

NKS-299 ISBN 978-87-7893-375-1

# NKS-R Decommissioning Seminar 2013

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# Abstract

The previous NKS seminar on decommissioning was held at Studsvik in 2010. Since then there has been high activity in the field of decommissioning nuclear facilities and an influx of new people to the field. Therefore Institutt for energiteknikk (IFE) together with ndcon, Statens strålevern (SSV), Dansk Dekommissionering (DD) and Fortum got funding from the NKS for a new decommissioning seminar to take place in 2013 at IFE in Halden, Norway. The title of the seminar was "NKS-R Decommissioning Seminar 2013". It took place Wednesday-Thursday 6-7th November 2013 and provided a good opportunity for the participants to meet colleagues and exchange experiences from completed and on-going decommissioning projects as well as discuss the future. A number of presentations about new knowledge and lessons learned were given in addition to round table discussions where issues and experiences of decommissioning from the Nordic countries were discussed. This report is the final report from IFE to NKS summing up the results and conclusions from the seminar.

# Key words

Workshop; decommissioning, dismantling, nuclear facilities, release, facilities, soil, management, final disposal, waste, training, motivation, planning

NKS-299 ISBN 978-87-7893-375-1

Electronic report, February 2014 NKS Secretariat P.O. Box 49 DK - 4000 Roskilde, Denmark Phone +45 4677 4041 www.nks.org e-mail nks@nks.org



# **NKS-R Decommissioning Seminar 2013**

**Final Report from the** 

# NKS-R Decom-sem, Decommissioning seminar 2013, NKS\_R\_2013\_106 (Contract: AFT/NKS-R(13)106/1)

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### **Acknowledgements**

NKS conveys its gratitude to all organizations and persons who by means of financial support or contributions in kind have made the work presented in this report possible.

# **Disclaimer**

The views expressed in this document remain the responsibility of the author(s) and do not necessarily reflect those of NKS. In particular, neither NKS nor any other organisation or body supporting NKS activities can be held responsible for the material presented in this report.

# 1. Introduction

The previous NKS seminar on decommissioning was held at Studsvik in 2010. Since then there has been high activity in the field of decommissioning nuclear facilities and an influx of new people to the field.

Therefore Institutt for energiteknikk (IFE) together with ndcon, Statens strålevern (SSV), Dansk Dekommissionering (DD) and Fortum got funding from the NKS for a new decommissioning seminar to take place in 2013 at IFE in Halden, Norway.

The title of the seminar was "NKS-R Decommissioning Seminar 2013". It took place Wednesday-Thursday 6-7<sup>th</sup> November 2013 and provided a good opportunity for the participants to meet colleagues and exchange experiences from completed and on-going decommissioning projects as well as discuss the future. A number of presentations about new knowledge and lessons learned were given in addition to round table discussions where issues and experiences of decommissioning from the Nordic countries were discussed.

This report is the final report from IFE to NKS summing up the results and conclusions from the seminar.

# 2. Seminar preparations

The preparations started in the spring 2013 with the establishing of a seminar coordination group. The participants in the group were:

- Anne Sørensen (DD)
- Eurajoki Tapanai (Fortum)
- Naeem Ul Syed (SSV)
- Per Lidar (ndcon)
- Niels-Kristian Mark (IFE) coordinator of the project

In addition István Szőke from IFE had an important role in defining the topics and reviewing the proceedings.

The group created a website with all important information regarding the seminar (<u>http://projects.hrp.no/nks-decom-2013/</u>). After the seminar the presentations, the proceedings and the list of participants were available for download from the website.

In addition, invitations were sent to a large group of people and companies based on the list of the participants from previous NKS seminars and the personal contacts of the coordination group. A copy of the invitation can be found in Appendix 1.

The practical issues in relation to arranging the seminar was very well taken care of by the IFE secretary, Brit-Kari Bjørlo.

### 3. The decommissioning seminar

### **3.1 Objectives**

The objectives of the seminar were to:

- To survey international and national regulations, recommendations and guidelines for the decommissioning of nuclear facilities.
- To exchange experience in the field of nuclear decommissioning from both completed and on-going projects, as well as the latest research and development efforts.

- To identify gaps in current practice and regulation, and define key areas for future research and development.
- To gather and disseminate knowledge in decommissioning, clearance and disposal of waste from decommissioning projects.

