International Atomic Energy Agency

NUCLEAR POWER
Current, Future Prospect and The Agency's Activities

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IAEA

1. **Nuclear Power Generation**

   - current status –

2. **Nuclear Power for sustainable development**
3. **Future prospect**
4. **IAEA activities**

439 NUCLEAR PLANTS in OPERATION

❑**26 June 1954** Obninsk connected to the grid

❑**50 years later (August 2004)**

-Commercial NPPs in Operation:

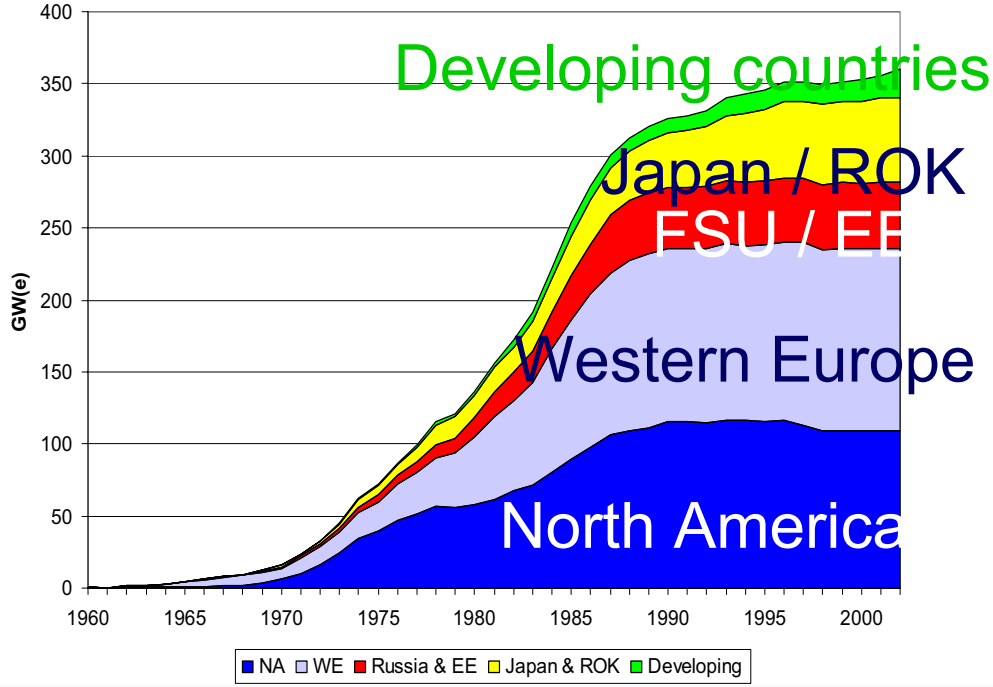
439 (~**360** GWe)

-Share of nuclear electricity

16%

-Plateau since 1990's

❑**Slowdown in the 90's in NA/WE/FSU & EE**



Slowdown in the 90's in countries used to have active deployment programme

❑ Possible background of slowdown

1) Electricity market deregulation

a) Deregulation exposed excess capacity that had accumulated in the regulated markets

b) Utility management had to transition to short term economics

2) Slow growth of electricity demand

Efficiency improvements resulted in changes in elasticity (Growth of KWhr / Growth of GDP) in advanced countries :

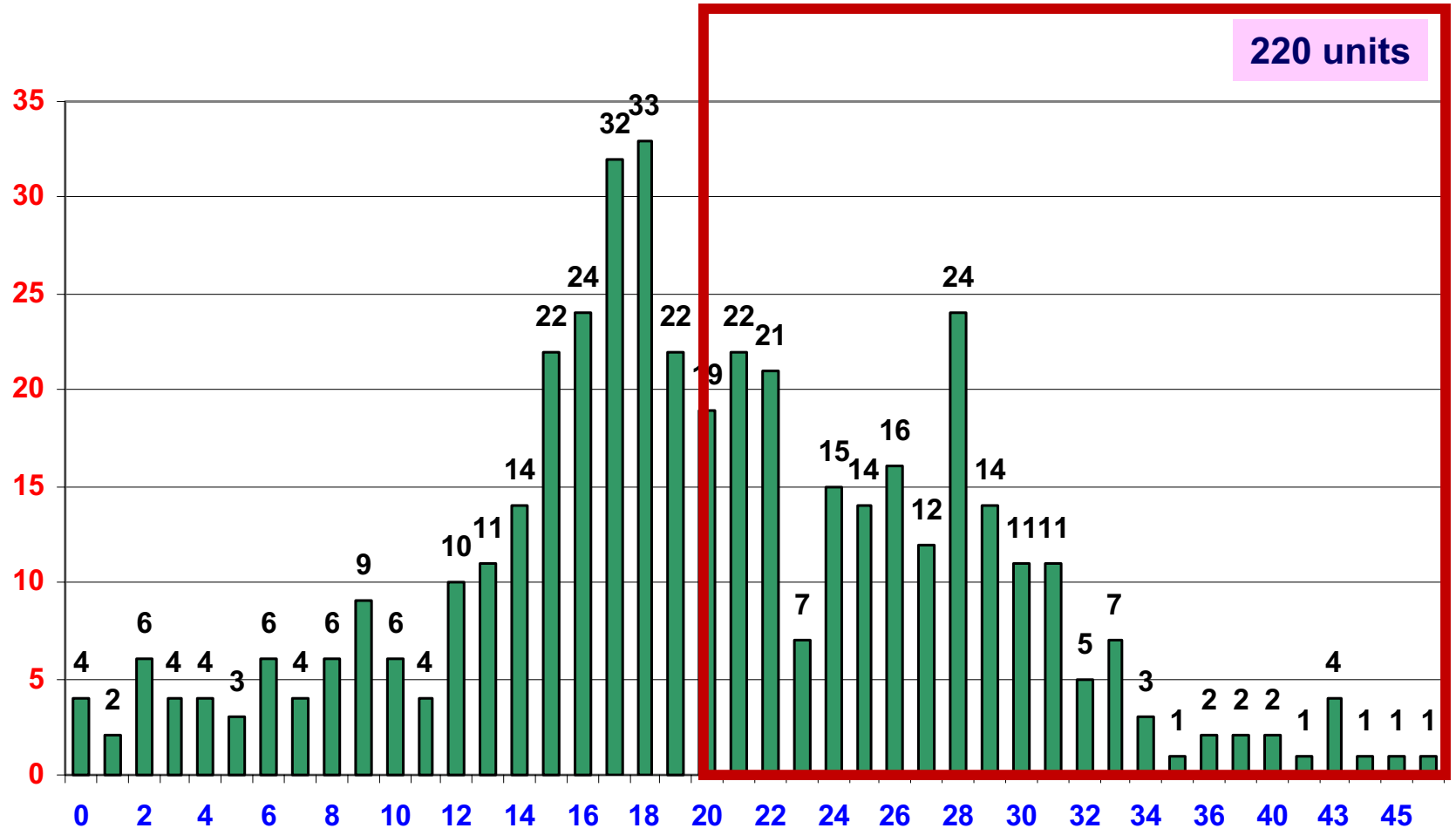
Delayed effect of the Oil Embargo

3) Public Perception

Accident at TMI(1979) and Chernobyl (1986) enhanced negative public perception, particularly in Europe

