出國報告（出國類別：其他）

赴北歐參訪再生能源、環保、核廢料管理與其生態保育出國報告

服務機關：行政院國家科學委員會
姓名職稱：朱敬一　主委
林宗泰　處長
李佳卉　副研究員
派赴國家：挪威、瑞典
出國期間：102 年 8 月 13 日~8 月 22 日

報告日期：102 年 11 月 11 日

摘要

藉由了解歐洲重要已開發國家其能源安全、儲能、節能及生態保育之政策與技術，行程中會晤挪威再生能源與環保相關機構及瑞典核廢料管理與其生態保育單位。

挪威藉由地利之便，利用豐富的水資源發展完整的水力發電並兼顧環保。發電量除供該國使用外，亦可出售至鄰近國家；瑞典 SKB 為一核廢料管理的顧問公司，在核廢料營運管理及與民眾溝通上具成功經驗，可供台灣參考；永續生態示範區原為一嚴重土壤汙染的區域，藉由淨化汙染土壤、廢棄物處理及水資源再利用等技術，並規劃完整的設施及公共建設，建構成高科技生態城市，成為全世界生態城市的典範。

目　次

壹、目的

了解歐洲重要已開發國家其能源安全、儲能、節能及生態保育之政策與技術為旨，行程中主要為會晤挪威再生能源與環保相關機構及瑞典核廢料管理與其生態保育單位。

行程規劃如下：

月/日 (星期)	行程
08/13 (二)	自台北搭機赴歐
08/14 (三)	訪團拜會挪威代表處
08/15 (四)	參訪奧斯陸再生能源及環境聚落 (Oslo Renewable Energy and Environment Cluster-OREEC) 奧斯陸搭機赴 Trondheim
08/16 (五)	訪團拜會位於 Trondheim 之再生能源暨環境設計中心 (Center for Environmental Design & Renewable Energy-CEDREN) 自 Trondheim 搭機赴 Bergen。
08/17 (六)	週末；資料整理暨訪團工作會議(聽取駐歐盟科技組業務報告)
08/18 (日)	資料整理
08/19 (一)	Oslo 搭機赴瑞典 Stockholm 拜訪 SKB 核能集團 (核廢料處理議題) 拜訪 KTH 皇家科技大學能源系主任 Prof. Torsten Fransson (綠色能源、能源效益、能源儲存議題)
08/20 (二)	參訪 Hammarby sjostad http://www.hammarbysjostad.se/ (永續經營城市) 抵德國法蘭克福與駐德科技組舉行工作餐會
08/21 (三)	自法蘭克福搭機返台

貳、考察內容說明及建議

8/15/13 (Thursday)

I. OREEC - Oslo Renewable Energy and Environment Cluster

A. Host: Per-Olav Louvstad, Project Manager, OREEC；Dr. Arve Holt, Institute for Energy Technology (IFE), Erik Footland, Akerhus Energy(See below)

From left to right: Erik Footland, Akerhus Energy, Per-Olav Louvstad, Project Manager, OREEC；Dr. Arve Holt, Institute for Energy Technology (IFE),

B. Attendees: 朱主委、林處長、曾組長、李教授

C. Host: Per-Olav Lauvstad, Project Manager, OREEC；Dr. Arve Holt, Research Director, Energy and Environmental Technology, Institute for Energy Technology；Bjorn Simonsen, Head of Secretariat, Norwegian Hydrogen Forum/The Hydrogen Council

D. The legal status of OREEC is a Membership Association.

E. Members cover: Renewable energy producers, the supply industry, research institutions, universities and educational institutions, financial institutions and consultants. Currently OREEC has 35 registered members.

F. Objective

1. The overall objective of OREEC is to increase innovation and business development among its members.

G. Activities

1. Competence development for better recruitment

a. (Coordinating cooperation between industry and educational institutions)

b. Provide lecturers from industry to high schools and universities

c. Coordinate students' and universities' needs for bachelor and master projects in industry

d. (Educational programmes on all levels between primary school and university)

2. Internationalization

a. Exploit business opportunities through OREEC's well-established cooperation with international cleantech cluster organizations

3. Innovation through optimized use of resources

a. (Match well established members with financial and other resources with start-ups that represent interesting technologies.)

b. Visualization and mutual exploitation of the cluster's total resources within research, finance, internationalization, commercialization, etc.

c. Participation in lighthouse projects through consortia

d. Stimulating innovation through OREEC's Innovation Park concept

4. Matchmaking, conferences and seminars

H. Focus Areas

1. (Energy recovery from waste)
2. Solar energy - thermal and PV technology
3. Hydrogen and fuel cell for transportation
4. Bio-energy
5. Energy Efficiency
6. Hydropower

I. Discussions

1. 挪威本身有極高的水壩，同時該國的雨量豐富，由於水力發電可以快速供電，所以該國的再生能源不需要思考再生能源的儲存。
2. 該國的電費約為每度台幣 3 元。
3. 由於該國的電費相對低，所以全國的 PowerGrid 均為電網，僅南部地區有一個小的 GasGrid，該國平均每戶用電 20-30kw-hr。
4. 雖然該國有極佳的風場，居民贊成離岸風力，但反對陸基風場，因此目前該國有許多研究在作離岸風力研究，再加上該國雄厚的海洋工程能力，所以這個部份的能力與產業技術相當先進。

5. 該國的 SmartGrid 內部建有完整的 Demand & Response 設計，可以完全依據市場價格、能源供需曲線等，來自動決定採買瑞典電力、打開或關閉水力電廠的渦輪等，以進行「削峰填谷」。

