The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

1962-9

Joint ICTP-IAEA School of Nuclear Knowledge Management

1 - 5 September 2008

Nuclear Energy for 21st Century - Needs for KM

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Nuclear Knowledge Management Unit

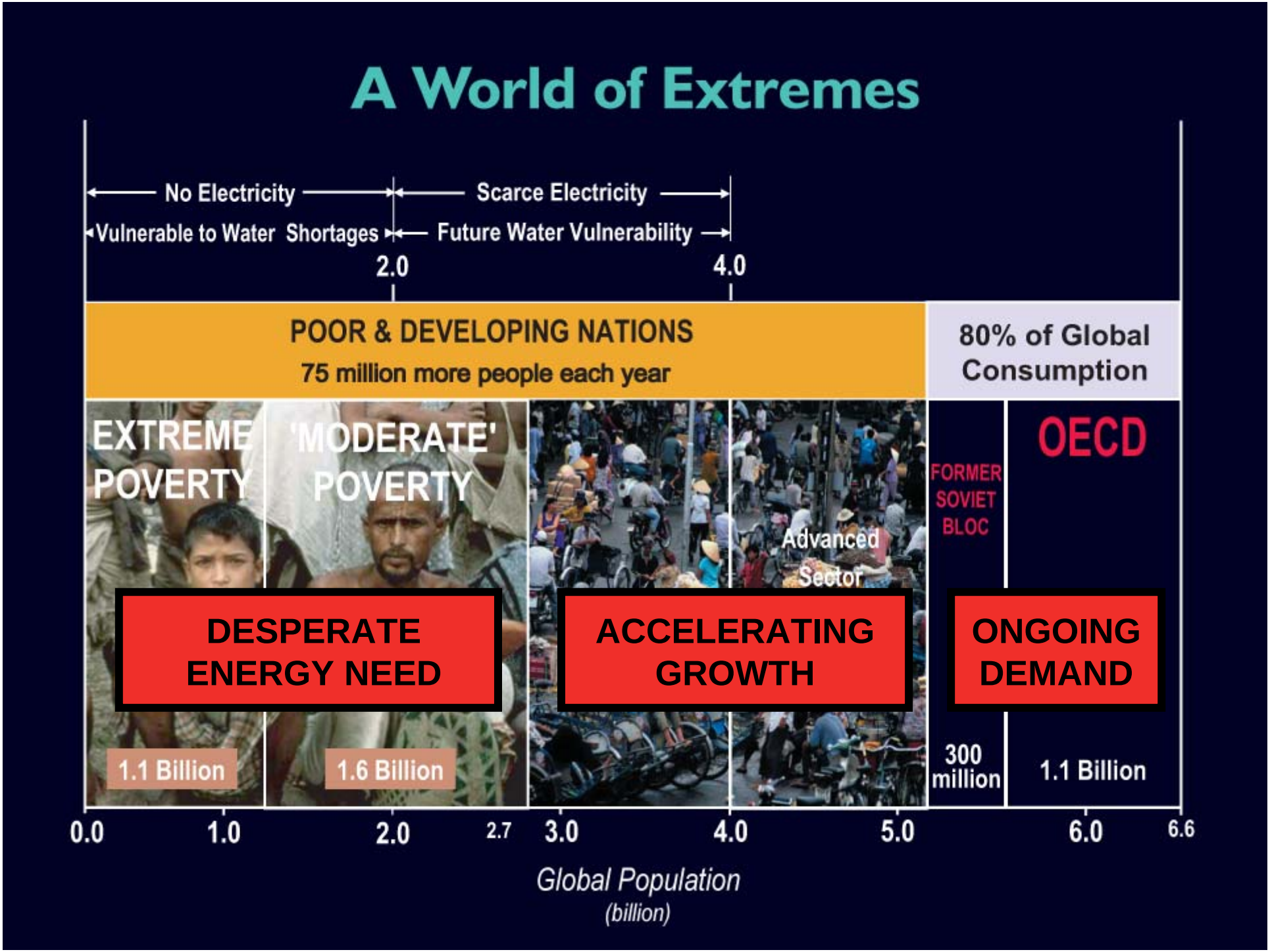
ENERGY FOR THE 21ST CENTURY AND THE NEED TO MANAGE NUCLEAR KNOWLEDGE

Key Topics

1. The “Return” for Nuclear Power and the need for Managing Nuclear Knowledge.
2. The HUMAN RESOURCE an need for NKM
3. The NKM program of the Agency - Key Initiatives and projects.
4. 2020 and beyond.

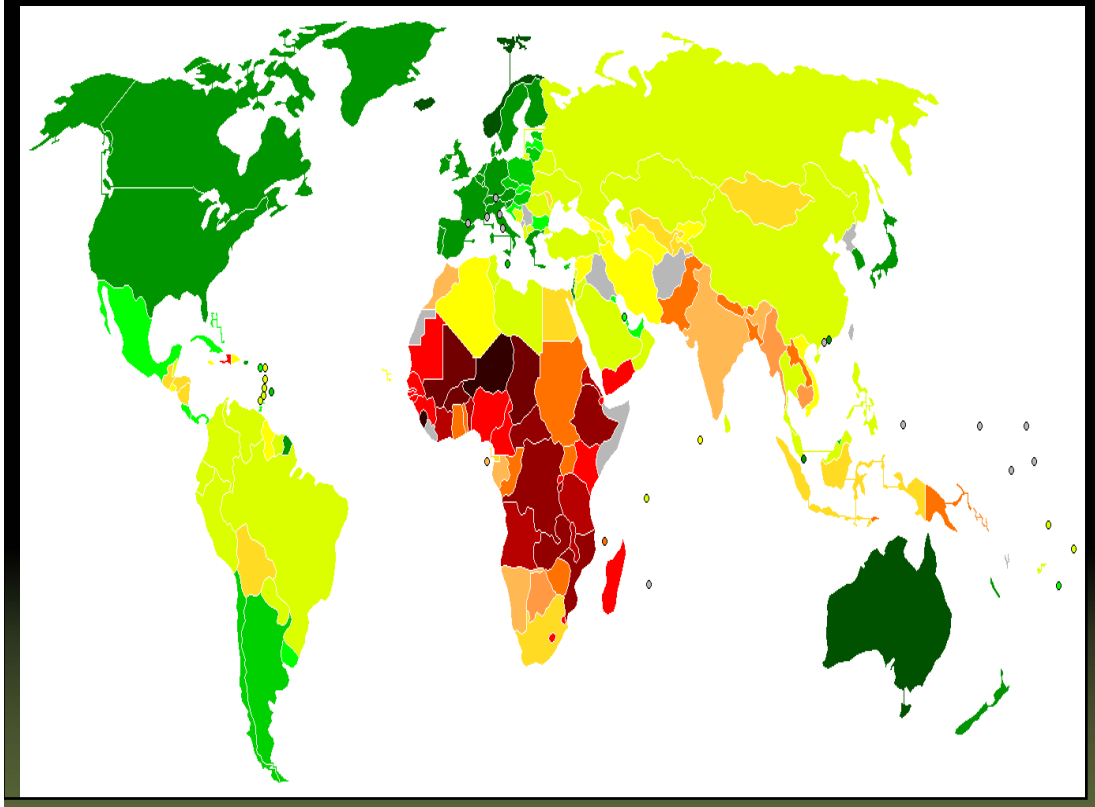
An energy hungry world…

A World of Extremes



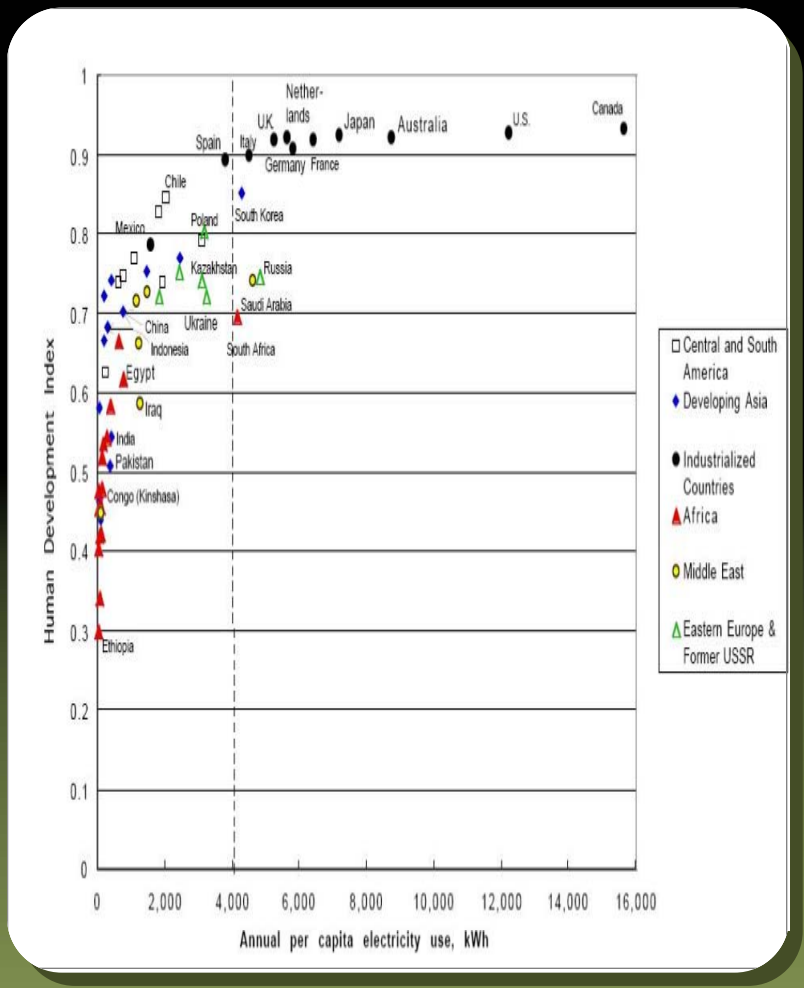
The UN human development index

(based on GDP, Life expectancy and Education)



over 0.95
0.90-0.949
0.85-0.899
0.80-0.849
0.75-0.799
0.70-0.749
0.65-0.699
0.60-0.649
0.55-0.599
of 0.50-0.54
of 0.45-0.49
0.40-0.449
0.35-0.399
0.30-0.349
<0.30
N/A

