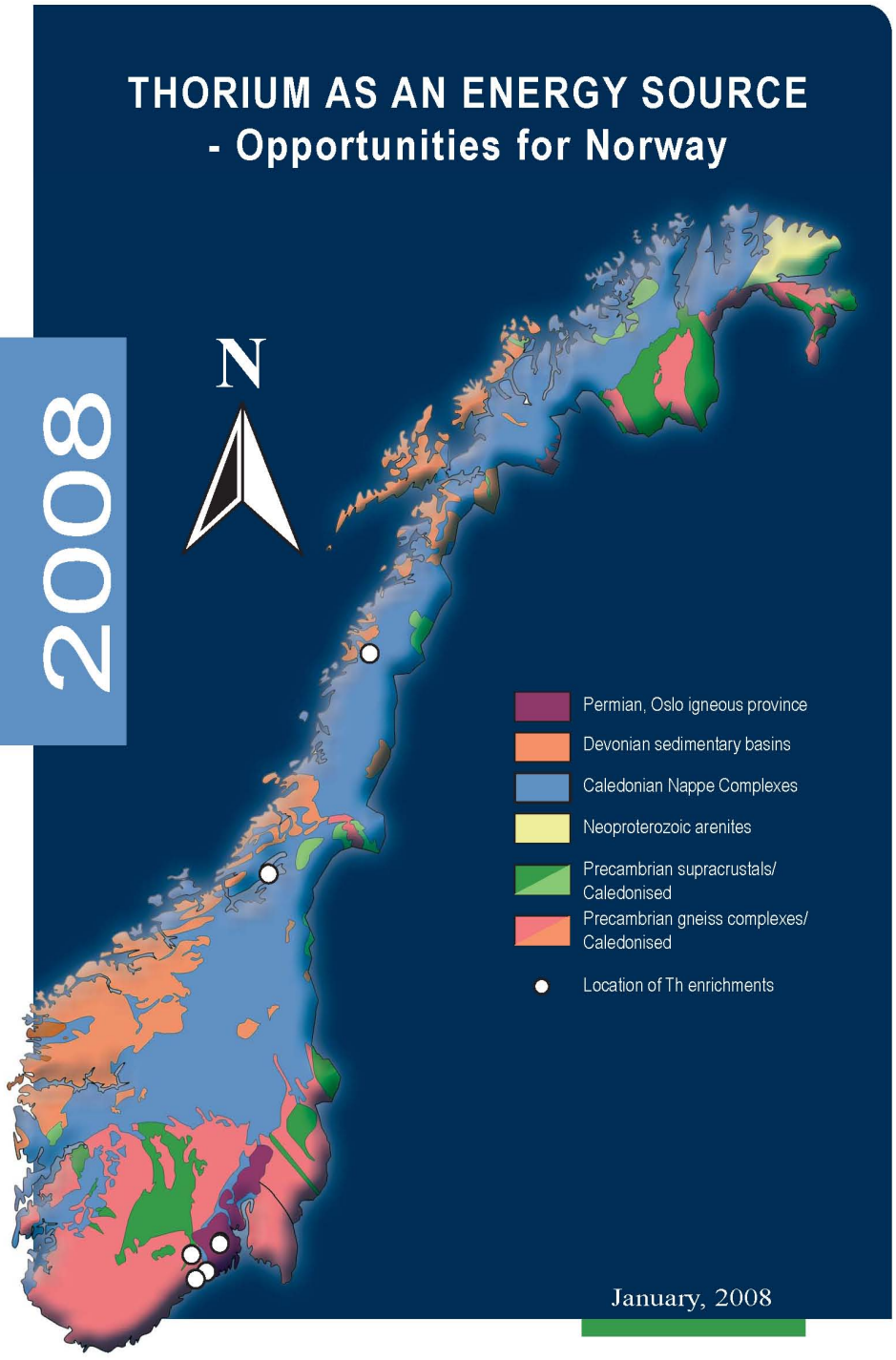