# 3.2 Target audience and participants

The conference aimed to bring together operators, regulators, scientists, consultants, and contractors from the Nordic countries (and invitees from other countries) to exchange information and views on a number of the topics related to decommissioning, release of materials and management of waste.

At the seminar were 36 participants representing almost every branch in decommissioning, including operators and regulators. Among them were quite a lot of young people of which several gave a presentation.

In Appendix 2 is a copy of the list of participants with company names and e-mail addresses.

# 3.3 Programme

There were three topical sessions that covered issues relating to:

- Decommissioning and dismantling of nuclear facilities
- Release of materials, facilities and soil (site)
- Management and final disposal of waste from decommissioning projects

On the 2<sup>nd</sup> day group discussions to place followed by presentation of the conclusions in the forum. Five groups were established and the questions to discuss were:

- 1) How can visualisation technology (VR) be used in decommissioning?
- 2) Is motivation of the staff a problem in decommissioning? If so how to improve it?
- 3) How to transfer knowledge in decommissioning?
- 4) The role of the regulator and the operator? And their cooperation? Experiences? Proposals about how to improve it?
- 5) The right approach to decommissioning planning?

In addition there were a conference dinner and a visit to IFE's facilities in Halden where IFE presented the research and activities taking place in the Man Technology Organisation (MTO) and Nuclear Safety and Reliability (NUSP) sectors.

A copy of the program can be found in Appendix 3.

### **3.4 Proceedings and presentations**

In the seminar invitation the following issues was proposed as basis for proceedings and presentations:

- 1) Review and comparison of national and international regulations and recommendations for the decommissioning of nuclear facilities, and the management of waste from decommissioning projects.
- 2) Practical experience from ongoing and completed decommissioning projects, as well as research in the decommissioning area, including the topics below:

A. Clearance of materials, buildings and sites from decommissioning projects.

- B. Management, storage and final disposal of waste from decommissioning projects (waste routes).
- C. Improved radiological characterization for reducing radioactive waste from decommissioning projects.
- D. Creation, optimization, visualization and maintenance of decommissioning plans (incl. resource allocation) and decommissioning databases.
- E. Safety measures (radiological & conventional) for workers and residents (including preparedness for emergencies).
- F. Conservation and transfer of knowledge and experience between decommissioning projects, and to the next generations (for shaping future decommissioning practice).
- G. Training of current and future field operators, supervisors and radiation protection personnel in nuclear decommissioning.
- H. Communication and cooperation between operators, consultants and regulatory agencies (regulatory supervision).
- I. Communication with politicians, the media, and the public (for improving public acceptance).
- J. Decommissioning studies of new plants and facilities in operation.

In the seminar were given 16 presentations including the welcome speech by IFE. In connection with 8 of the presentations were proceedings. The titles of the 15 technical presentations and proceedings with the name of the presenter are given in the table below. The speakers had 20 minutes for the presentation and 5 minutes for questions.

Session 1 Decommissioning and dismantling of nuclear facilities	Chairman: Michael Louka (IFE)
becommissioning and dismanning of nuclear radiates	
Establishing decommissioning plans, managing the transition period betwee	en operation and
decommissioning, and the decommissioning of the pool reactor Thetis in G	ihent, Belgium
Geert Cortenbosch (Bel V)	, 0
Decommissioning of the Danish research reactor, DR3	
Kirsten Hjerrild Nielsen (Danish Decommissioning)	
The Loviisa nuclear power plant decommissioning plan update 2012	
Matti Kaisanlahti (Fortum Power and Heat oy)	
Overview of decommissioning in Sweden A regulator's perspective	
Mathias Leisvik (Swedish Radiation Safety Authority)	
FiR 1 Triga Research Reactor Decommissioning plans, EIA process, Nuclea	r waste issues
Olli Vilkamo (VTT Technical Research Centre of Finland)	
Detailed Decommissioning Studies for the Oskarshamn and Forsmark Nucl	ear Power Plants in Sweden
Gunnar Hedin (Westinghouse Electric Sweden AB Västerås, Sweden)	
Decommissioning Waste Management Planning for the Barsebäck Nuclear	Power Plant
Henrik Widestrand (Vattenfall Research and Development AB)	
Human-centred technologies for nuclear decommissioning	
István Szőke (Institutt for energiteknikk)	