HDI and Electricity

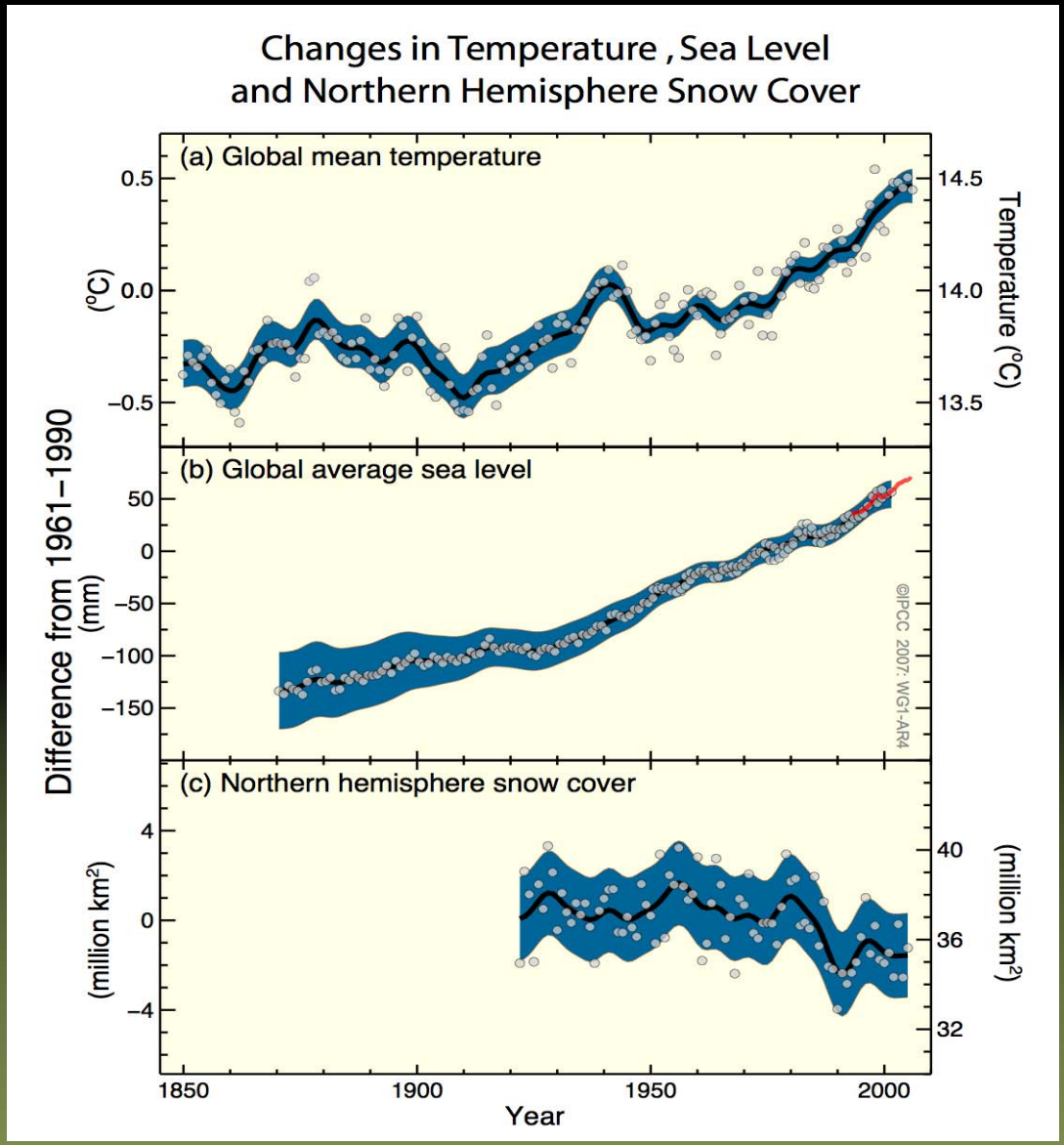


Climate change realities

Global mean
temperature

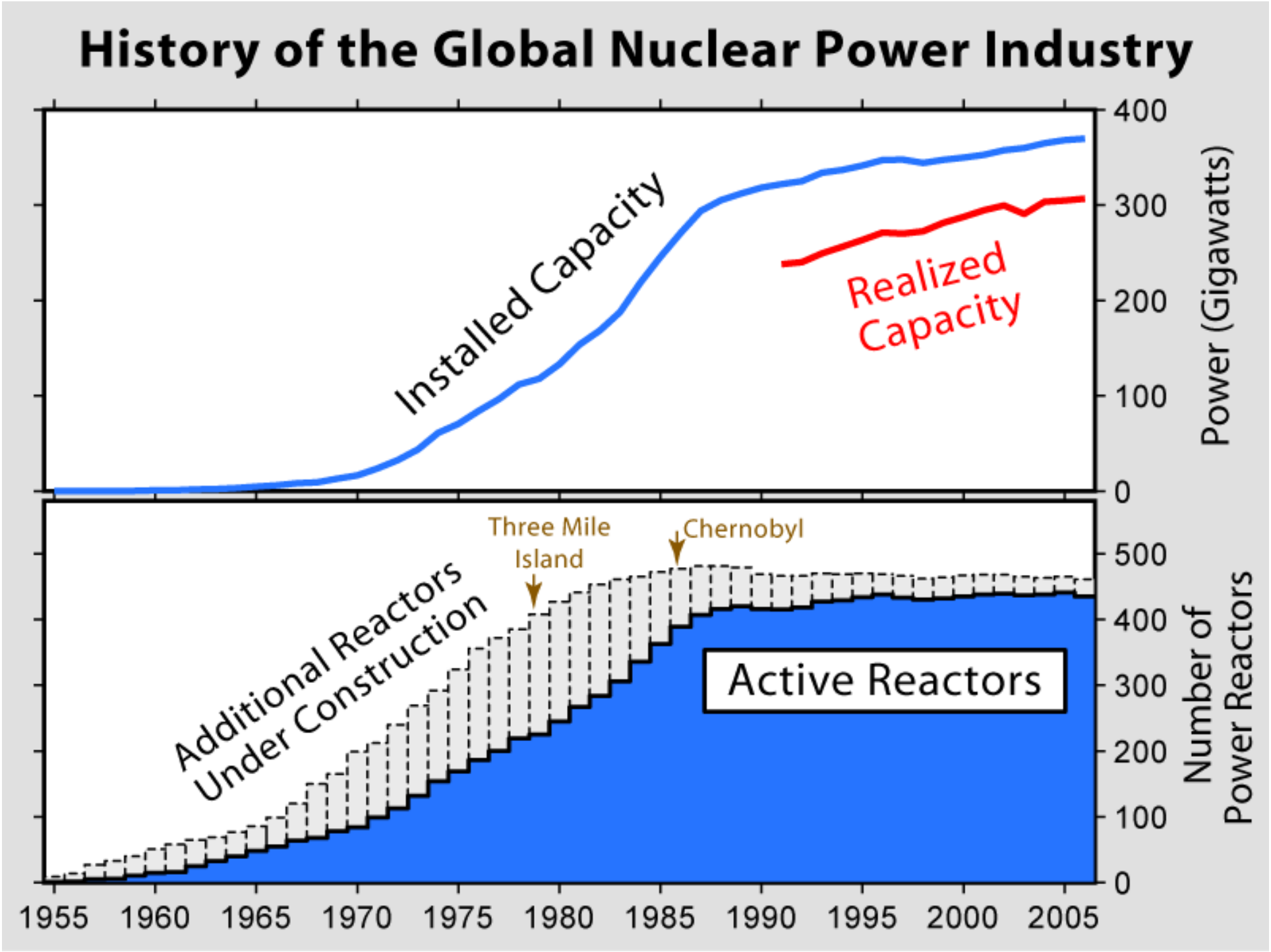
Global average
sea level

Northern hemisphere
Snow cover

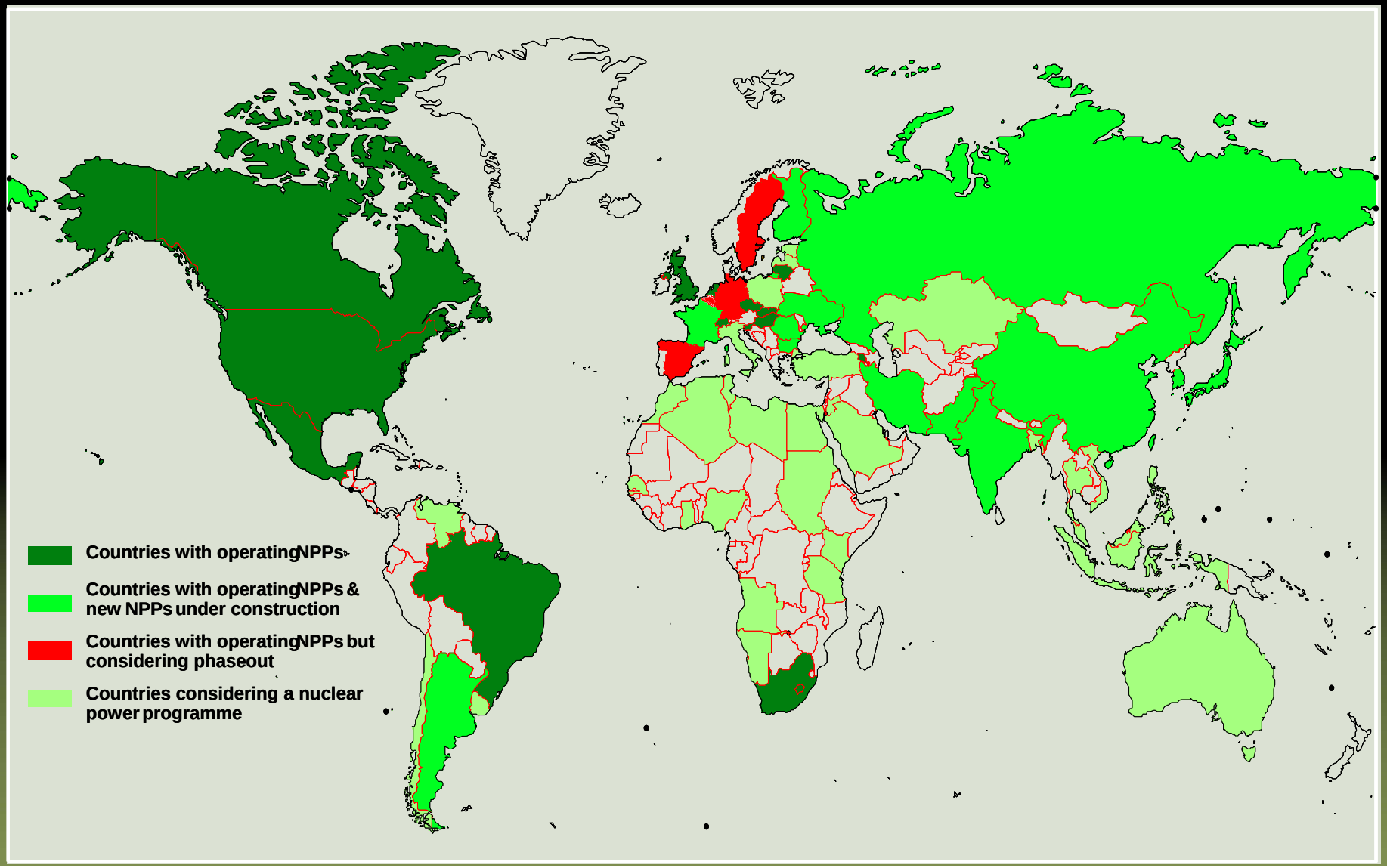


Nuclear Power: A Global Return!

- Unprecedented levels of efficiency & capacity utilisation of nuclear reactors in key countries (US, France, Japan, Russia)
- A robust and accumulating record of operational safety, backed by a pervasive global nuclear safety culture
- Political progress in implementing the scientifically sound concept of waste disposal using deep geological repositories
- The truest barometer: expansive growth plans for nuclear power in major nations in both the developed and developing worlds
- The future of the planet Earth becomes a major concern


History of the Global Nuclear Power Industry
Installed Capacity
Realized Capacity
Power (Gigawatts)
400
300
200
100
0
Three Mile Island
Chernobyl
Additional Reactors Under Construction
Active Reactors
Number of Power Reactors
500
400
300
200
100
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

Countries involved or wishing to be involved



"Rising expectations correspond to a rising demand for nuclear knowledge and competent workforce."

"People are likely to be the worst bottleneck"

Nuclear Knowledge

- A resource which was created by absorbing other resources,
  - Has its **own *cost***
  - Has to be **managed** in an efficient and effective manner to help to reach *organizational or national goals*.

Nuclear knowledge

- Involves virtually every area of physical sciences and engineering
- Requires a complex infrastructure
- Must be based on firm technical understanding to manage safety, economics, & innovation
- Takes many years to build up the knowledge base

Nuclear Knowledge

- Specifics for nuclear knowledge are:
  - its **long-term accumulation** and the long life cycle of facility operation;
  - **remarkable investment** from governments (public money);
  - security, non-proliferation and safety concerns; **international obligations**
  - needs **large critical mass of basic nuclear science** to support practical applications.

Nuclear knowledge – a remarkable achievement of society

Who owns Nuclear knolwedge

- Governments, including regulators;
- Designers, vendors, utilities, operators, suppliers, consultants, and support organizations;
- Training and academic institutions;
- Research and Development (R&D) organizations;
- The Public and Non Governmental Organizations (NGOs); and
- International organizations.

The situation in Member States?

- Both developed and developing Member States face knowledge management problems.
- Many already have NKM programmes in place, but efforts are fragmented.
- Sufficient experience has not yet been gained by all.

The developed nuclear countries

- **Developed countries are the custodians of nuclear knowledge** accumulated over decades. *There is consensus that actions need to be taken to preserve its key parts.*
- Problem: ***effective knowledge transfer between generations of workers,*** *the need to sustain and develop sufficient human resources* to sustain the operation of existing facilities and to prepare for a possible expansion in the future.

The developing countries

- **Developing countries face different knowledge problems:** *capacity building, access to and transfer of knowledge to the "country of growth"*.
- **Knowledge and human resources need to be build up for new nuclear power programmes,** and knowledge needs to be sustained (and not be brain-drained).

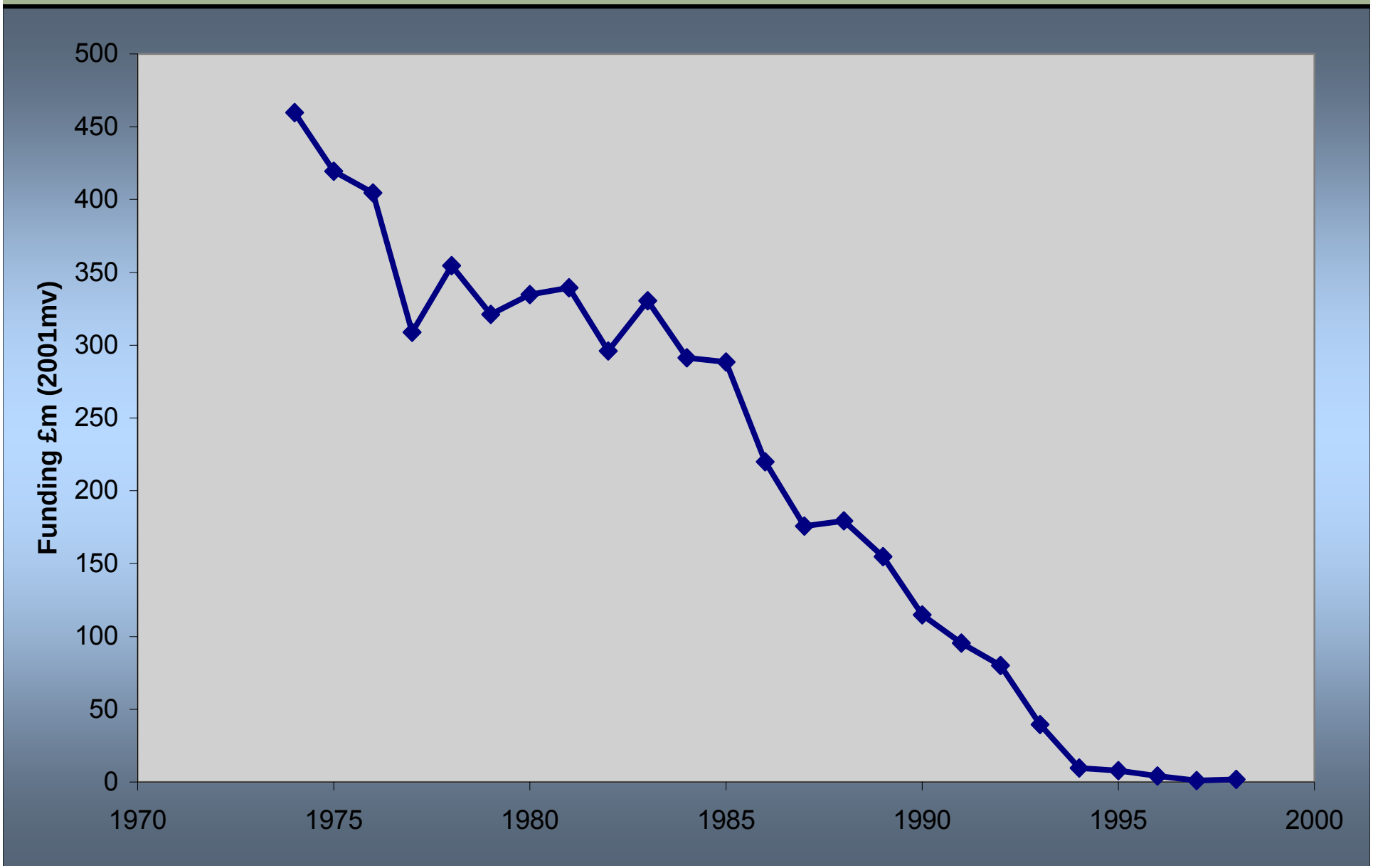
The Knowledge problems …

- Aging of nuclear personnel, retirement,
- Loss of valuable nuclear knowledge,
- Degradation in technology skills and know-how,
- Possible degradation in safety of current installations?
- Dilution or loss of innovation potential?
- Research & Development?
- Education & Training?
- **Renaissance = " Mission impossible**"?

