Keeping the Lights on: The Revival of Nuclear Energy

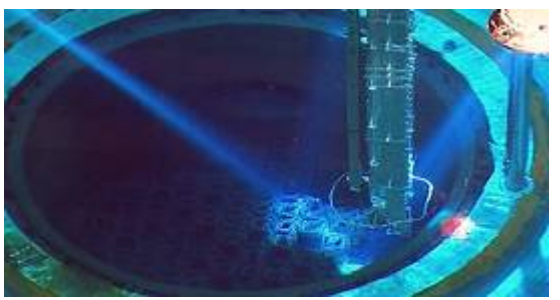
Nuclear Power
A key part of Europe's energy mix today and into the future

Dr. Roland Schenkel
Director-General
European Commission, Joint Research Centre
'Robust science for European Union policy-making'

Chicago, 12-16 February 2009 – AAAS Annual Meeting
Final version available on: http://www.jrc.ec.europa.eu

What's influencing the debate right now?

- Climate change √
- Security of supply √
- Economic recession √
- Public anxieties √

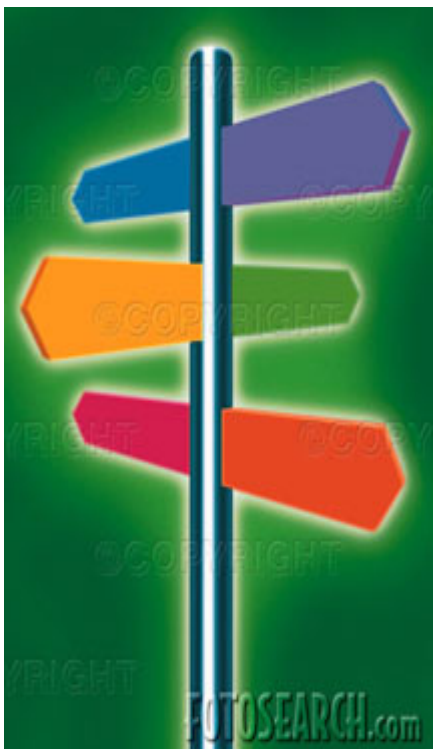


Questions we must ask

- Why are governments willing to revisit the 'thorny' question of nuclear?
- Is the public being correctly informed?

Key drivers of today's presentation

1. **Setting the scene** → is nuclear energy an attractive option either being reinforced or considered by governments for good reason? *Yes!*
2. **Competitiveness and sustainability** → does nuclear energy make economic sense? *Yes!*
3. **Health & safety, environment** → do nuclear fission reactors have a proven track record of being *safe* and *green*? *Yes!*
4. **Nuclear waste management** → despite public perceptions, do *solutions* exist? *Yes!*
5. **Security & non proliferation** → is nuclear energy a dual use technology where *civilian ≠ military* use? *Yes!*
6. **Take-home message** → nuclear energy is a *viable* and *green* option for Europe's energy needs



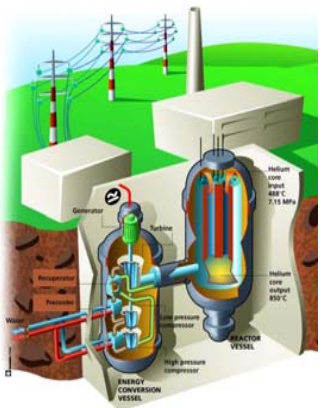
The Evolution of Nuclear Power

First Reactors (proto-types)