Session 2 Release of materials, facilities and soil (site)	Chairman: <b>Per Lidar (Studsvik)</b>
Scaling factors in clearance measurements on decommissioning waste a Jens Søgaard-Hansen (Danish Decommissioning)	t Danish Decommissioning.
The use of PIPS detectors for measuring pipes Thommy Larsen (Danish Decommissioning)	
Characterization of nuclear waste from decommissioning Xiaolin Hou (Center for Nuclear Technologies, Technical University of Der	nmark)
Determination of Plutonium Isotopes (238Pu, 239Pu, 240Pu, 241Pu) in E Yihong Xu (Center for Nuclear Technologies, Technical University of Denr	nvironmental and Waste Samples nark)
Decomissioning of Ranstad Uranium Works Jonatan Jiselmark (Studsvik Alara Engineering AB)	
Session 3 Management and final disposal of waste from decommissioning projects	Chairwoman: Anne Sørensen (DD)
Treatment and conditioning of metallic intermediate level waste Per Lidar (Studsvik Nuclear AB)	
RPV in-situ segmentation combined with off-site treatment for volume r Per Lidar (Studsvik Nuclear AB)	eduction and recycling

The presentations and proceedings are available for download at the seminar website (http://projects.hrp.no/nks-decom-2013/download/). The password for the site is "nks-halden-2013".

# 4. Group discussions

The group discussions on the last day of the seminar took place in five groups with separate issues and a presentation of the conclusions by each group in a plenary session.

### 4.1 Issues for the discussions

The issues to choose between for the discussions were formulated in the five questions:

- 1) How can visualisation technology (VR) be used in decommissioning?
- 2) Is motivation of the staff a problem in decommissioning? If so how to improve it?
- 3) How to transfer knowledge in decommissioning?
- 4) The role of the regulator and the operator? And their cooperation? Experiences? Proposals about how to improve it?
- 5) The right approach to decommissioning planning?

The groups had approximately 1 hour for the discussions followed by the plenary session, which lasted 45 minutes.

### 4.2 Output from the discussions

The groups discussed enthusiastically their issue and as before the groups felt they could have used even more time. In the plenary session many interesting comments and thoughts were presented. It turned out that the groups had broadened their area of interest finding links to the other issues and the discussion in the plenary session was very fruitful.

### **5.** Conclusions

The overall impression from the seminar is that it was very useful for sharing experience and can contribute to developing a Nordic resource pool on decommissioning. Also the social part of the seminar was successful.

Motivation of the staff is a well-known challenge in decommissioning and compared to the operation of a nuclear site decommissioning the same site represents a very different mindset, and it is a big challenge to keep the staff motivated and to avoid that the best qualified personnel leave. A Nordic seminar like the one reported here could contribute in making decommissioning more interesting for young people as a career path. Therefore one should continue with the NKS seminars in decommissioning. A fine occasion for the next seminar could be a seminar in Finland with a visit to the new reactors under construction there.



# NKS-R Decommissioning Seminar 2013

Updated invitation 09-09-2013

A Nordic seminar on decommissioning of nuclear facilities

#### WEDNESDAY-THURSDAY 6-7<sup>TH</sup> NOVEMBER IN HALDEN, NORWAY

#### Introduction

The last NKS seminar on decommissioning was held at Studsvik in 2010. Since then there has been high activity in the field of decommissioning nuclear facilities and an influx of new people to the field. This seminar will provide an excellent opportunity to meet colleagues and exchange experiences from completed and on-going decommissioning projects as well as discuss the future.

The seminar is being organized by Institutt for energiteknikk (IFE), ndcon, Statens strålevern, Dansk Dekommissionering and Fortum.

Information is available online on the seminar website:

http://projects.hrp.no/nks-decom-2013/

#### **Objectives**

The objectives of the seminar are:

- To survey international and national regulations, recommendations and guidelines for the decommissioning of nuclear facilities.
- To exchange experience in the field of nuclear decommissioning from both completed and on-going projects, as well as the latest research and development efforts.
- To identify gaps in current practice and regulation, and define key areas for future research and development.
- To gather and disseminate knowledge in decommissioning, clearance and disposal of waste from decommissioning projects.

#### **Target audience**

The conference aims to bring together operators, regulators, scientists, consultants, and contractors from the Nordic countries (and invitees from other countries) to exchange information and views on the topics listed in the call for papers below.

#### Working language

The working language of the seminar will be English. All communications, abstracts and papers must therefore be in English.

#### Programme

Three topical sessions will cover issues relating to

- Decommissioning and dismantling of nuclear facilities,
- Release of materials, facilities and soil (site), as well as







- Management and final disposal of waste from decommissioning projects.

