represents an expansion of information that was almost unimaginable a few years ago. The shifting political blocs, and growth of the European Union with the fora for collaboration which it provides, will all change the face of the future.

But if fifty years' history in a period of dramatic political and technical changes is anything to go by, then *NKS* with its close working relations among competent circles in the countries, and personal confidence built up over the years, will be sufficiently flexible to adapt its coming programmes accordingly. It has a good pedigree and is well suited to continue representing a Nordic perspective to the discussions of the future.

Notes

Note 2.1 Participants in the first *Kontaktorgan* meeting 1957

(DK) Hans Henrik Koch, H. Stevenius Nielsen, Torkil Bjerge, Chr. L. Thomsen, Per Loft, Hans von Bülow; (FIN) Martti Muttro; (IS) Tryggvi Sveinbjørnsson; (NO) Jens Chr. Hauge, Bjarne Eriksen, Olav R. Kåsa, Raider Melien; (SE) Gustav Cederwall, Harry Brynielsson, Hans Håkansson.

Note 3.2 Members of NA 1967

Hans von Bülow, Franz Marcus, Mogens Møller-Madsen, Frits Heikel Vinther, Ilkka Mäkipentti, Uolevi Luoto, Olavi Vapaavuori, Viking O. Eriksen, Roar Rose, Bo Aler, Göthe Malmlöw, Peter Margen, Alf Larsson.

Note 3.4 *Committee* members 1968

Viking O. Eriksen, Henrik Ager-Hanssen and Roar Rose from IFA, Mogens Møller-Madsen, Cecil F. Jacobsen and Frits Heikel Vinther from Risø, Gunnar Holte and Alf Larsson from AE, Uolevi Luoto, Ilkka Mäkipentti and Olavi Vapaavuori from Finland as well as Franz Marcus.

Note 3.5. Members of *NARS* 1969

Per Frederiksen, Henning Jensen, Tapio Eurola, Antti Vuorinen, Kjell P. Lien, Knut Solem, Lars Carlbom, Erik Jansson with S. Thykier-Nielsen as secretary.

Note 3.8. Members of the *Contact Group* from 1970

Hans von Bülow, Ilkka Mäkipentti, Knut Solem, Alf Larsson, and, as its first secretary, Niels Arne Gadegaard

Note 4.1 *Committee* members 1974

Jon O. Berg, Niels W. Holm, Gunnar Holte, Marcus, and the contact persons Göran Carleson, Niels Kaiser (followed by Aksel Olsen in 1975), and Heikki Reijonen.

Note 4.3: Members of *NKS* 1975

Jon O. Berg, Lars Carlbom, Thomas Eckered, Ingvald Haga, Niels W. Holm, Marcus, Mogens Møller-Madsen, Veikko Palva, Seppo Väisänen and, as secretary, Heikki Reijonen

Note 4.4-A: The First NKS programme

Quality Assurance, **QA**.
Chairman of steering group: Jarl Forstén from VTT

- K-1: QA in design, manufacturing and construction
- K-2: Terminology
- K-3: Check lists
- K-4: Inspection
- K-5: QA during operation
- K-6: Feed-back of experience
- K-7: Extent of QA
- K-11: QA-guide
- K-12: Filing QA documents
- K-13: Principles for evaluation of suppliers

Radioactive Waste management, **AO**.
Chairman of steering group: Franz Marcus

- A:1 System and risk analysis for reactor waste
- A:2 Availing knowledge
- A:3 Radioactivity content of reactor waste

Control room design, **KRU**.
Chairman of steering group: Jens Rasmussen from Risø

- P1: System and job description
- P2: Control room design
- P3: Human reliability
- P4: Operator training

Radioecology, **RA**.
Chairman of steering group: Jan Olof Snihs from SSI

R1: Bioindicators
R2: Transport models for radionuclides in the Baltic Sea
R3: Sediment sampling, analysis and intercalibration
R4: Control programme for reactor sites
R5: Thule investigations
R6: Dispersion of radioactive material through sludge

Authority work, **MY**.