Current Reactors

Advanced Reactors

Future Systems



1950 1970 1990 2010 2030 2050 2070 2090

Generation I

Various types

Generation II

Pressurised Water Reactor
Boiling Water Reactor

900-1300 MW

Generation III

Evolutionary Pressurised Reactor

Generation IV

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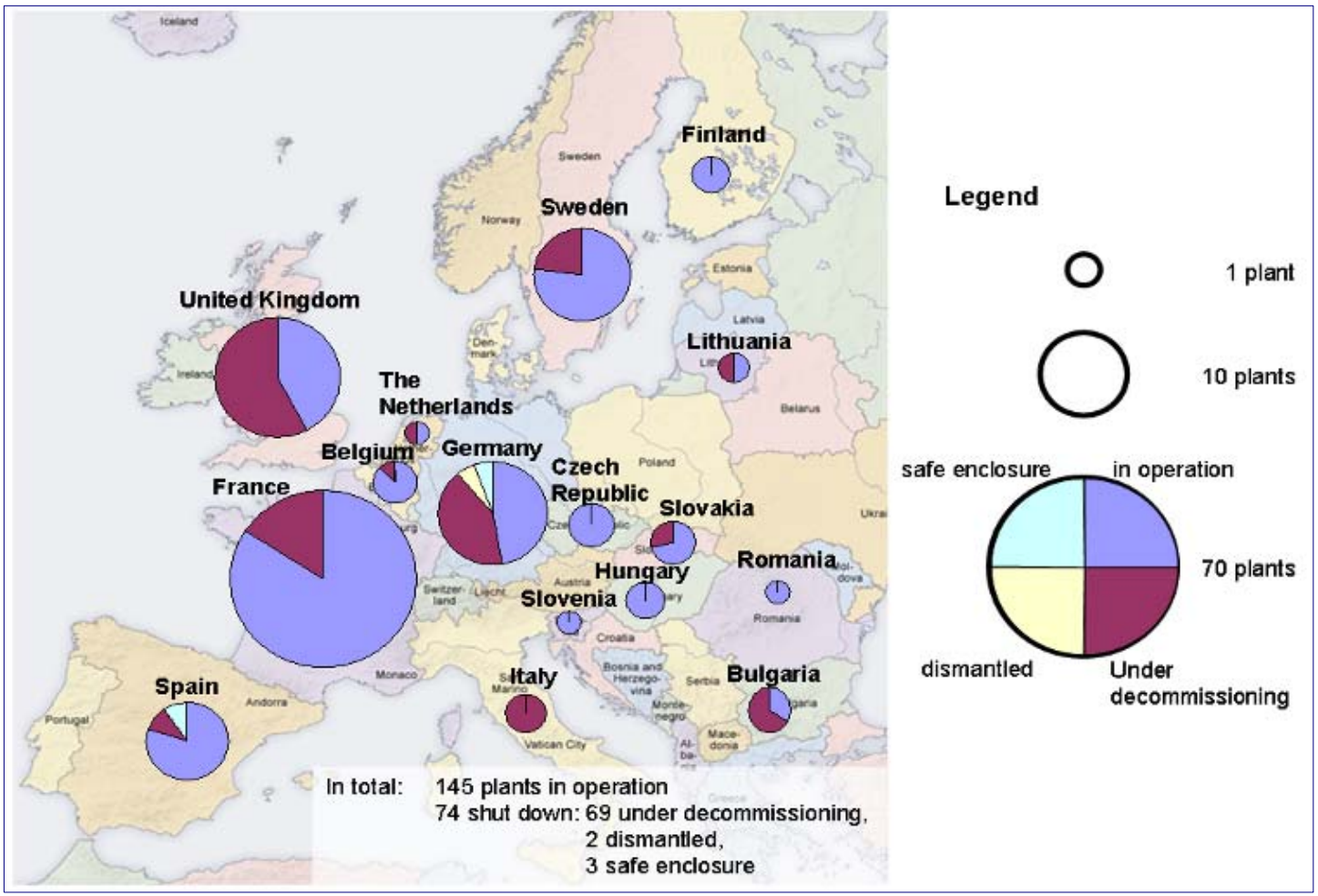
Who's producing nuclear energy?

Nuclear power provides over 50% of Europe's base load electricity



KEY FACTS

- EU 27: 145 reactors (2007) in operation (133 GWe) in 15 countries
- 8 new reactors are under construction
- 31% of total electricity production in Europe is via nuclear
- Reactor life-extension requests have been made in France, Sweden, Finland & Hungary
- Phasing out of reactors is planned in Belgium, Germany & Spain

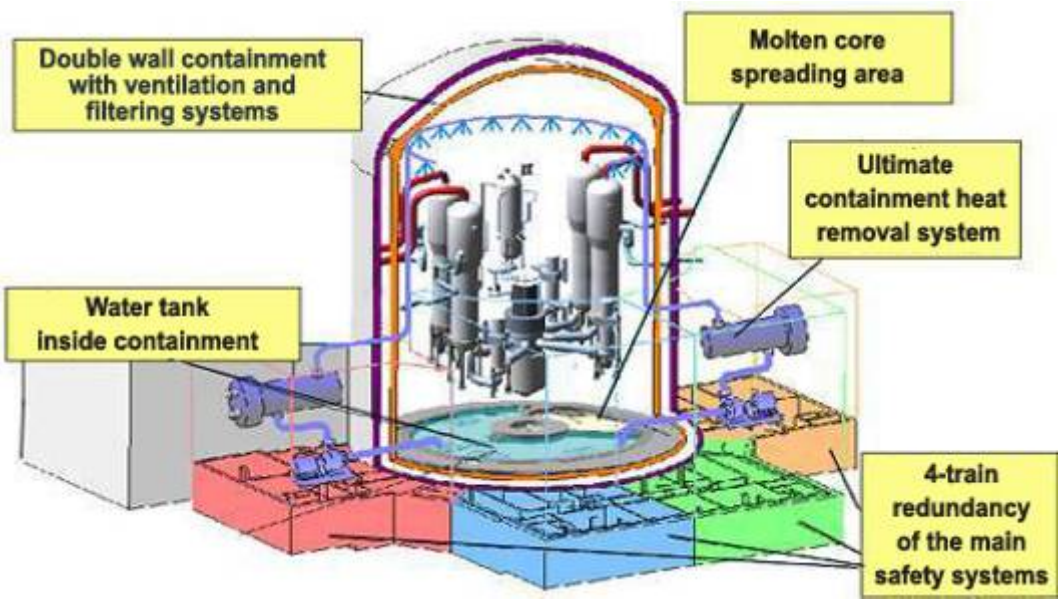
EU27, 30/06/2007 (Ref. European Commission (TREN))