There will be a conference dinner in the evening of the first day of the seminar.

In the afternoon of the last day, visits to IFE's facilities in Halden will be arranged. IFE will present the research and activities taking place in the Man Technology Organisation (MTO) and Nuclear Safety and Reliability (NUSP) sectors.

#### **Call for papers**

You are invited to submit one-page abstracts for papers and/or posters (maximum 300 words) addressing one or more of the following topics:

- Decommissioning and dismantling of nuclear facilities,
- Release of materials, facilities and soil (site),
- Management and final disposal of waste from decommissioning projects.

The starting point is that the seminar will span the entire decommissioning field where technical, economical, societal, and other issues are raised. Presentations and discussions may address issues such as

- Review and comparison of national and international regulations and recommendations for the decommissioning of nuclear facilities, and the management of waste from decommissioning projects.
- Practical experience from ongoing and completed decommissioning projects, as well as research in the decommissioning area, including the topics below:
  - a. Clearance of materials, buildings and sites from decommissioning projects.
  - b. Management, storage and final disposal of waste from decommissioning projects (waste routes).
  - c. Improved radiological characterization for reducing radioactive waste from decommissioning projects.
  - d. Creation, optimization, visualization and maintenance of decommissioning plans (incl. resource allocation) and decommissioning databases.
  - e. Safety measures (radiological & conventional) for workers and residents (including preparedness for emergencies).
  - f. Conservation and transfer of knowledge and experience between decommissioning projects, and to the next generations (for shaping future decommissioning practice).
  - g. Training of current and future field operators, supervisors and radiation protection personnel in nuclear decommissioning.
  - h. Communication and cooperation between operators, consultants and regulatory agencies (regulatory supervision).
  - i. Communication with politicians, the media, and the public (for improving public acceptance).
  - j. Decommissioning studies of new plants and facilities in operation.





The abstracts, as well as the papers and the presentations, should be written in English. Supplement your abstract with author name(s), company or organization, contact details and presenters.

#### EXTENDED DEADLINE FOR ARRIVAL OF ABSTRACTS IS FRIDAY 20<sup>TH</sup> SEPTEMBER 2013

Abstracts are reviewed by working groups, one group per session. Authors of accepted papers and posters will be notified no later than Friday 27<sup>th</sup> September 2013.

For accepted papers for oral presentation:

# DEADLINE FOR SUBMISSION OF FULL PAPER AND ASSOCIATED POWER POINT PRESENTATION IS FRIDAY $11^{\rm TH}$ OCTOBER 2013

This deadline also applies for copies of accepted poster presentations.

#### **Documentation**

A report with papers, presentations and posters and conclusions from the group discussions will be produced and distributed to all participants after the seminar.

#### **Participation**

All persons wishing to participate in the seminar are requested to register at the seminar website.

#### THE LAST DAY FOR REGISTRATION IS MONDAY 23<sup>RD</sup> SEPTEMBER 2013

#### Costs

The fee for participating in the seminar is NOK 2 800.

The fee includes lunches, ingestion during coffee breaks and the conference dinner in addition to the seminar documentation.

The seminar fee can be paid with a credit card when you register via the seminar website.

#### Accommodation

A hotel room can be booked via IFE through the seminar website. IFE has reserved a large number of rooms at the hotel where the seminar will take place and at a nearby hotel. Both hotels are in the centre of Halden, just a short walk from the railway station. For additional information, please visit the seminar website.

#### **Contact**

More information is available on the seminar website:

#### http://projects.hrp.no/nks-decom-2013/

If you have questions or concerns about the seminar program please contact:

#### Niels-Kristian Mark (mailto:niels.kristian.mark@hrp.no).

He is also the recipient of all documentation (abstracts, papers, presentations, etc.) related to the seminar.

If you have questions or concerns about the accommodation, food, payment, travel or other practical issues please contact:

Brit-Kari Bjørlo (mailto:brit.kari.bjorlo@hrp.no)