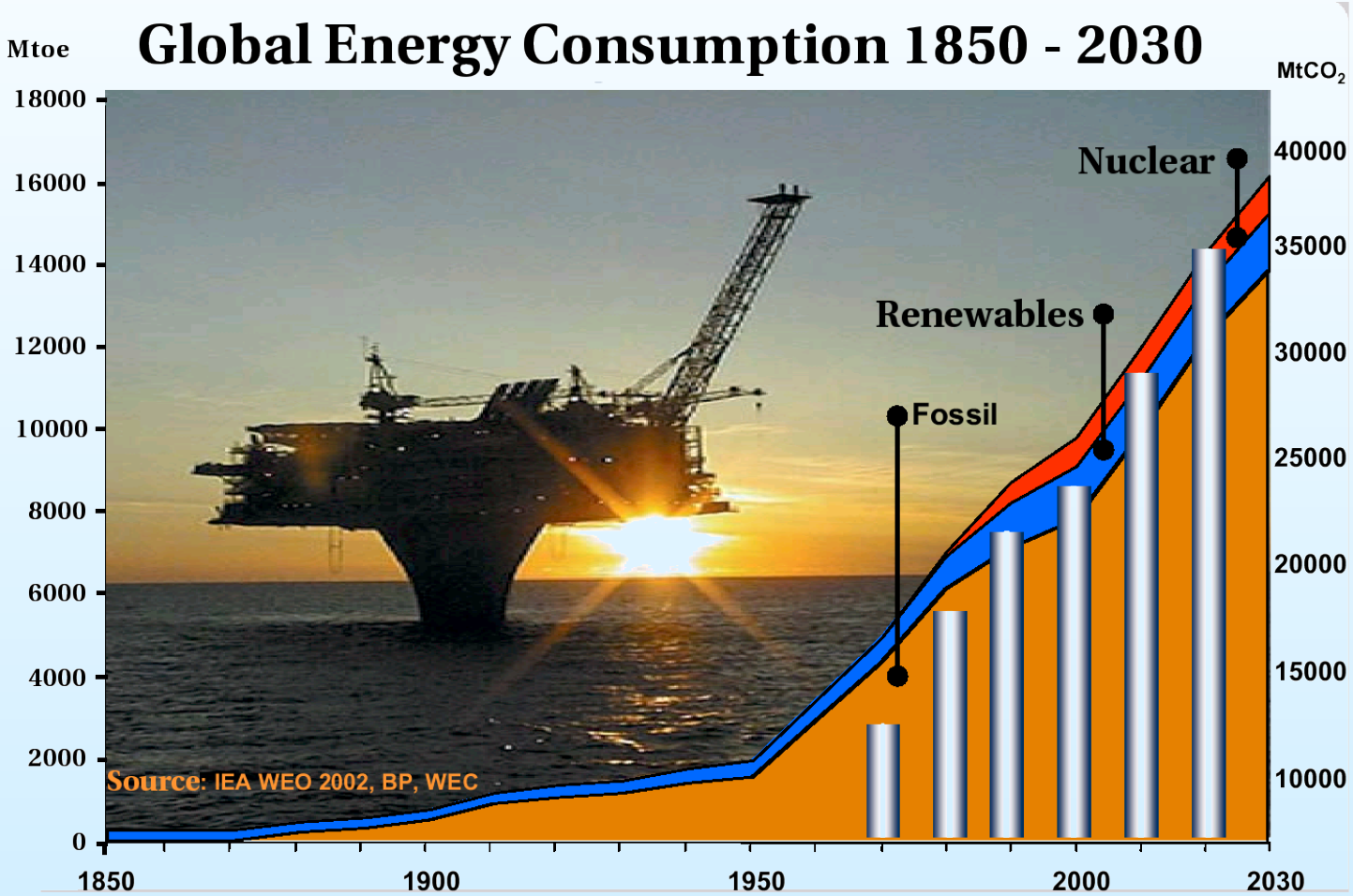


