National Survey Paper - Denmark

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DANSK DEKOMMISSIONERING

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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. The consumption of various energy products is not distributed in the same way as production, so some products are imported even though, taken overall, Denmark is self-sufficient in energy.

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 [2] where further details can also be found.

In 2010, the total production of oil, gas and renewable energy exceeded the total energy consumption by 21 per cent. This is a decline from previous years, when production exceeded consumption by up to 56 per cent (in 2004). Lower oil production primarily caused this decline.

2.1 Production of oil and gas

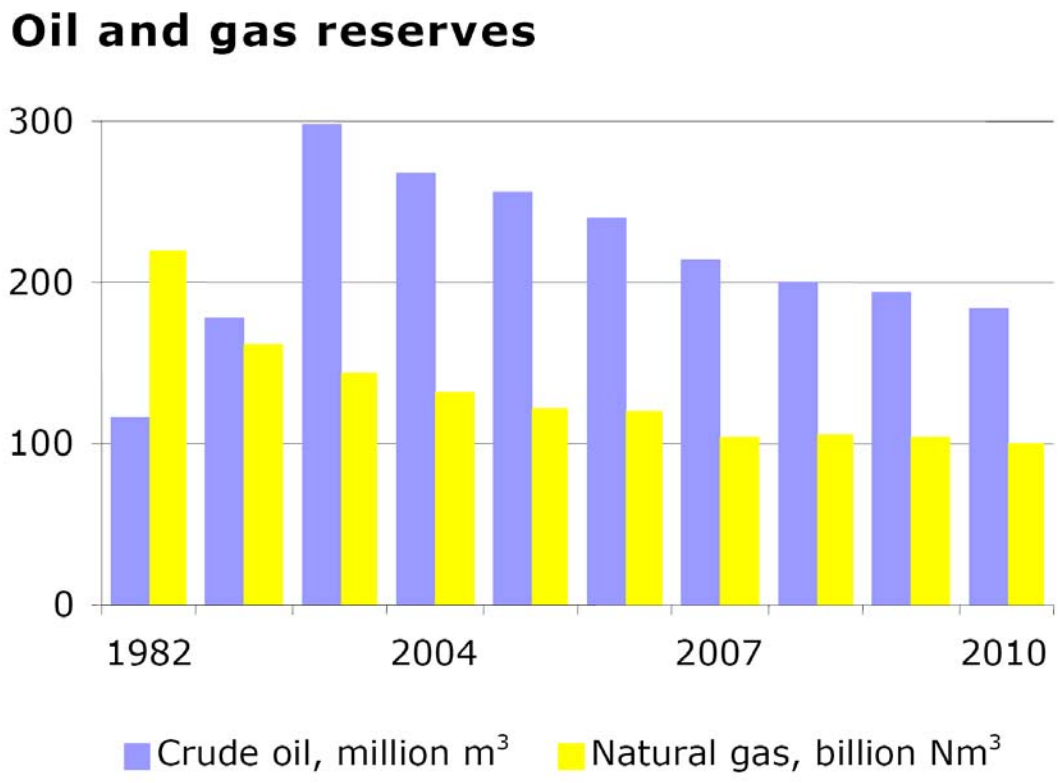
In 2010, oil and gas production was 70 per cent higher than total oil and gas consumption. This is considerably lower than in 2010, where oil and gas production exceeded consumption by 80%, and is primarily due to a large decrease in oil production.

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.

At the beginning of 2006 there were almost 50 platforms in the Danish part of the North Sea and the production was led from the reservoir layers via 130 wells to the production facilities. At the same time water and/or gas was injected into 120 wells so as to increase production.

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.