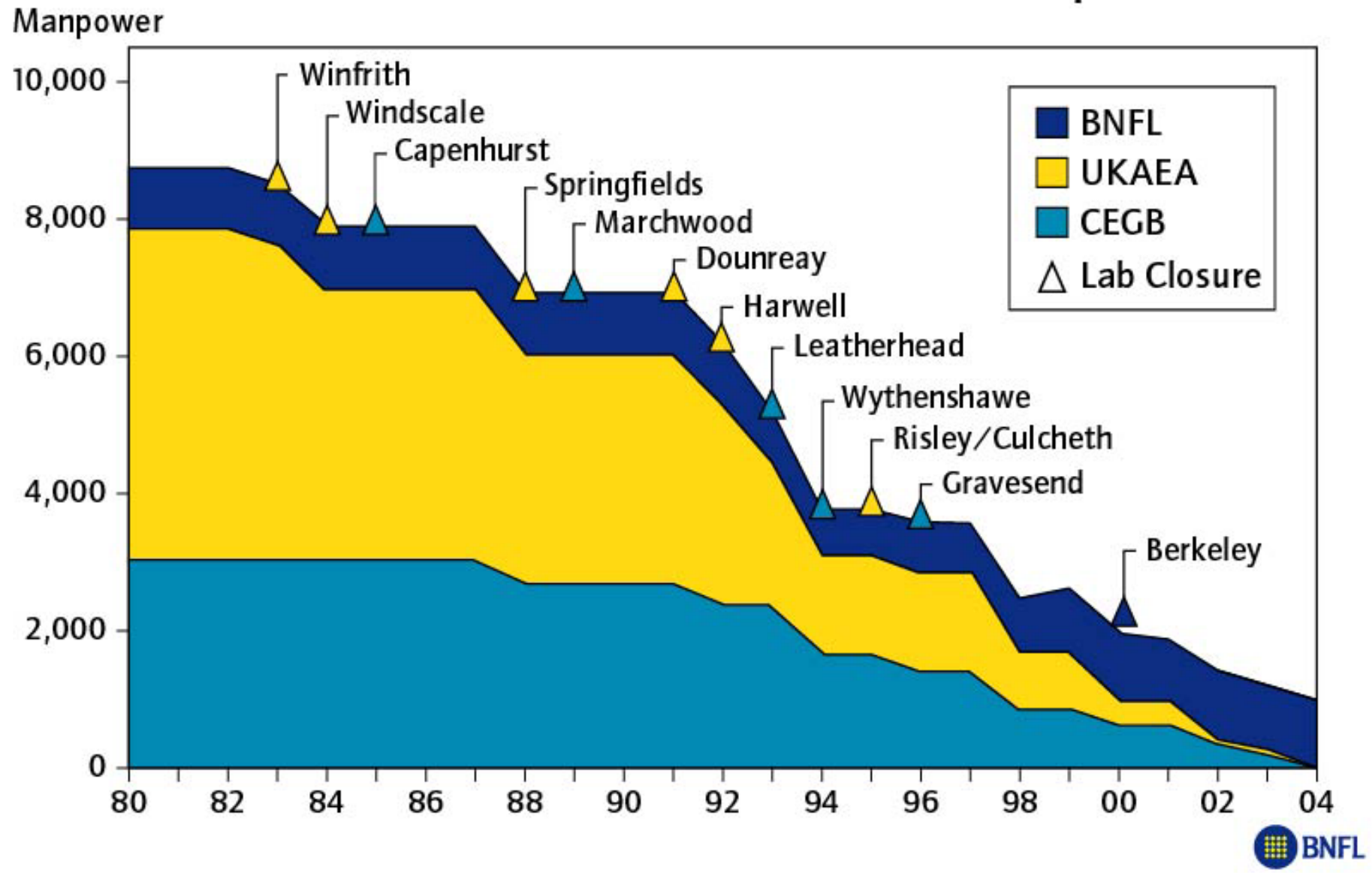
MANAGING NUCLEAR KNOWLEDGE

THE HUMAN RESOURCE AND SOMETHING MORE…

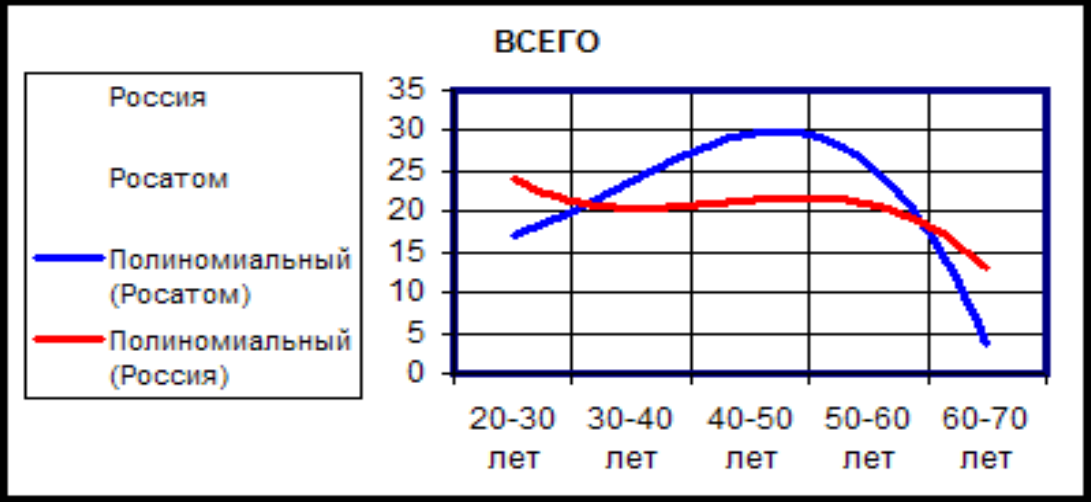
Financing R&D in UK

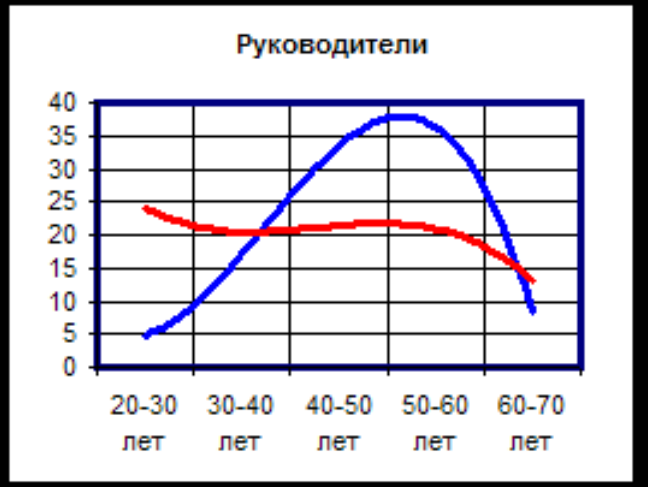


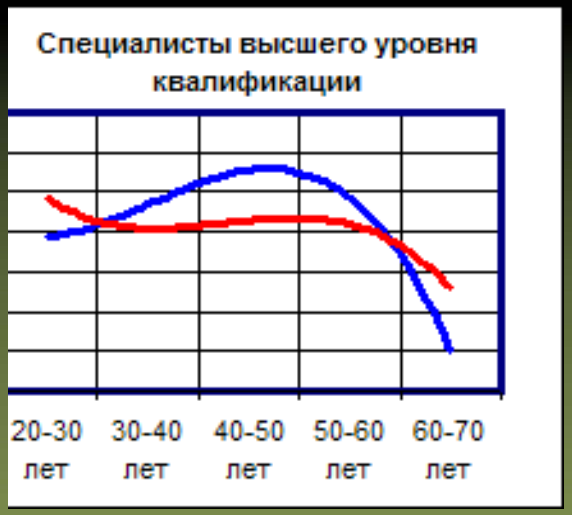
Nuclear research potential of UK

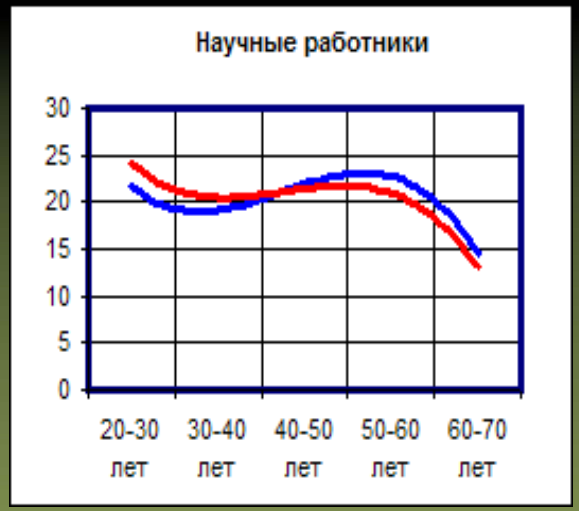


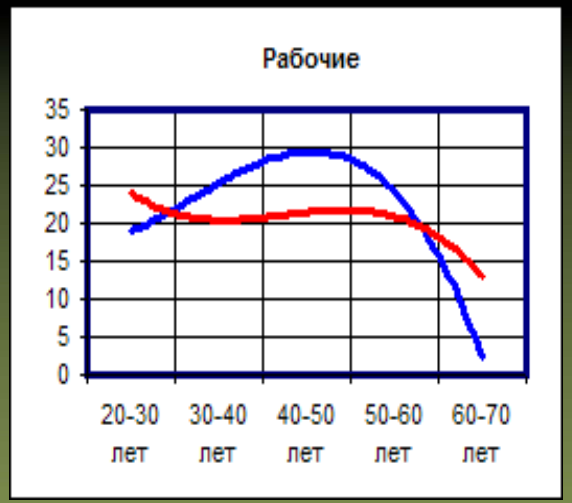