4) Economic reforms in Russia and EE countries

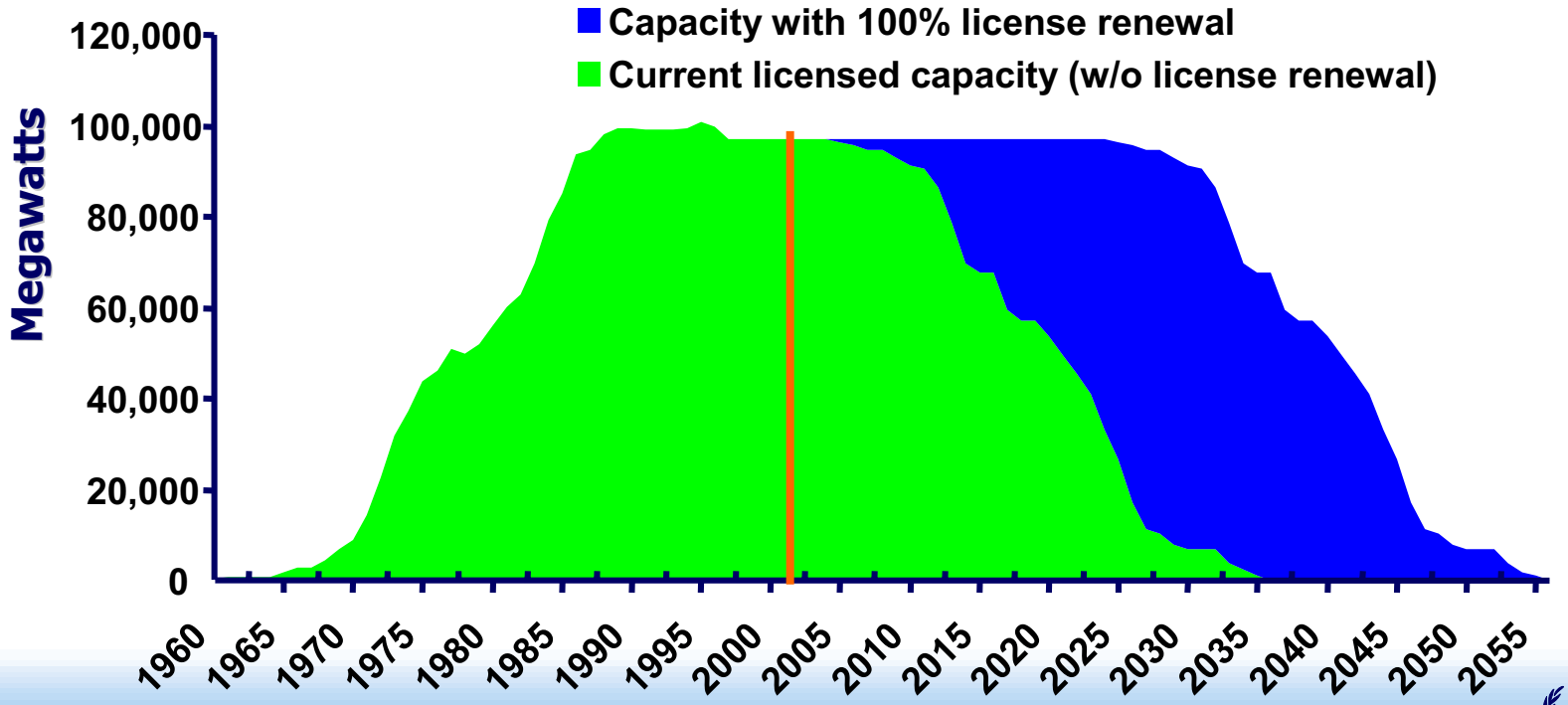
Age of Nuclear Power Plants



Plant Life Management (PLiM)

- Life = Components specific (degradation, obsoleteness)
- Monitoring and replacement
- "License Renewal" (US), "Periodic Safety Review" (Europe)
- Coupled with power uprating, enhancing capacity

✓ US projection

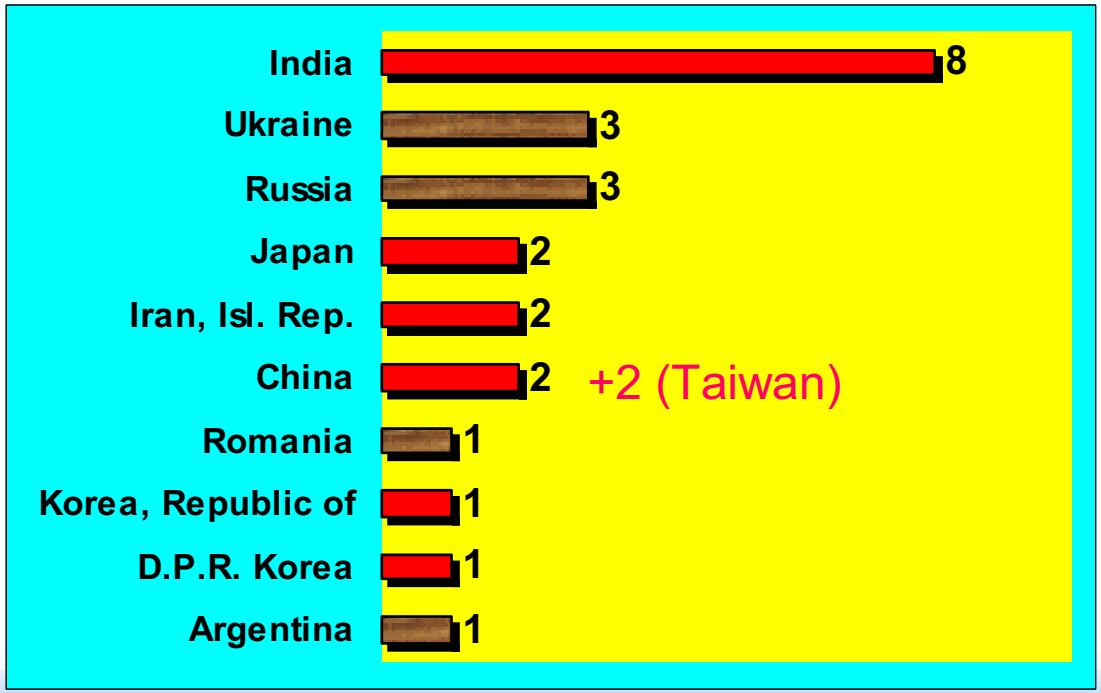


Current expansion of nuclear power

Current growth in regions;