Thorium Report Committee

Main Results

Professor Mikko Kara,
Chairman of the Committee

CHALLENGE FOR THE MANKIND!



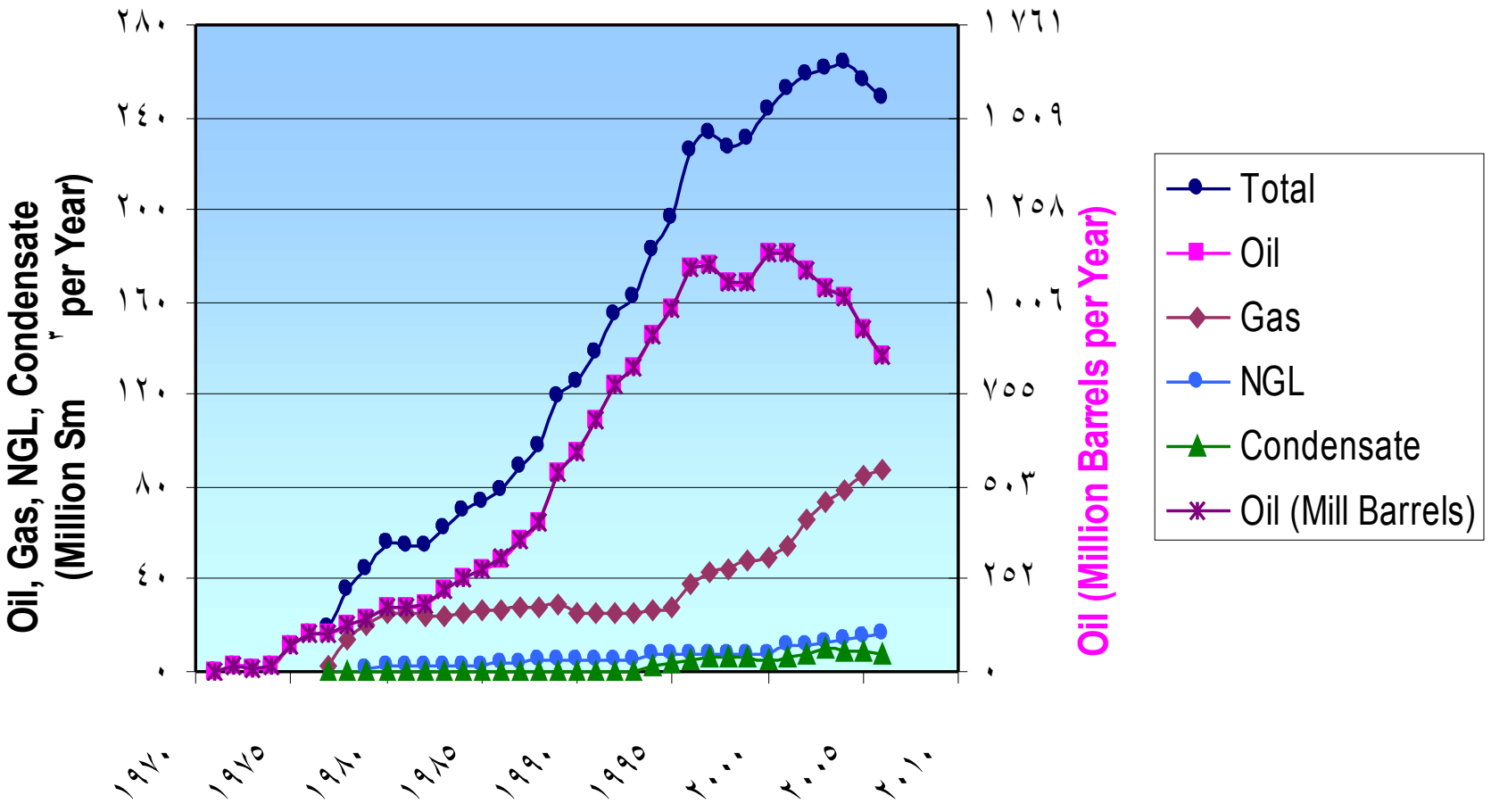
ENERGY IS TOP ON AGENDAS

EU IS FRONT-RUNNER:

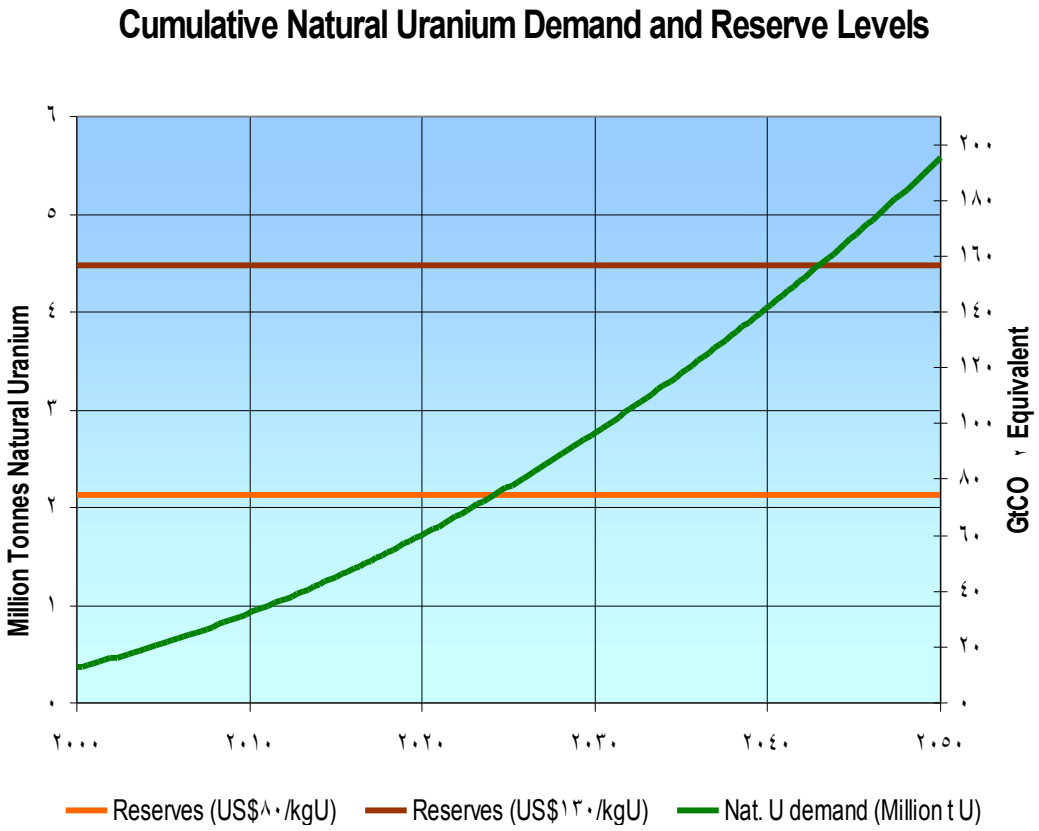
The EU Climate and Energy Package - Targets by 2020:

- *Reduction of greenhouse gas emissions by 20 % compared to 1990 level.*
- *Reduction of energy consumption by 20 % compared to 1990 level.*
- *Increase the share of renewable sources in the EU energy mix to 20 %.*
- *Increase the share of biofuels of transport petrol and diesel to 10 %.*