M1: Regulations for handling and storage of radioactive waste
M2: Physical protection of installations and transportation of nuclear material
M3: Emergency policy and organisation
M4: Authorities' control of operation

Note 4.4-B: NKS' Evaluation criteria

Project choice	Relevance in relation to national needs and International programmes Suitability for joint Nordic work Effect on an extended Nordic co-operation
Working forms	Project organisation, efficiency and complications Planning and management of programme Financing through Nordic and national funds Contacts with interested bodies
Project results	Accomplishment of project plan Compliance with goals Added value due to Nordic co-operation
Use of results	Practical exploitation Problems of application Resulting activities

Note 4.4-C: Evaluators of the First NKS programme

Erik Jansson in conjunction with Lars Högberg (QA), Jan Olof Snihs together with Curt Bergman and Leif Moberg (AO), Veikko Palva (KRU), Niels Busch together with Frits Heikel Vinther (RA), Jan Olav Berg (MY)

Note 5.1: *Committee* members 1977

Jon O. Berg, Niels W. Holm, Marcus, L.-Å. Nöjd, Aksel Olsen, Veikko Palva

Note 5.2. The *Committee* energy group 1977

Ove Dietrich, Marcus, Peter Margen, Roar Rose (followed by Kjell Solberg in 1979), Pekka Salminen

Note 6.1. Working group on mutual assistance 1985

Anneli Salo, J.C. Lindhé, Marcus, Teero Paasiluoto, Hans Ryder, Kåre Øfjord. Leif Blomquist acted as secretary.

Note 6.2-A: Members of *NKS* 1979

Per-Eric Ahlström, Jon O. Berg, Stig Bergström, Thomas Eckered, Christian Gräslund, Mauro Kuuskoski, Marcus, Mogens Møller-Madsen, Aksel Olsen, Veikko Palva, Jan Olof Snihs.

Note 6.2-B: The Second NKS programme

Reactor safety, **SÄK**.

Chairman of steering group: Christian Gräslund from SKI

SÄK-1: Probabilistic risk analysis and licensing
SÄK-3: Small break LOCA analysis
SÄK-4: Corrosion in nuclear power plants
SÄK-5: Heat transfer correlations

Human reliability, **LIT**.

Chairman of steering group: Björn Wahlström from VTT

LIT-1: Human errors in service and maintenance
LIT-2: Safety oriented organisation and human reliability
LIT-3.1: Data supported planning
LIT-3.2: Computer-aided operation of complex systems
LIT-3.3: Experimental validation of operator support
LIT-4: Planning and evaluation of operator training

Radioactive waste, **AVF**.

Chairman of steering group: Poul Emmersen from the Danish Nuclear Inspectorate

AVF-1: Reactor waste from abnormal occurrences
AVF-2: Long-term properties of waste products
AVF-3: Project catalogue of Nordic R&D waste projects
AVF-4: Hydrocoin
AVF-6: Decommissioning

Quality Assurance, **KVA**.

Chairman of steering group: Börje Ahlnäs from ASEA-Atom

Radioecology, **REK**.

Chairman of steering group: Jan Olof Snihs from SSI

REK-1: Large reactor accidents, consequences and countermeasures
REK-2: Intercalibration
REK-5A: Methods and Biotest
REK-5B: Models and measured data

Note 6.2-C: Members of *NKS* 1981-85

Jon O. Berg, Niels Busch, Thomas Eckered (followed by Per-Eric Ahlström), Poul Emmersen/Per Suhr, Lars Högberg (followed from 1984 by Lennart Hammar), Mauri Kuuskoski (followed by Anders Palmgren from 1983), Marcus, Sören Norrby, Jan Olof Snihs, Veikko Palva; later also Tapio Eurola, and Kaare Øfjord.

Note 6.2-D: Evaluators of the Second NKS programme

Ami Rastas and Bjarne Regnell (SÄK), Mats Danielsson (KVA), Kåre Netland (LIT), Bengt Edwall (AVF), Uffe Korsbech (REK); Lennart Hammar and Pekka Silvennoinen (NKS).

Note 6.3-A : Members of *NKS* 1985-89

Per-Eric Ahlström, Jon O. Berg, Poul Emmersen, Tapio Eurola (followed by Jukka Laaksonen), Lennart Hammar, Sigurður Magnússon, Marcus, Søren Mehlsen, Bjarne Micheelsen, Sören Norrby, Anders Palmgren (followed by Bjarne Regnell), Pekka Silvennoinen, (Ingvard Rasmussen), Kaare Øfjord (followed by Knut Gussgard), Jan Olof Snihs, and, from 1987 Svante Nyman.