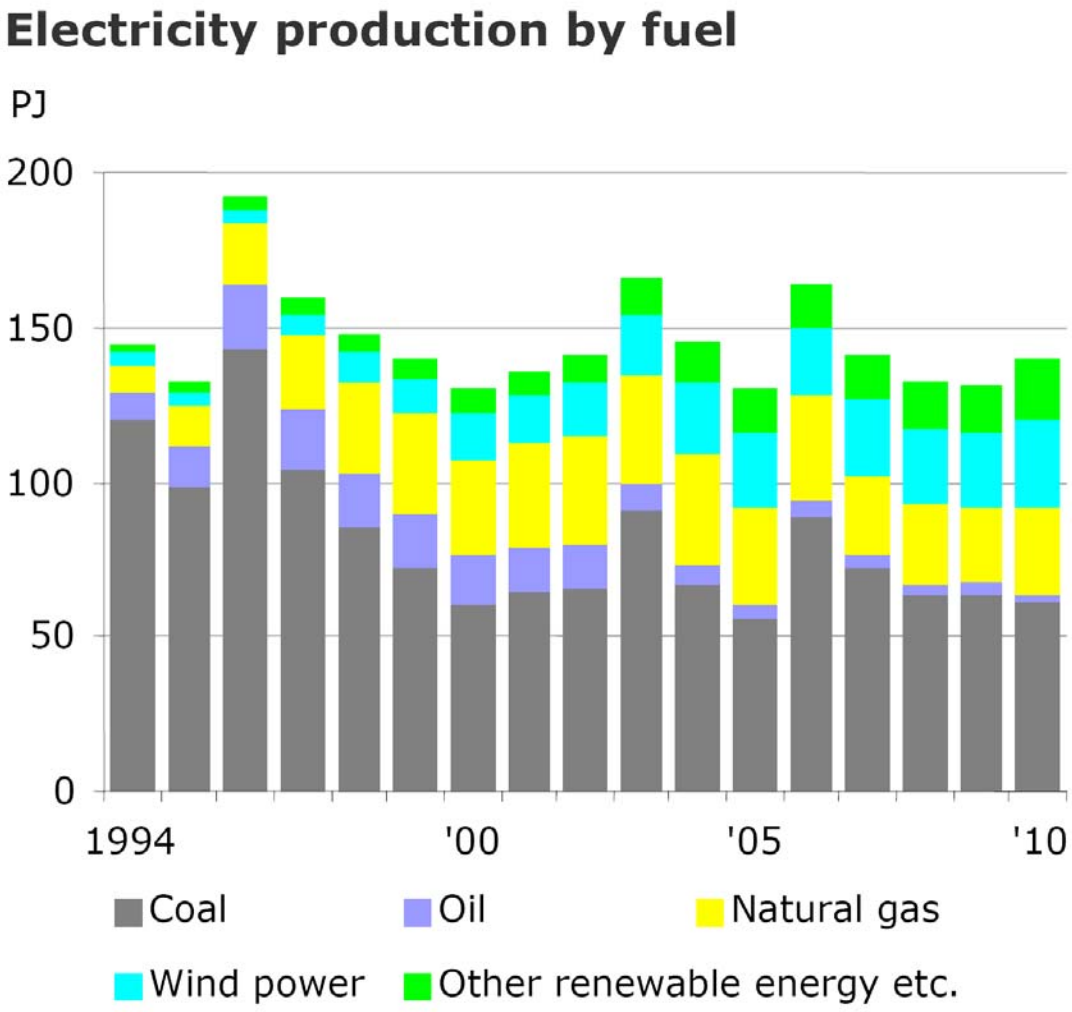
2.2 Production of electricity

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 to a lesser extent biomass. Decentral CHP plants encompass around 600 generators, industrial and local plants. They typically use natural gas, waste, biogas and biomass. The number of wind turbines has declined since 2000, because many small old turbines were replaced by fewer larger plants. The total capacity was nearly constant from 2002 to 2007, and increased recent years, mainly by the commissioning of off-shore wind farms. By 2010 there were 5000 wind turbines with total capacity 3.8 GW. Of these, 400 wind turbines were off-shore turbines with a capacity of 870 MW.

The figure below shows the type of fuel used for the production of electricity (PJ). The very significant variation in coal-fired electricity generation is mainly due to variation in hydro production in Norway and Sweden. The years 1996, 2004 and 2006 were particular ‘dry’ years.



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 that connects the two Danish systems from mid-2010, and is the co-owner of the electrical interconnections to Norway, Sweden and Germany.

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.