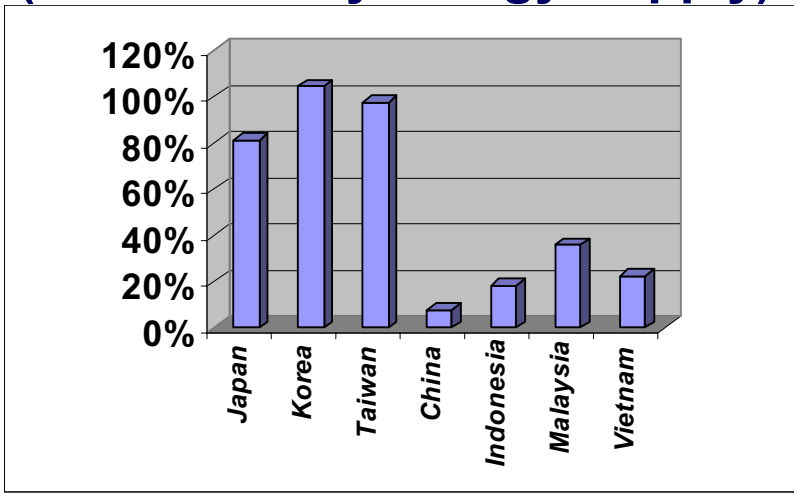
- Per capita energy demand growth
- Energy supply security concern (scarcity in resources)
- 18 out of 26 in Asia

Current construction



Source : IAEA – PRIS

Import / TPES
(Total Primary energy Supply)



Source : IEA energy Static & Bal. of OCED/ non – OCED countries 2000-2001

Activities for near term deployment - Europe -

Finland

The fifth NPP unit in Finland (Olkiluoto 3 in 2008)

France Twin 1600MWe EPRs at Frammanville

Bulgaria Belene NPP; started construction in 1987, suspended in 1991 due to social and political changes. Whether to deploy a new plant or resume construction at Belene expected to come to conclusion in 2004

Ukraine, Slovakia..

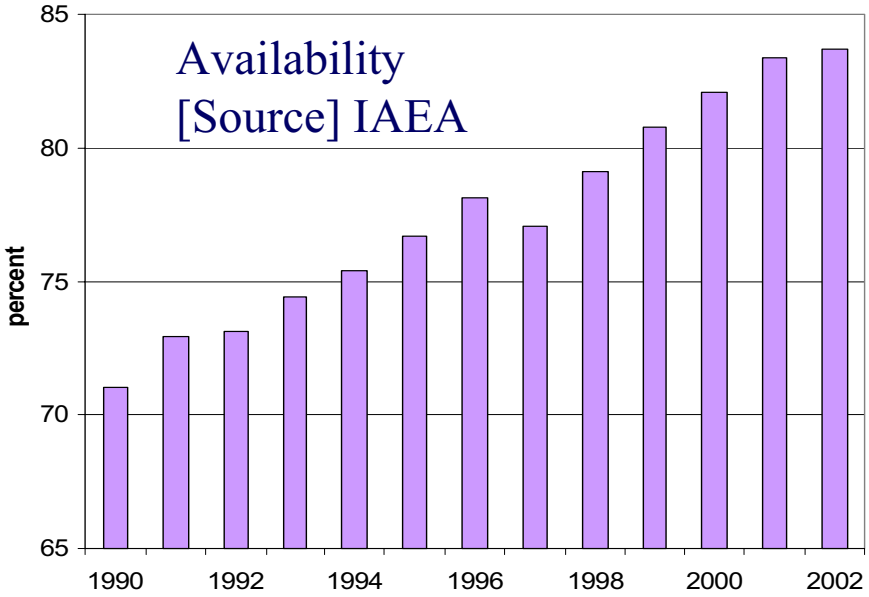
Activities for near term deployment - US -

- **DOE's "National Energy Policy" (2001)**
  Recommends the expansion of nuclear energy as a major component of national energy policy
- **Industry's vision (2002)**
  Outlines an approach to meet future energy demand by adding 50GWe of new nuclear generating capacity by 2020
- **DOE/NEI 's "Nuclear Power 2010 Program " (2002)**
  Explore sites for new construction, demonstrating a new regulatory process, and implementing strategies to enhance the business case for building new plants
- **ESP(Early Site Permit) applications (2003)**
  Clinton (Exelon), North Anna (Dominion), Grand Gulf (Entergy)
- **Three utility-vendor Consortiums for COL (2004)**
  North Anna (Dominion, AECL..), Bellefonte (TVA, Toshiba..), NuStart (GE/WH..)

Improvements in availability & safety-related indicators in the world

The reason behind

1) Information exchange, emulation of best practice
2) Risk-informed performance-based regulation (especially in the US)
   - ✓ Use of insight from PSA
   - ✓ Results-oriented rather than prescriptive



3) Consolidation in the industry
   - ✓ In a way more nuclear plants being operated by those who did it best.

On the other hand

- ✓ Events with similar root causes still recurring, even in countries with well established nuclear programmes and extensive experience
- ✓ Complacency, weaknesses in technical competence, management system

Economics

- **Current plants : performing well economically**
  - ✓ Nearly or fully amortized;
  - ✓ Achieving high availability;
- **New plants : economic challenges**
  - ✓ Market de-regulation and privatization changed the criteria
  - ✓ Before amortization, tough competition
  - ✓ University of Chicago Study (August 2004)

    Levelized power generation cost by new plants w/o externalities

    Nuclear 3.8-5.7 Coal 3.5-4.5 Gas 3.3-4.1 (cent/KWhr)

    → Proposed federal financial policies for new nuclear plan
- Informed decision-making by energy planner/decision-maker
  - ✓To alleviate unnecessary burden in the later generations
  - ✓Nuclear : Most costs are internalized while others not

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Increased concern over Strategies for Sustainability

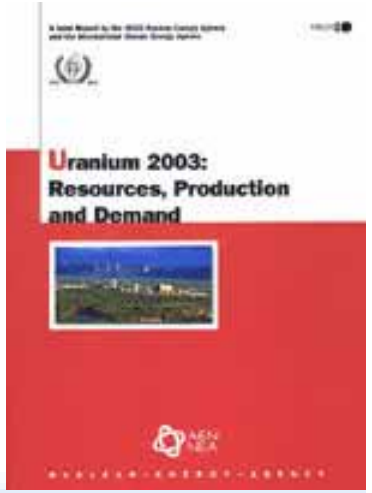
- Brundtland Report (1987)
- Agenda 21 in "Earth Summit (1992)
- World Summit on Sustainable Develop. (Johannesburg, 2002)
- Focus on
  - a) equity within and across countries as well as across generations
  - b) integration of three dimensions
    - economics,
    - environment
    - social, with a complimentary dimension of
    - institutional framework necessary to implement
- ISED (Indicators for Sustainable Energy Development) measuring energy related;
  - Accessibility / Affordability / Security /Efficiency and Environmental Impact