Note 6.3-B: The Third NKS programme

Release, dispersion and environmental effects, **AKT**.

Chairman of steering group: Per-Eric Ahlström from SKB, with Arne Pedersen/Klaus Kilpi and Ulf Tveten as co-ordinators.

AKTI-110:	Nordic project group
AKTI-130:	Benchmark and sensitivity analysis
AKTI-150:	Chemical issues
AKTI-160:	Transport of aerosols
AKTU-210:	Dispersion in the environment
AKTU-240:	Winter conditions and rural areas
AKTU-242:	Nordic Chernobyl data base
AKTU-270:	Health/economic consequences and countermeasures

Radioactive waste management, **KAV**.

Chairman of steering group: Pekka Silvennoinen from VTT, with Leif Moberg as co-ordinator.

KAV-315: Models for safety analysis
KAV-330: Geological aspects
KAV-350: Decommissioning
KAV-360: Transportation
KAV-390: Waste from a larger activity release

Risk analysis and safety philosophy, **RAS**.

Chairman of steering group: Lennart Hammar from SKI, with Gunnar Johansson/Bo Liwång as co-ordinators

RAS-410: Optimation of radiation protection in power plants
RAS-430: Natural radiation, nuclear and chemical waste
RAS-450: Optimising of technical specifications
RAS-470: Risk analyses related to PSA
RAS-490: Safety philosophy

Materials, **MAT**.

Chairman of steering group: Søren Mehlsen from ELSAM, with Kari Törrönnen as co-ordinator.

MAT-510: Corrosion in sea water systems
MAT-530: Intergranular stress corrosion
MAT-550: Crack arrest
MAT-570: Elastic-plastic fracture mechanics

Advanced information technology, **INF**.

Chairman of steering group: Jon O. Berg from IFE, with Verner Andersen as co-ordinator.

INF-640.1: On-site prototype systems
INF-640.2: Of-site prototype systems
INF-650: Design of experiments and evaluation
INF-660: Experiments with prototype systems

Note 6.3-C: Evaluators of the Third NKS programme

Heikki Kalli (AKT), Heikki Raumolin (KAV), Jørgen Firing (RAS), Christer Jansson (MAT), Arne Jensen (INF)

Note 6.4: The 'Annerberg group' 1986

Rolf Annerberg, Sven Olaf Boman, Poul Emmersen, Atle Fretheim, Suzanne Frigren, Sigurður Magnússon, Antti Vuorinen, Risto Tienari.

Note 8.1: Co-sponsors for the NKS programme 1990-93 and from 1994

Imatran Voima OY, TVO Power Company, the Swedish Nuclear Training and Safety Centre (KSU), the Oskarshamn Power Board (OKG), the Swedish Board for Spent Nuclear Fuel (SKN), the Swedish Rescue Services Board, the Swedish State Power Board (Vattenfall), Sydkraft AB, the Swedish Nuclear Fuel and Waste Management Company (SKB). From 1994 also: the Finnish Ministry of the Interior and the Norwegian Ministry of the Environment.

Note 8.2-A: The NKS Consortium group 1990-93 and from 1994

Knut Gussgard (followed by Ole Harbitz), Lennart Hammar, Sigurður Magnússon, Ilkka Mäkipentti (followed by Sakari Immonen), Bjørn Thorlaksen, Franz Marcus (followed by Torkel Bennerstedt).

Note 8.2-B: *NKS* 1990-93

Knut Gussgard, Lennart Hammar, Sigurður Magnússon, Marcus, Lasse Mattila, Bjarne Micheelsen (followed by Frits Heikel Vinther), Svante Nyman, Anneli Salo (followed by Leif Blomqvist followed by Raimo Mustonen), Bjarne Regnell, Helge Smidt Olsen, Jan Olof Snihs, Olof Söderberg, Bjørn Thorlaksen, Kåre Ulbak, Erik-Anders Westerlund.

Note 8.2-C: The Fourth NKS programme

Emergency preparedness, **BER**.

Chairman of reference group: Leif Blomqvist with Erling Stranden as co-ordinator;

BER-1: Dispersion and environmental consequences
BER-2: Measurement and exchange of data
BER-3: Intervention procedures and levels
BER-4: Information to the public
BER-5: Emergency exercises
BER-6: Recovery of contaminated areas

Waste and decommissioning, **KAN**.