The Russian nuclear workforce



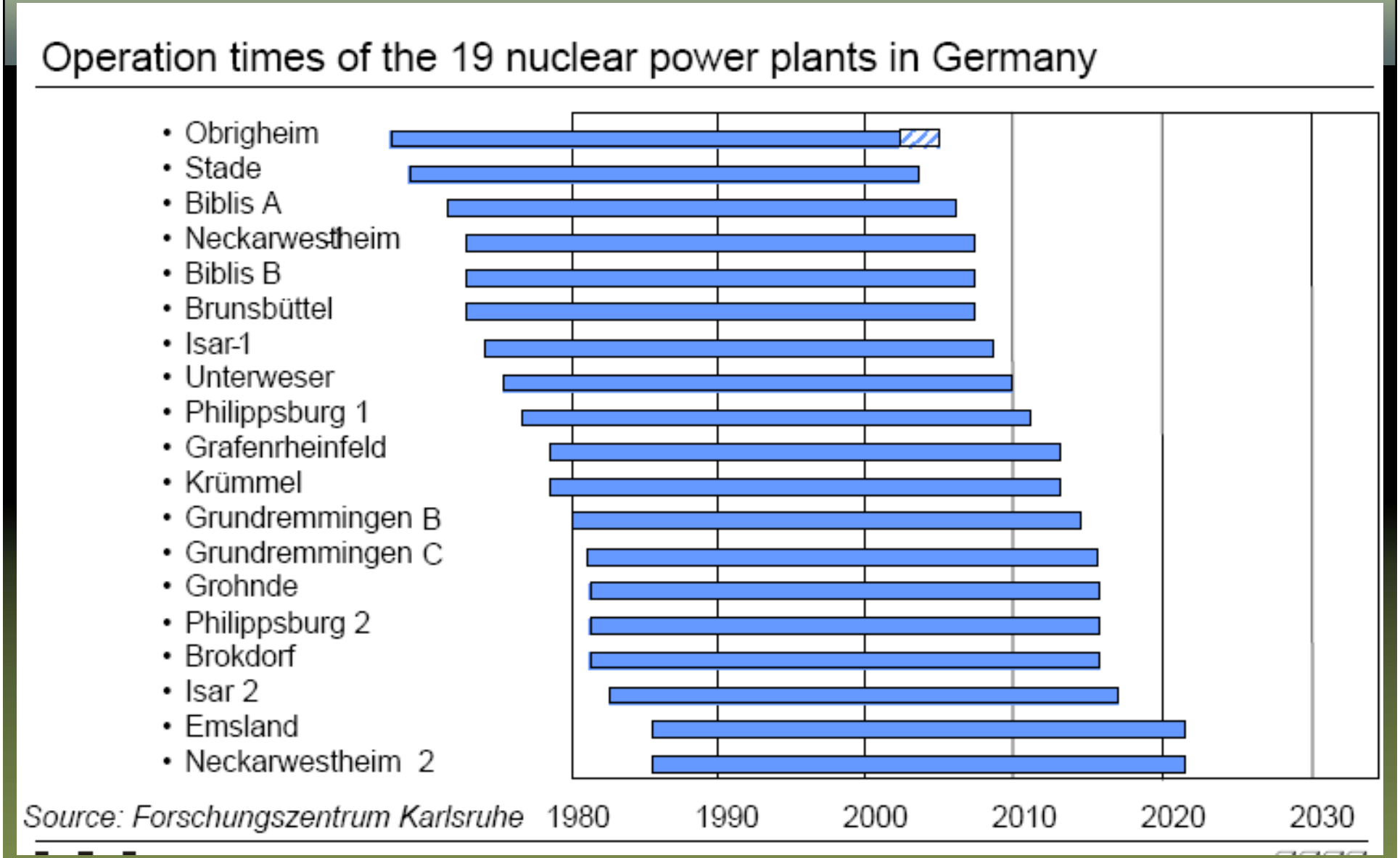




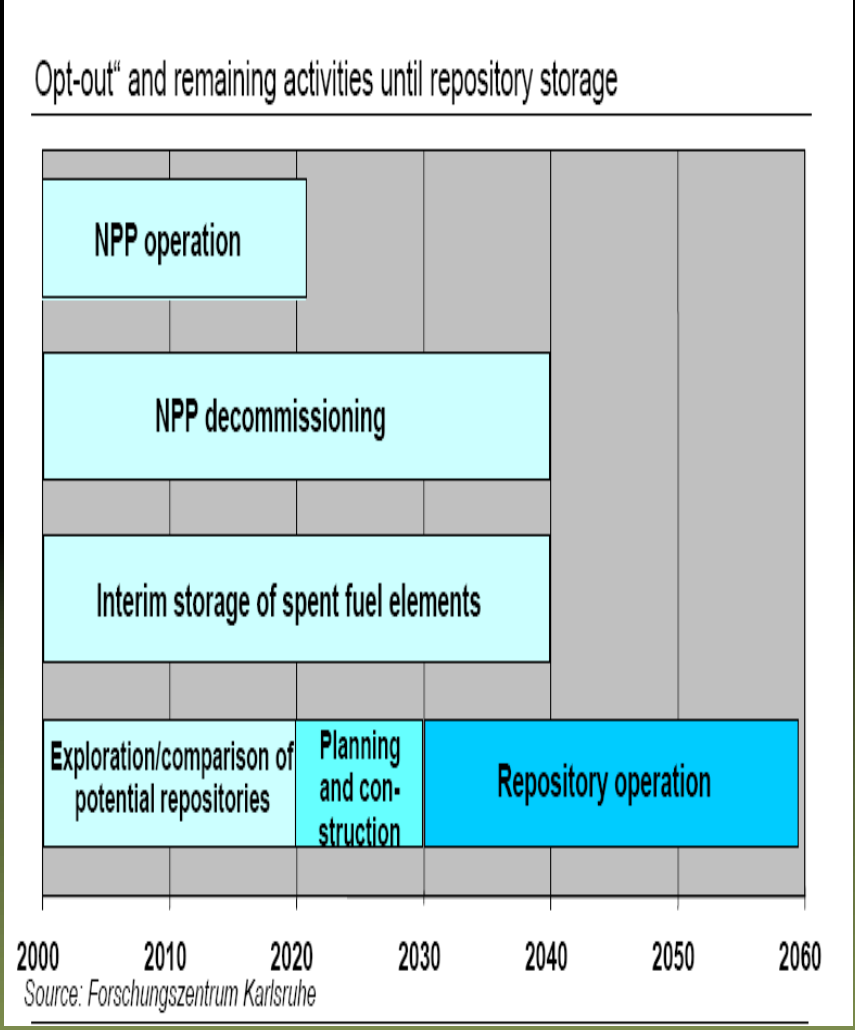


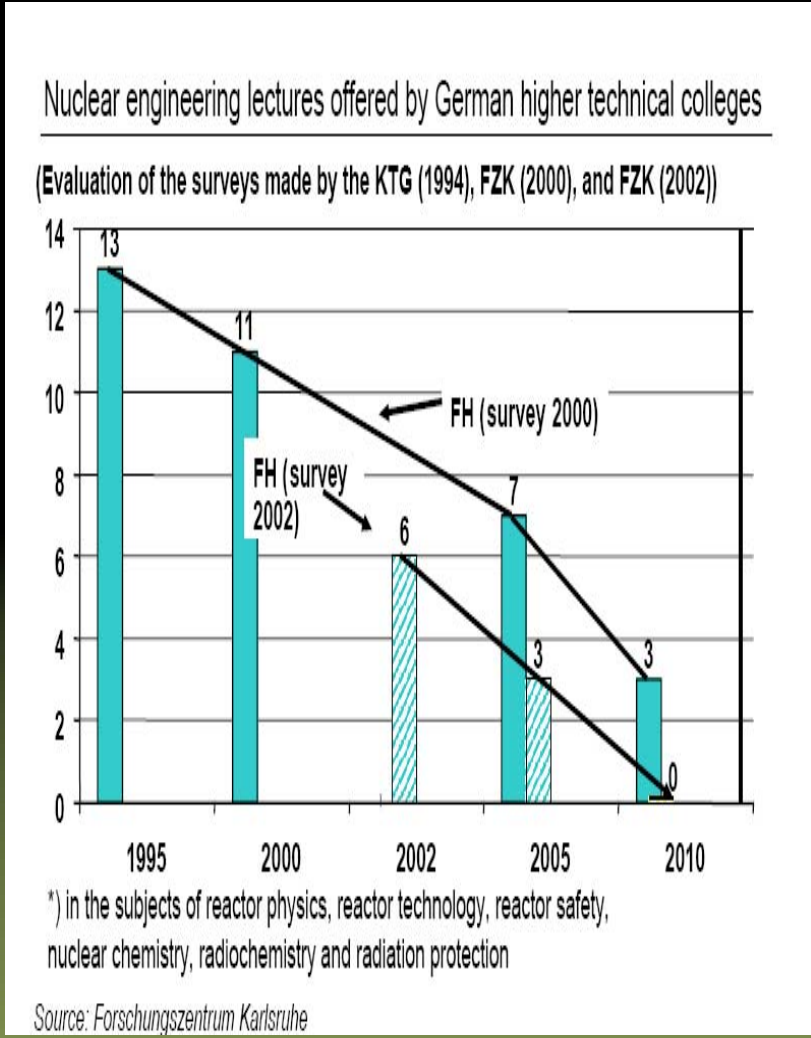


The German Phase-out

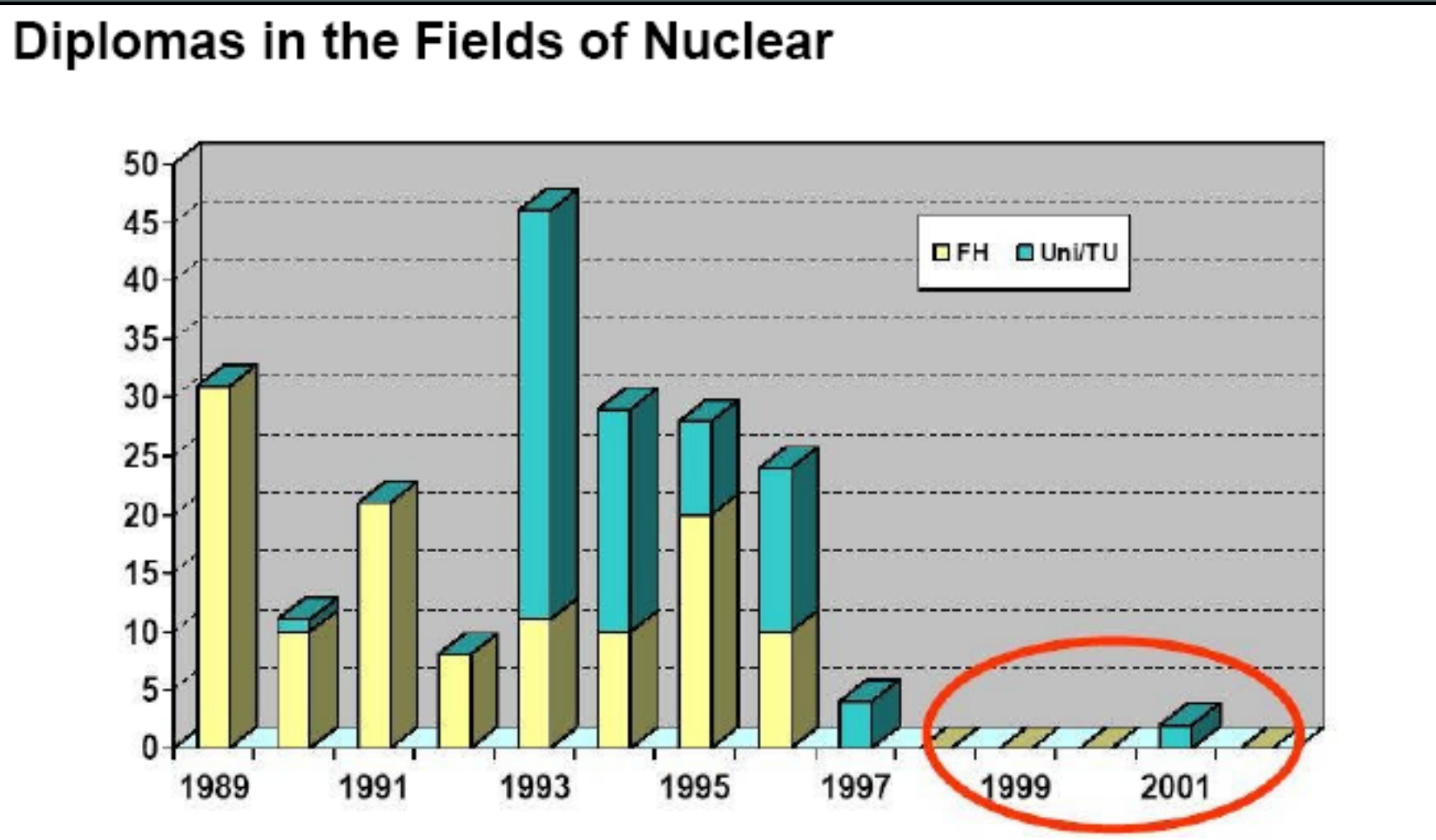


Need for nuclear specialists in Germany



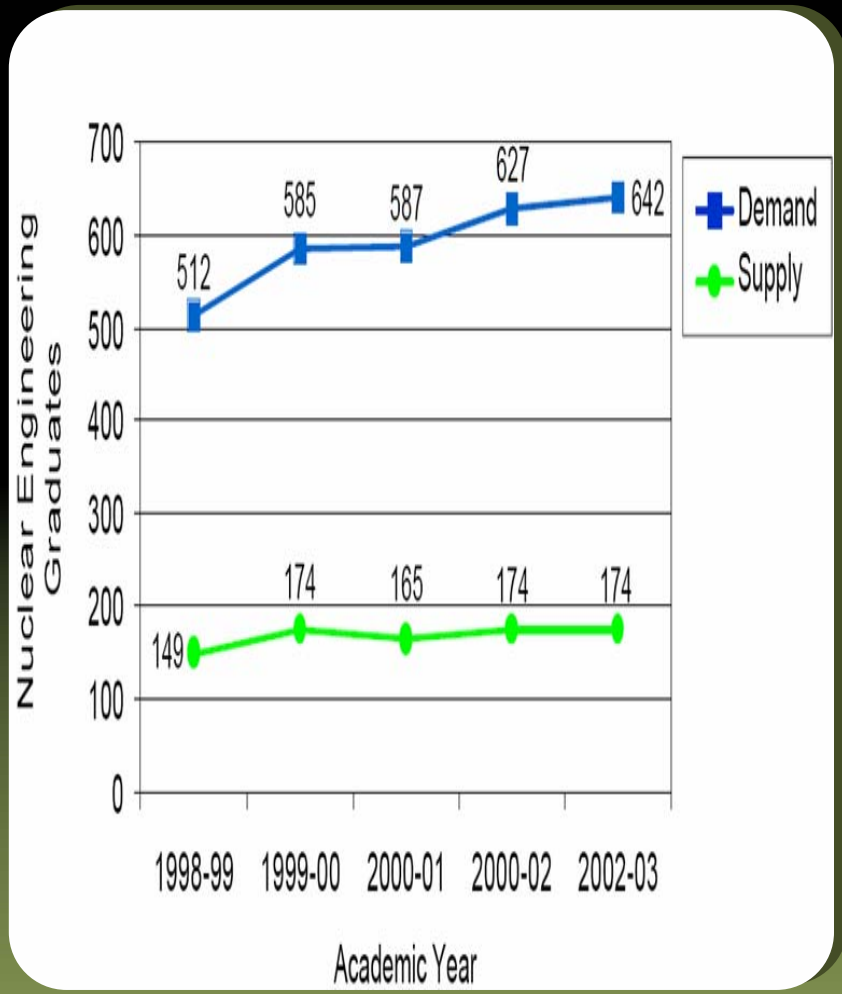


The next nuclear generation of Germany?

