



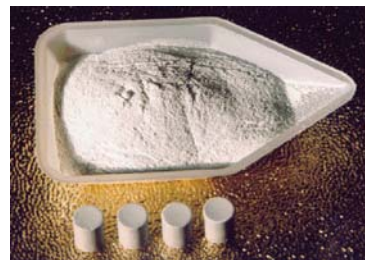
Thor Energy
Scandinavian Advanced Technology

Thorium power Abundant climate neutral energy source



Why Thorium?

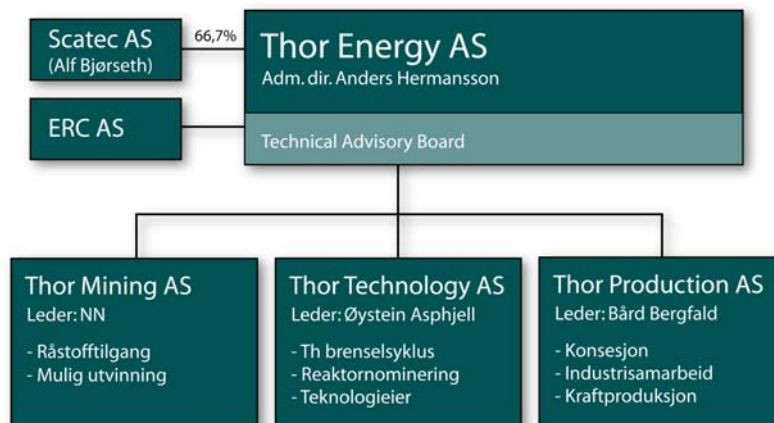
- Global need for inexpensive, CO₂-free power
- Abundant, available resource
- Longer cycles, less waste
- Acceptable waste characteristics



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Why Thorium in Norway?

- CO2-free without subsidies
- National resource
- Forseeable power cost
- Improved waste characteristics
- May burn spent uranium fuel + plutonium
- Improved safety characteristics
- Proliferation resistance/break-off from bomb issues
- Increased revenue from hydroelectric
- Potential for saving the heavy industries



Goal:

Build and operate 2 Thorium-based power plants of +2000MWe each in Norway, start 2017

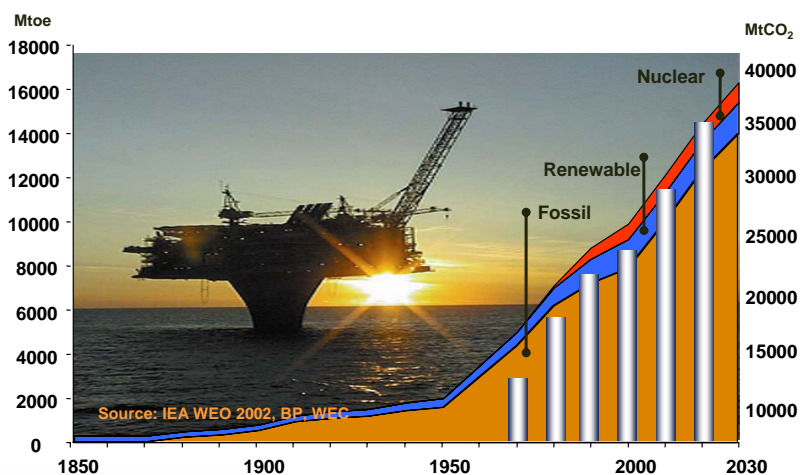


Work in progress:

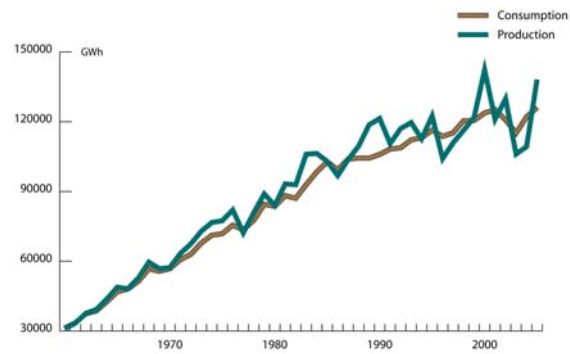
1. **Technical feasibility**, development and approval of Thorium fuel-cycle and identification of suited reactor.
2. Developing possible mining/processing of Thorium from the **Fen deposit** in Ulefoss.
3. Informing Norwegian public and political sector of the potential for substantial, inexpensive, **climate neutral** power plants.
4. Possible cooperation with utilities and large, **power consuming industries** for future power take-off.
5. Preparations for application for a **commercial license** for building and operating a Thorium power plant in Norway.