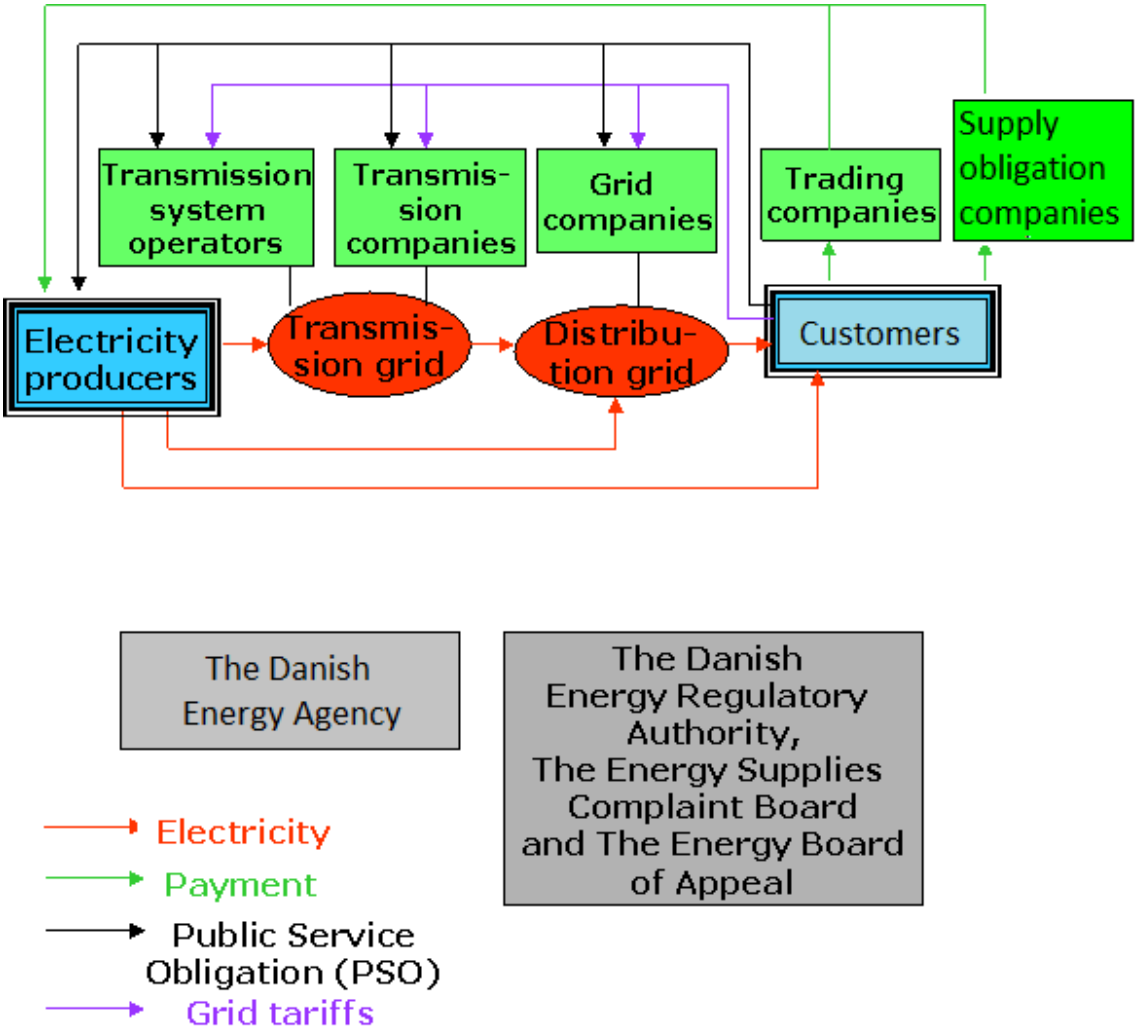
Electricity companies with an obligation to supply are trading companies obliged to supply electricity to those customers who have not chosen their own supplier in the free market. All such companies have to provide electricity to all customers at reasonable terms and competitive prices.

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. In the western part of Denmark the penetration of wind power has increased to 25 % per cent of the consumption on an annual basis. Thus, wind power has a significant impact on the hourly price of electricity. In the eastern part of Denmark wind power covers about 16 % of the consumption.

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.