Chairman of reference group: Kåre Ulbak from the Danish Institute of Radiation Hygiene, with Johan Andersson as co-ordinator;

KAN-1.1: Clearance from regulatory control
KAN-1.2: Decommissioning of a pilot plant
KAN-1.3: Conservation of information
KAN-2: Waste from cleanup of contaminated areas
KAN-3: Geological and climatological processes

Radioecology, **RAD**.

Chairman of reference group: Erik-Anders Westerlund from the Norwegian Radiation Protection Authority, with Henning Dahlgaard as co-ordinator;

RAD-1: Education, quality assurance
RAD-2: Aquatic radioecology
RAD-3: Agricultural radioecology
RAD-4: Natural ecosystems

Reactor safety, **SIK**.

Chairman of reference group: Lennart Hammar from SKI with Risto Sairanen as co-ordinator.

SIK-1: Safety evaluation
SIK-2: Severe accidents
SIK-3: Safety of neighbouring reactors

Note 8.2-D: Evaluators of the Fourth NKS programme

Göran Steen (BER), Leiv Berteig (KAN) and Heikki Niini (KAN-3), Olli Paakkola (RAD), Paul Ølgaard (SIK)

Note 8.4-A: The Fifth NKS programme and its project leaders

Reactor safety: **RAK**.

Chairman of reference group: Bjørn Thorlaksen from the Danish Emergency Management Agency

RAK-1: Strategy for reactor safety. Kjell Andersson.
RAK-2: Prevention of severe reactor accidents. Ilona Lindholm.

Waste Management: **AFA.**

Chairman of reference group: Erling Stranden from the Norwegian Radiation Protection Authority

AFA-1: Safety at disposal of waste. Karin Brodén.

Radioecology and Emergency provisions: **EKO.**

Chairman of reference group: Sigurður Magnússon from the Icelandic Radiation Protection Institute

EKO-1: Marine radioecology. Sigurður Emil Pálsson.
EKO-2: Long ecological half-lives in semi-natural systems. Tone D. Bergan
EKO-3: Preparedness strategy and procedures. Jens Hovgaard.
EKO-4: Emergency preparedness and information. Eldri Naadland.
EKO-5: Planning for clean-up operations. Thomas Ulvsand.
as well as
SAM-4: Information issues. Vibeke Hein.

Note 8.4-B: The *NKS* Board 1994-97

Magnus von Bonsdorff, Torkel Bennerstedt, Ralf Espefält, Lennart Hammar (followed by Christer Viktorsson), Sigurður Magnússon, Benny Majborn, Franz Marcus (until 1995), Lasse Mattila, Raimo Mustonen, Magne Røed, Pekka Salminen, Helge Smidt Olsen, Jan Olof Snihs, Erling Stranden, Bjørn Thorlaksen, Kaare Ulbak.

References

There has never been a central archive for documents and minutes of meetings related to Nordic co-operative ventures in the nuclear field. This is a consequence of the decentralised set-up where essential co-operation takes place directly between the organisations involved. The author of this story had many working documents available in his own files, but many of them were of intermediate character and will not be readily available in the future.

Below is a list, although in no way complete, of specific references consulted by the author. It should be noted that all minutes of meetings mentioned are in Scandinavian languages.

Minutes of meetings

Early Nordic meetings, for example

13 May 1955 (norske, svenske, danske rådgivende atomenergiutvalg)
18-19 April 1955 (Nordic Foreign Ministers)
17 November 1956 (Nordic expert group under the Nordic Co-ordination group)
5 January 1957 (Nordic Coordination group of Ministers)

The Kontaktorgan

Minutes[1] from the 68 meetings 1957-89 in the *Kontaktorgan* (NKA) can be found in national archives through the ministries that were involved. The same goes for meeting in its *Contact Group*.

Groups initiated by the Kontaktorgan

Minutes from meetings in the *Committee* (NAK) 1968-82 and the *Directors* from 1970 (NA, later NIS) exist in archives at the national research organisations.

Minutes from meetings in the *Officials* (EK/ÄK) and the *Ministers* can be found at the secretariat of the Nordic Council of Ministers in Copenhagen.

