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DANSK DEKOMMISSIONERING

European Atomic Energy Society

Combined Meeting

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NATIONAL SURVEY PAPER

DENMARK

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1. INTRODUCTION

Danish Decommissioning (DD) [1] and DTU [2] are the Danish representatives in EAES.

DD is responsible for the decommissioning of the nuclear research facilities at Risø. These facilities are the only nuclear facilities in Denmark.

DTU is the Technical University of Denmark. DTU undertakes education, research, public sector consultancy and innovation within the natural and technical sciences, including nuclear technologies.

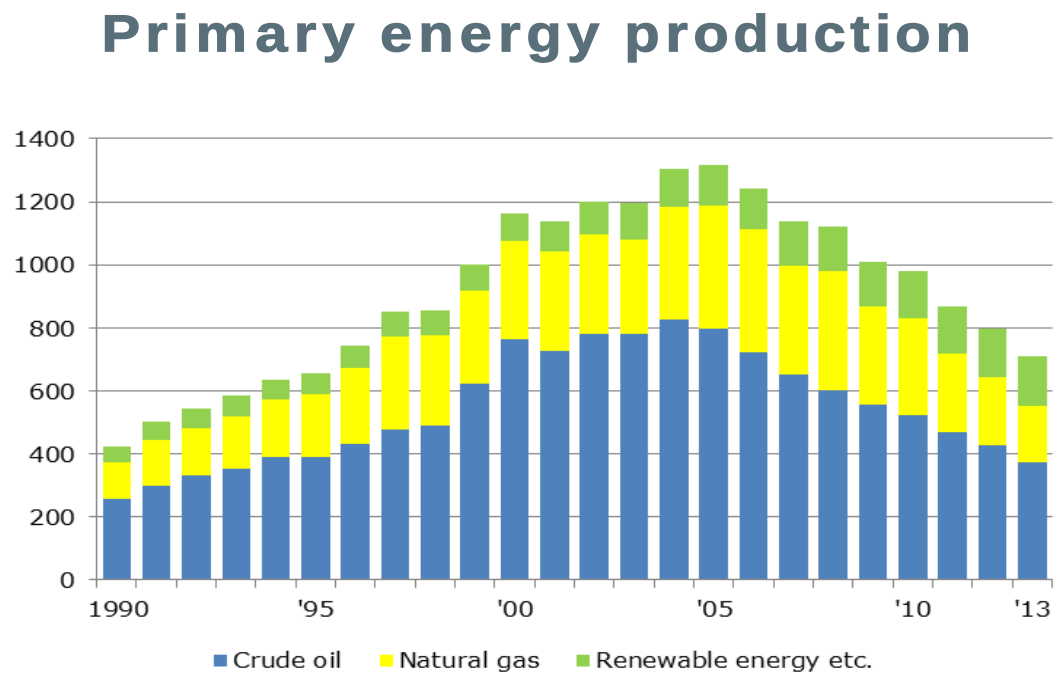
2. ENERGY SOURCES AND PRODUCTION

Denmark has been net self-sufficient in energy since 1997. Self-sufficiency is measured in terms of energy production and consumption, calculated on the basis of energy statistics. Around 2005 the degree of self-sufficiency was more than 200 %. This is now declining. Much of the information given in this report concerning energy sources and production has been taken from the web site of the Danish Energy Agency [3] where further details can also be found.

2.1 Production of oil and gas

In 2010 the oil and gas production came from 19 fields in the North Sea. Mærsk Oil and Gas AS is operator of 15 of these fields, whilst DONG E&P AS is operator of three and Hess ApS of one.

The operators report how much oil, gas and water is produced from each field to the Danish Energy Agency. Gas and oil reserves in Denmark have been decreasing since 2000, cf. the figure below.