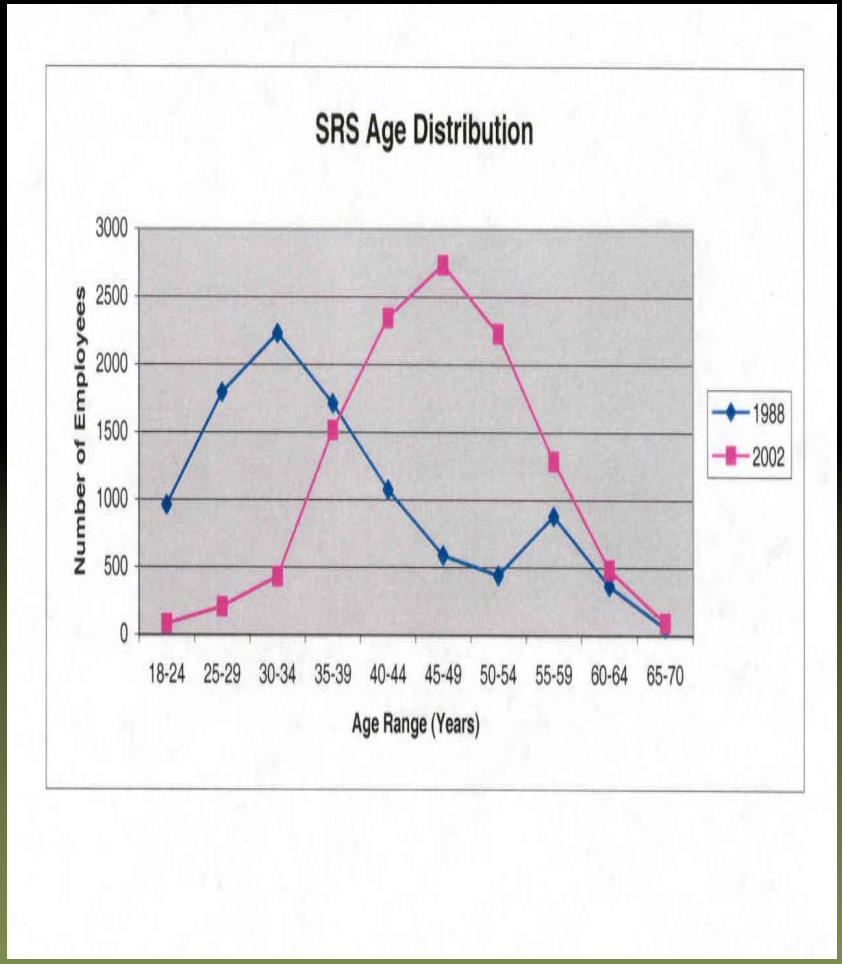


USA landscape

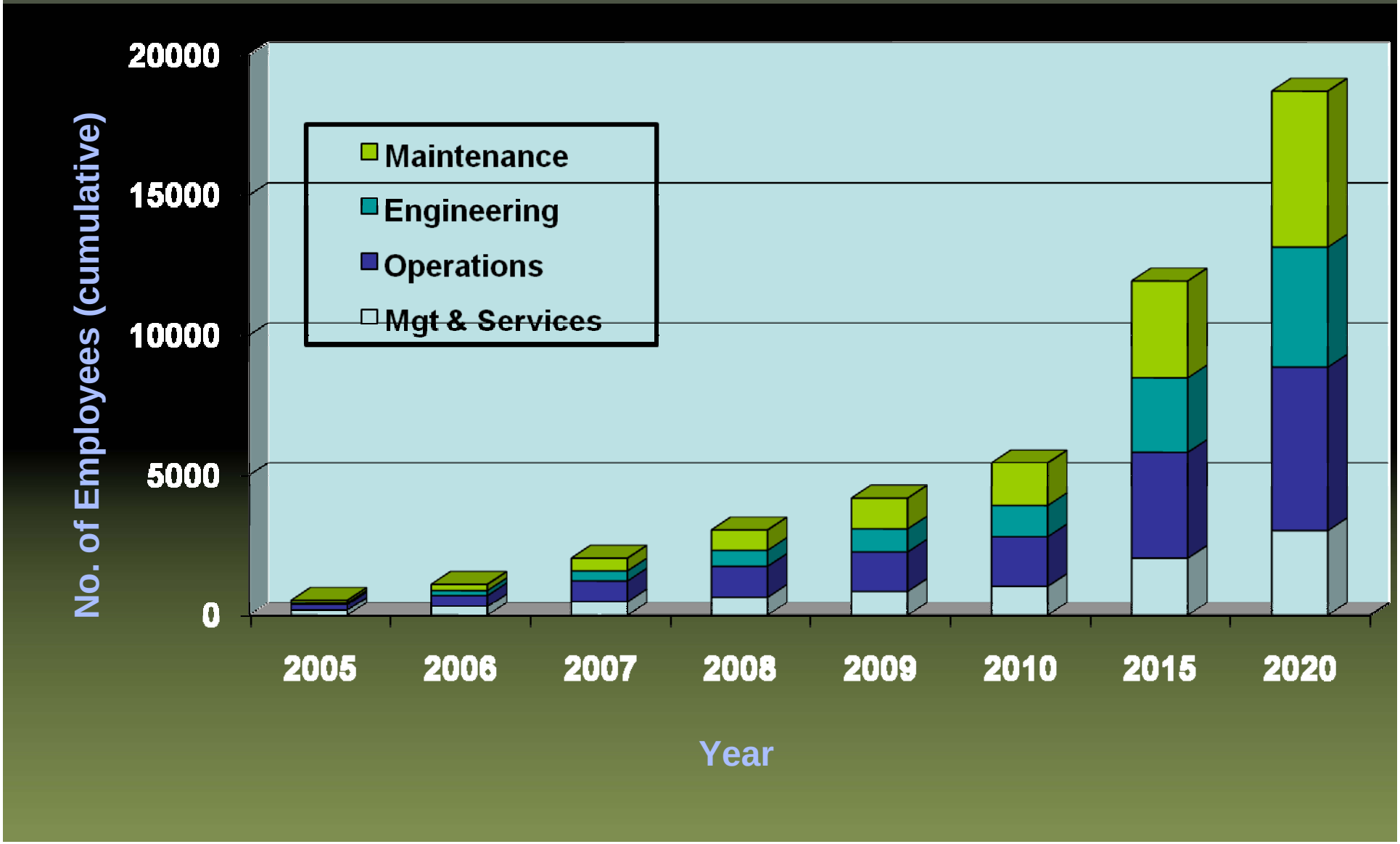
Demand and supply in NE



Trends in Nuclear Chemistry Programs

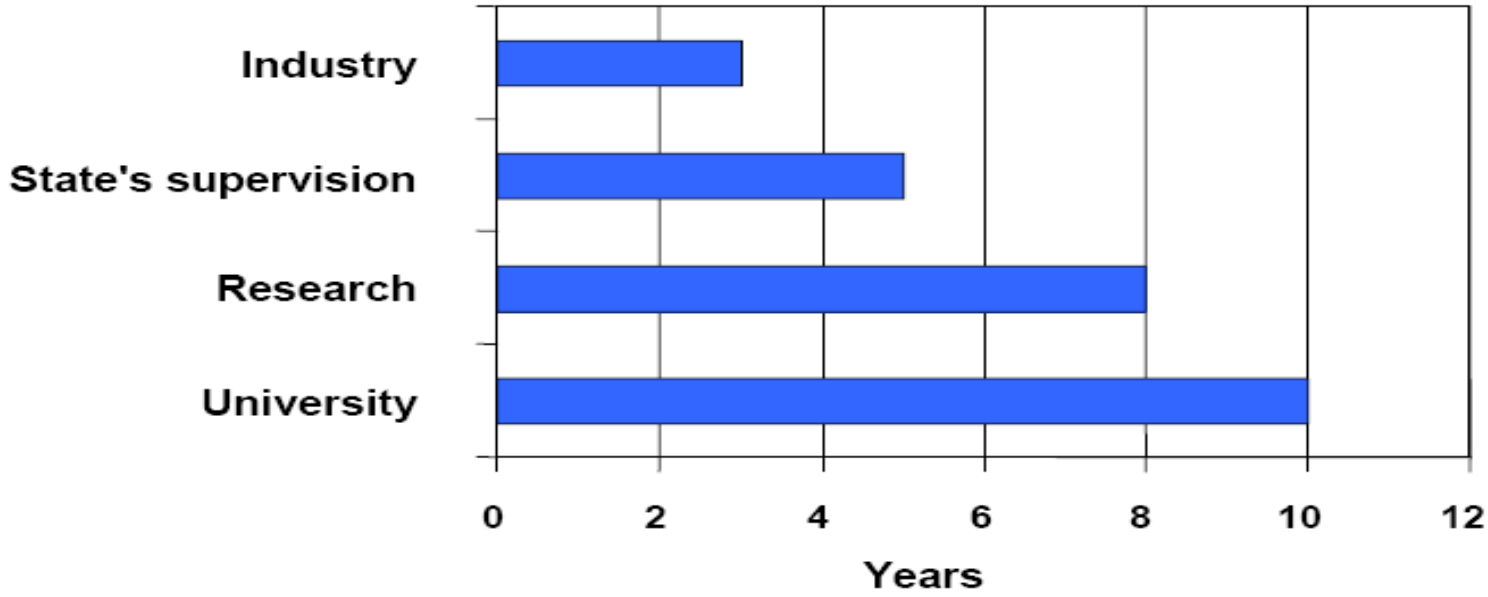


Manpower for Operating China NPPs



Time to build competence

Times for establishing nuclear engineering competence



Source: S. Griffiths, J. Royen: „Assuring future nuclear safety competence “, NEA News 2000 - No. 18.1

A Case Study in Europe

Conducted by Fichtner

Survey of Safety Convention Reports and IAEA own data

Interview partners included

Conducting of Interviews

Operators	Regulators and TSOs	Additional Organisations
▪ Germany (E.ON, EnBW) ▪ Czech Republic (CEZ) ▪ Slovakia ▪ Finland (FORTUM) ▪ Belgium (SUEZ) ▪ UK (British Energy) ▪ Sweden (Vattenfall) ▪ Spain (ANAV) ▪ Romania (Nuclearelectrica) ▪ Bulgaria (Kozloduy)	▪ Germany (UM BaWü, TÜV Süd, KTG) ▪ Finland (STUK) ▪ Sweden (SKI) ▪ Spain (CSN) ▪ France (ASN) ▪ Bulgaria (BNRA, written statements)	▪ EU DG RTD ▪ FORATOM ▪ DALTON Inst. (UK)

source: FMB

Qualification requirements

- Qualification requirements applicable to Nuclear Safety Important Personnel

Qualification Requirements	Target group
Well defined (e.g. IAEA)	• Operating staff within NPP
Depending on the organisation	• Experts at the utility headquarters • Supervisory personnel and experts in the plant • Nuclear Safety Important Personnel with authorities and TSOs

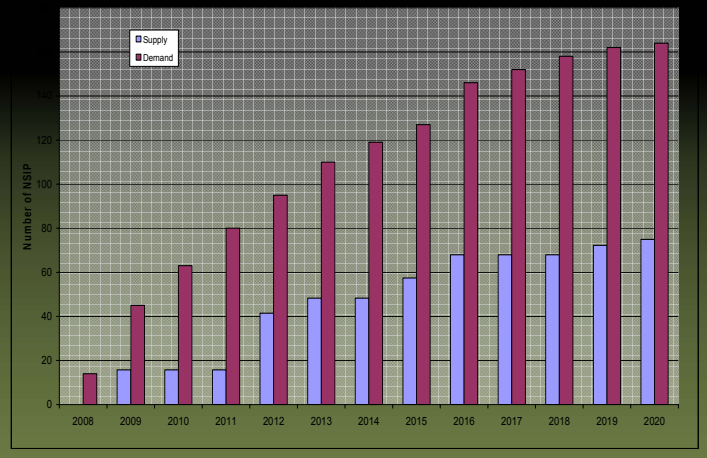
source: FMB

Number of vacancies with the Key Players until 2020

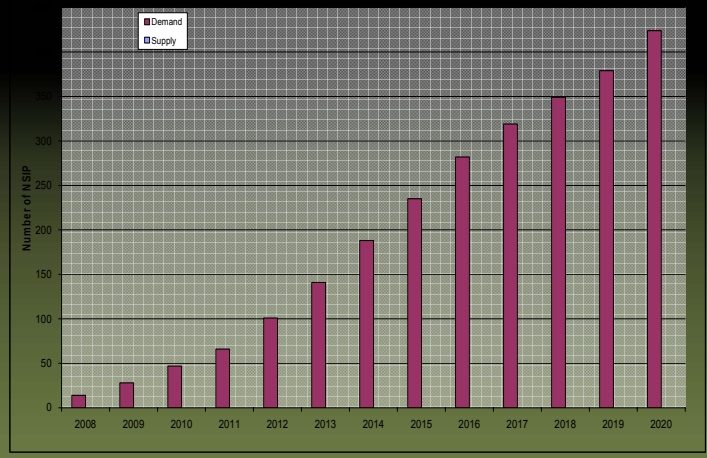
Results for the Member States (Examples)

Germany

- When executing current Atomic Law (Phase-out Scenario) moderate demand for nuclear safety important personnel (NSIP) is further reduced by available staff from decommissioned NPPs
- In case of NPP operation according to technical lifetime demand for NSIP is high



NSIP in NPP Operators (phase-out scenario)



NSIP in NPP Operators (technical life-time)

source: FMB

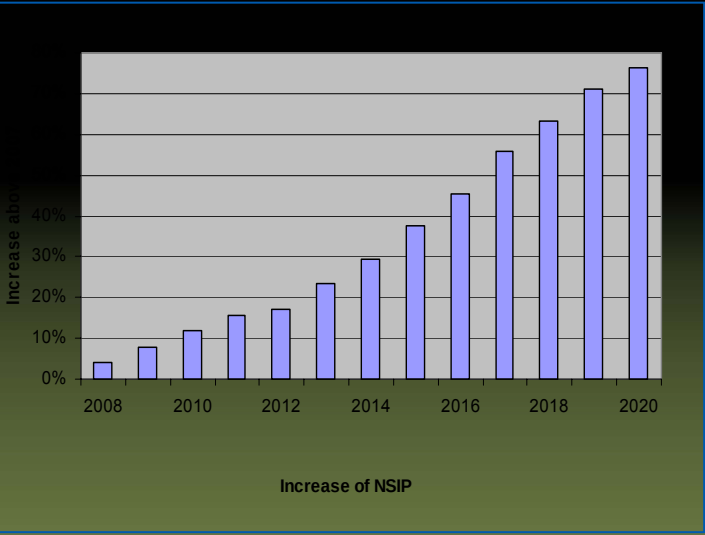
Number of vacancies with the Key Players until 2020

Results for the Member States (Examples)

Finland

- High demand due to expanding nuclear power generation

Total demand for NSIP in Finland



Increase of NSIP

source: FMB

Hiring practice of personnel for nuclear safety

- Results of investigation into hiring practice

Hiring Practice and Experience

Operating personnel in the NPPs	Supervisory personnel and experts with Utilities, Authorities and TSOs
Current Hiring Practice and Experience	
• Up to five years prior to need for replacement a young graduate is hired • Training according to the applicable regulations organised by the NPP/Utility, qualification tested by Authority	• Supervisory personnel in the NPP and utilities should have 5 - 10 years experience generally within the Utility/plant • Authorities and TSOs train on-the job

Results for the Member States (Examples)

Germany: Number of applicants decreasing (from >100 for one vacancy in the NPPs in the 1990-s to about 15 recently) but still sufficient. Only few with nuclear background.

Belgium: Number of young engineers as applicants satisfactory, however, lack of technicians.

source: FMB

Re-educate and re-train

- Results of investigation into measures to prevent lack of safety

General approach in the Member States to train operation personnel in the NPPs

- Shift personnel in NPPs in all Member States is trained (in the plant and/or in external facilities) according to well defined requirements for qualification
- The qualification is verified by the pertinent authority

Education and training of supervisory personnel and experts

- Most common method to qualify the personnel is the „Training-on-the-job“
- In few cases written and qualified procedures exist, more common is an individual process
- Consequently, the training and qualification gained may vary significantly
- Lack of knowledge in general fundamentals of nuclear safety and engineering and hence insufficient overall understanding of nuclear safety may result

source: FMB

Measures taken

- Few examples of initiatives

Finish approach

- Finish universities have traditionally been backbones of nuclear education and training
- Since four years utilities, authority, research organisations and nuclear supply industry join forces with the universities in basic nuclear training of their employees

Belgian initiative

- SUEZ started in 2006 a specific program to prevent a lack of nuclear engineers by hiring university graduates of different disciplines to be trained for two years in nuclear engineering and subsequently take over responsibilities in one of SUEZ subsidaries

Recent German initiatives

- Universities and research organisations are attempting to join forces
- Utilities have started initiatives to cooperate closely with the universities in the education and training of nuclear experts

source: FMB

Current role of the Universities

Assessments of the “clients”

- **“It is more important to find good engineers for our nuclear safety related jobs without nuclear background than average ones with some nuclear knowledge. We have had and still have to train our specialists anyway”**
- **“Basic nuclear education at the universities have declined substantially within the last decades. We can’t wait until the universities have adjusted to the current situation and educate students according to our needs”**

Education and training of supervisory personnel and experts

- The curriculum frequently is not sufficiently co-ordinated, neither among themselves nor with their “clients”
- The universities in particular in the Western Europe Member States educate much less students in nuclear engineering than are needed by the industry
- International initiatives like ENEN, NEPTUNO or WNU have still to demonstrate their value for maintaining high level of nuclear safety

source: FMB

Some thoughts

- Until 2020 more than 4500 NSIP are needed by the Key Players as a replacement due to retirement or for new NPP operation in the Member States
- About 40 % represent operating personnel in the NPPs that is trained within the operators' organisation according to well defined procedures
- For training of supervisory personnel in the NPPs, utilities, authorities and TSOs in general no regulated procedures exist

Some thoughts cont.

- Co-ordinated education in nuclear engineering at the universities has in Eastern Europe Member States resulted in significant supply of qualified personnel for the Key Players
- Immobility and costs for the students as well as reluctance of universities to harmonize curriculum in nuclear engineering have hampered measurable results of international initiatives

How critical is the situation?

- The loss of knowledge, experience and infrastructure can prove to be enormous.

- The need to preserve today's level of development of nuclear technologies requires urgent actions now and prolonged efforts in the future

IAEA Meeting of Senior Officials
on Managing Nuclear Knowledge
June 2008

Agency role

- The role for the Agency is to assist in the transfer of knowledge from “centres of competence” to the “centres of growth”.

- Potentially **high risk of knowledge loss** and **additional cost for future generations** must be avoided, and the Agency can help to integrate this long-term aspect into today's strategic decisions.

Why not leave it to the market?

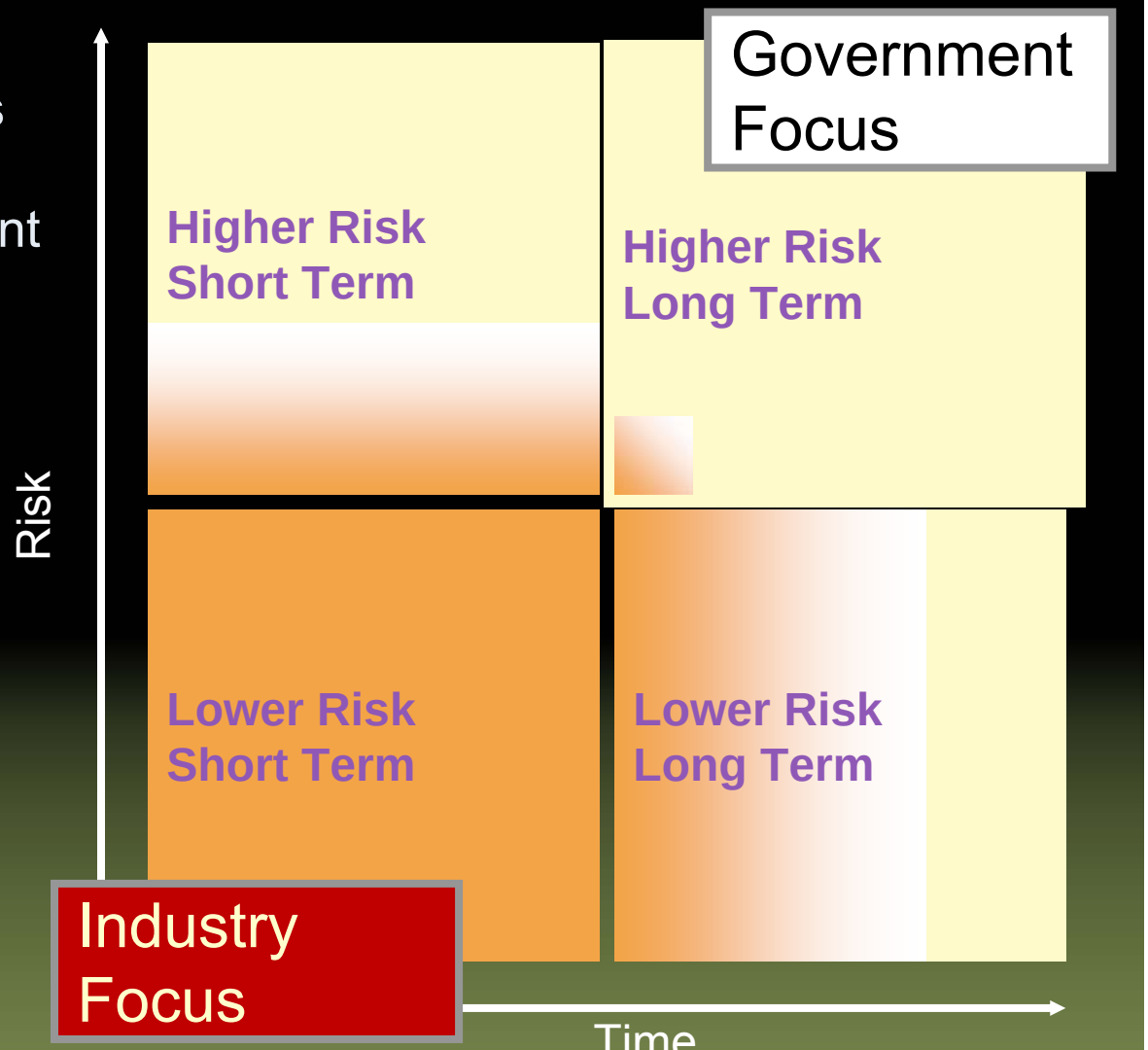
Are we not duplicating industry?