Global energy consumption 1850-2030



Power; consumption v. production



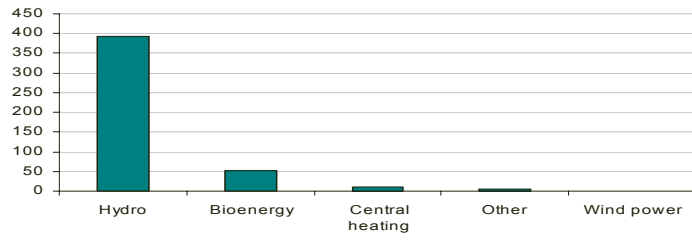
Norway – energy nation

- The world's sixth largest hydro power producer
- The world's third largest petroleum exporter
- The world's fourth largest gas exporter
- The world's third largest Thorium reserves

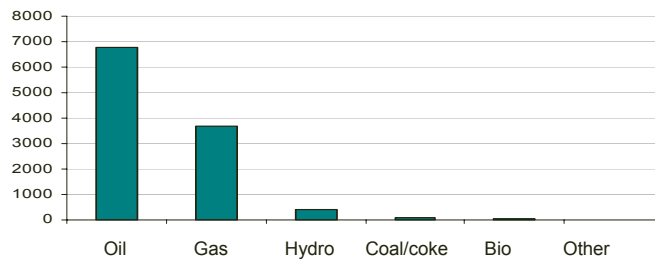
- Primary industry with focus on energy
- Secondary industry with focus on energy
- Educational systems with focus on energy
- Well developed laws and regulatory agencies on energy
- Political focus on energy as base for industry and society



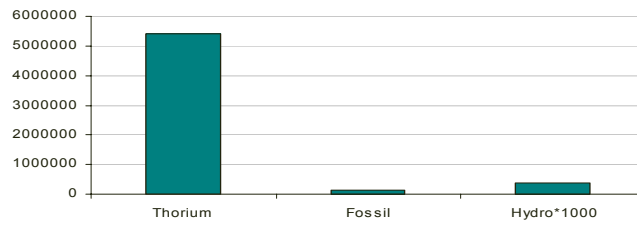
Renewable Energy Production, Norway 2004, PJ



Energy Production, Norway 2004, PJ



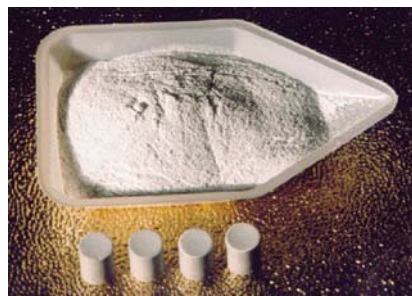
Energy Reserves, Norway 2004, PJ



Thorium: From black to white fuel:



Uranium (UO₂)



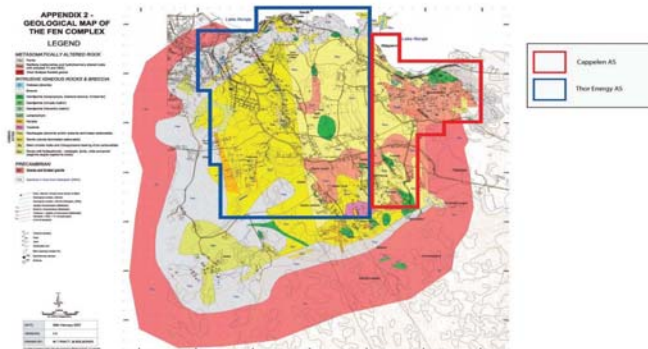
Thorium (ThO₂)