NORWEGIAN PETROLEUM PRODUCTION APPROACHING ITS PEAK



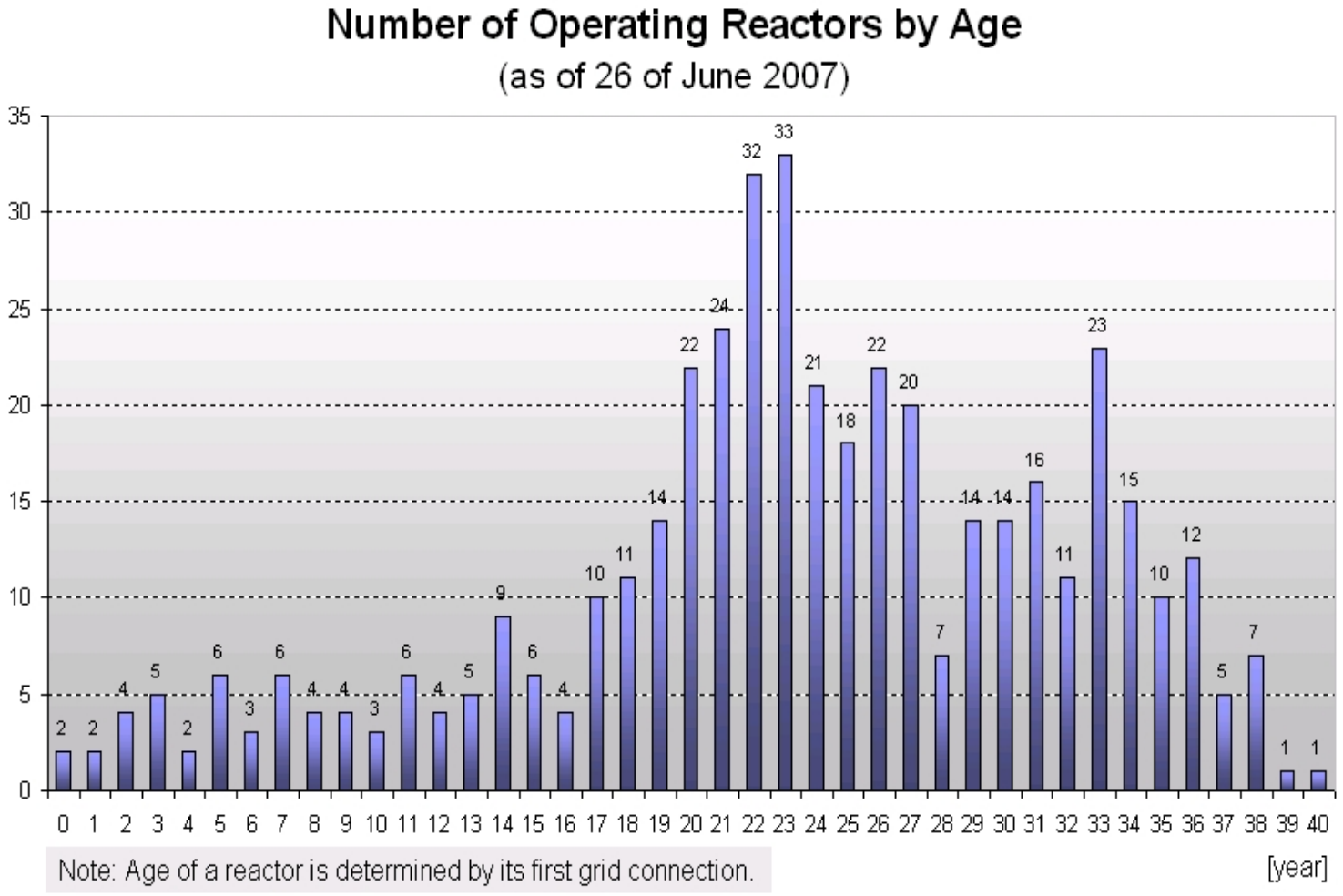
CUMULATIVE NATURAL URANIUM DEMAND AND RESERVES



Nuclear Energy Agency's Reference Scenario

- Continued nuclear growth
- Reported uranium reserves used right after 2040
- Reported reserves depend on demand – might increase
- Breeder reactor technology will change this development