[1] Such minutes are not official documents, as noted in the *Kontaktorgan* minutes of its 21st meeting on 6 September 1966

NKS

Minutes exists, partly at research organisations involved, partly at radiation protection and reactor safety authorities, from meetings in *NKS* since 1975, and from steering groups of its project areas since 1977.

The Chiefs

Minutes of meetings of the radiation protection authorities can be found at the authorities (for example at SSI), while others are filed at the nuclear inspectorates.

Others

Minutes exist from a great number of other working groups. Most of these have been filed by the research institutes (the *Committee* energy group, for example), authorities that participated in the work (such as those discussing NORDEK), or by utilities (those related to NORDEL).

Status reports from the *Committee* (NAK):

Statusrapport og organisationsforslag

NAK(70)7, 1970-06-12

Statusrapport for årene 1971 og 1972,

NAK(73)5, 1973-01-26

Statusrapport for perioden 1973 - medio 1975,

NAK(75)4, 1975-07-03

Beretning medio 1975 - ultimo 1977.

NAK(78)1, 1978-04-03

Plans for NKS' four-year programmes, and their evaluation reports:

NU 1976:28	Utvidgat nordiskt samarbete inom kärnsäkerhetsområdet
NORD	Utvärdering av det nordiska kärnsäkerhetsprogrammet 1977-1980
NU B 1980:15	Säkerhetsforskning inom energiproduktionsområdet - Plan för fortsatt nordiskt projektarbete
NORD 1987:7	Evaluering af NKA's sikkerhedsprogram 1981-85
NU 1984:13	Plan för NKA's kärnsäkerhetsprogram 1985-1989
NORD (1990)	Evaluering af NKA's sikkerhedsprogram 1985-89
NU 1989:5	Plan for Nordisk kjernesikkerhetsprogram 1990-1993
NKS (1994)	Evaluering af NKS programmet 1990-93
NKS (1993)	Plan for Nordisk kernesikkerhedsforskning 1994-97

Conference papers by Franz Marcus:

IAEA Geneva 1971:

An approach to regional – Nordic – co-operation in the nuclear energy field (In: Proc. 4th Int. Conf. Geneva, 1971) UN, New York, Vol. 1, page 627

EAES-symposium, Studsvik September 26-27, 1979

Current Co-operation among Energy Research Institutes in the Nordic Countries

IAEA Vienna September 1982:

Regional co-operation in the nuclear field: The Nordic experience (In: Proc. Nuclear Power Experience) IAEA, Vienna, Vol. 5, page 533.

IAEA May 1983 in Seattle:

Nordic co-operation in nuclear waste management (In: Intern. Conf. on Radioactive Waste Management) IAEA, Vienna, Vol. 1, page 287.

UN Geneva 1987:

Regional co-operation – The Nordic experience. (In: United Nations Conference for the Promotion of International Co-operation in the Peaceful Uses of Nuclear Energy) UN, New York, Technical reports, Vol.1, page 1

Nordic Radiation Protection Society Reykjavik 1996
Nordic co-operation in nuclear safety (In: Proc. nrps) Geislavarnir ríkisins, Reykiavik, page 57

Interviews

Many people were interviewed by the author of the story, among them the following 56 persons

From Denmark:

Verner Andersen
Per Erik Becher
Hans von Bülow
Niels Busch
Finn Erskov
Henny Fredriksen
Per Frederiksen
Kay Heydorn
Niels W. Holm
Kurt Lauridsen
Aksel Olsen
Eva Petersen
Klaus Singer
Paul Ølgaard
Asker Aarkrog

From Finland:

Magnus von Bonsdorff
Pekka Jauho
Ilkka Mäkipentti
Jorma K. Miettinen
Olli Paakkola
Björn Palmén
Anders Palmgren
Veikko Palva
Bjarne Regnell
Pekka Silvennoinen
Antti Vuorinen

From Iceland:

Magnús Magnússon
Ágúst Valfells

From Norway:

Torolf Berthelsen
Thorstein Bøhler
Gordon Christensen
Viking O. Eriksen
Karen Garder
Leiv Berteig
Knut Gussgard
Rolf Lingjærde
Per Ole Nielsen
Kjell Solberg
Ulf Tveten
Nils Godtfred Aamodt

From Sweden:

Per-Eric Ahlström
Bo Aler
Pehr Blomberg
Paul Ek
Erik Haeffner
Lennart Hammar
Arne Hedgran
Erik Hellstrand
Lars Högberg
Alf Larsson
Bo Lindell
Peter Margen
Shankar Menon
Jan Nistad
Svante Nyman
Hans-Göran Thorén

Articles, books etc. consulted by the author

H.v. Bülow:	Atomenegisamarbejdet i Europa, Økonomi og politik (Copenhagen) 2-3 1959
INFCIRC/49	Nordic mutual emergency assistance agreement in connection with radiation accidents. IAEA 8. Nov. 1963
Håkan Sterky	Fragment av mina kärnminnen. Reaktorn 1967 nr. 6 (Studsvik)
NU 1968:15	Indstilling om udvidet kernekraftsamarbejde i Norden, 26. Juni 1968
NU 1969:11	Udvidet nordisk økonomisk samarbejde (Nordek-rapporten)
Industridepartementet	Svensk atomenergipolitik. 1970
Lindell & Löfveberg	Kärnkraften, människan och säkerheten, Allmäna förlaget 1972

NU 1974:4	Convention on the protection of the Environment between Denmark, Finland, Norway and Sweden, 19 February 1974
NAK-brochure	early 1974
NU 1974:26	Nordisk energisamarbejde
Gunnar Randers	Lysår. Gyldendal Norsk forlag 1975.
NU 1975:30	Nordiskt samarbete inom forskning, utveckling och teknologiförmedling på energiområdet
NU 1975:35	NARS Recommendations
Lindh, Grill & Palmgren	Co-ordination of international safety co-operation: the Nordic example. IAEA CN 39, 1980
NU 1981:1	Ökat Nordiskt forskningssamarbete
Liv Linde, NORD 1982	Om teknologi, kommunikasjon og samfunn
xxx	Rapport fra den dansk-svenske komié om Barsebäckverket, marts 1985
xxx	Retningslinier for kontakt vedrørende nukleare anlæg ved grænser mellem Danmark, Finland, Norge og Sverige, *ibid.* Appendix XII.1 (a)
Sven Bergquist	De heta åren, 1985
Devell et al.	How the fallout from Chernobyl was detected in the Nordic countries. Nuclear Europe 11/1986
Sven Lalander	NORDEL 25 år 1963-1988. Jubileumsskrift 1988.
Karl-Erik Larsson	Kärnkraftens historia i Sverige. Kosmos 64:1987
Astrid Forland	På leiting etter Uran. Forsvarsstudier 3/1987
Nuclear Europe	The energy scene in the Nordic countries. Nov 1987
Astrid Forland	Atomer for krig eller fred? Forsvarsstudier 2/1988
Erik Söderman	RAMA III final report, 1989-02
Sigvard Eklund	Några erinringar från utvecklingen av atomenergi i Sverige. Teknikum, Uppsala universitet 1990-01-15
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S.Leijonhufvud	Parantes? 1994
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Abel-Larsen, H. et al.: Heat transfer correlations in nuclear reactor safety calculations, vol. 1 & 2 (1985)

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Elkert, J. et al.: Management of radioactive waste resulting from nuclear fuel damage (1985)

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Radioecology (REK)

Snihs, J.O.: Nordisk radioekologi - en sammanfattning av 4 års nordiskt samarbete (1986)

Tveten, U: Towards more realistic assessment of reactor accident consequences - A Nordic project (1985)

Taipale, T.K.: The sampling and analysing methods of radionuclides used in the Nordic countries for environmental samples (1985)

Ericson, S.O.: Radiological implications of coal and peat utilization in the Nordic countries (1985)

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Aro, I. et al.: Severe accident analyses. A Nordic study of codes (1989)

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Roed, J.: Deposition and removal of radioactive substances in an urban area (1990)

Nuclear waste management (KAV)

Moberg, L.: Aspects of nuclear waste management after a 4-year Nordic programme (1990:114)

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Christensen, T. et al.: Natural radiation, nuclear wastes and chemical pollutants (1990:32)

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Hirschberg, S.: Dependencies, human interactions and uncertainties in probabilistic safety assessment (1990:57)

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Henriksson, S.: Corrosion in seawater systems (1988:102)

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Tveten, U.: Dispersion prognoses and consequences in the environment - a Nordic development and harmonization effort (1995:544)