Source: www.ens.dk graphs2013.ppt

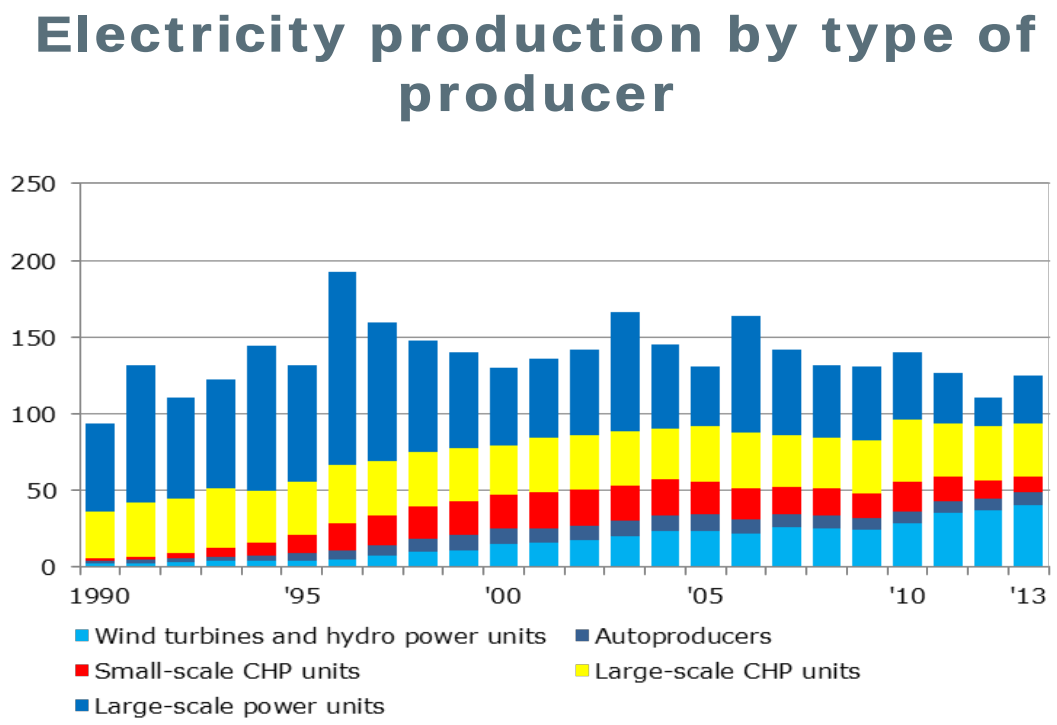
2.2 Production of electricity

Electricity generation in Denmark can be divided into three main types of units:

- central power stations with heat extraction to six urban regions
- decentral CHP plants (combined heat and power) with district heating supply for towns and villages
- wind turbines

Central power stations are located on 15 special sites and primarily use coal and biomass. Decentral CHP plants encompass around 600 generators, industrial and local plants. They typically use natural gas, waste, biogas and biomass. The total capacity of wind turbines was nearly constant from 2002 to 2007, and has increased significantly recent years, mainly by the commissioning of off-shore wind farms. By 2014 wind power's share of domestic electricity supply was 51%. in Denmark West (synchronised with the European Continental grid) and 21% in Denmark East (synchronised with the Nordic grid). With the planned deployment of new off-shore wind turbines the share will increase to more than 50% by 2020 in the country as a whole, compared to 40% in 2014. It means that hourly electricity from wind will vary from zero to far more than the domestic consumption. Thus, the key issue for electricity generation in Denmark will be balancing these variations by a wide range of measures: demand response, heat pumps, electric boilers and heat storages in district heating networks supplied by CHP, individual heat pumps, electric storages, e.g. electric vehicles, and international electricity trade,

The figure below shows the development in the various types of production of electricity (PJ). The very significant variation in power only generation is mainly due to variation in hydro production in Norway and Sweden. The years 1996, 2004, 2006, 2010 and 2013 were particular 'dry' years.