NUCLEAR FLEET IS RETIRING



DEVELOPMENT IS TIME-CONSUMING

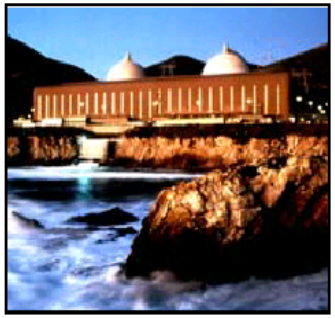
Generation I

Early Prototype Reactors

- Shippingport
- Dresden, Fermi I
- Magnox

Generation II

Commercial Power Reactors



- LWR-PWR, BWR
- CANDU
- AGR

Generation III

Advanced LWRs

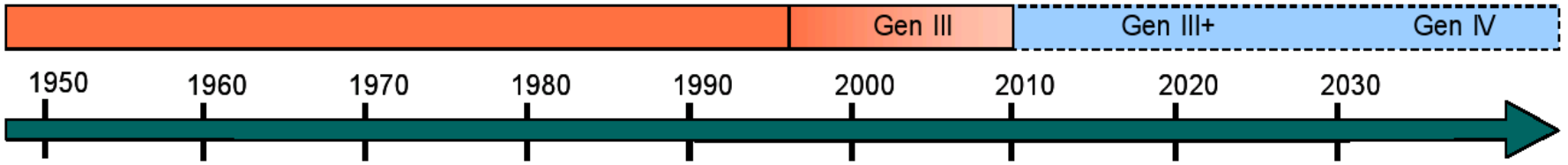
- ABWR
- System 80+
- AP600
- EPR

Generation III +

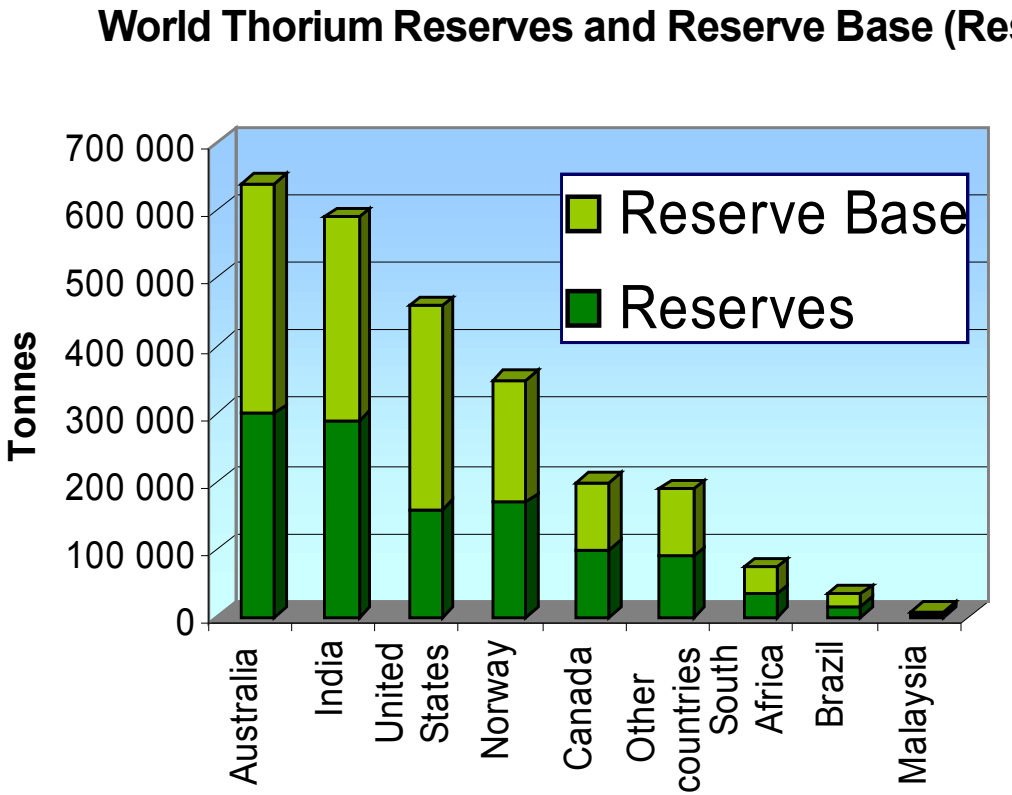
Evolutionary Designs Offering Improved Economics for Near-Term Deployment

Generation IV

- Highly Economical
- Enhanced Safety
- Minimal Waste
- Proliferation Resistant



THORIUM IN NORWAY



US Geological Survey claimes that:

- Norway has one of the major thorium reserves in the world.