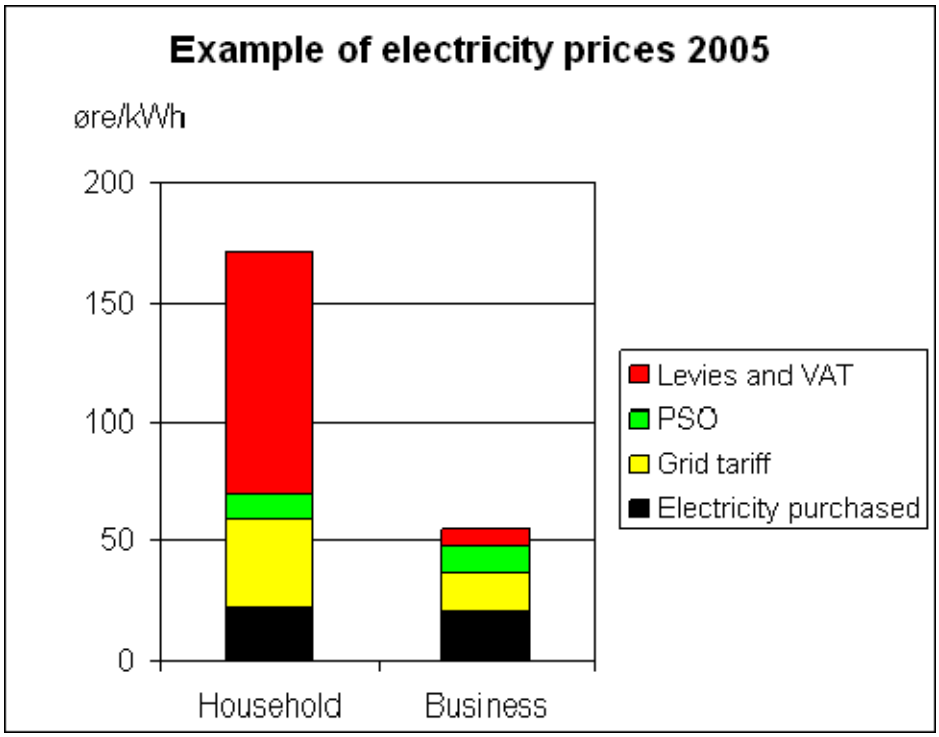
Consumer electricity prices
The total price paid by consumers consists of the following elements:

- 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

In Denmark, various technologies are used to heat buildings and domestic water. Some use oil or gas furnaces and others use bio fuel furnaces (e.g. wood chips, wood pellets or straw). All consumers with their own heating furnaces purchase their own oil, gas or bio fuel.

Most heat consumers - 6 out of 10 - receive their heat from a public heat supply. This is an area in which plants have been built and pipes laid in the ground to deliver hot water (or steam) – known as district heating (DH) – or natural gas to consumers. DH is produced by incineration of urban waste, Combined Heat and Power plants (CHP) or peak-load boilers. CHP produce both heat and electricity. Fuel consumption is thus reduced by about 30% as compared to the separate production of heat and electricity. The spread of co-generated heat and electricity has meant that most plants, which previously generated either heat or electricity, now produce both electricity and heat. Today, about 80% of DH is co-produced with electricity.

Public supply is primarily found in areas in which homes or businesses are in close proximity, that is, in cities and towns. Heating comprises approx. 80 per cent of the energy consumption of private households, excluding energy for transportation.

2.5 Nuclear power

On 29 March 1985 a majority of the Danish Parliament (Socialdemokratiet (the Social Democratic Party), Socialistisk Folkeparti (the Socialist People's Party), det Radikale Venstre (the Danish Social-Liberal Party) and Venstresocialisterne (the Left Socialist Party of Denmark)) adopted a decision on public energy planning without nuclear power.

Nuclear power remains an unpopular issue in the Danish energy debate. However, over the last year more voices have been raised in favour of re-thinking the role of nuclear power, in particular in view of the apparent difficulty in reducing CO_2 emissions. Still, the public attitude to nuclear power remains largely negative.

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 European Fusion Energy 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

The Strategic Research Council supports research in areas politically defined. In 2009 – 2010 the focus is on research themes such as: future energy systems, competitive, environmental technology and the future climate, and a climate adaptation. Further information is available on http://en.fi.dk/.

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

The Risø site is located about 6 km north of the city of Roskilde (about 40 km west of Copenhagen) at the shore of Roskilde Fjord as shown in the photo below. Reactor DR 2 can be seen in the foreground. DR 3 is situated at the left hand side of the peninsula. The Hot Cell facility is the light area with a chimney seen above DR 2. Decommissioning of the nuclear research facilities at the site is carried out by the state organisation Danish Decommissioning, which is organisationally and financially independent from the research laboratory.