Source: www.ens.dk graphs2013.ppt

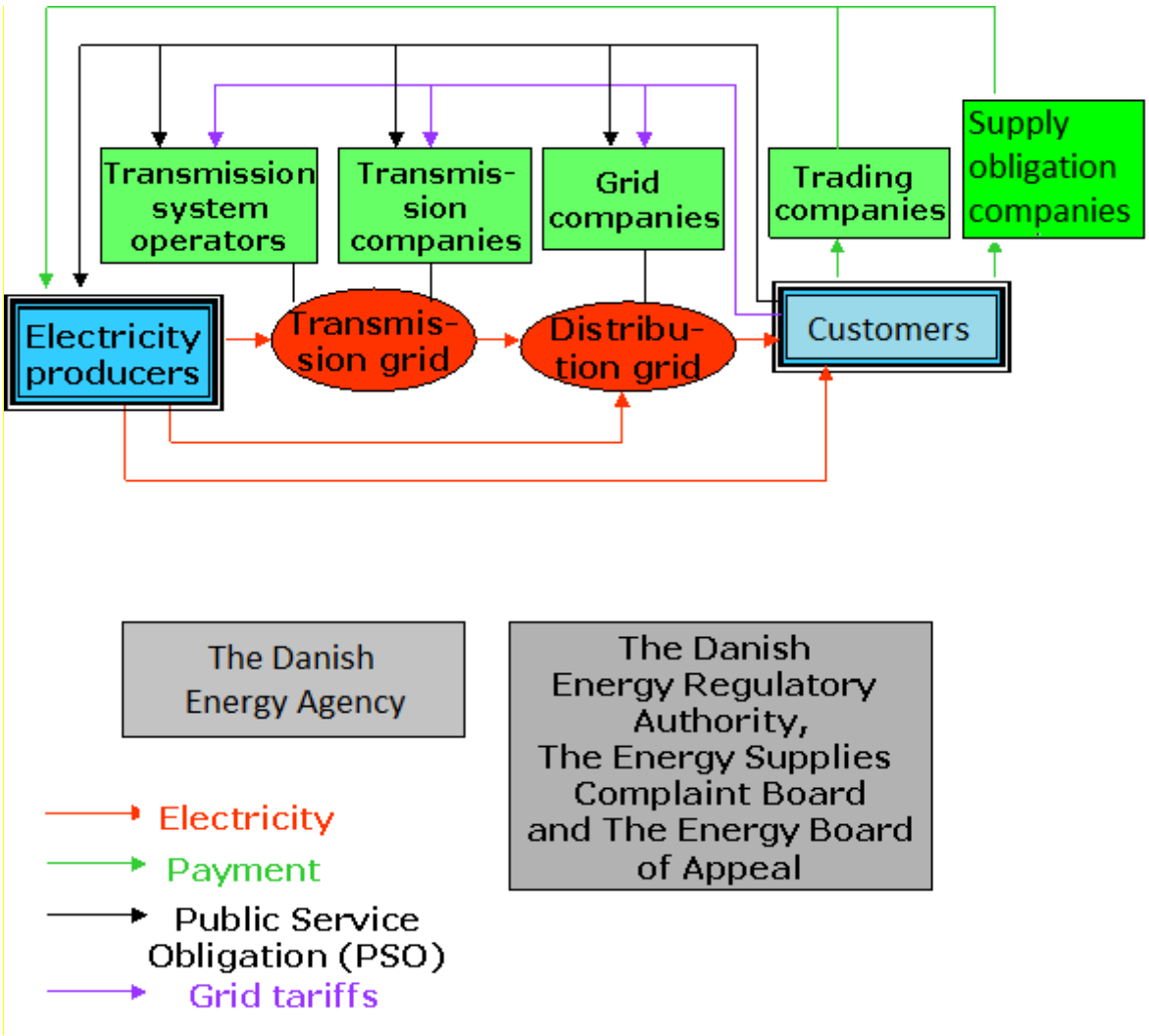
2.3 The electricity market

Since 2005, the state-owned company Energinet.dk has been in charge of maintaining the overall short-term and long-term security of electricity and gas supply and developing the main Danish electricity and gas transmission infrastructure.

Energinet.dk owns the natural gas transmission system and the 400 kV electricity transmission system, part of the transmission grid, and the 600 MW Great Belt HVDC link, which connects the two Danish systems from mid-2010, and is the co-owner of the electrical interconnections to Norway, Sweden and Germany. New connections to neighbouring countries will be developed together with large off-shore wind farms.

The graph on the following page illustrates the structure of the Danish electricity market.

- The transmission system operators have to ensure the function of the system and proper support for producers of environmentally-friendly electricity.
- Transmission companies own and run the transmission grid.
- Grid companies own and run the distribution grid.
- Trading companies trade electricity on a purely commercial basis.
- Electricity companies with an obligation to supply are trading companies obliged to supply electricity to those customers who have not chosen their own supplier in the free market. All such companies have to provide electricity to all customers at reasonable terms and competitive prices.
- The Danish Energy Agency (in few years called The Danish Energy Authority) lays down rules, grants approvals for generating and transmission plants and systems etc.
- The Danish Energy Regulatory Authority (DERA) monitors prices and terms for the collective supply companies and handles complaints against them.
- The Energy Supplies Complaint Board is a private board that handles civil legal complaints between private customers and the energy companies. It also considers cases concerning customer agreements for the purchase and supply of electricity, gas and heat. Finally, it considers cases related to other related goods or services.
- The Energy Board of Appeal is the body that addresses appeals resulting from decisions passed by DERA and the Energy Agency.