J. Briefing of IFE by Dr. Arve Holt

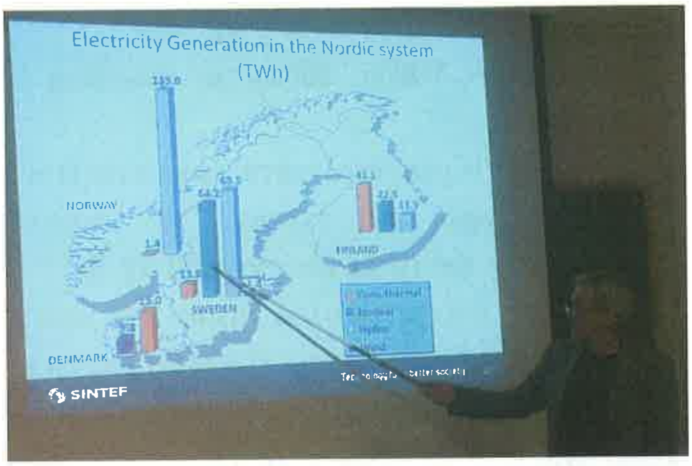
1. Independent foundation established in 1948
2. Contracted research institute
3. Was concentrated on nuclear energy, later converted into energy research
4. Vision: IFE shall be a leading international energy research institute
5. Main activity areas: nuclear safety and reliability, energy and environmental technology, etc.
6. Nuclear safety and reliability
   a. Main activity areas: operation of the Halden research reactor, fuel and material technology, international safety research
   b. 150 employees, turnover US$30Million
7. Safety Man-Technology Organization MTO
   a. Main activity areas: man-machine-communication, control room technology, VR-technology, Hammlab & VR-center: Halden MTO-center, 85 employees, Turnover: US$15Million
8. Nuclear Technology and Physics
   a. Main activity areas: operation of the JEEP II research reactor, nuclear technology, radiopharmaceuticals, electron beam welding
      1. IFE has technology in using nuclear radiation to make a uniformly doped silicon for making high-power ingot. This technology has generated quite a few revenues for its scientific research by making this type of ingot for Asia manufacturers
   b. 100 employees, Turnover: US$33 Million
9. Energy and Environmental Technology
   a. Main activity areas: wind energy, solar cell technology, energy storage, energy system analysis, Geo processes, environmental technology, silicon production, isotope analysis , radioactive waste treatment
   b. 70 employees, Turnover: US$26 Million
10. Wind energy
    a. Main objective model and develop new innovative solutions for

offshore wind: modeling of behavior of offshore wind turbines, concept evaluation and evaluation and development, advanced rotor aerodynamics, wind turbine and park wake

11. Solar cell technology
    a. Main objective model is to develop new novel cost efficient silicon based solar cells: developing improved fabrication processes and concepts, including laser processing, and advanced light trapping; developing characterization methods; investigations of the effect of material quality upon solar cell efficiency
    b. Developed a new silicon technology that can have efficiency up to 20-25% and IFE is looking for investor/funding to develop this technology further.
12. Energy Storage
    a. Main objective is to develop new energy storage solutions for both transport and stationary sector: Li-ion battery development, metal hydride batteries, testing of commercial batteries, hydrogen storage/compression, system integration
13. Energy system analysis
    a. Main objective is to analyze the future energy system in order to fulfil the future energy demand: TIMES/MARKAL, national and international models, energy resources, conversion and transmission, historical and future demand for energy services
14. Geo processes
    a. Main objective is develop better understanding of subsurface earth related to Coe storage and EOR: reservoir processes, reactions, deformation and flow; Co3 utilization and storage, ; generation and expulsion of hydrocarbons; basin modeling/geodynamics
15. Environmental technology
    a. Research focus on development of new materials and technologies, as well energy efficient and environmental friendly processes: gas separation technologies, innovative materials for energy generation, reactor and process technology, pre and post processing of CO2
16. Silicon production
    a. Main objective is develop novel nano to micro sized silicon

particles for solar and other novel application: silicon from silane decomposition; free space, fluidized bed; and centrifuge reactor technology;

17. Waste technology
    a. Main focus is to operate the only radioactive waste treatment plant in Norway: low and intermediate level radioactive waste is handled, R&D on reduction in the waste volume (IFE has capability in handling the high level nuclear waste), operator of the national combined storage/disposal facility for radioactive waste in Himadalen
18. Energy split in some European countries when compared to that of Norway



K. Status for hydrogen for transport in Norway by Bjorn Simonsen (www.hydrogen.no/hydrogenradet)
   1. Oil and gas sector: yearly revenues: $68 billion Kron and with 26% of CO2 emission
   2. Stationary power generation : 3%of total CO2 emission
   3. Land based industry: 22% of total Co2 emissions
   4. Transport sector: 19% of total CO2 emission: due to revenue from oil and land based industry, transport sector is the most attractive sector to cut emissions.
   5. Why ZEVs (Zero Emission Vehicle: battery vehicles) in Norway? (These ZEVs cost 3 times more when compared to normal gas vehicles)
      a. 96% renewable electricity (127 TWh/yr total, st.)
      b. Tax-exemption (Tax: ~100%)
      c. VAT-Exemption (25%)
      d. Access to public transport lanes

e. Free driving on toll-roads
f. Free public parking (and charging)
g. 10% of annual road fee
h. Free passage on ferries
i. OSLO city council announce that there will be 200 electric charging stations every year
j. Results: percentage of population owns ZEVs is the highest in the world, only 24% of these owners are corporate owners