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Lundby, J.E.: Decommissioning of a uranium reprocessing pilot plant (1994:594)

Jensen, M.: Conservation and retrieval of information - elements of a strategy to inform future societies about nuclear waste repositories (1993:596)

Lehto, J.: Cleanup of large radioactive contaminated areas and disposal of generated waste (1994:567)

Radioecology (RAD)

Dahlgaard, H.: Nordic radioecology - The transfer of radionuclides through Nordic ecosystem to man (Elsevier)

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Pershagen, B.: Nordic studies in reactor safety (1994:544)

Laakso, K. et al.: Safety evaluation by living probabilistic safety assessment and safety indicators (1994:614)

Nonbøl, E.: Design and safety features of nuclear reactors neighbouring the Nordic countries (1994:595)

Kontaktorgan-seminars

From 1973 through 1989 annual seminars were organised by the *Kontaktorgan*. The purpose was in each case to deal with a subject that could lead to subsequent joint Nordic actions. The seminars should also contribute to develop a common view on the subject. Participants in the seminars were selected from different professional areas so as to provide a broad, heterogeneous group of interests. Working groups were always included, so that everybody present would be an active participant.

There were generally around 70 participants at each seminar and they lasted two days. Ample occasions for informal contacts were provided. Scandinavian languages were mostly used, but the indistinct Danish pronunciation gave rise to difficulties, in particular for those Finns who did not have Swedish as their mother tongue. After one of the seminars, a Finnish participant, when asked for written comments, wrote: "Danskan skulle förbjudas" (Danish should be forbidden).

The pages in square brackets indicate where the seminar is mentioned in the text.

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Transportation of nuclear materials.
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Waste: disposal of glassified waste (KBS). With NORDEL.
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Environmental effects of electricity generation. With NORDEL.
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The nuclear fuel cycle in a Nordic perspective.
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Lidingö 26.-27. October 1983 [149]

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Risk analysis. With SRE (Society of Reliability Engineers) and NORDEL.
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Chernobyl. With Nordic authorities for environment and radiation protection.
Skokloster, 3.-4. November 1986 [197]

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Abbreviations and acronyms

ABB	ASEA Brown Boveri
AEC	US Atomic Energy Commission
AE	The Swedish ‘Aktiebolaget Atomenergi’
AEK	Danish Atomic Energy Commission
AFA	Waste projects in Fifth NKS programme
AKT	Release, dispersion and environmental effects projects in Third NKS programme
AO	Waste management projects in First NKS programme
AVF	Waste management projects in Second NKS programme
BER	Emergency projects in Fourth NKS programme
BRS	see DEMA
BWR	Boiling Water Reactor
CEC	Commission for the European Communities
Chiefs	Nordic committee of authorities (radiation protection, reactor safety)
DEMA	Danish Emergency Management Agency
DKK	Danish Kroner
DOE	US Department of Energy
EAES	European Atomic Energy Society
ECU	European Currency Unit
ELSAM	Danish electrical utility
ENEA	OEEC’s European Nuclear Energy Agency
EKO	Radioecology and emergency projects in Fifth NKS programme
EU	European Union
FIM	Finnish Mark
HIM	Finland’s Ministry of Trade and Industry

HSST	NRC's 'Heavy- Section Steel Technology program'
HWR	Heavy Water Reactor
IAEA	International Atomic Energy Agency
IEA	OECD's International Energy Agency
IFA	Norway's Institute for Atomic Energy
IFE	Norway's Institute for Energy Technology
INF	Advanced information technology projects in Third NKS programme
IVO	Finnish electrical utility: Imatran Voima Oy
KAN	Waste and decommissioning projects in Fourth NKS programme
KAV	Radioactive waste management projects in Third NKS programme
KBS	Swedish Nuclear Fuel and Waste Management Co
Kontaktorgan	Nordic Liaison Committee for Atomic Energy
KRAFTIMPORT	Danish electrical utility
KRU	Control room projects in First NKS programme
KSU	Swedish Nuclear Training and Safety Centre
KVA	Quality Assurance projects in Second NKS programme
LOCA	Loss Of Coolant Accident
LOFT	NRC's 'Loss Of Fluid Test' programme
LIT	Human reliability projects in Second NKS programme
LWR	Light Water Reactor
MAT	Material science projects in Third NKS programme
Ministers	Nordic Council of Ministers
MW	Megawatt
MX	Marviken Experiments
MY	Authority projects in First NKS programme
NA	Nordic Atomic Co-operation group
NARS	Nordic Working Group on Reactor Safety
NEA	OECD's Nuclear Energy Agency