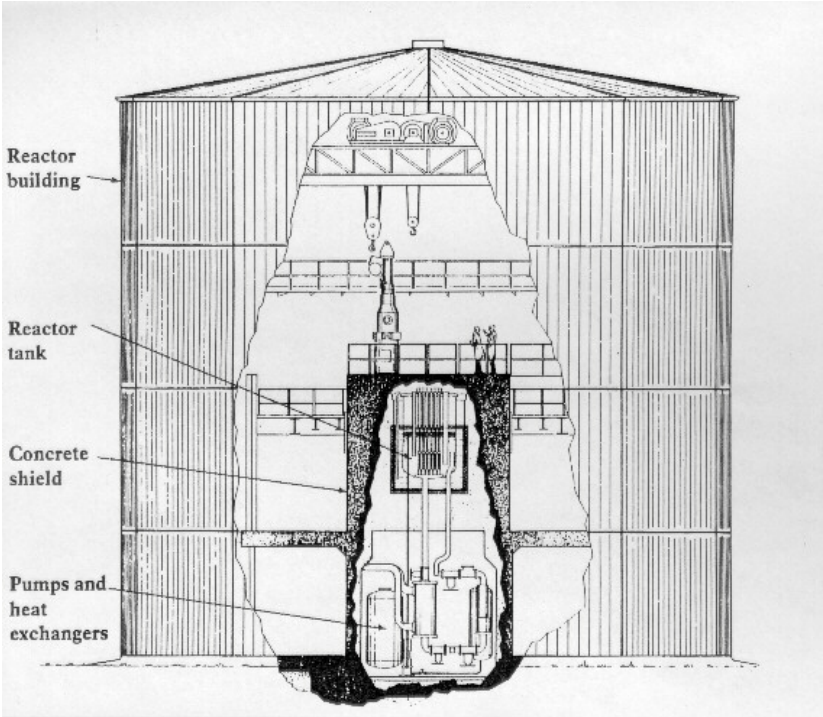
4.2. Decommissioning progress since the previous report to the EAES CM

Research reactor DR 3

DR 3 was a 10 MW tank type reactor with heavy water as moderator and coolant and a graphite reflector. It is of the DIDO/PLUTO family designed in the UK. DR 3 went critical for the first time in January 1960 and since then was operated in a 4-week cycle with 23 days of continuous operation and 5 days shut down. It had its last operation in April 2000 and was finally shut down

in September 2000. After the final shut down the fuel elements were removed and shipped to the US and also the heavy water was shipped away for use as feed in heavy water power reactors.

All peripheral and only slightly active systems have been dismantled. The decommissioning plan for the final dismantling was submitted to the nuclear regulatory authorities in August 2011 and approved in December. Funding for the final dismantling has been granted by the Parliament's Finance Committee, and actual dismantling of the internal, very active, parts of the reactor is planned to commence in 2013 after a number of preparatory works have been carried out in 2012. The decommissioning of DR 3 is expected to be completed by 2018.



Cut-away drawing of DR 3

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 decommissioning of the facility will comprise decontamination of the interior surfaces of the cells by remote controlled grit blasting, followed by a more "hands-on" removal of possible remaining contamination. The surfaces are painted steel lining and steel tables. The majority of the contamination consists of ^{60}Co, partly in the form of 1 mm^3 pellets, and ^{137}Cs plus actinides from the post irradiation examinations of fuel elements.

The project has suffered a number of delays, partly due to difficulties with tendering processes for acquisitions of major equipment. After removal of a number of hot particles by means of remote controlled vacuum cleaning, the grit blasting of the internal surfaces is now planned to start in the last quarter of 2012. Clearance of the facility is expected to be given in 2013.

One challenge that meets the decommissioning project is the fact that the facility to be decommissioned is located inside a building that is being used by the research laboratory. In the sketch below the area demarcated by red line is the cell row itself, while the other areas demarcated by green, violet and turquoise are the working areas for the decommissioning project. All the remaining parts of the building are occupied by offices and laboratories. This situation has proven to be a challenge, both with respect to space and to securing that the radiation levels in the surrounding areas do not exceed levels permissible for the general population.

4.3. Final disposal of radioactive waste

The Danish Parliament has decided that a final repository for Low- and Intermediate level radioactive waste shall be established in Denmark. Over the last three years preparatory studies have been carried out, comprising transport safety studies, a theoretical assessment of three concepts for a repository, and the identification of about 20 possible sites from a geological point of view. These studies were published early May 2011, including the identification of six sites that were singled out as preferable from a geological point of view. Due to general elections in the autumn 2011 the process of selecting fewer locations for more detailed examination has been standing still. However, at the time of writing this the process seems to be moving again with the expectation that the number of candidate locations will be narrowed down to two or three in the autumn 2012.

All waste generated from the decommissioning activities will be stored at the Risø site until a repository has been constructed. A new intermediate storage facility has been established for this purpose.

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