6. Nordic MoU with Toyota, Nissan, Honda, and Hyundai
   a. Intension is the make sure Norway will be the early entry market for internal leading companies
7. CHIC/HyNor Oslo Bus
   a. Fueling station by night and day
   b. 5 VanHool FC buses: 350km per charging (one day total trip distances)
   c. 2 x 60 Nm^3/h electrolyzers (use electricity to split water into hydrogen and oxygen; two compressors to compress hydrogen), daily capacity= 260 Kg H_2
      1. Norway solves the low volumetric energy problem (~1/7 of the oil) by producing the hydrogen on site (Norway has the electric power grid to do the hydrogen production on site)
8. H_2OSL: hydrogen at OSLO airport
   a. Feasibility study completed 2012
   b. Pre-project continues in 2013
9. Oslo/Akerhus
   a. Hydrogen strategy
10. National Hydrogen Action Plan
11. Areas where Norway could play pivotal role
    a. Provider of technology of the market
    b. Early market for FCEV base on the world' s early test market

L. Brief introduction of Akerhus Energy
   1. Hydropower in Norway
      a. 100 companies
      b. 600 power plants
      c. 30,000 MW
      d. Annual capacity: 120TWh
      e. Almost half of the Europe water storage capacity but only 5% of the total energy capacity

2. Economy of Akerhus Energy
   a. Business areas: hydropower, power management, district heating, finance
3. Power production
   a. Number of employees in Akerhus energy ins 84
   b. Number of employees to run 9 power plants is 21+ management 7
4. There is a strong regulation in controlling the amount of water can be used for power production: A water management association runs and controls the regulation dams. A set of rules to maintain the interests of all 16 companies. The prediction is that Norway will have more rainfalls. The flood control capacity is being modified at this moment to accommodate the prediction.
5. The sediments is not a large problem in the dam. However, there is a lot of the unwanted intake that must be excavated from the reservoir almost daily.
6. Akerhus EnergiPark
   a. Wood chips: used primarily in the winter time
   b. Bio-oil (produced from waste of food industry): used primarily to handle the peak load
   c. Bio-gas/landfill: hydrogen production
   d. Heat pump to produce cooling
   e. Solar heat collectors

M. 再生能源電廠(Akerhus EnergiPark)的參觀討論(Host: Per-Olav Louvstad, Project Manager, OREEC, Erik Footland, Akerhus Energy)
1. 改用 thermal pipe 來傳遞熱能，而非使用電流來傳遞能源，這個方法可以讓該地區使用 wood chip，並且藉此將原本單純釋放 CO2 的 wood chip 腐爛程序轉換成能源。除此之外，還使用太陽熱板來加熱水到 80-85 度 C，將熱水輸送到客戶家中，從客戶家中回到熱電廠的溫度約為 60 度 C 左右。
2. 目前挪威每年新長成的木材，超過所使用的木材，所以整體林相在變年輕，許多地方的植披在增加中。
3. 由於挪威約有 90-95%的 electricity 乃是由水力發電產生(約 40%的能源乃是由水力發電產生，另外 40%的能源乃是由石油產生，另外還有一部分的能源從 wood burning 產生)，再加上冬天酷寒，所以該國冬天幾乎所有的 household 均不關閉能源，換言之，隨手關燈、關暖氣的習管在挪威是不成立的，舉例而言，丹麥的訓練，乃是隨手關閉能

源在挪威的滑雪勝地經常造成挪威的 facility 損壞!良好的能源節約習慣反而造成問題!

8/16/13 (Friday)

I. NTNU & CEDREN - Centre for Environmental Design of Renewable Energy

A. Host: Dr. Anund Killingtveit, Dept. of Hydraulic and Environmental Engineering, NTNU；Prof. Jochen Aberle, Dept. of Hydraulic and Environmental Engineering, NTNU；Dr. Petter Stoa, VP Research Strategy and International Affairs, SINTEF Energy Research；Mr. Atle Harby, Center Director, Center for Environmental Design of Renewable Energy (CEDREN), Water Resources, SINTEF Energy Research；Mr. Nils Olav Tangvik, Sales Manager, Smart Generation, Powel

B. Attendees: 朱主委、林處長、曾組長、李教授、李副研究員

The following figures are for NTNU

C. 52 departments in 7 faculties; 11,685 student applications with NTNU as first choice, 22,349 registered students, 7,752 admitted in 2012, 3,326 BS and MS awarded, 374 Ph.D. awarded with 36% women

D. Budget: 714 M NOK; 585,000 of owned and rented premises

E. ~10% foreign nationals as students at NTNU; ~1/3 of NTNU' s Ph.D. candidates are international, ~1/4 NTNU' s academic staff is international (the most internationalized university in Norway)

F. Faculty of Engineering is one of the 7 faculties with Budget: 32M €; +28M € external activities

G. Hydropower in Norway

1. There is a Norway ministry in dealing with petroleum, hydropower, etc. However, Ministry of Petroleum and Energy, Ministry of Finance, Ministry of the Environment, and Ministry of Trade and Industry (owns the power companies) are the 4 ministries related to power/energy in Norway.

2. Hydropower produced more than 90% of the electricity, which were all used within Norway. The petroleum industry produced around 20 times of the energy, which were all exported.