Security of long-term energy supply

Uranium resources availability depending options of use

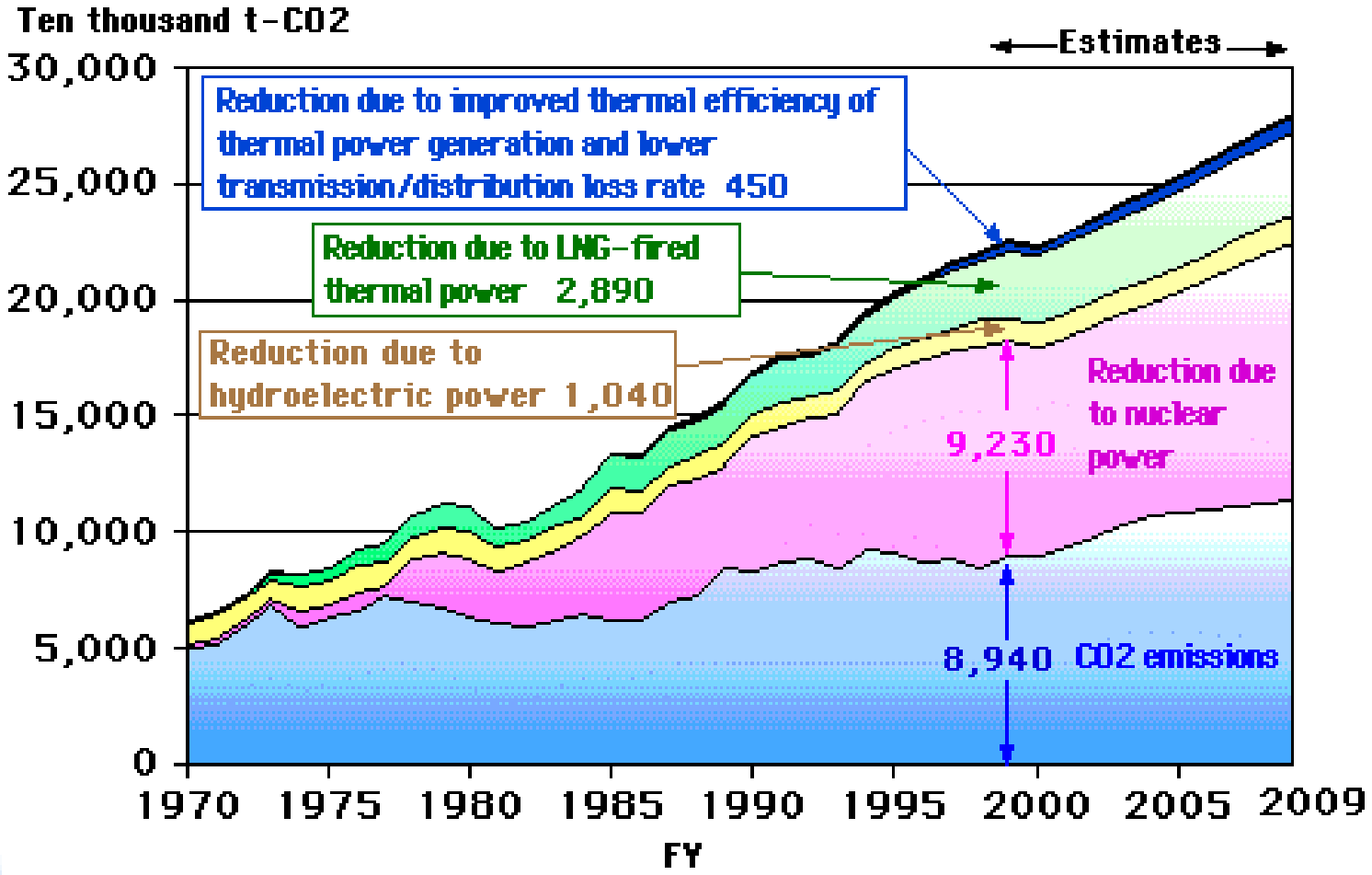
	Know CR/ 2002 demand	Total CR/ 2002demand
LWR once-through	85 years	(270 years)
MOX to LWR(once)	100 years	(300 years)
FR Recycle	2550 years	8500 years

*CR (Conventional Resources:
known=4.6MTon, Total=14.4MTon)
[Source] NEA/IAEA “Uranium 2003” (Red Book)



Environmentally & Socially Responsible choice

Case of An Electric Power Company (40% Nuclear, 30% Gas)



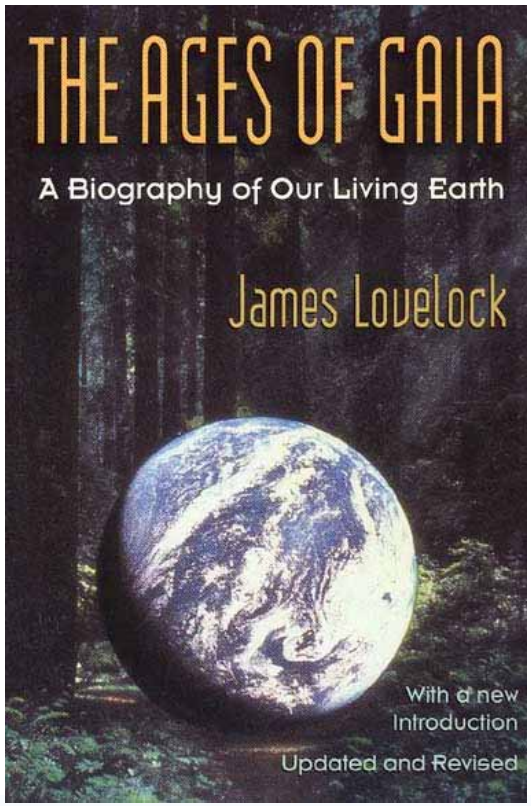
James Lovelock

"Nuclear power is the only green solution"

…..By all means, let us use the small input from renewables sensibly, but only one immediately available source does not cause global warming and that is nuclear energy.

What makes global warming so serious and so urgent is that the great Earth system, Gaia, is trapped in a vicious circle of positive feedback……..

(Independence, 24 May 2004)



Ian Fells

Ian Fells (chairman of the UK-based New and Renewable Energy Centre (NaREC) and an energy adviser to the EC and European Parliament) remarks in “EU Reporter”.
“It is foolish to set renewables against nuclear as though they are alternative strategies; simple arithmetic shows that this will not work“

Renewables and EU Energy Strategy

provided by various Governments to encourage growth of the wind industry. However growth has stalled in Denmark and Ireland because operators of the distribution grid find that with more than 20% of intermittent, embedded wind supply the grid becomes unstable and difficult to operate.

This unpredictable supply from wind, (there were 52 days in Denmark in 2003 when the wind did not blow at all) means that substantial, expensive and usually polluting back-up from coal would not even meet the UK target of 20% renewable electricity by 2020.

But even if the EU renewable targets for 2010 are met, with wind providing 50% of the supply, there remain a number of problems for EU energy policy. It is clear for example that renewable electricity cannot replace nuclear power, which currently supplies 36% of EU15 electricity. Germany, Belgium and the UK have announced their intention of phasing out nuclear power over the next ten to twenty

The current enthusiasm for “sustainable development” leads many politicians to hope that green, renewable energy will save the day. This is wishful thinking.

achieve. The UK, formerly a gas exporter expects to be importing 50% of its requirements by 2010 and 80% by 2020, the figures for the EU are even more alarming; and UK electricity will be 75% gas based by 2020. This puts question around security of supply as also costs. Looking further ahead to 2050, the 60% reduction in carbon dioxide espoused by the UK government as necessary to stabilise the greenhouse effect, will require a leap forward in energy policy thinking. This target, as far as the UK is concerned, calls for a freezing of energy demand at current levels fifty years hence, 40GW of renewable energy (a 20fold increase on 2000) and 45 new pressurised water reactors of the Sizewell type, according to the Royal Commission on Environmental Pollution (Spring 2000). A recent paper from the Energy Strategy Unit of the UK Department of Trade and Industry to an International Workshop on Energy Supply in Paris (June

“...time to make painful decisions...”