The Geological Survey of Norway:

- Thorium has never been specifically explored for
- Fen Complex most promising
- Low concentration 0.1 – 0.4 wt%
- Grain size too small for the traditional flotation processes
- Norway has a potential *resource*
- More investigations necessary to define as a *reserve*

THORIUM AS A NUCLEAR FUEL

- Preparation of thorium fuel is more complex and expensive than for uranium fuel
- Thorium as a nuclear fuel is technically well established and behaves remarkably well in LWR and HTR
- Reprocessing thorium fuels will require a very substantial amount of development work
- Waste management will in principal follow known procedures and methods
- Radiation protection requirements for the thorium cycle will be lower than those of the uranium cycle
- Technically, one of the best ways to dispose of a plutonium stock pile is to burn it in a thorium-plutonium MOX fuel

INDUSTRIAL EXPERIENCE OF THORIUM
Critical (Normal) Reactors - Selfsustaining

Country	Name	Type	Power	Operation
Germany	AVR	HTGR	15 MW_e	1967 - 1988
Germany	THTR	HTGR	300 MW_e	1985 - 1989
UK, OECD-EURATOM also Norway, Sweden & Switzerland	Dragon	HTGR	20 MW_{th}	1966 -1973
USA	Fort St Vrain	HTGR	330 MW_e	1976 – 1989
USA, ORNL	MSRE	MSBR	7.5 MW_{th}	1964 – 1969
USA	Shippingport & Indian Point	LWBR PWR	100 MW_e 285 MW_e	1977 – 1982 1962 – 1980
India	KAMINI, CIRUS & DHRUVA	MTR	30 kW_{th} 40 MW_{th} 100 MW_{th}	In operation

MOST PROJECTS USING THORIUM WERE TERMINATED BY THE 1980s

Main Reasons:

- The thorium fuel cycle could not compete economically with the well-known uranium cycle
- Lack of political support for the development of nuclear technology after the Chernobyl accident
- Increased worldwide concern regarding the proliferation risk associated with reprocessing of spent fuel

Except for India:

- That utilize thorium for its long term energy security

THORIUM IN NUCLEAR REACTORS
Accelerator Driven System (ADS)

Sub-critical Reactor – Needs external neutron source

- Proton accelerator ⇨ Neutrons to the reactor core
- Reactor core containing thorium
  (and some U-235 or transuranic waste)
- No ADS pilot scale in operation yet
- *Myrrah project* started in 1997 (Belgium)
  ⇨ expected in operation by 2016 - 2018

RECOMMENDATIONS

- The potential contribution of nuclear energy to a sustainable energy future should be recognized
- It is essential to asses whether thorium in Norwegian rocks can be defined as an economical asset for the benefit of future generations
- The development of an ADS using thorium is not within the capability of Norway working alone. Joining the European effort in that field should be considered.
- Norway should strengthen its international collaboration by joining the EURATOM fission programme and GIF programme on Generation IV reactors suitable for the use of thorium

RECOMMENDATIONS (cont.)

- Any new nuclear activity in Norway, e.g. thorium fuel cycles, would need strong international pooling of human resources, and in the case of thorium strong long-term commitment of the education and basic science side. All these should be included in the country level strategy aiming to develop new sustainable energy sources

SUMMARY

- The current knowledge of thorium based energy generation and the geology is not solid enough to provide a final assesment regarding the potential value for Norway of a thorium based system for a long term energy production.
- The Committee recommends that the thorium option be kept open in so far it represents an interesting complement to the uranium option to strengthen the sustainability of nuclear energy