3. Hydropower in Norway: Resource base

a. High precipitation: 4000- 6000 mm/year typically 1000-2000

b. Low evaporation: 100-400 mm/year

c. High runoff: 15 - >100 m (6 of the waterfalls are higher than 300 m, 4 of the waterfalls are between 250-300 m)

d. 1303 Hydropower plants (Scattered all over the country), 333 > 10 MW (still under rapid development); total capacity: 20172 MW as of Jan 1, 2012; annual generation: 130 TWh; storage capacity: 84 TWh (50% of Europe’ s total)
e. 99% of electricity is supplied by hydropower in Norway, connected to Sweden, Denmark, Russia, Netherland
f. Largest hydropower producer in Europe, No. 7 in the world behind China (~700 TWh), Brazil (~450 TWh), US (~350TWh), Canada, Russia, India
g. Mainly consumed in Norway: ~26,000 kWh/capita; also supplies peaking and balancing power to Nordic countries
h. 相形之下，台灣的水力發電約為 4.5TWh (see below:)
台灣現有水力發電設備裝置容量: 明潭發電廠1664.12千瓩共13部機組,大觀發電廠1110千瓩共9部機組, 大甲溪發電廠1104.365千瓩共21部機組,東部發電廠183千瓩共16部機組, 石門發電廠130千瓩共3部機組, 桂山發電廠110.72千瓩共7部機組,卓蘭發電廠80千瓩共2部機組, 曾文發電廠50千瓩共1部機組, 萬大發電廠36千瓩共3部機組, 蘭陽發電廠26.375千瓩共6部機組, 高屏發電廠5.48千瓩共4部機組,合計總裝置容量4499.03(千瓩) (~4.5TWh)共85部機組
i. Modern development: widely distributed in space, connected by tunnels, often based on natural reservoir, underground power plants, water collection in many brook intakes, water transfer by tunnels and shafts (to avoid building many small and uneconomic dams)
j. The most complex projects is Ulla-Forre system, which even collects the water and pumped the water up to higher elevation lake for storage
k. Next step: upgrading of the old dams and plants
l. Power exchange capacity to other countries (around 5% transmission loss): Planned 1400 MW to England, 1400 MW to Germany before 2020
m. The rocks in Norway is stable and there is no earthquake in Norway, which is quite different from the situations in Taiwan.

4. Organization energy research in Norway: Energy 21 advises Ministry of Petroleum and Energy
   a. Research Council of Norway: set up EnergiX due to study done

by Energ21 in order to coordinate the overall energy research activities

H. SINTEFF

1. 2100 employees, 1400 researchers, colleagues from 71 countries, 33% of the staff are women, want to have close 100% Ph. D. research experience equivalent academic staff, one of the most attractive workplaces in Norway
2. An independent, non-profit, mission based: "technology for a better society"
3. Since 1970, SINTEFF and NTNU have established companies that have created 3700 jobs, with a combined annual turnover of 100M€
4. More than 90% income comes from contracts won in open competition, ~8% basic grants from the Research Council of Norway, 19% project grants from the Research Council of Norway, 10% public sector contract (overall 45% budget derived from Research Council of Norway)
5. Research with an application in mind
6. SINTEFF energy Research (Office building opened at 1959) is around 345 staff, which is around 10% of the overall staff. However, close to 50% of the staff is working on energy related research since Norway is basically an energy Nation. Plan for a new energy lab in Trondheim.
7. World class site for research on power system analysis, subsea power supply, high-voltage components, CCS (Carbon Capture and Storage), etc.
8. Global European and Norwegian drivers
   a. Norway: energy for oil and natural gas production, oil and natural gas in the high north, natural gas as transition agent, large scale balancing
   b. Europe's grand challenges: energy, security of supply, climate, value creation, innovation, aging population
   c. Global megatrends: demographic change, urbanization, climate, globalization
9. SINTEFF energy mission: we shape the future energy solutions (priority contribute in the transition to and an realization of the sustainable energy system of the future)
10. Norway's energy research priorities:

a. Energy policy, economy and society
b. Spent 50% of fund in renewable energy and 1/3 of the 50% fund in the Center of Excellence programs.

11. Strategic Energy Technologies Plan (SET Plan)
12. SINTEFF takes part in EERA (European Energy Research Alliances) (See photo below:)

13. NSON: north sear offshore and storage network (A RD&D project/program initiative)
    a. The need for NSON includes harvesting offshore wind, connect national energy markets to enhance security, stabilized prices and increase cost efficiency, provide large-scale hydro balancing, etc.
    b. The gain: significant lower overall socio economic cost and industrial innovation opportunities
14. Sustainable international research cooperation
    a. Social: meet and discuss, personal relations/trust, work together in projects
    b. Economic: funding
    c. Environment: succeed in reaching common goal share infrastructure, more Skype?

<u>The following figures are for CEDREN</u>

I. Budget: 250 M NOK for 2009-2016
J. The centre is founded by The Research Council of Norway and energy companies, and is one of eight centres that are part of the scheme Centre for Environment-friendly Energy Research (FME).
K. The centre is joint operation by the public Research Council, the private energy industries, and the engaged research institutes and universities.
L. Interdisciplinary research center for technical and environmental development of hydro power, wind power, power line rights-of-way and implementation of environment and energy policy.
M. Vision: "An internationally recognized research center for environmental design of renewable energy - integrating technology, nature and society."
N. Slogan: "Renewable energy respecting nature."
O. Objectives: CEDREN will deliver:

1. Knowledge about renewable and sustainable energy production
2. Innovation and new opportunities for renewable energy solutions
3. Outstanding dissemination and targeted communication of processes and results

P. More Specifically: The center is focused on hydro and wind power production and power transmission systems.

Q. Six Focuses:

1. HydroPEAK - Future hydropower design
2. EnviPEAK - Effects of rapid and frequent flow changes
3. (-- Tools and methods to analyze the impacts and mitigation measures?)
4. EnviDORR - Increased power and salmon production
5. (-- Collate the best research groups on salmonid ecology, hydrology and hydropower operation models?)
6. GOVREP - (How to combine environmental and energy policy concerns?)
7. BirdWind - Bird-friendly localization and design of new onshore wind power plants.
8. OPTIPOL - Optimal design and routing of power lines
9. (-- Define where and how new power lines can be built, and how existing lines can be adapted for optimal ecologic and economic outcome?)