gests that an element of insurance be incorporated

tidal, solar and biomass and all the nuclear power plants

[SOURCE] EU Energy 17 Sept 2004

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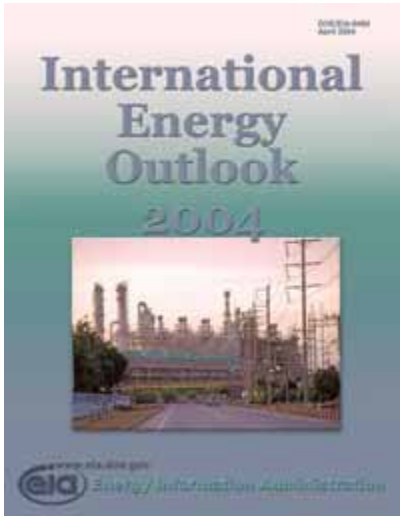
Outlook for nuclear power

- **Medium-term projections not necessarily in favour of nuclear, although foresee increase in Energy/Electricity consumption**

  Example

  DOE/International Energy Outlook 2004

  Nuclear Power slight increase but fall by 2025



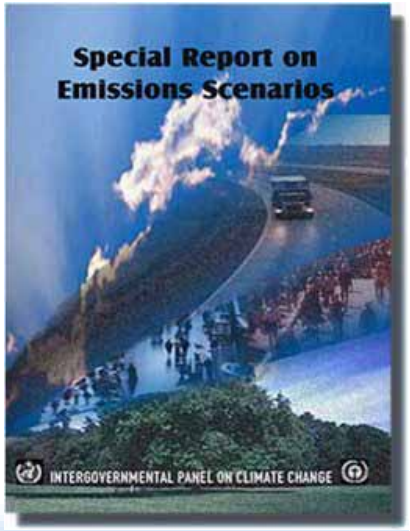
- **Credible longer-term energy demand and supply analyses consistently foresee a growing role for nuclear power.**

  Example

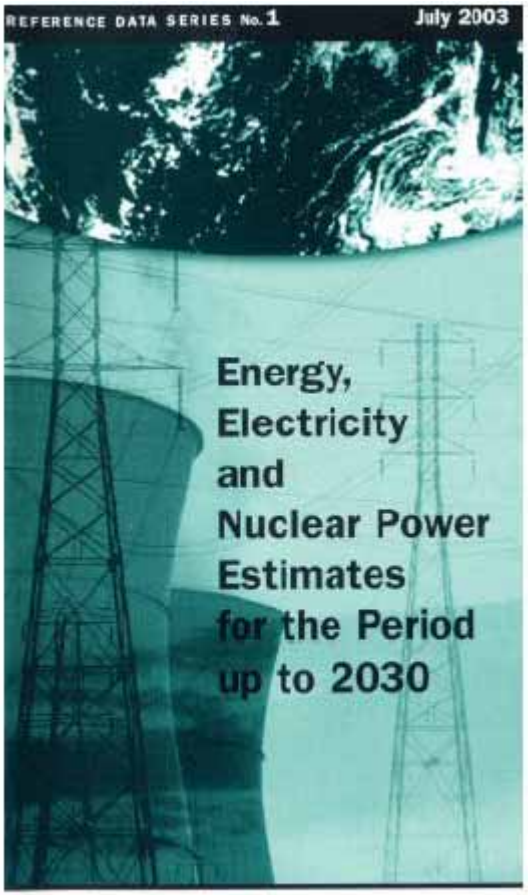
  IPCC-SRES 4 storylines by 2050 (2000)

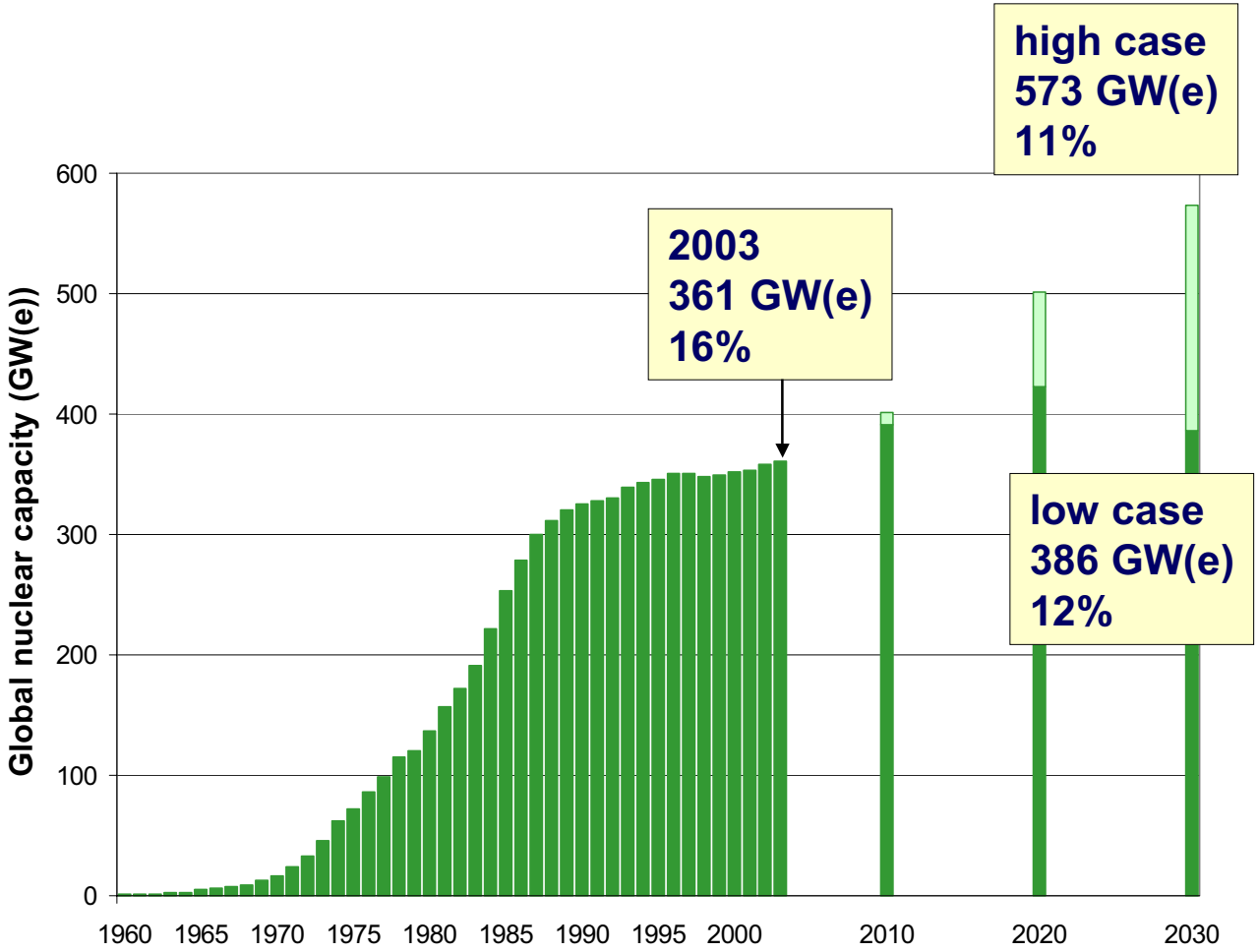
  Energy use by 2.5 times by 2050

  Nuclear Power by 5 times (average)