Wholesale electricity market prices

Electricity in Denmark is divided into two small markets, each with strong connections to the neighbours, but with no direct connection between each other until 2010. Cross-border trade is significant, but varies with the hydro power production in Scandinavia. Since 1999 and 2000 the two parts of Denmark (east and west of the Great Belt) have been bidding areas with separate area prices of the Norwegian based Nordic Power Exchange, Nord Pool (from March 2010 within Nasdaq OMX Commodities), covering Denmark, Norway, Sweden and Finland and parts of Germany. The hourly variation in wind power range from practically zero to far more than the national electricity consumption. Thus the prediction of wind supply is very significant for the wholesale electricity price.

Nord Pool operates a day-ahead spot market with regional hourly prices (Elspot), an intraday market with continuous power trading up to one hour prior to delivery (Elbas), and a financial market for the following days, weeks, months and annual contracts up to five years. The participants in the markets are power producers, distributors, industries and brokers. On the day-ahead market a 'system price' is calculated covering the whole area of Nord Pool assuming no network constraints. In hours when congestion occurs on interconnections between bidding areas (Finland, Sweden, Norway (divided in two or more areas), and Denmark (east and west) separate hourly area prices are calculated

In addition to the spot market, Nord Pool also operates a financial market with futures and forward prices and a range of other prices, including the European Emission Trading system for CO_2 allowances.

Consumer electricity prices

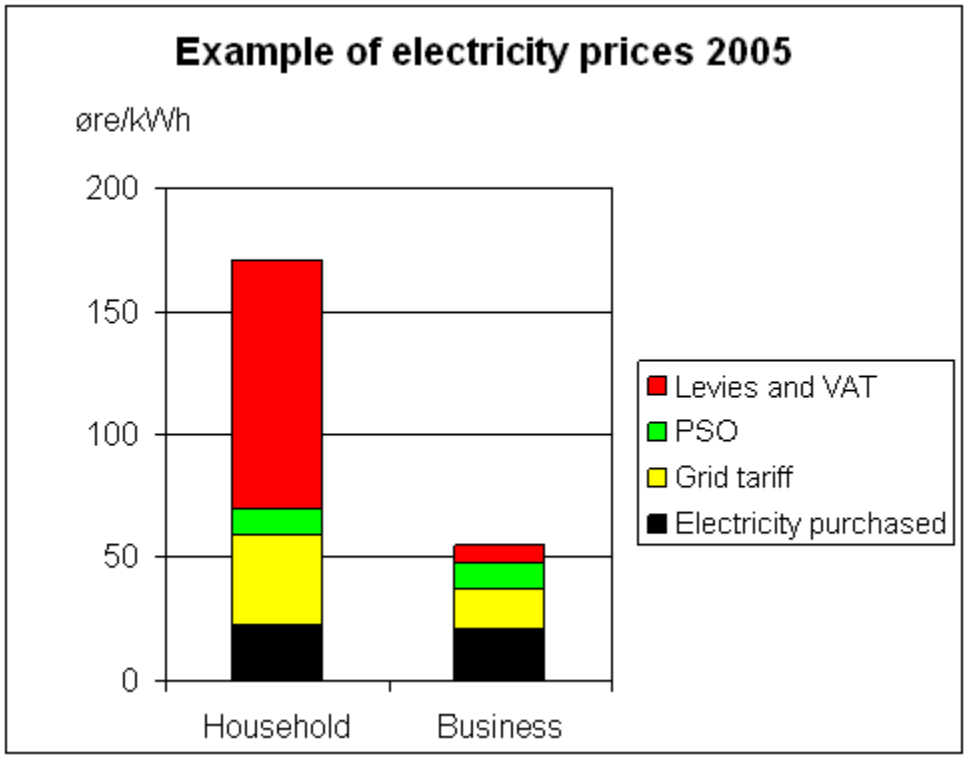
The total price paid by consumers consists of the following elements:

- market electricity price
- grid tariffs, i.e. payments to the grid owner and transmission system operator for transmission
- PSO (public service obligation)
- subscription to grid owner and electricity dealer
- plus state levies and VAT

The total price depends on:

- the consumer category
- grid owner
- location
- market prices etc.

The figure below illustrates the composition of the electricity price for a household with a consumption of 4,000 kWh/year and a business with a consumption of 1,000 MWh/year. The figure is based on numbers from 2005, but the changes since have not been substantial.