R. Main topics:

1. Hydropower technology for the future
2. Environmental design of hydropower: more energy and more salmon
3. Impact of birds in wind power

S. CEDERN will deliver outstanding dissemination and targeted communication of processes and results (view: the center has the mission to make sure all stakeholders understand the energy policy, impact, etc. based on scientific knowledge)

T. New technologies: laser scanning of tunnels and sand trap (advanced scientific equipment, modeling 3D flow, and explaining processes, suggesting mitigation), etc.

U. Wind power and birds: site specific problem → studies found out that selecting the sites correctly can avoid conflicts, identified only two species (Eagle and Grose) got killed by Wind power tower (Eagle got killed by the blade and Grose got killed by colliding to the tower)

Eagle

Grose

V. Powel developed software to optimize hydropower utilization, design, implementation, operation, etc.

W. 水力電廠的參觀

2006 年新建的水平式渦輪機軸承

1909 年所建的垂直式渦輪機、發電機(接近 100 年的水力機械仍舊運轉良好)

X. 根據 Dr. Anund Killingtveit, Dept. of Hydraulic and Environmental Engineering, NTNU 所言，目前挪威的水力發電效率極高，約可達到渦輪機 92-95%效率、發電機 98%效率、變壓器 99%效率，整體加起來，現代水力發電機械從水能到電能的整體轉換效率約在 90%左右。

8/19/13 (Monday)

I. SKB (Swedish Nuclear Fuel and Waste Management Company) Visit

A. Host: Magnus Holmqvist, President, SKB International AB；Hans Forsstrom, Senior Advisor, SKB International AB (See below)

From left to right: Hans Forsstrom, Senior Advisor, SKB International AB；Magnus Holmqvist, President, SKB International AB

B. Attendees: 朱主委、林處長、曾組長、李教授、李副研究員、經濟部凌家裕組長

C. Detailed Sweden Nuclear Waste Management were presented (see SKB Presentation to Taiwan delegation August 2013.ppt)

D. Owned by the producers of nuclear energy in Sweden with 400 employees and turnover of 140 million EUR.

E. Mission

1. To manage and dispose of the radioactive waste from the Swedish nuclear power plants, also deal with radioactive waste from medical care, research and industry.
2. To develop and realize a method for safe disposal of this radioactive waste

F. History

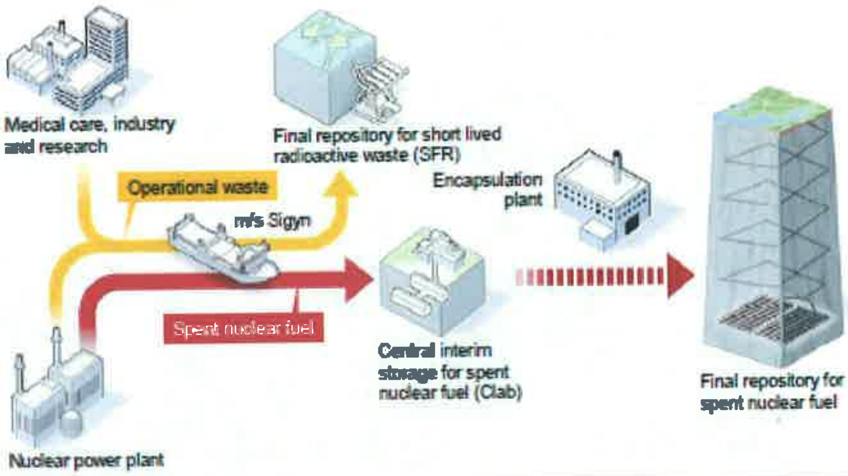
1. 1954 - first research reaction operation
2. 1972—first nuclear power reactor in operation
3. 1980 - a statement by parliament: nuclear energy should be phased out no later than 2010
4. 1984 - Nuclear Activities Act : the owners of the nuclear power plants are responsible for handling disposal of radioactive