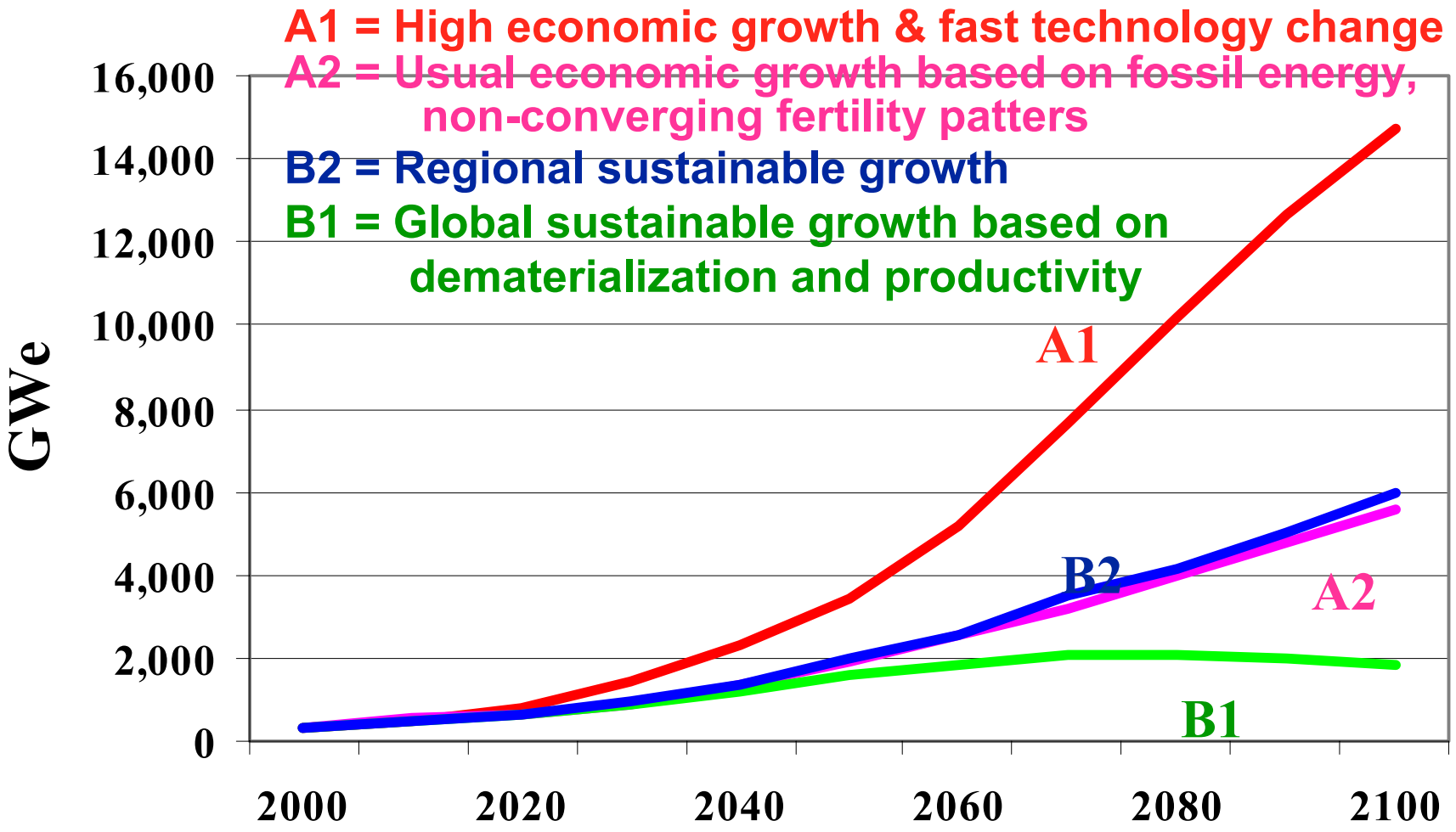


Energy Projections through 2030 by IAEA





Nuclear Power in the IPCC-SRES (2000)



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Expected activities to bridge the Gap

1. Excellence in operation of existing resources, continued vigilance in safety and safeguard…

2. Helping infrastructure building and Improving institutional systems

3. Technological innovation

4. Non- electricity application

5. Disseminate objective, reliable information on nuclear technologies and its applications to build public trust

(1) Excellence in operation of existing resources, continued vigilance in safety and safeguard…

Agency is :

❑ Accumulating, disseminating good practices and guidelines through CRP, seminars, technical meetings, technical documents ... on such issues as

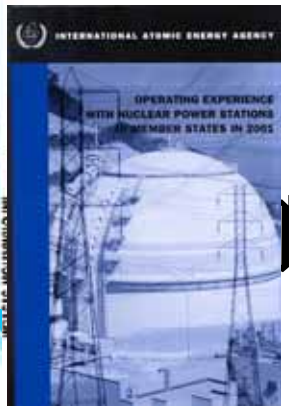
- ✓ Human performance improvement
- ✓ Plant Life Management
- ✓ Decommissioning
- ✓ Application of various advanced technologies for NPP
- ✓ Continuous process improvement
- ✓ Change management
- ✓ Strategy to ageing workforce

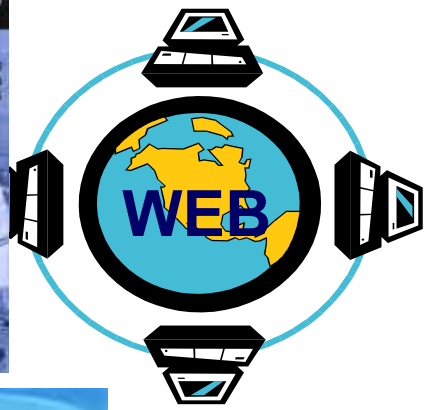
❑ Acting as repository of information and providing various database such as;

- ✓ PRIS (Power Reactor Information System)
- ✓ INIS (International Nuclear Information System)
- ✓ Material and design database : IDPNPP, IDRPVM