# 6.2 List of participants









List of participants at the NKS seminar 6-7 <sup>th</sup> November 2013 in Halden			
Last name	First name	Email	Company short name
Cortenbosch	Geert	genevieve.lauwers@belv.be	Bel V
Xu	Yihong	yihxu@dtu.dk	Center for Nuclear Technologies, Technical
	(kulla	22	University of Denmark
Hou	Xiaolin	xiho@dtu.dk	Center for Nuclear Technologies, Technical
			University of Denmark
Hannesson	Haraldur	harh@dekom.dk	Danish Decommissioning
Larsen	Thommy	tla@dekom.dk	Danish Decommissioning
Nellemann	Thomas	tne@dekom.dk	Danish Decommissioning
Nielsen	Kirsten	khn@dekom.dk	Danish Decommissioning
Soegaard-Hansen	Jens	jens.soegaard@dekom.dk	Danish Decommissioning
Sørensen	Anne De Maeyer	anne.soerensen@dekom.dk	Danish Decommissioning
Sjöholm	Jan	jan.sjoholm@ebsteknik.se	Extrem borr & sågteknik SP AB
Sjöholm	Dorthe	dorthe.thell@ebsteknik.se	Extrem borr & sågteknik SP AB
Ek	Mirkka	mirkka.ek@fortum.com	Fortum Power and Heat Ltd
Kaisanlahti	Matti	matti.kaisanlahti@fortum.com	Fortum Power and Heat oy
Kallio	Harriet	harriet.kallio@fortum.com	Fortum Power and Heat Oy
Bratteli	Joachim	Joachim.Bratteli@hrp.no	Institutt for energiteknikk
Edvardsen	Svein Tore	Svein.Tore.Edvardsen@hrp.no	Institutt for energiteknikk
Louka	Michael	Michael.Louka@hrp.no	Institutt for energiteknikk
Mark	Niels-Kristian	niels.kristian.mark@hrp.no	Institutt for energiteknikk
Porsmyr	Jan	Jan.Porsmyr@hrp.no	Institutt for energiteknikk
Szöke	lsván	lstvan.Szoke@hrp.no	Institutt for energiteknikk
Niittymäki	Henri	henri.niittymaki@stuk.fi	Radiation and Nuclear Safety Authority
Norberg	Thomas	thomas.norberg@solvina.se	Solvina AB
Syed	Naeem Ul Hasan	naeem.ul.syed@nrpa.no	Statens Strålevern
Nästrén	Catharina	catharina.nastren@ssm.se	Strålsäkerhetsmyndigheten
Jiselmark	Jonatan	jonatan.jiselmark@studsvik.se	Studsvik ALARA Engineering
Vreede	Patrick	patrick.vreede@studsvik.com	Studsvik ALARA Engineering
Lidar	Per	per.lidar@studsvik.se	Studsvik Nuclear AB
Strid	Karin	karin.strid@studsvik.se	Studsvik Nuclear AB
Leisvik	Mathias	mathias.leisvik@ssm.se	Swedish Radiation Safety Authority
Enlund	Henrik	henrik.enlund@vattenfall.com	Vattenfall Research and Development
Widestrand	Henrik	henrik.widestrand@vattenfall.com	Vattenfall Research and Development
Sandebert	Camilla	camilla.sandebert@vattenfall.com	Vattenfall research and development AB
Vilkamo	Olli	olli.vilkamo@vtt.fi	VTT Technical Research Centre of Finland
Hedin	Gunnar	hedingl@westinghouse.com	Westinghouse Electric Sweden AB
Nordin	Jan	nordinjg@westinghouse.com	Westinghouse Electric Sweden AB
Persson	Per	per.persson@afconsult.com	ÅF