2.4 Heat Supply in Denmark

More than 50% of the market for space heating is supplies by district heating (DH), which is being expanded in areas with sufficient beat densities. Areas with less heat density are typically supplied by natural gas for individual boilers. Oil boilers and direct electric heating are used mostly in areas with low densities. DH is produced by incineration of urban waste, combined heat and power plants (CHP), mainly from large plants, and peak-load boilers. More than two-thirds of thermal electricity and district heating generation is CHP. Heat storages are important in district heating systems to allow electricity generation in CHP plants to respond to variations in wind power. Electrical driven heat pumps are supported to replace direct electric heating and oil boilers, which will add to the flexibility in electricity generation.

2.5 Nuclear power

For many years nuclear power has not been an issue in Denmark. The size of nuclear units and their operation pattern is becoming increasingly incompatible with the Danish electricity system, because the key issue is balancing the variations in wind power on a few-days or weekly basis – in addition to the traditional seasonal and annual variations of hydro power in Scandinavia.

Nuclear R&D is limited to the level required to maintain an expertise allowing the government to make independent national assessments, to support the operation and decommissioning of the nuclear facilities at Risø, and to ensure a scientific and technical backup for the authorities. Nuclear related research in Denmark is mainly concerned with radiation protection, nuclear emergency preparedness, radiation in the environment, and applications of nuclear methods in research, industry and the health sector.

DTU and a few other Danish institutions participate in the Nuclear Fission Safety Research Programme of the European Commission, particularly in the radiation protection part of the programme, and also in the Nordic Nuclear Safety Research Programme.

DTU also participates in the EUROfusion Consortium of the EU Horizon2020 Research Programme.

Danish Decommissioning participates in a number of activities under the IAEA related to decommissioning. A DD staff member is also involved in work under the ICRP.

3. POLICY AND R&D IN NON-NUCLEAR ENERGY FIELDS

The Danish energy policy has three focus points: security of supply, climate impact and cost effectiveness. The Danish government stated in its government platform from January 2007 that Denmark should be a green and sustainable society with a visionary climate and energy policy (http://www.ens.dk/en-US/policy/Sider/Forside.aspx). To meet these political goals, various funding schemes offer public grants to R&D in new energy technologies.

EUDP or *Programme for Energy Technology Development and Demonstration* supports the development and demonstration of new energy technologies. The program is headed by an independent Board, appointed by the Minister for Climate and Energy, which decides on EUDP priorities. Administration of EUDP will be carried out by a secretariat in the Danish Energy Agency.

Energinet.dk (the electricity and gas system operator) provides funding for energy RD&D projects concerning environmentally friendly production of power. Further information on www.energinet.dk.

Dansk Energi – (*The Danish Energy Association)* is a commercial and professional organisation for Danish energy companies. It provides funding for energy RD&D projects concerning efficient use of electricity. The programme focus areas are buildings, LED (Light Emitting Diode) lighting and cooling technology. Further information is available on www.danskenergi.dk

Innovation Fund Denmark (formerly The Strategic Research Council) invests in new knowledge and technology creating growth and employment in Denmark. Further information is available on http://innovationsfonden.dk/en

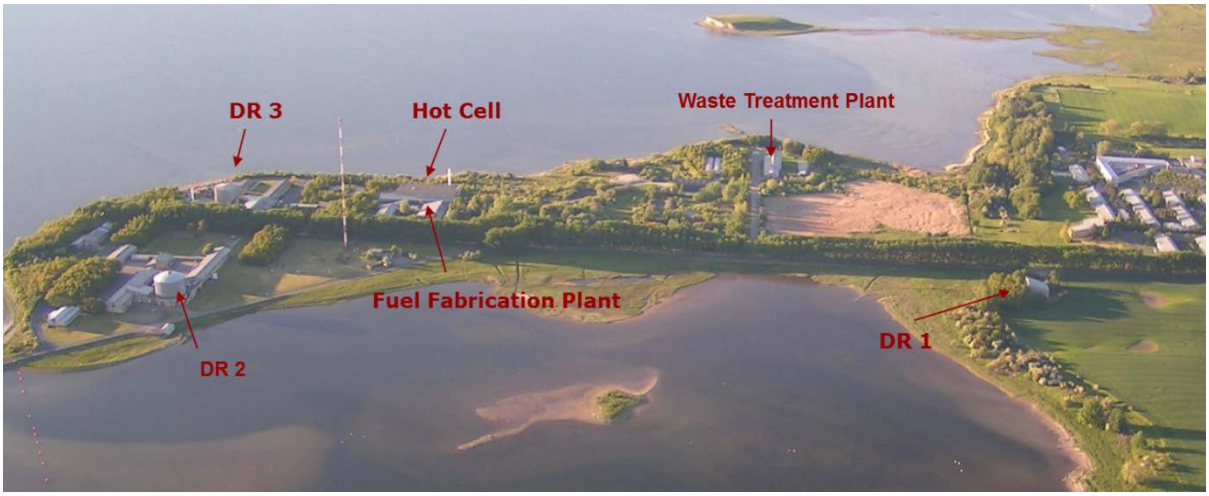
Højteknologifonden (the Danish National Advanced Technology Foundation) aims to enhance growth and strengthen employment by supporting strategic and advanced technological priorities within the fields of research and innovation. The foundation shall make a special effort to promote research and innovation in small and medium-sized enterprises. Support is not restricted to energy technologies, but so far between 20 % and 30 % of the budgets have been allocated to energy technology projects. Further information can be found on www.hoejteknologifonden.dk.