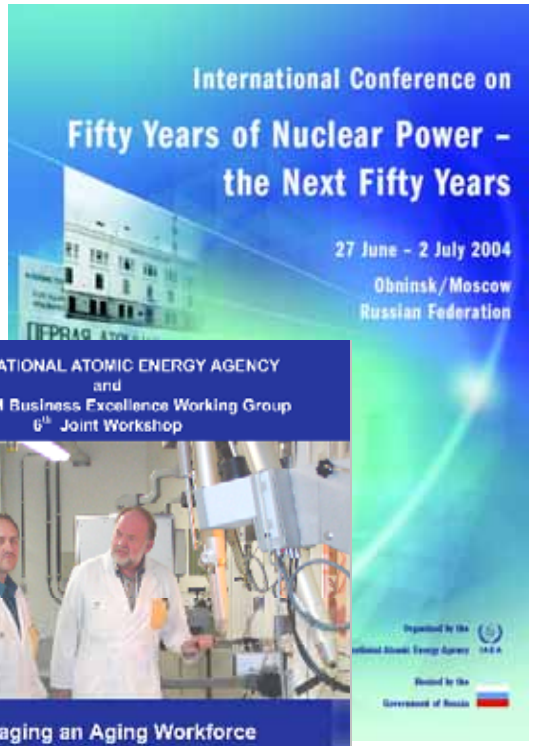
Preserving & Disseminating information

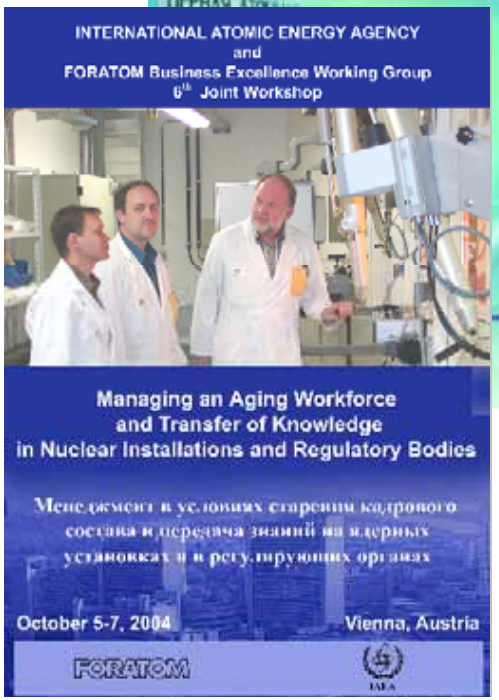
Database
Documents
Conferences and Symposia…



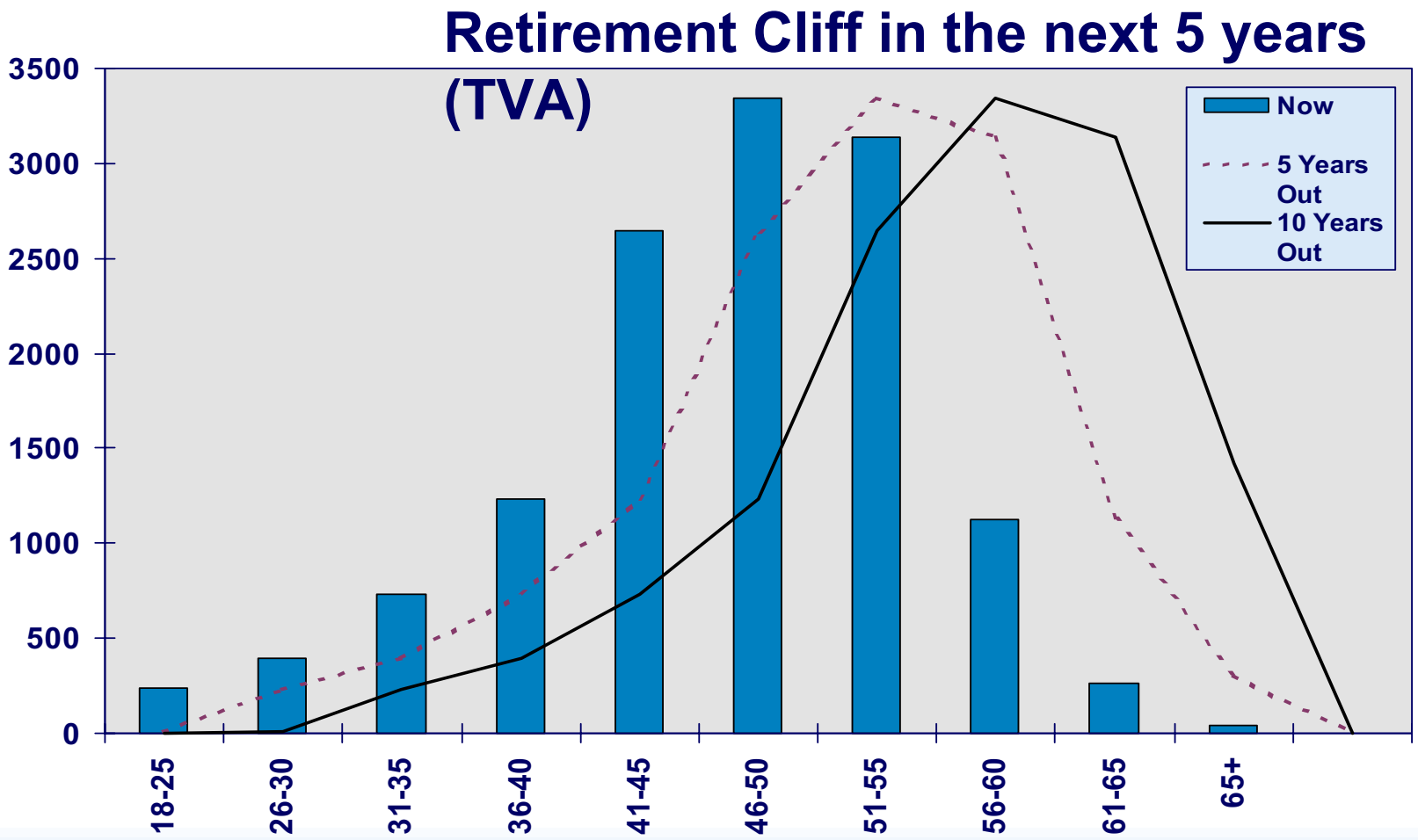


Country Nuclear Power Profiles





Aging of Personnel in Nuclear Business



Preservation of Knowledge in aging crisis

Agency is ;

- Supporting Knowledge Management activities thr.
  a) World Nuclear University (WNU)
  →the first deliverable : a WNU Summer Institute in 2005
  b) Fast Reactor Data Retrieval and Knowledge Preservation Initiative for a comprehensive, international inventory of FR data and knowledge
  c) ANENT (Asian Network for Higher Education in Nuclear Technology)
  d) Dessimination of good practices

[Example] TVA's Knowledge Retention Process - Retaining Critical Knowledge

Step 1. Conduct a ***Knowledge Loss Risk Assessment***
identify positions/people where the potential knowledge loss is greatest and imminent

Step 2. Determine Approach to Capture Critical Knowledge & implement knowledge retention plan

Step 3. Monitor and Evaluate

(1) Excellence in operation of existing resources, continued vigilance in safety and safeguard…

Agency is :

- Promoting the acceptance of the entire corpus of IAEA Safety Standards as the global reference

- Providing Review services for the better on a wide spectrum of nuclear activities in the Member States
  - OSART(Operation safety)
  - TranSAS(Radioactivity transport)
  - EPREV (Emergency Preparedness Reviews)
  - ORPAS (Occupational Radiation Protection Appraisals)
  - RaSIA (Radiation Safety Infrastructure Appraisal (RaSIA)
  - IPPAS (Physical Protection)

- Establishing Safety Standards for Management Systems

(2) Helping infrastructure building and Improving institutional systems

❑ Infrastructure building in developing countries

- Growth of NP expected in areas of population growth, economic growth and consequential per capita energy consumption
- Infrastructure (regulation, safeguard regime, training and industrial background, financing, liability, bi-lateral nuclear agreements, transport of nuclear material etc.)