- Markets can create and preserve knowledge **only in areas of commercial interest** and during the time this interest lasts.

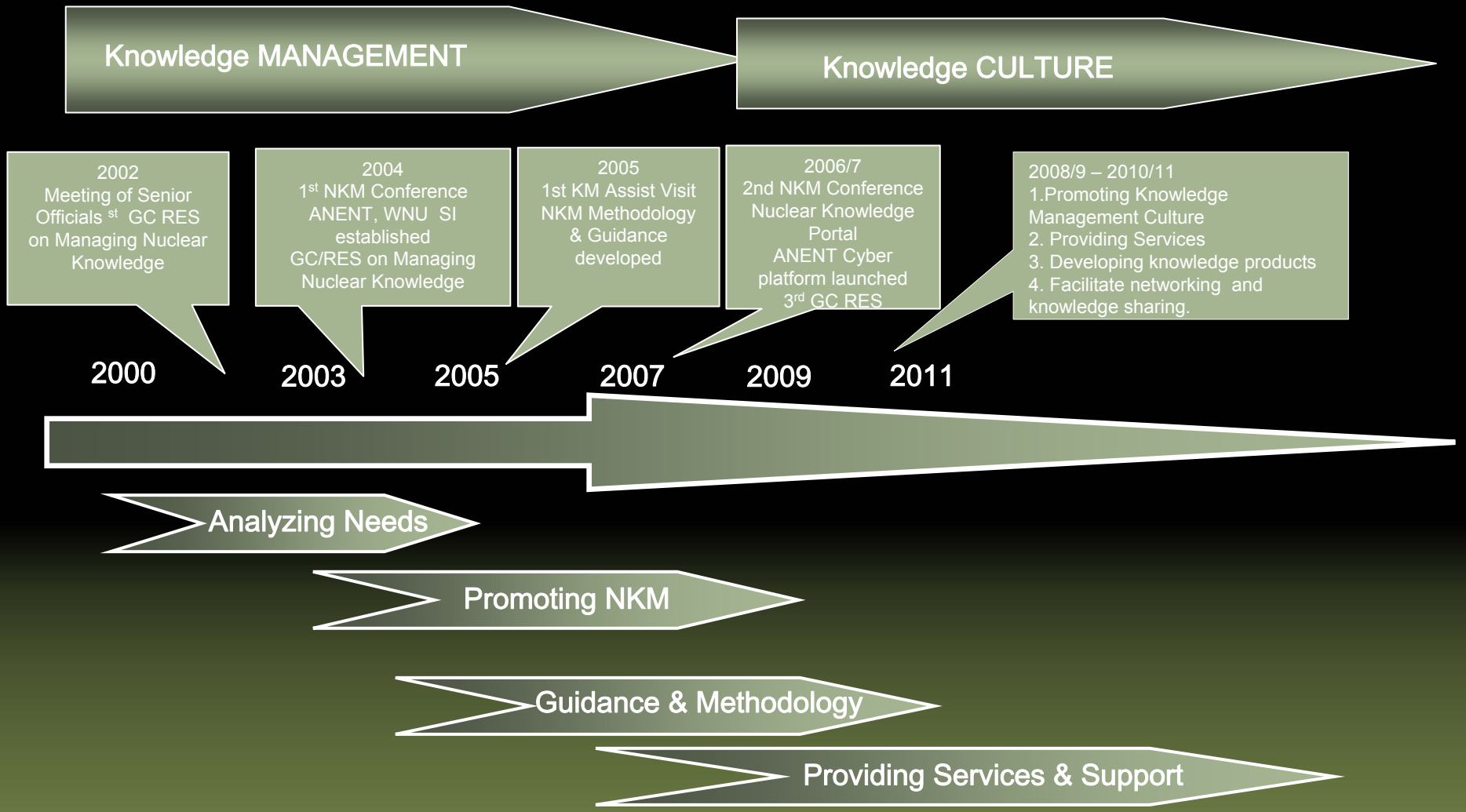
- **Managing nuclear knowledge requires long-term planning** and remains in the responsibility of governments as a part of national development plans and international obligations both for developed and developing countries.

Players and Roles

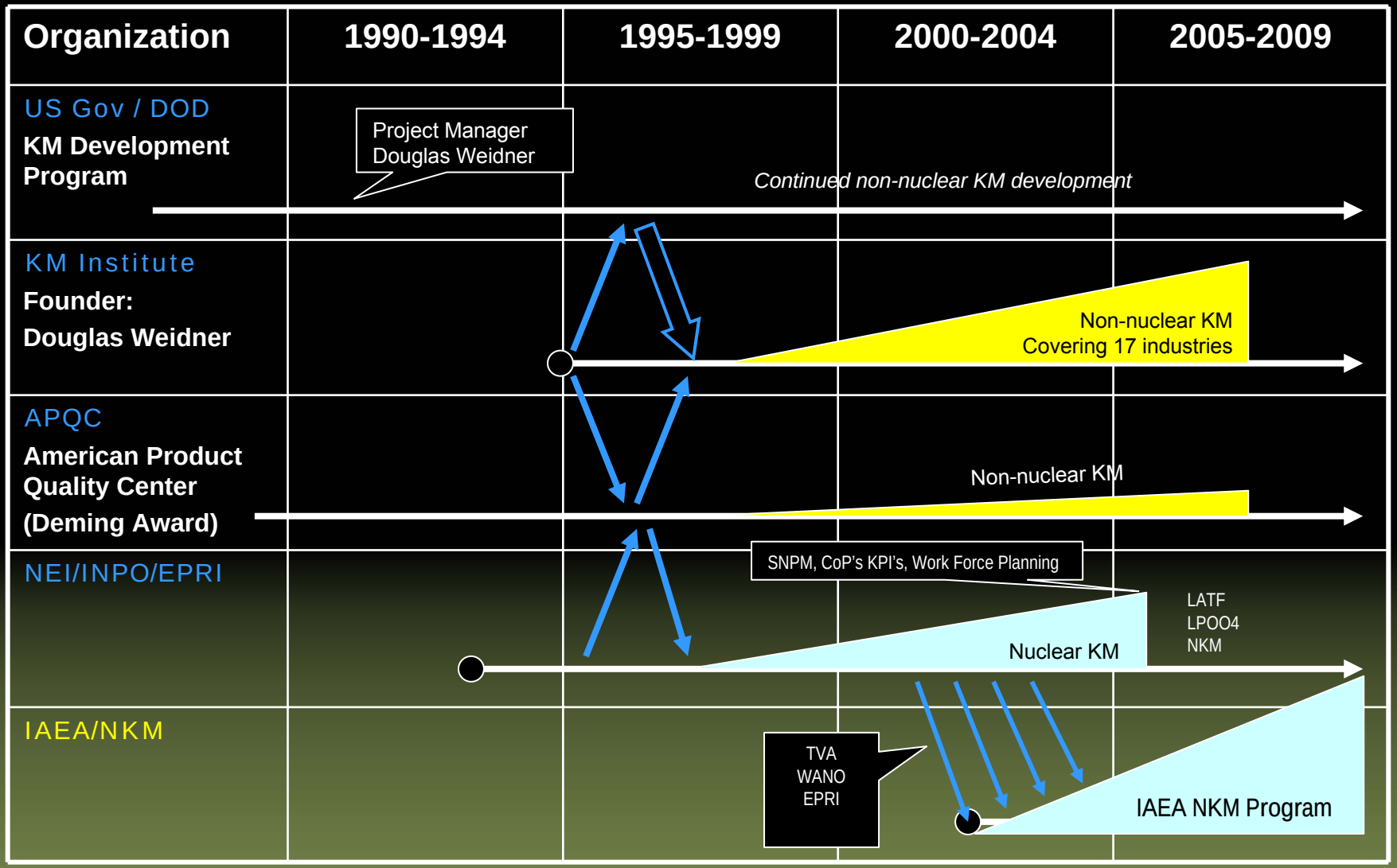
- **Industry must address immediate requirements**
  - Design, delivery, and operations need constant focus
  - Safety and regulation
  - Economics
- **Governments must address longer term issues**
  - Policy-making
  - R&D for
    - Pre-commercial
    - Strategic
    - Regulatory
  - Underlying science
  - Education & infrastructure
  - **Agency** → Government



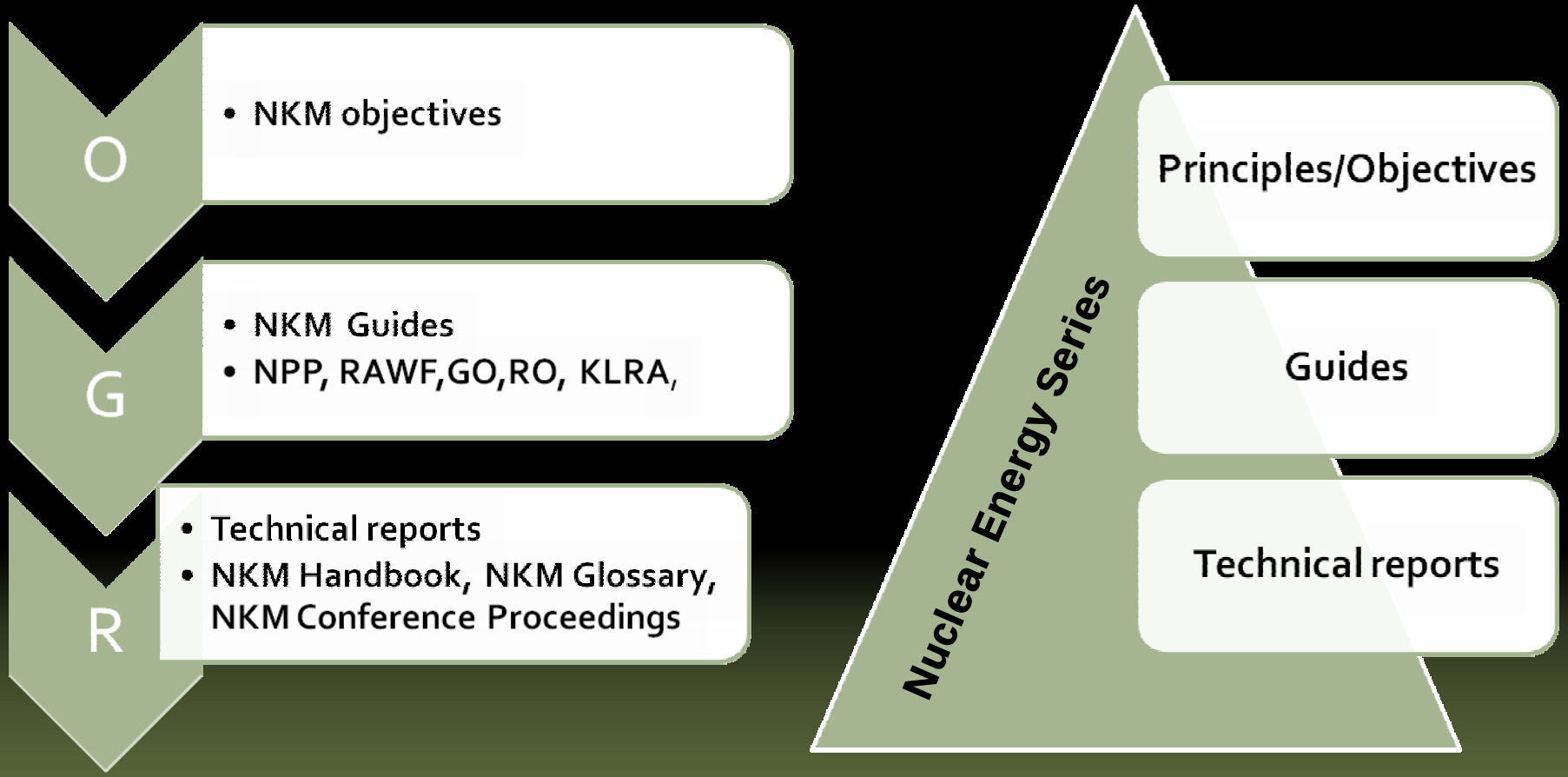
Agency' Programme Evolution



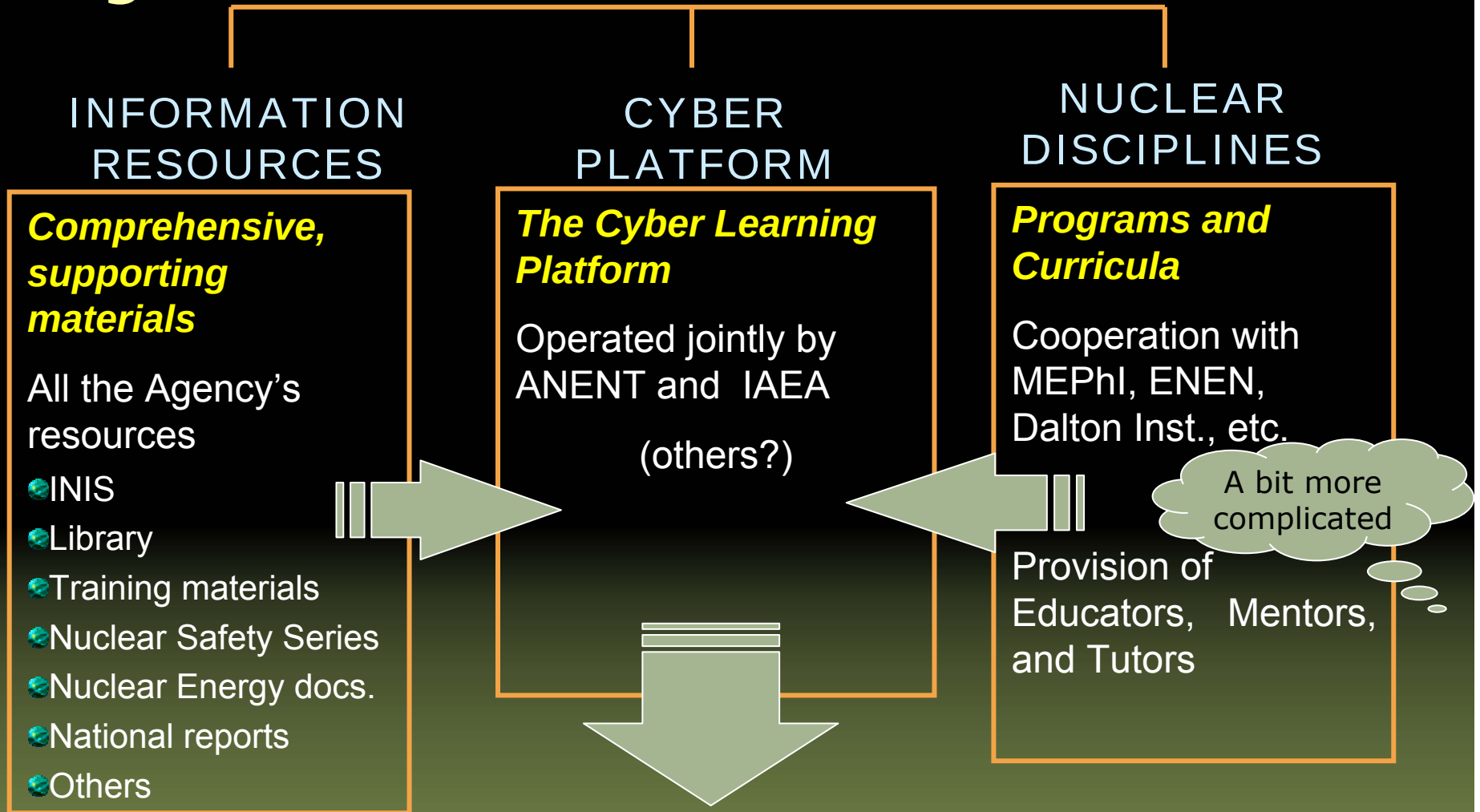
NKM – "Big Picture"