Soevite from Ulefoss



Fen resource ownership



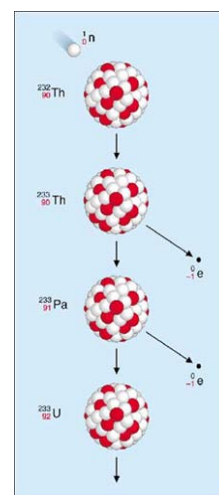
Nuclear sceptics have had their reasons

1. Risk of severe **accidents** – the overcriticality problem
 - China syndrome
 - Chernobyl
2. The **bomb** connection
 - The uranium cycle was bomb motivated
 - Enormous global plutonium inventories
3. **Waste** – how dangerous for how long?
 - How do you secure anything for >100.000 years?
 - Radiotoxic characteristics of transuranics



1. Thorium is a near breeder, and needs extra neutrons

- No expensive and controversial enrichment needed
- Thorium needs added neutrons
- Optimal neutron source is plutonium waste
- Thorium has better chemical and physical behaviour in the reactor than uranium
- Fuel design is key to success
- Less (neutrons) is more (safety)!



2. Thorium is not the bombmakers choice

“IAEA is not concerned with the tenth or thousandth nuclear device of a country. IAEA is only concerned with the first.

-And that will certainly never be based on a thorium fuel cycle.”



Bruno Pellaud

Former Deputy Director General IAEA
Non proliferation

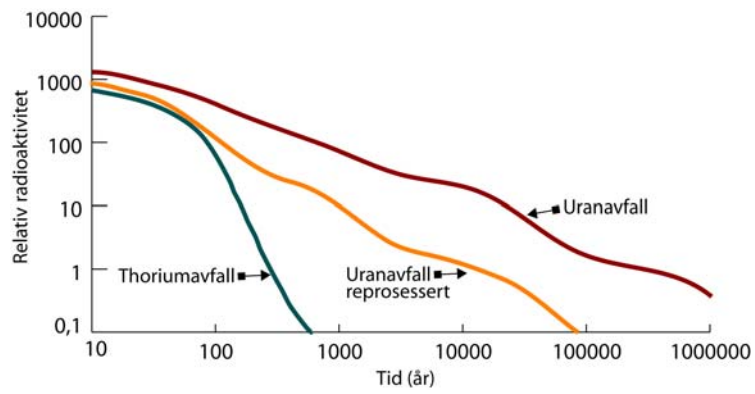


3. Waste – the big issue

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Li	Be											B	C	N	O	F	Ne																														
Na	Mg											Al	Si	P	S	Cl	Ar																														
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr																														
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Pb	Te	I	Xe																														
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																														
Fr	Ra	Ac-Lr	Rf	Db	Sg	Bh	Hs	Mt	Uu ¹	Uu ²	Uu ³	Uu ⁴	Uu ⁵	Uu ⁶	Uu ⁷	Uu ⁸	Uu ⁹																														
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La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu																																	
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr																																	



Neutral waste within centuries



Coal ash, Longyear city, June 2007



IAEA, status report May 2005

...in recent times, the need for proliferation-resistance, longer fuel cycles, higher burn up, improved waste form characteristics, reduction of plutonium inventories and in situ use of bred-in fissile material has led to renewed interest in thorium-based fuels and fuel cycles in several developed countries.....

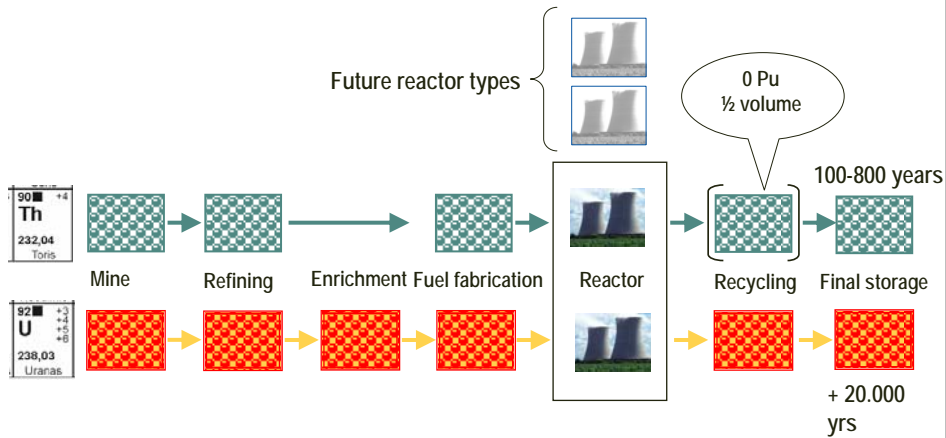


Key data for a thorium power plant

- 2 reactors of 1000-1350 MWe each
- Power production ~18-20 TWh/year
- Production cost (all included) 20-30 øre/kWh
- Basics for localisation; Sea, grid and industrial clusters