Agency is helping MS to establish:

1) Conditions to facilitate the deployment of INS
2) Informed decision-making for capacity building

- Multi-lateral FCC

❑ Changes in market structure and Needs for Evaluation for sustainability:

- Electricity business deregulation

-Agency is willing to coordinate/help MS for international harmonization of regulatory requirements and industrial codes and standards

- Consideration of environmental externality & energy security credit

(3) Technological innovation for sustainable energy supply

The Agency is:

Assisting the R&D of interested MS through scientific and technical information exchange, collaborative assessments, and CRP in;

(a) Proven means and new approaches for improving economics of new water-cooled reactors;
(b) Data from experiments on natural circulation heat removal, and methodology for determining reliability of passive systems that utilize natural circulation;
(c) Data base of reactor material thermo-physical properties;
(d) Reducing calculational uncertainties for LMR core reactivity coefficients;
(e) ADS technology and collaborative R&D on ADS and other transmutation systems safety parameters
(f) Data for GCR core physics and thermo-hydraulics code benchmarking;
(g) GCR fuel technology
(h) SMR

…….

INPRO

(International Project on Innovative Nuclear Reactors and Fuel Cycles)

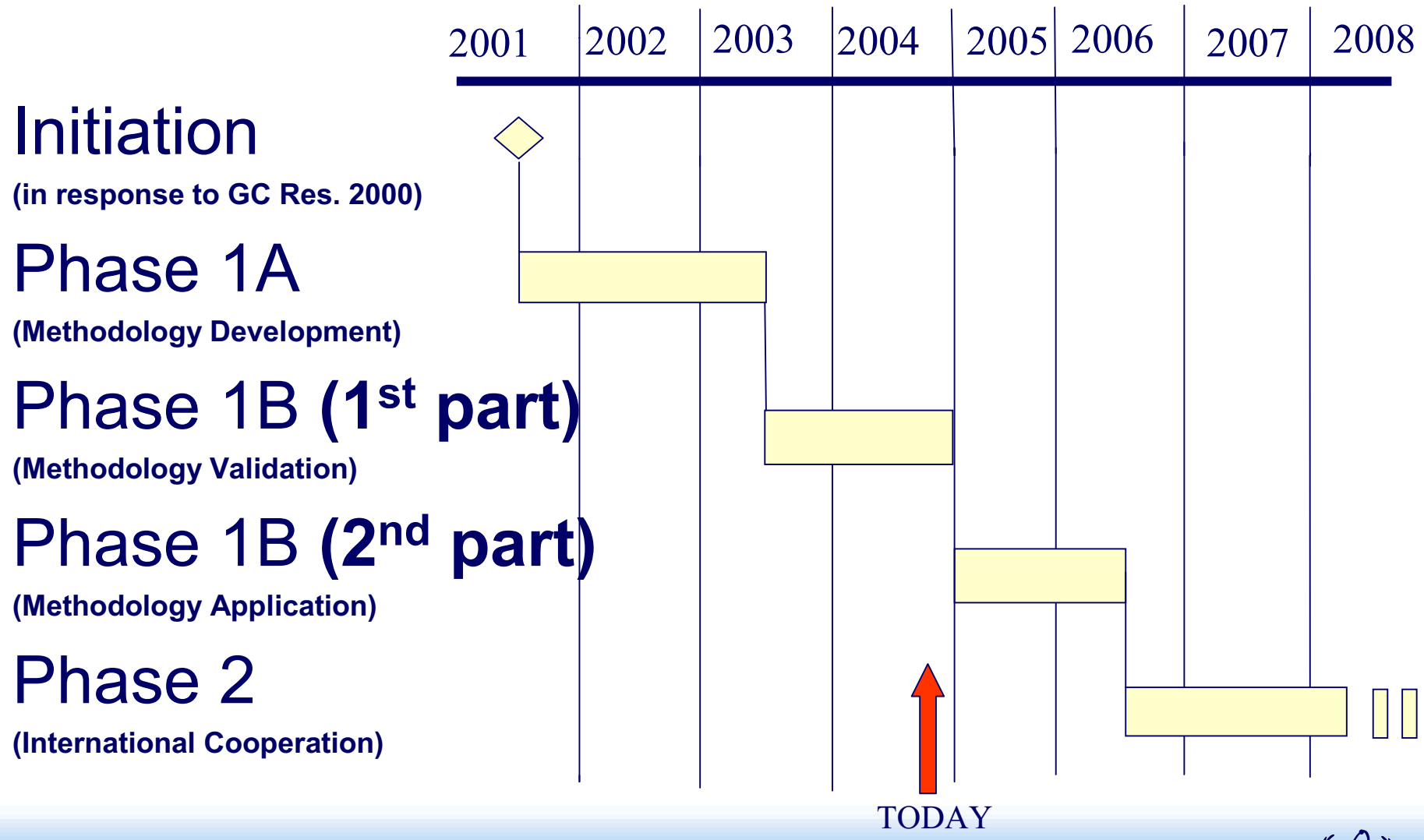
- **IAEA General Conference Resolution in September 2000**
- **Goals**

- To help ensure that nuclear energy is available to contribute in fulfilling energy needs in the 21st century in a sustainable manner;
- To bring together both technology holders and technology users to consider jointly the actions required to achieve desired innovations in nuclear reactors and fuel cycles.

- **21 Participants** (Oct. 2004): increasing

  Argentina, Armenia, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, France, Germany, India, Indonesia, Republic of Korea, Pakistan, Russia, South Africa, Spain, Switzerland, The Netherlands, Turkey and the European Commission + Observers

INPRO Schedule



INPRO : Phase IB

- **July 2003-June 2004: Validation of methodology**
- **Six National case studies**
  - ✓ Argentina with CAREM-X (Integral reactor),
  - ✓ India with Advanced Heavy Water Reactor,
  - ✓ Korea with DUPIC fuel cycle (LWR Spent Fuel to HWR),
  - ✓ Russia with BN family (Fast Reactor)
  - ✓ China with Pebble Bed Gas-Cooled Reactor
  - ✓ Czech Republic with Molten Salt Reactor
- **Eight Individual Case Studies**
  - ✓ Russia (International fuel cycle center, SMRs, ADS/fusion/renewables, hydrogen/ desalination, DESAE)
  - ✓ India (International fuel cycle centers and FBRs)
  - ✓ France (Systems with fast spectrum of neutrons)
  - ✓ Argentina (autonomous fuel cycle option)
- **Feedback from Industry and Regulators**

INPRO-GIF Interactions

- As compared w/GIF, INPRO has participation from both Technology Holders and Users
- Relations

✓ Continuous Participation of IAEA in GIF policy Group (as an Observer)

✓ GIF participated in INPRO Steering Committee Liaison meeting between GIF & IAEA/INPRO (GC)

✓ GIF peer review of INPRO Methodology in January 2004

✓ IAEA experts invited to GIF WG meetings (safety, non-proliferation, security)

✓ Planned co-operation in the analysis of sustainability

✓ IAEA CRP on SCWR T/H

Conclusions

1. Nuclear electricity :
   - ✓ 16% worldwide
   - ✓ Nr. of NPPs : plateau in Advanced countries
   - ✓ NPP performance improving
   - ✓ Needs Informed decision-making by energy planner/decision-maker

2. The future role of nuclear energy :
   - ✓ Expected grow for sustainable development
   - ✓ Due to Inherent advantages of Nuclear Energy

3. Agency assists MS for :
   - ✓ Ensuring nuclear energy option
   - ✓ Improving safe and efficient operation

…atoms for peace