waste

The Nuclear Waste Fund

0.01 SEK per kWh
of nuclear electricity

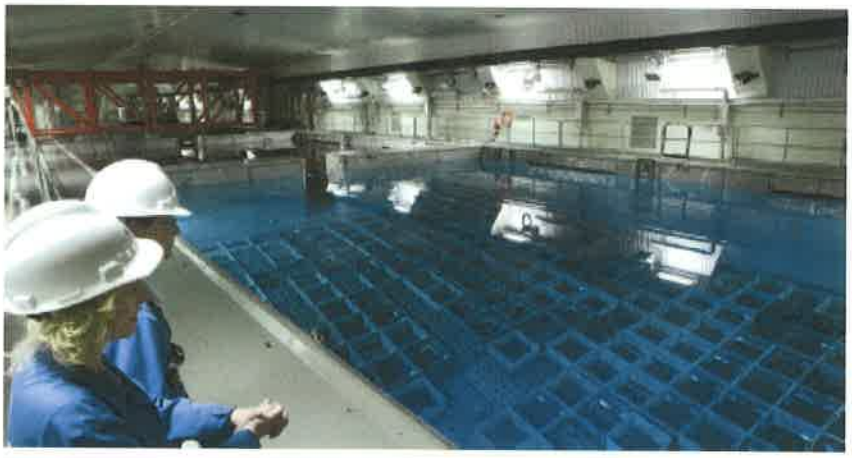
SKB's system



Central Interim Storage Facility for Spent Nuclear Fuel, Clab, at Oskarshamn

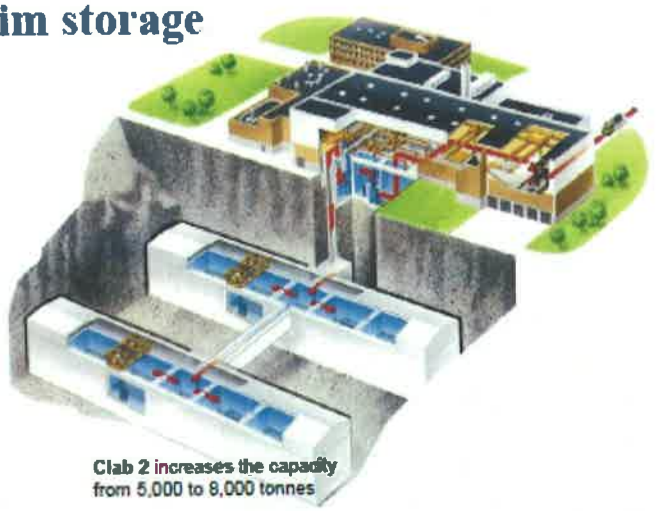
SKB

Interim storage



SKB

Interim storage

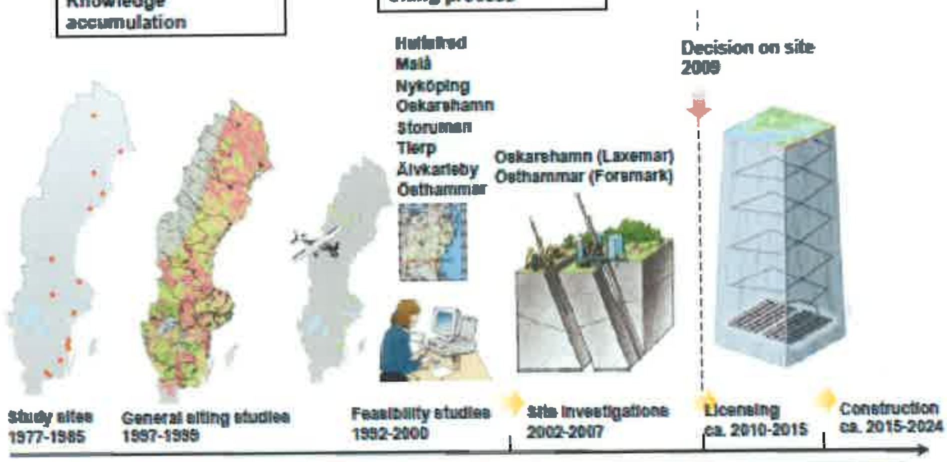


Clab 2 increases the capacity from 5,000 to 8,000 tonnes

Siting of a repository for spent nuclear fuel

Knowledge accumulation

Siting process



June 2009 - SKB selects Forsmark for the repository for spent nuclear fuel

The application to construct the repository will be submitted later this year – if the proposed site and method (KBS-3) is approved by the Government, construction can start at the earliest 2015 and operation 2025

Main reason for selection of Forsmark:

Considerable better conditions for long term safety of a repository

Photomontage of a repository for spent nuclear fuel at Forsmark

SKB

Building of public trust

SKB

Talking with the local people

SKB

Consultation sessions

SKB

Open facilities to visitors

SFR Repository

Canister laboratory

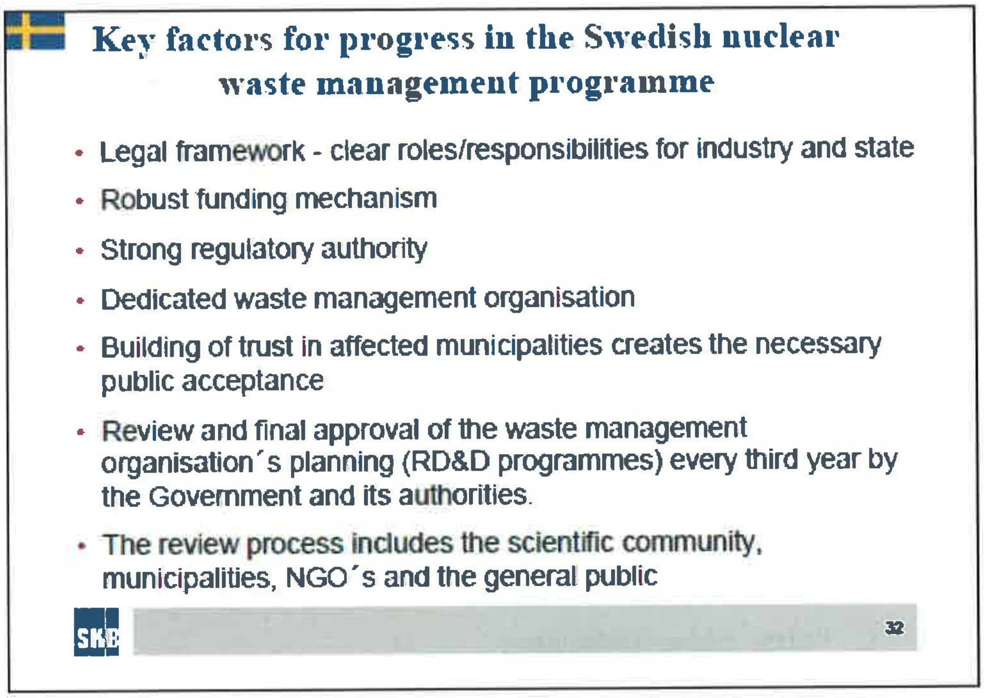
Clab – interim storage of spent nuclear fuel