# NKS-R Decommissioning Seminar 2013

# Program for the NKS seminar 6-7<sup>th</sup> November at the Thon Hotel in Halden

WEDNESDAY 6 <sup>Th</sup> NOVEMBER		
08.30-09.00	Registration	
09.00	Seminar opening	Welcome: Jan Porsmyr (IFE)
09.15-12.05	Session 1 Decommissioning and dismantling of nuclear facilities	Chairman: Michael Louka (IFE)
09.15-09.40	Establishing decommissioning plans, managing the transition period between operation decommissioning, and the decommissioning of the pool reactor Thetis in Ghent, Belgiur Geert Cortenbosch (Bel V)	and n
09.40-10.05	Decommissioning of the Danish research reactor, DR3 Kirsten Hjerrild Nielsen (Danish Decommissioning)	
10.05-10.30	The Loviisa nuclear power plant decommissioning plan update 2012 Matti Kaisanlahti (Fortum Power and Heat oy)	
10.30-10.50	Coffee break	
10.50-11.15	Overview of decommissioning in Sweden A regulator's perspective Mathias Leisvik (Swedish Radiation Safety Authority)	
11.15-11.40	FiR 1 Triga Research Reactor Decommissioning plans, EIA process, Nuclear waste issue Olli Vilkamo (VTT Technical Research Centre of Finland)	S
11.40-12.05	Detailed Decommissioning Studies for the Oskarshamn and Forsmark Nuclear Power Pla Gunnar Hedin (Westinghouse Electric Sweden AB Västerås, Sweden)	ants in Sweden
12.05-13.30	Lunch at Haldens klub	
13.30-13.55	Decommissioning Waste Management Planning for the Barsebäck Nuclear Power Plant Henrik Widestrand (Vattenfall Research and Development AB)	
13.55-14.20	Human-centred technologies for nuclear decommissioning István Szőke (Institutt for energiteknikk)	
14.20-16.55	Session 2 Release of materials, facilities and soil (site)	Chairman: <b>Per Lidar (Studsvik)</b>
14.20-14.45	Scaling factors in clearance measurements on decommissioning waste at Danish Decom Jens Søgaard-Hansen (Danish Decommissioning)	missioning.
14.45-15.05	Coffee break	
15.05-15.30	The use of PIPS detectors for measuring pipes Thommy Larsen (Danish Decommissioning)	
15.30-15.55	Characterization of nuclear waste from decommissioning Xiaolin Hou (Center for Nuclear Technologies, Technical University of Denmark)	
15.55-16.20	Determination of Plutonium Isotopes (238Pu, 239Pu, 240Pu, 241Pu) in Environmental a Yihong Xu (Center for Nuclear Technologies, Technical University of Denmark)	nd Waste Samples
16.20-16.45	Decomissioning of Ranstad Uranium Works Jonatan Jiselmark (Studsvik Alara Engineering AB)	









18.30	<b>Guided tour at the Fredriksten fortress</b> (Buss from outside the Thon Hotel) NB: It is recommended to wear good footwear and clothing since the guiding is outdoor	
19.30	Dinner at the Fredriksten kro	
THURSDAY 7 <sup>TH</sup> NOVEMBER		
09.00-12.00	Session 3 Chairwoman:   Management and final disposal of waste from decommissioning projects Anne Sørensen (DD)	
09.00-09.25	Treatment and conditioning of metallic intermediate level waste Per Lidar (Studsvik Nuclear AB)	
09.25-09.50	RPV in-situ segmentation combined with off-site treatment for volume reduction and recycling <i>Per Lidar (Studsvik Nuclear AB)</i>	
09.50-10.10	Coffee break	
10.10-11.20	Group discussions	
11.20-11.55	Group presentations	
11.55-12.00	Seminar closing	
12.00-13.15	Lunch at Thon Hotel	
13.15	<b>Bus departure to IFE</b> NB: Please leave your suitcase at the hotel due to the limited space and the logistics at IFE	
13.30-15.30	Guided tours at IFE	
	- The MTO Labs: The Virtual Reality Lab and the Future Lab	
	- The Halden reactor NB: You will have to show ID at the Halden reactor.	

The presentations and the papers will be available at the NKS seminar website at the end of each seminar day (<u>http://projects.hrp.no/nks-decom-2013/</u>)

Title	NKS-R Decommissioning Seminar 2013
Author(s)	Niels-Kristian Mark
Affiliation(s)	Institutt for energiteknikk
ISBN	978-87-7893-375-1
Date	February 2014
Project	NKS-R / Decom-sem
No. of pages	14
No. of tables	1
No. of illustrations	0
No. of references	0

The previous NKS seminar on decommissioning was held at Studsvik in Abstract 2010. Since then there has been high activity in the field of decommissioning nuclear facilities and an influx of new people to the field. Therefore Institutt for energiteknikk (IFE) together with ndcon, Statens strålevern (SSV), Dansk Dekommissionering (DD) and Fortum got funding from the NKS for a new decommissioning seminar to take place in 2013 at IFE in Halden, Norway. The title of the seminar was "NKS-R Decommissioning Seminar 2013". It took place Wednesday-Thursday 6-7th November 2013 and provided a good opportunity for the participants to meet colleagues and exchange experiences from completed and on-going decommissioning projects as well as discuss the future. A number of presentations about new knowledge and lessons learned were given in addition to round table discussions where issues and experiences of decommissioning from the Nordic countries were discussed. This report is the final report from IFE to NKS summing up the results and conclusions from the seminar.

Key words Workshop; decommissioning, dismantling, nuclear facilities, release, facilities, soil, management, final disposal, waste, training, motivation, planning