4. DECOMMISSIONING OF THE NUCLEAR FACILITIES AT THE RISØ SITE

4.1. Introduction

At the Risø peninsula in Denmark there were six nuclear facilities to be decommissioned in 2003 including three research reactors (shown in the figure below).

- DR 1 (2 kW, homogeneous core)
  - Fully decommissioned
  - The reactor building and land was released for unrestricted use in 2006
- DR 2 (5 MW, pool type)
  - Fully decommissioned in 2008
  - The reactor building is still in use for other nuclear purposes
- DR 3 (10 MW, heavy water cooled and moderated)
  - Removal of the internal parts are ongoing
  - Decommissioning is planned to be completed in 2018
- Hot Cells (six cohesive concrete cells)
  - Preparations for grid blasting are ongoing
  - Decommissioning is planned to be completed in 2019
- Fuel Fabrication Facility (produced fuel for DR 2 and DR 3)
  - Fully decommissioned in February 2015
  - Release for unrestricted use of the building awaits approval from the nuclear authorities
- Waste Treatment Plant (still in operation)
  - Planning for decommissioning will start in 2016

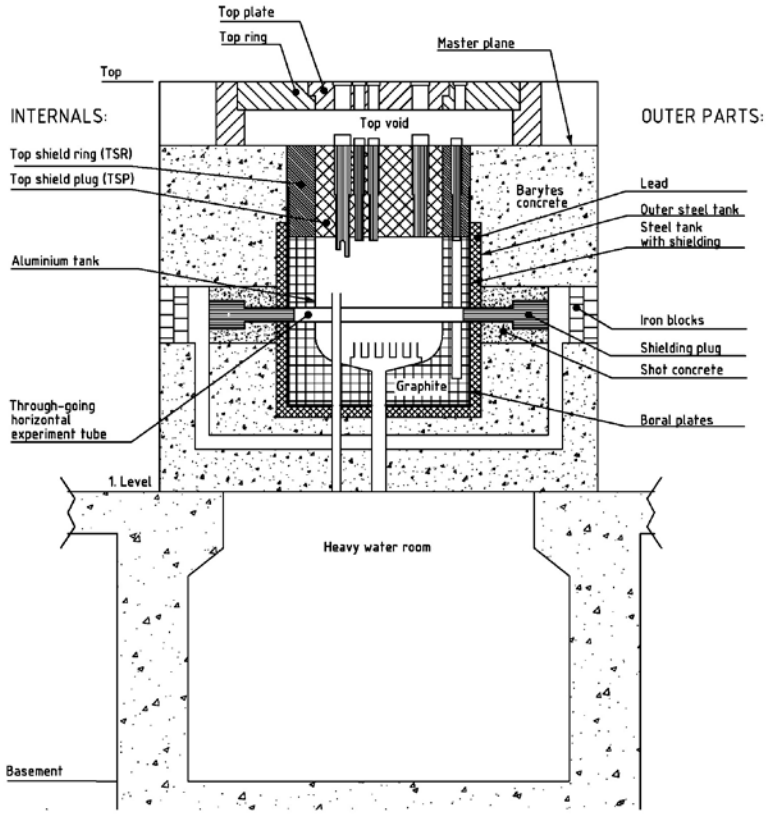


The location of the six nuclear facilities in Denmark at the Risø peninsula.