Knowledge Management Methodology



The Agency's ANENT project



WNU partnership

- A. Strengthening University Curricula
- B. Developing Future Leaders
- C. Ensuring Security in Global Nuclear Energy Systems
- D. Training to Enhance Industry Operations
- E. Sharing Advances in Nuclear Science
- F. Improving Secondary School Introductions to Nuclear Technology

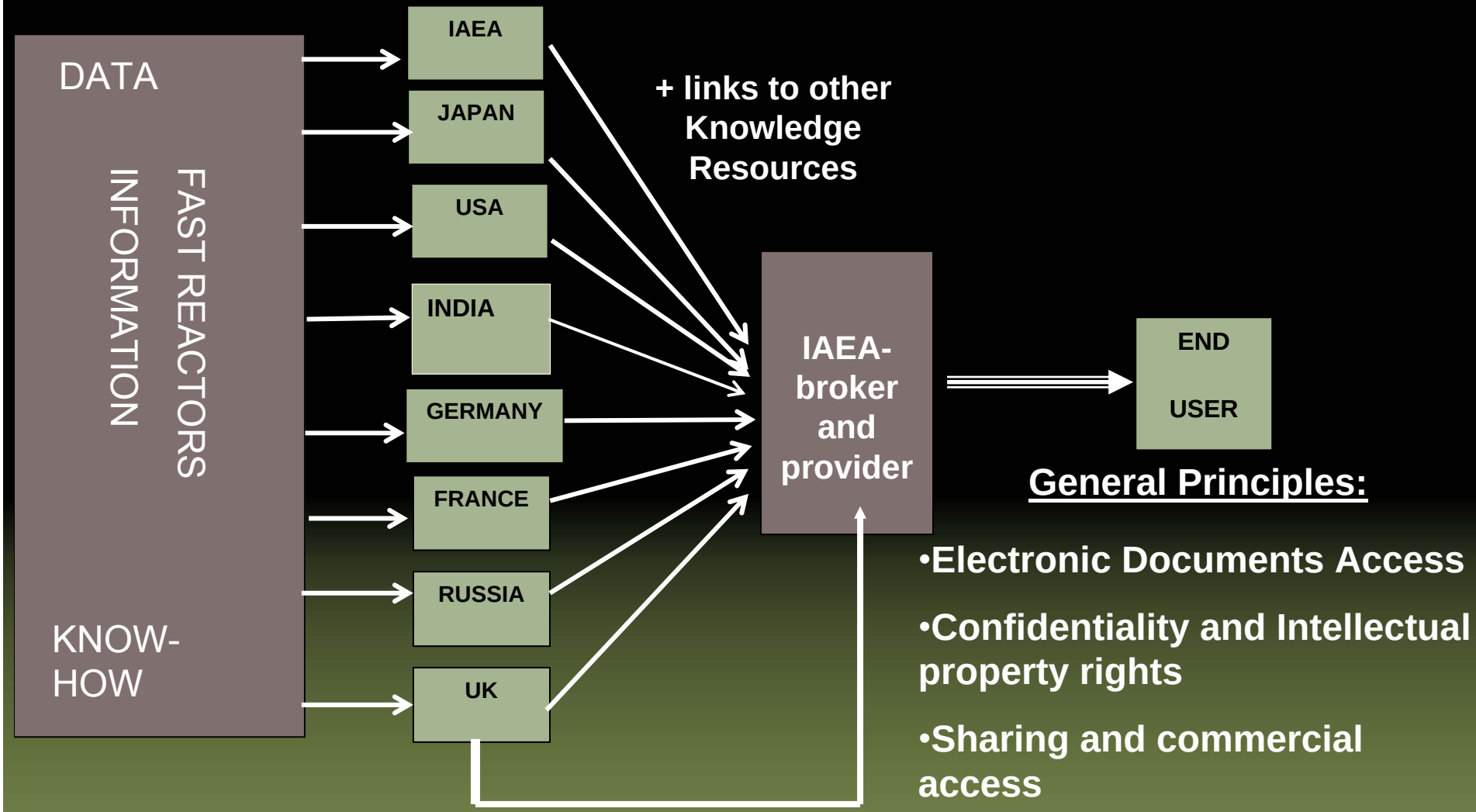
WORLD NUCLEAR UNIVERSITY

ATOMS FOR SUSTAINABLE DEVELOPMENT

The Knowledge Assist Visits

- Evaluation of organizational NKM elements,
- Analysis of organizational needs for NKM,
- Support in developing a Strategy for NKM,
- Assistance in methods and tools for NKM,
- Risk assessment of knowledge loss.

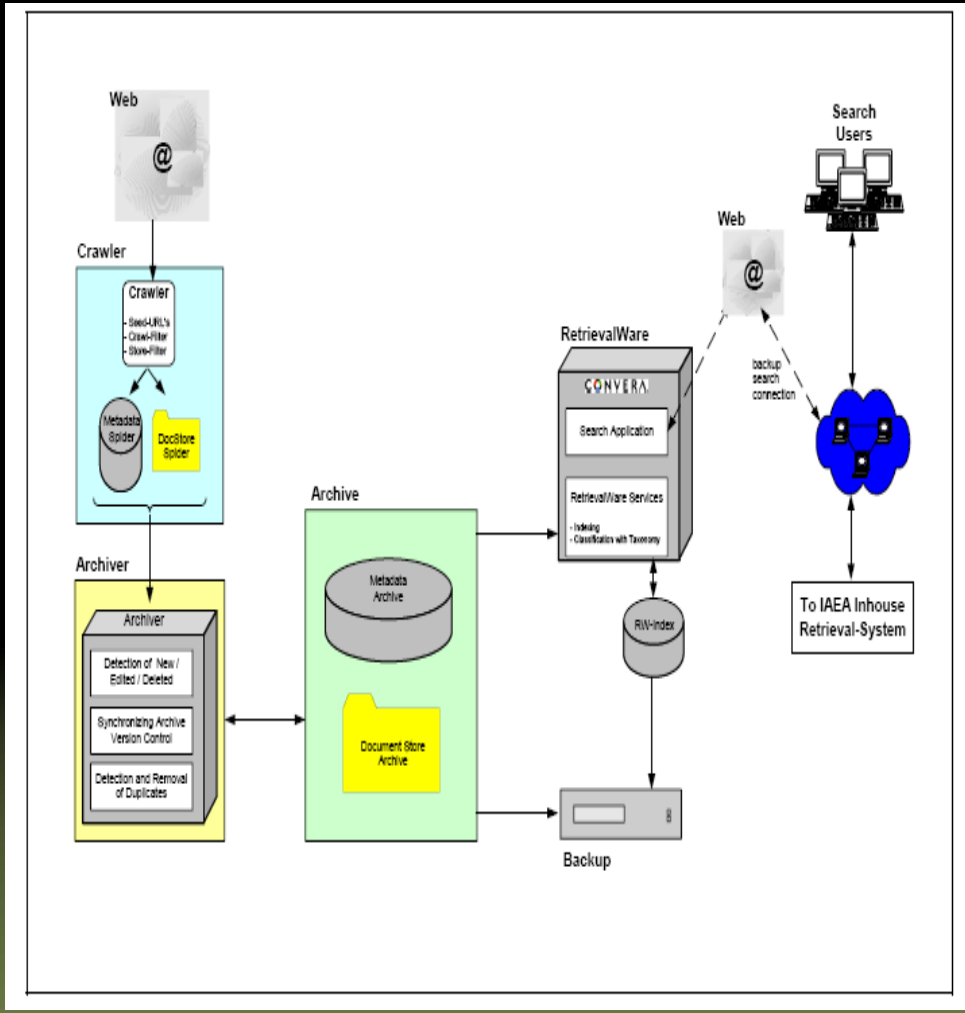
Fast Reactor Knowledge Partnership



General Principles:

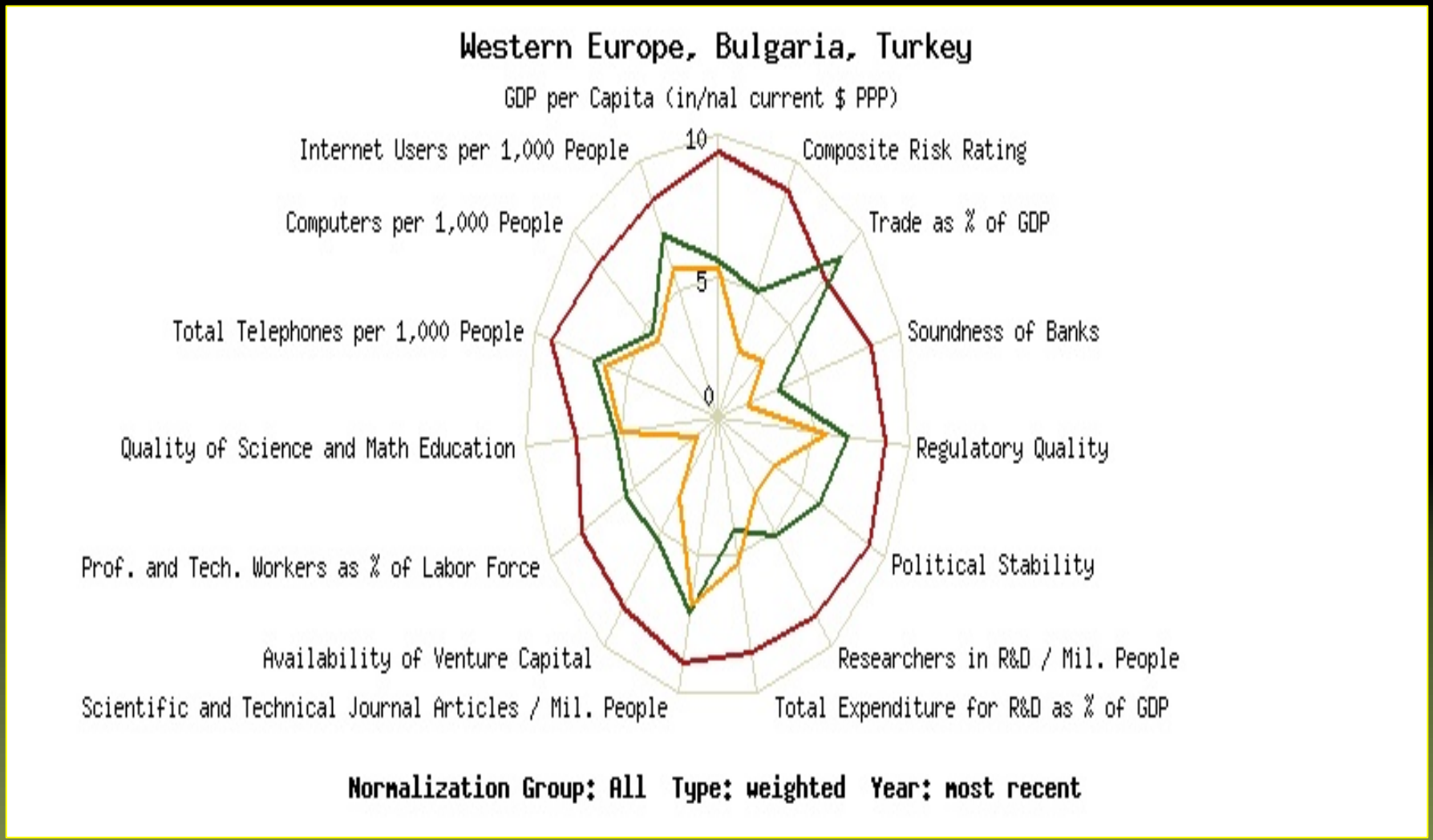
- **Electronic Documents Access**
- **Confidentiality and Intellectual property rights**
- **Sharing and commercial access**

Archiving the "Nuclear Internet"



1. A web crawler will identify and download (harvest) nuclear information resources from the Internet.
2. The harvested materials will be automatically indexed and stored in a high-volume archive with version control.
3. A customised version of an advanced search engine will index all contents and make them accessible to the user.
4. Specialised analysis tools will be developed

Designing a Nuclear Knowledge Index



Managing Nuclear Knowledge and the New generation

The IAEA is the world's center of nuclear cooperation and works for the safe, secure, and peaceful use of nuclear technologies.