NIS	[the *Directors*] Nordic research institutes' committee of directors
NKS	Nordic Committee for Nuclear Safety Research
NPT	Non-Proliferation Treaty
NOK	Norwegian Kroner
NRC	US Nuclear Regulatory Commission
NRPA	Norwegian Radiation Protection Authority
NORDEK	Nordic Economic Community
NUNA	documents related to NORDEK
NVE	Norwegian Water Resources and Electricity Board (Norges Vassdrags- og Elektricitetsvesen)
OECD	Organisation for Economic Co-operation and Development
OEEC	Organisation for European Economic Co-operation
Officials	Committee of senior servants of the *Ministers*
OKG	Swedish utility: Oskarshamnsverkets Kraftgrupp AB
PBF	NRC's 'Power Burst Facility'
QA	Quality Assurance projects in First NKS programme
RA	Radioecology in First NKS programme
RAD	Radioecology projects in Fourth NKS programme
RAK	Reactor safety projects in Fifth NKS programme
RAS	Risk analysis and safety philosophy projects in Third NKS programme
RBMK	Soviet graphite moderated power reactor ("Reaktor Bolshoy Moshscnosty Kipyashchiy" = large effect boiling reactor)
REK	Radioecology projects in Second NKS programme
RKS	Nuclear Safety Board of Swedish Utilities (Rådet för kärnkraftsäkerhet)
SAS	Scandinavian Airlines System
SEK	Swedish Kroner
SIK	Reactor safety projects in Fourth NKS programme
SIS	Danish National Institute of Radiation Hygiene

SMHI	Swedish Meteorological and Hydrological Institute
SKB	Swedish Nuclear Fuel and Waste Management Company (formerly SKBF)
SKI	Swedish Nuclear Power Inspectorate (Statens Kärn-kraftinspektion)
SRV	Swedish State Rescue Board (Räddningsverket)
SSI	Swedish Institute of Radiation Protection (Statens Strålskyddsinstitut)
STUK	Finnish Centre for Radiation and Nuclear Safety
SV	National Swedish Power Board (Statens Vattenfallsverk)
SÄK	Reactor safety projects in Second NKS programme
TMI	Three Mile Island reactor in Harrisburg
TNA	Danish Nuclear Inspectorate
TVO	Finnish electrical utility: Teollisuuden Voima Oy
UNSCEAR	United Nations' Scientific Committee on the Effects of Atomic Radiation
Vattenfall	see SV
VTT	Technical Research Centre of Finland
VVER	Soviet light water reactor
WMO	World Meteorological Organisation

List of names

The persons listed in this table are those mentioned in the text. Many other persons have contributed actively to the co-operation described. It is somewhat casual who is included and who is not. Apologies for those neglected.

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The Norwegian Institute for Energy Technique
The Swedish Radiation Protection Authority
The Swedish Nuclear Power Inspectorate

Half a Century of Nordic Nuclear Co-operation

By Franz R. Marcus

In 1947 the first approach was made between Norway and Sweden who each had started to develop its own ‘atomic pile’. Nordic co-operation in nuclear energy intensified when all five countries, each in their own way, joined the race towards the use of nuclear energy for electricity generation. Networks built up over several decades were instrumental in putting Nordic countries at the forefront of nuclear development and enabled them to adapt their collaboration to changing needs. As views on nuclear power changed, collaboration focused on safety and environmental concerns. In 1997, after fifty years, emergency preparedness is emerging as one of the greatest issues.

The person employed by the five Nordic countries to organise the practical side of this co-operative venture records its progress from the immediate post-war years to the present day. A citizen of Denmark, he started work in the nuclear field in 1957, initially working in Norway, and in Sweden for periods of time. Since his appointment in 1967 he moved continuously between countries, meeting hundreds of people involved in the collaborative process.

This story is not a scientific study in the usual sense but rather a recollection of events as seen by the author who has reviewed the evidence of the copious files and interviewed many of those who participated over the years. It complements the many national historical records being issued in these years in individual Nordic countries.

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