Äspö laboratory

SKB

Visits to SKB exhibition aboard m/s Sigyn

SKB



G. Nuclear Sweden: owns 12 nuclear power plant

H. Spent fuel and radioactive waste management Clear responsibilities in legislation
   1. The owners of the nuclear power plants are responsible for handling and final disposal of spent fuel and operational radioactive waste
   2. Sweden does not intend to reprocess the spent fuel currently.

I. SKB’ s method for disposal of spent nuclear fuel-KBS-3
   1. Fuel pellet of uranium dioxide → spent nuclear fuel (BWR fuel assemblies) → copper canister with cast-iron insert (copper does not corrode) → deposit deep underground repository
   2. The two repositories near Stockholm are around 150 km. The site selection processes were generated from the failed experiences SKB have had for the two northern potential nuclear waste sites. Immediately after the referendum failed to pass, SKB immediately packed and left as promised. The act of keeping the promise becomes a good starting point for future potential sites.
   3. Dialogue and involvement
      a. Sweden has a very strong local decisive power as the overall government structure has only two levels, which can thus move the things forward quicker than that of the US system/situation.
   4. Expectations of positive effects of the repository

a. Direct jobs at the repository and SKB administration
b. Index of highly educated personnel - increase in cultural activities, etc.
c. Local procurement - more jobs in local businesses
d. Improved infrastructure
e. Improved infrastructure
f. Improved health care
g. Improved quality in schools
h. Spin-off effects - creates future jobs
   Note: Money does not directly appear in the list mentioned above. The Sweden tax system distributed the largest share of tax income to the local community. This system is good for the local community to make a decision.
i. Value added programme
   1. Total 2 billion SEK over 15 years
   2. 25% to Osthammar ("winner"), 75% to Oskarshamn ("loser")
   3. Legal agreement between SKB, power companies and two local municipalities
   4. Support to projects of common benefit to the parties, e.g. :
      a. Education, research and local business
      b. Development of tourism
      c. Improved road, ferry terminal
      d. Housing development
      e. Business development (SKB Naringslivsutvckling AB)
      f. Studies of future local work force demand and new enterprises.
j. Clear responsibility and financing
   1. Financing: nuclear company pays ~0.01 TWD/kwh to create the nuclear waste fund
k. There are 4 nuclear power companies pays for the nuclear waste fund.
   1. Vatttenfall is 100% state owned
   2. E-on is a Germany company and is 100% private owned.
   3. The other two companies have some private fund, some state fund, and some other nation' s national fund.
l. Summing up: some key factors for progress in the Swedish

programme

1. Legal framework
2. Some regulatory authority
3. Dedicated waste management organization
4. Building a trust in affected municipalities creates the necessary public acceptance
5. Long-term planning of the waste management organization (RD&D programmes) reviewed every third year by the Government and its authorities, with input from the scientific community, municipalities, NGO's and the general public
6. Experiences gained by SKB in management, technology approach, scientific bases and communication
7. The nuclear waste fund includes the cleanup actions, etc. to last 30 years after the power plant stops operational. Note: SKB helps other countries pursue the social understanding and social readiness.
8. Sweden's law forbids importing nuclear waste from other nations.

J. 台灣(目前的核廢料處理方法：Radioactive Waste Management in TW -2013.ppt)與 SKB 公司未來可能的合作議題

1. 台電公司與瑞典 SKB 公司於 2010 年 6 月 29 日簽訂合作備忘錄(MoU)，雙方主要之合作項目如下：
   a. 組織與營運(Organization and management)
   b. 成本估算與財務(Cost estimation and financing)
   c. 策略與規劃(Strategy and planning)
   d. 系統分析 (System analysis)
   e. 研究發展規畫 (R&D programming)
   f. 場址調查 (Site investigation)
   g. 地質實驗室實驗 (Geological Laboratory experiments)
   h. 低放射性廢棄物最終處置 (low-level waste disposal)
   i. 運輸系統 (Transportation system)
   j. 用過核子燃料深層地質處置 (Deep geological disposal of spent nuclear fuel)
   k. 利害關係人溝通 (Stakeholder communication)
   l. 訓練 (Training)
2. 鑒於 SKB 公司在核廢料營運管理的成功經驗，及配合台灣核能後端營運各項計畫之進展，建議雙方未來加強交流合作的議題：

a. 核廢料營運專責機構之籌設及運作模式；

b. 高、低階核廢料最終處置計畫推展與技術交流合作。

K. SKB 請教代表團針對前述計畫，目前是否會有進一步的動作來建構更深入與更負責的核廢料處理。經過討論，認為在核四公投前，前述的規劃將不會是台電的重要議題。

L. <u>主委裁示</u>：由第二期能源國家型計畫規劃辦公室，邀請 Hans Forsstrom, Senior Advisor, SKB International AB(已由凌家裕組長先以電話邀請，並獲其同意參加。)以及他所建議的一位芬蘭或其他國家的核廢料處理溝通專家到台灣來參加一個討論中低強度核廢料處理、與民眾溝通/負責任作法的 Workshop，並請他比較各國核廢料處理程序、進程的狀態以供台灣參考，由我們出旅費，考慮由中經院擔任主辦單位，第二期能源國家型計畫規劃辦公室擔任指導單位，國科會擔任上級政策指導單位。考量在避開核四公投日期的狀況下(可考慮 2013 年 11 月)，舉辦 1 天的 workshop。