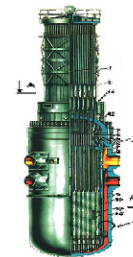


Fuel-cycle for Uranium and Thorium



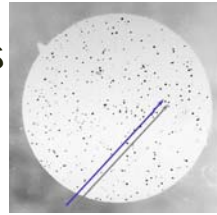
Conventional light water reactors - many possibilities

- 80 % of world reactor fleet, many vendors
- Several patents available on Thorium based and mixed fuel
- Optimal for high burnup of Plutonium waste
- Optimal mix is 80-85 % Thorium, 15-20 % Plutonium
- Rapid construction and lowest investment
- Turnkey powerplant +2000 MWe costs ~4 billion US\$



Conventional heavy water reactors – best neutron economy

- Only one vendor - Canada
- On power refuelling
- Very good neutron economy
- Optimal mix is 90-95 % Thorium, 5-10 % Plutonium
- Very flexible fuel concepts
- Turnkey power plant +2000 MWe costs ~4 billion US\$

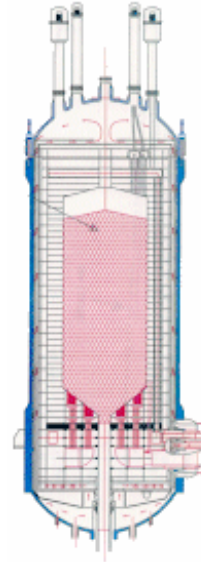
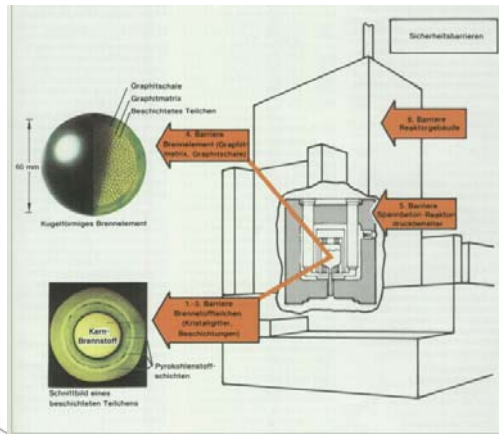


New, innovative reactors

- Pebble bed might get a comeback
- India has several interesting designs
- Western fast breeders might come later



Pebble beds



 **Thor Energy**
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Indian 500 MWe Thorium reactor construction

- India has nuclear and Thorium as main energy strategy
- Use surplus Pu-239 as seed fuel
- Only 450 kg Th/år



 **Thor Energy**
Scandinavian Advanced Technology

Thor Energy AS – human resources

Technical Advisory Board:

- Prof. Samim Anghaie, Professor at University of Florida
- Dr. Atam Rao, Director IAEA, Austria
- Mr. Thomas F Marcille, Chief Engineer, Los Alamos National Labs, USA
- Prof. Jon Samseth, member of IUPAC energy committee
- Prof. Paul Fehrenbach, Canada. Retired AECL director

Board of Directors

- Grete Sønsteby, Chairman of the Board
- Alf Bjørseth
- Christian Ringnes
- Bård Bergfald

Operational staff:

- Anders Hermansson, CEO
- Øystein Asphjell, Project Manager, Thor Technology
- Ellen Egeland, Nuclear Scientist
- Prof Thomas Lefvert, KTH
- Dr. Daniel Westlen, KTH
- Dr. Valentin Fhager, Chalmers

Several persons at universities and cooperating companies working for us on contracts



Possible reactor sites



Conclusions Norway – Thorium power

- Norway a leading energy nation – from oil & gas
- Norway an electrified nation – No. 1 in electricity consumption/capita
- Norwegian hydroelectric power a superb power resource for Europe
- Norway has enormous Thorium resources (>1.500.000 TWh)
- A Norwegian Thorium power plant is feasible – from a technical and financial point of view. Competitive cost
- 18-20 TWh low cost power may be available in 10 years – if welcomed
- Norway may reargue its nuclear position
- No Thorium power in Norway without political support