Three main pillars underpin the IAEA's mission:

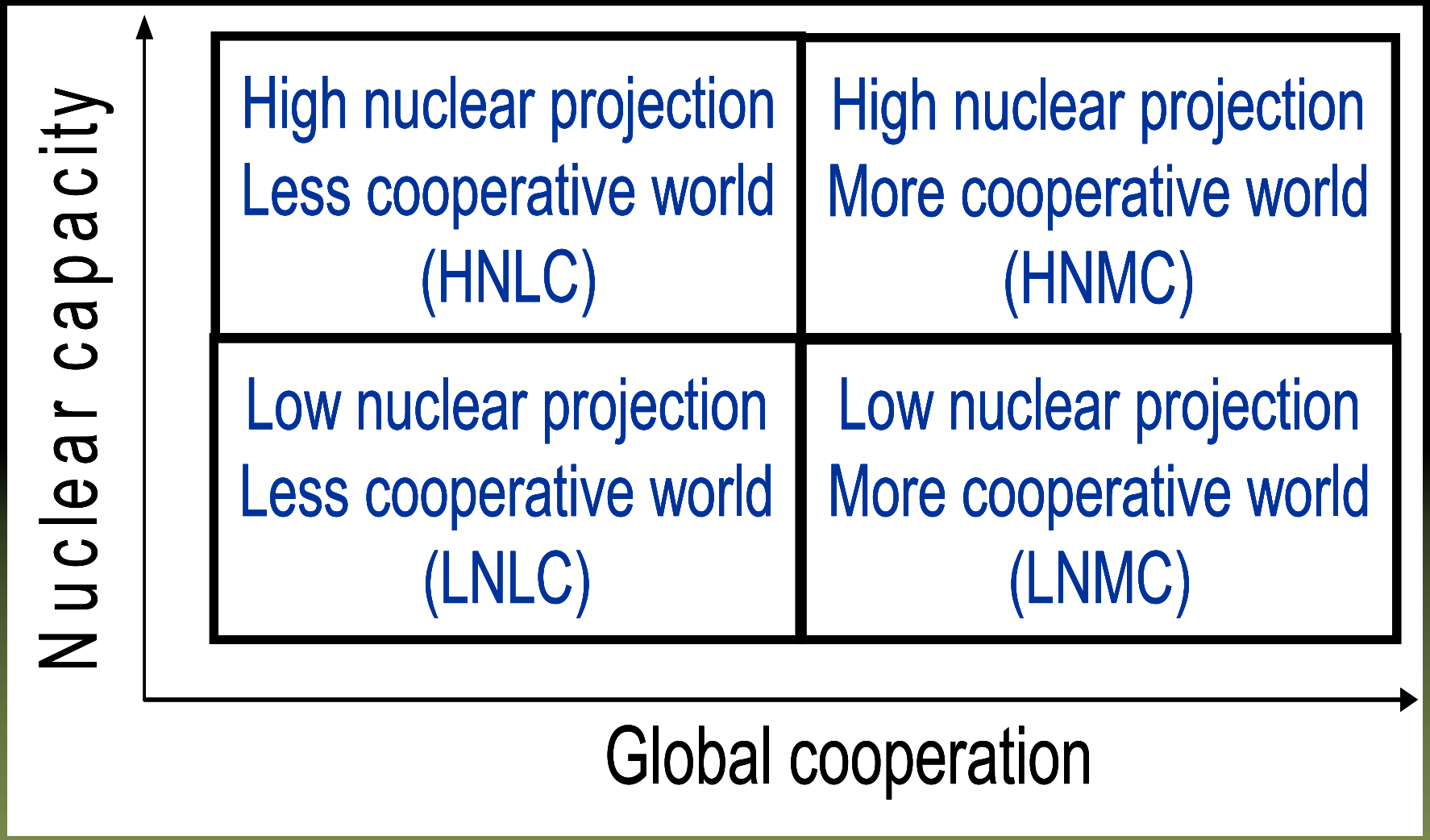
Click to learn more:

2020 and beyond

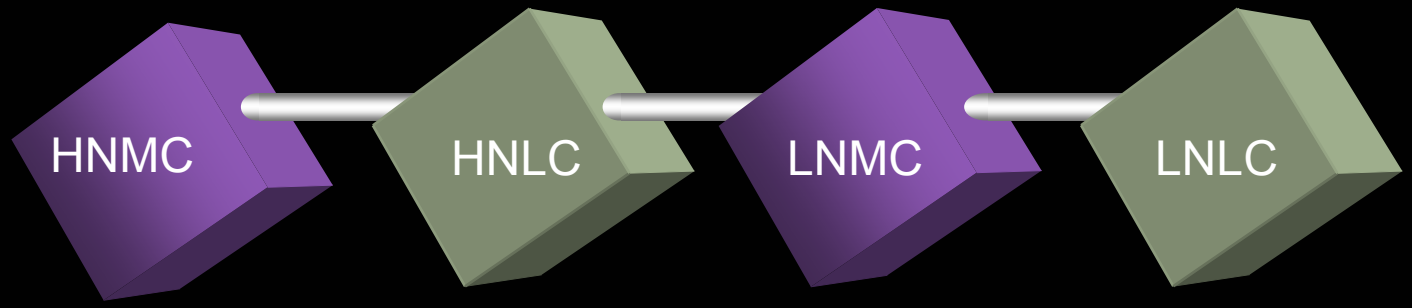
The future scope and volume of nuclear knowledge management activities in the Agency will depend on the development and use of nuclear power and other nuclear technologies and on the role and resources Member States are willing to install in the Agency.

The role of NKM will depend on which one of the two basic elements – ***sustaining*** or/and ***enlarging*** nuclear knowledge – will prevail in Member States.

Nuclear Development Scenarios



The High and the Low scenarios

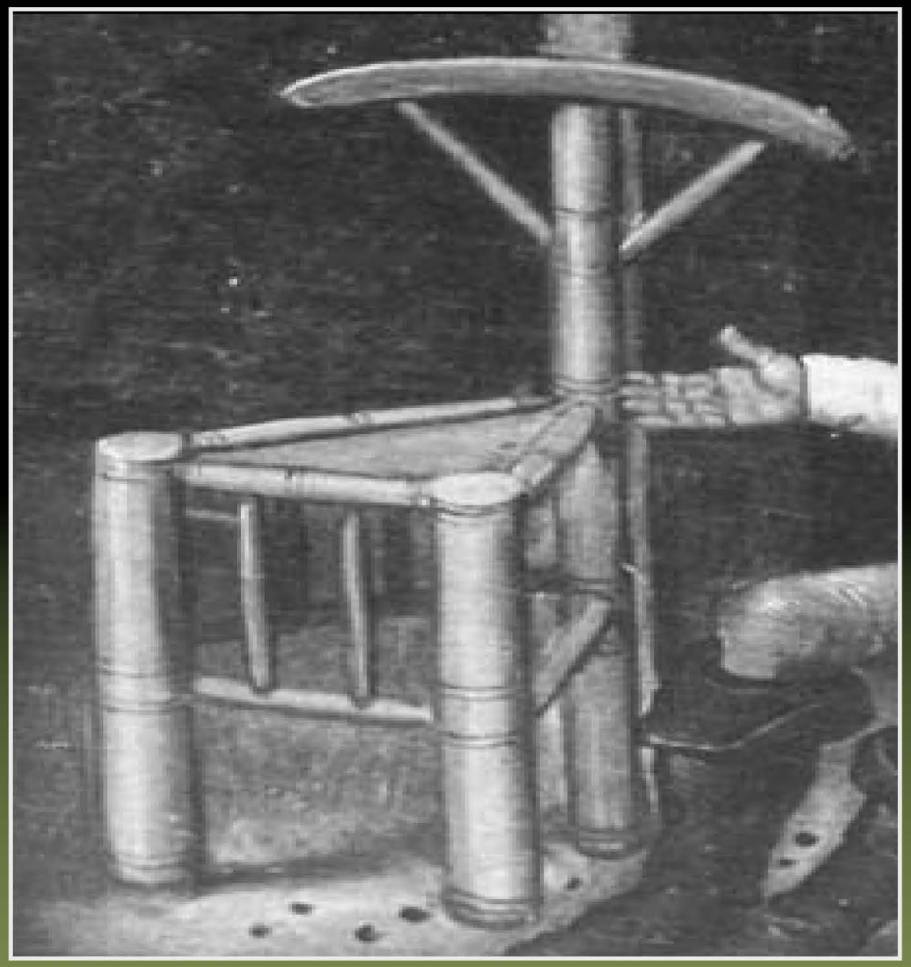


Strong Interest towards nuclear Technology with sustained political support in many regions of the world.

Strong interest in developed countries and moderate interest or lack of potential in the developing world.

The overall number of countries technology remains approximately the same. Many developing countries are investigating the possibility to use NP but give it up due to lack of resources and infrastructure

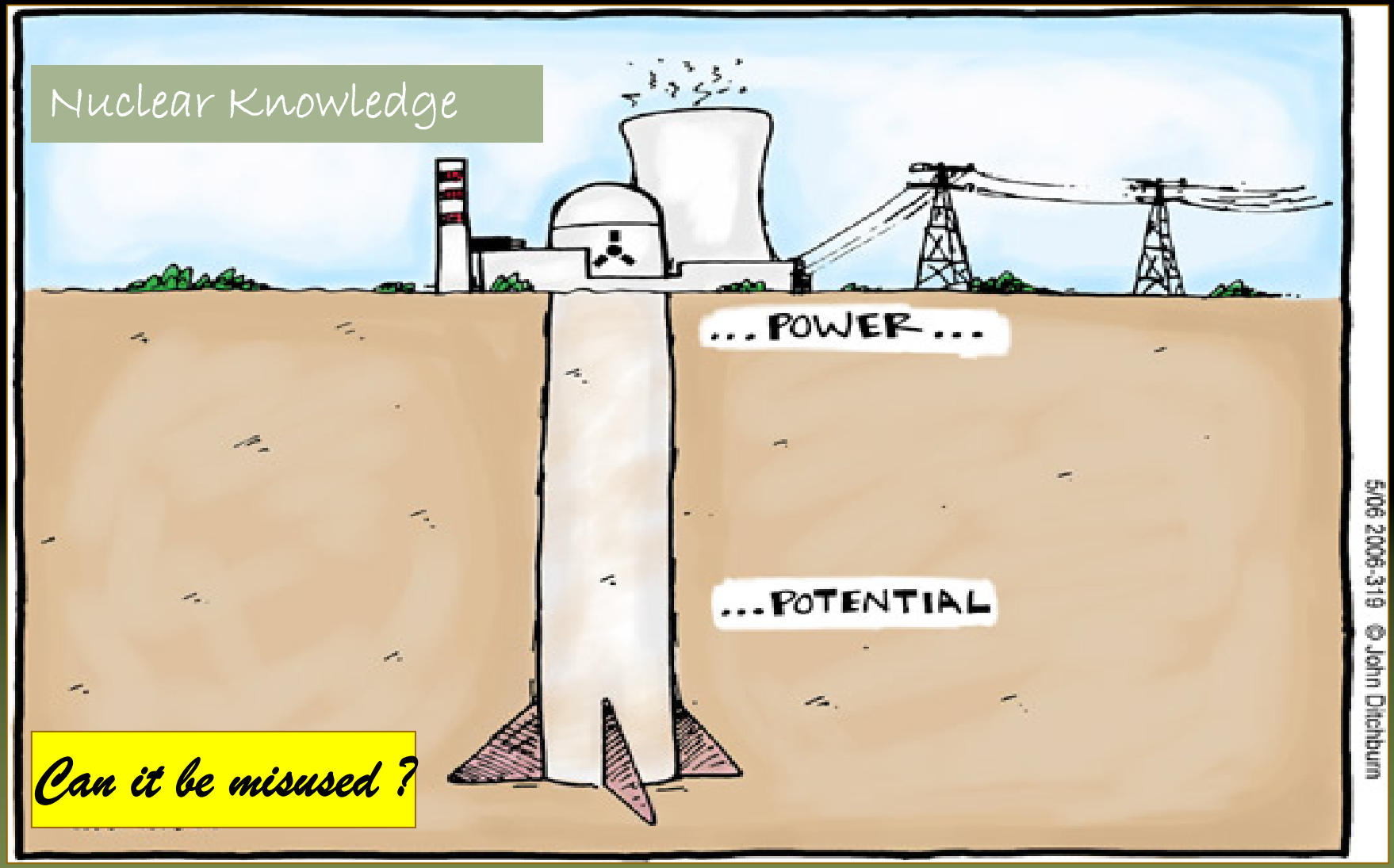
The Three legs of the chair . . . and Nuclear Energy



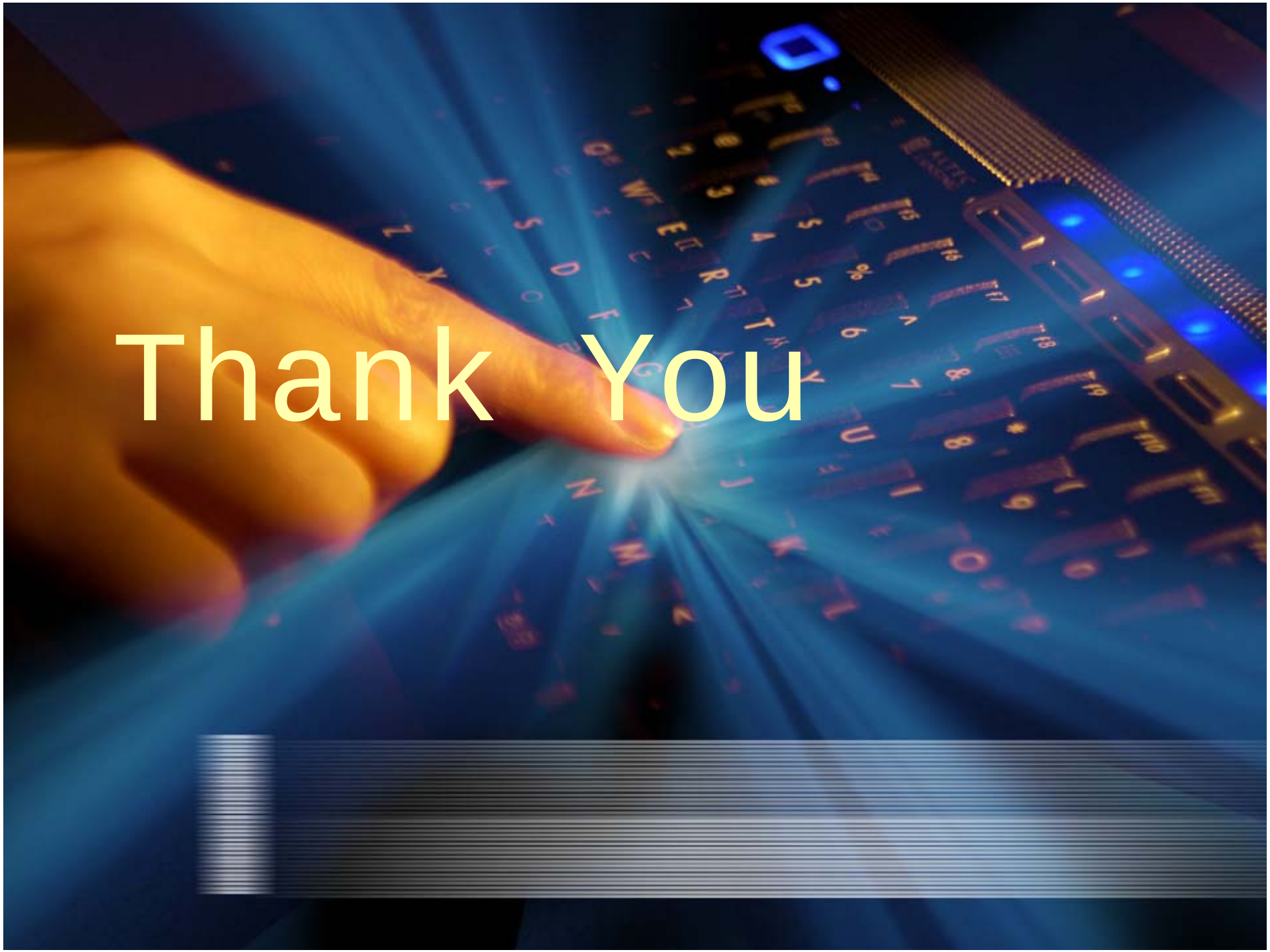
Pieter Breughel the Younger

1. Society must be convinced in the benefit of nuclear power
2. Nuclear Power should be used responsibly.
3. Nuclear Knowledge must be sustained and developed.

Responsibility One



Responsibility …. minus one


Thank You

Your best resource on Managing Nuclear Knowledge :
http://www.iaea.org/inisnkm