4.2. Decommissioning progress since the previous report to the EAES CM

Research reactor DR 3

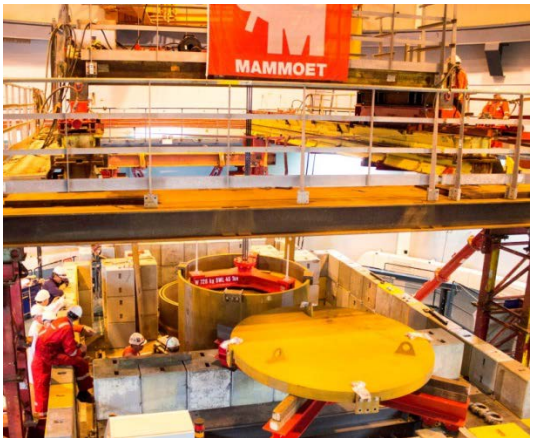
DR 3 (Danish Reactor 3) was a 10 MW_{th} heavy water cooled and moderated research reactor of the PLUTO type (English origin). It was in operation from 1960-2000. The main purpose was material testing, production of isotopes and silicon doping.



A cross sectional view of the DR 3 reactor.

The peripheral systems inside as well as outside the reactor building have been removed previously. The primary cooling system situated below the reactor block has been dismantled too. At the moment the internal parts are being removed.

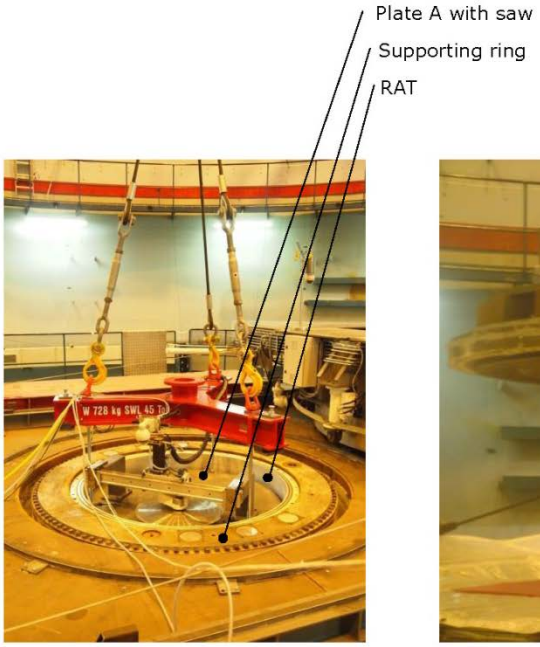
In 2014 a new Movable Top Shield has been installed instead at the reactor top. The Top Shield Plug (TSP) and Top Shield Ring (TSR) were removed from the reactor block using the same method.



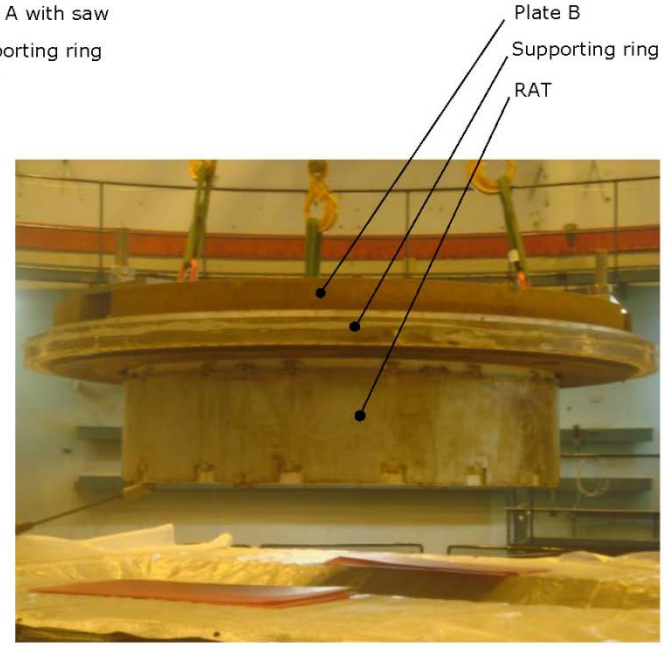
The setting is in place and the final test is performed

TSP in its shielding container being transported out of the reactor building on the SPMT

The upper part of the Reactor Aluminum Tank (RAT) has been cut and removed as well as shown at the pictures below:

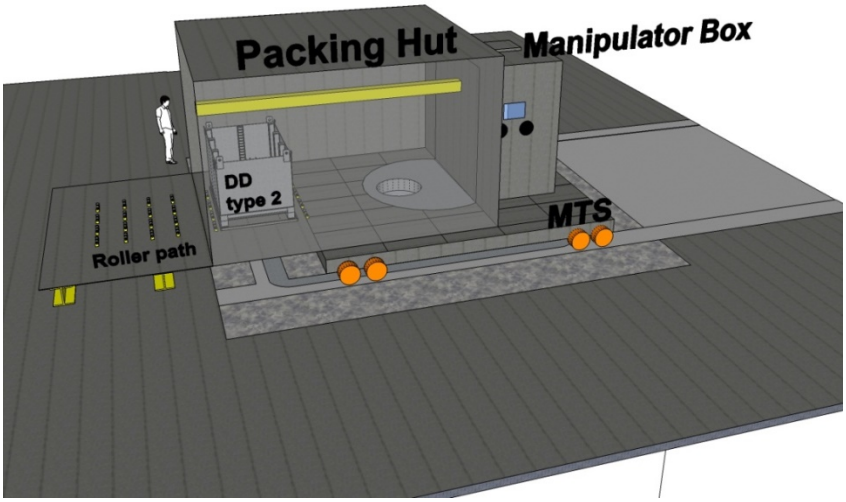


Cutting of the upper part of RAT



The cut off upper part of the RAT with a steel shroud mounted

The next step will be to remove the rest of the RAT and the Graphite reflector by use of a manipulator arm equipped with different tools. At first a packing hut and a manipulator box are to be installed on top of the MTS to keep a closed and controlled area in the reactor pit and be able to pack the waste directly into containers inside the packing hut.



Sketch of the packing hut and manipulator box to be mounted on MTS in June 2015

Next year the planning of the cutting of steel tanks with lead shielding inside and the biological shield will be carried out. The work are planned to be finished in 2017 followed by clearance measurement, final report and approval by the nuclear authorities. The release of the buildings for unrestricted use is estimated to take place in 2018.

The Hot Cell facility

The Hot Cell facility was commissioned in 1964 and operated until 1989. Following a partial decommissioning from 1990 to 1994, only a row of six concrete cells remains as a sarcophagus inside the building. The remaining part of the building has been free released and is now being used for other purposes by Risø DTU.

The current decommissioning started in 2008. The surroundings next to the cells were evacuated but the staff stayed in the rest of the building. This situation with neighbors so close to the hot cells has made the decommissioning work very difficult to carry out due to the limited space and the restrictions on dose rates. Initial work was done but the cells remain untouched.

In mid-2012 a new strategy for the Hot Cell project was chosen. The project was put back into planning phase and an option analysis for remote cleaning of the cells was carried out. As a result of this work the method for lowering the dose rate for manual entry in the cells was chosen: To construct two sets of mechanical arms respectively for remote blasting and for extraction. These arms are now constructed and undergoing tests before use.

It was also decided to rebuild the ventilation system which requires more space inside. Therefore it turned out to be necessary to evacuate more space from offices in the building. Mid 2015 when the additional space will be available the rebuilding of the ventilation system will then start. Afterwards the cleaning of the cells can start.

The Fuel Fabrication Plant

The fuel fabrication plant has been used for the fabrication of fuel elements for DR 2 and DR 3 using enriched uranium powder. It was in operation from 1960-2002.
The decommissioning started in 2013 and has now been completed. The work included cleaning or removal of inventory and equipment as well as surfaces. The final report is presently under preparation and items are awaiting measurements with the purpose of clearance.

Using a wall shaver on tihe ceiling of the room where the uranium powder was handled

Cutting up the floor with hot spots in the uranium handling room

4.3. Final disposal of radioactive waste

In 2003 The Danish Parliament decided that a final repository for Low- and Intermediate level radioactive waste shall be established in Denmark. The preliminary studies were published early May 2011, including the identification of six sites that were singled out as preferable from a geological point of view. In 2012 further geological investigations were carried out on the six sites. By the end of 2012 The Danish Parliament decided that a strategically environmental assessment should be established on the six sites. This work was planned to be carried out in 2013 and to be published in the beginning of 2014. Also in 2012 The Danish Parliament decided to add two other tracks in the work: In parallel to the strategically environmental assessments of sites for final disposal, the possibilities of long term storage or export has to be studied.

At the moment all radioactive waste in Denmark is stored at the Risø-site.

5. References

1. Danish Decommissioning http://www.dekom.dk/english.aspx
2. DTU, Center for Nuclear Technologies, http://www.nutech.dtu.dk/
3. Danish Energy Agency, http://www.ens.dk/en-us/Sider/forside.aspx