II. KTH Visit

A. Host: Professor Torsten Fransson, Education Director (work on "Flip the Classroom Approach/Teaching"), KIC InnoEnergy/Professor, KTH Industrial Engineering and Management；Professor Andrew Martin, Energy Technology, KTH；Associate Professor Anders Malmmouist, Energy Technology, Heat and Power, KTH (See below)

From left to right: Professor Torsten Fransson, Education Director (work on "Flip the Classroom Approach/Teaching"), KIC InnoEnergy/Professor, KTH Industrial Engineering and Management；Professor Andrew Martin, Energy Technology, KTH；Associate Professor Anders Malmmouist, Energy Technology, Heat and Power, KTH

B. Attendees: 朱主委、林處長、曾組長、李教授、李副研究員、經濟部凌家裕組長

C. Background on KTH

1. Sweden's largest technical university
2. >14,000 MSc students (include undergraduate students took 5 year

courses to get a MS degrees)

3. 65 international MSc programs with around 1200stduents/yr
4. No. 53 in QS world University Rankings (Engineering & IT)
5. Five research platforms: energy, ICT, materials, life science technology, transport

D. Department of Energy Technology (Highly technical oriented and work on tough problems related to power transmission and distribution, etc.)

1. Part of the School of Industrial Technology and Management
    a. Department organized into four divisions:
        1. Applied Thermodynamics and Refrigeration
        2. Energy and Climate Studies
        3. Heat and Power Technology
        4. Energy Systems Modeling
    b. ca 100 faculty, staff, and graduate students
    c. More information can be found at www.energy.kth.se

E. KTH Energy Platform

1. The KTH Energy Platform assembles expertise from a range of academic disciplines to focus on the transformation of today's energy systems in support of sustainable economic growth, reduced environmental impacts and improved national security. This effort encompasses traditional energy sources such as fossil fuels, nuclear and hydroelectric, more efficient transmission and distribution systems, emerging renewable sources such as wind and solar power, and storage technologies such as batteries and fuel cells.
2. Energy Research at KTH ~ 450 researchers, 48 research groups and 15 research centers
3. The Energy Platform coordinates education and research in pursuit of solutions that defy tidy categorization into traditional fields of study. From more efficient electric vehicle batteries to strategies for carbon sequestration to pursuit of commercially viable solar systems—and much more—KTH has staked out a leading position in developing the sustainable energy systems of the future.

F. Research in this division is highly applied and building the prototype has always been an emphasis.

G. Explore polygeneration:

1. Generation: electricity
2. Co-generation: electricity, gasification
3. Trigeneration: electricity, gasification heat
4. Polygeneration: electricity, gasification heat, water (The art of combining multiple energy sources)
    a. Integrated container-sized energy devices
    b. Ph.D. driven research projects in the polygeneration lab
        1. Concentrated solar power driven microturbine
        2. Pellets fired sterling microchip
        3. Membrane water distiller integration with microturbine
        4. Gasifier integration with microturbine
        5. Fuel cell integration with microturbine
        6. Polygeneation system integrated control
        7. Auxiliary power consumption control and minimization in small-scale system
        8. Absorption chiller integration with microturbine and cold storage
        9. Biogas production from student dormitories, etc.

H. Thermal energy storage based on phase changing materials

I. Emergency container sized polygeneration was being tested and potentially being installed/used and tested in Kenya since summer of 2010.

J. Explore Energy World Virtual University (www.exploreenergy.eu; flip the classroom approach)
    1. Online, open education
    2. Interactive learning materials
    3. Concentrated in polygeneration, biofuels and thermo-chemical conversion, turbo-machinery, thermal energy storage, concentrating solar power, advanced fuel cell technology.

K. InnoEnergy is part of EIT
    1. EIT is all about human capital, not Innovation and not Research.
    2. EIT label
        a. EIT labelled degrees and diplomas are based on the knowledge triangle.
        b. Criteria: student-centered education

8/20/13 (Tuesday)

永續生態示範區原為一嚴重土壤汙染的區域，藉由淨化汙染土壤、廢棄物處理及水資源再利用等技術，並規劃完整的設施及公共建設，建構成高科技生態城市，成為全世界生態城市的典範。

該城市的特色如下:

一、交通：以綠色運輸為目標，規劃腳踏車系統及汽車共用制度，搭配公車及捷運系統等公共交通系統，取代私人汽車的使用，減少廢氣排放。

二、生態維護：保留具特殊生態價值地區，溼地保護及維護該地區動、植物的生態多樣性。

三、再生/無汙染能源之利用：自社區汙水提取沼氣、太陽能、Bio-gas 及生質能等方式取得之能源，提供該社區公共區域、家庭及交通。

四、廢棄物資源分類：該社區沒有垃圾車，而是設立不同層級的垃圾收集站，將垃圾回收再利用。在社區之公共空間設置真空抽吸系統設，自動收集分類可再利用的紙張、可燃燒廢棄物、廚房的有機廢棄物及其他可循環再用的物體。

政府、學者、業界等共同參與該城設的規畫，以生態、健康的社區概念為目標，實施創新的基礎建設，不僅提升國內產業，亦同時將生態技術與概念行銷到世界各國。

資源回收--真空抽吸系統


生態維護