The rush to build or renew: What's behind this drive?

From Generation II to Generation III

Olkiluoto, Finland, 2008
Ref. Posiva, EURADWASTE 2008

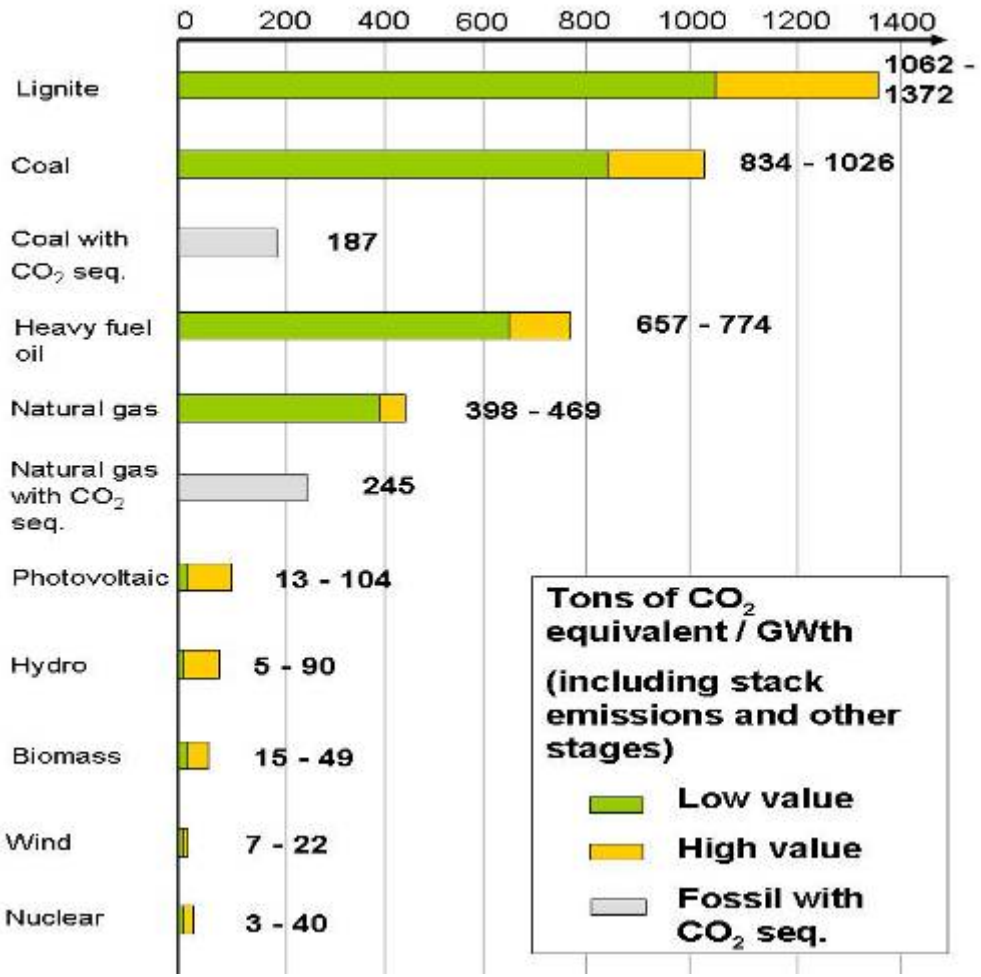
- 8 new constructions: Belene, Bulgaria (2), Olkiluoto, Finland (1), Flamanville, France (1), Cernovada, Romania (2), Mochovce, Slovakia (2)
- Further project proposals: Czech Republic, Hungary, Lithuania, Slovenia
- Positive indications: UK, The Netherlands, Italy



Generation III: European Pressurized-Water Reactor

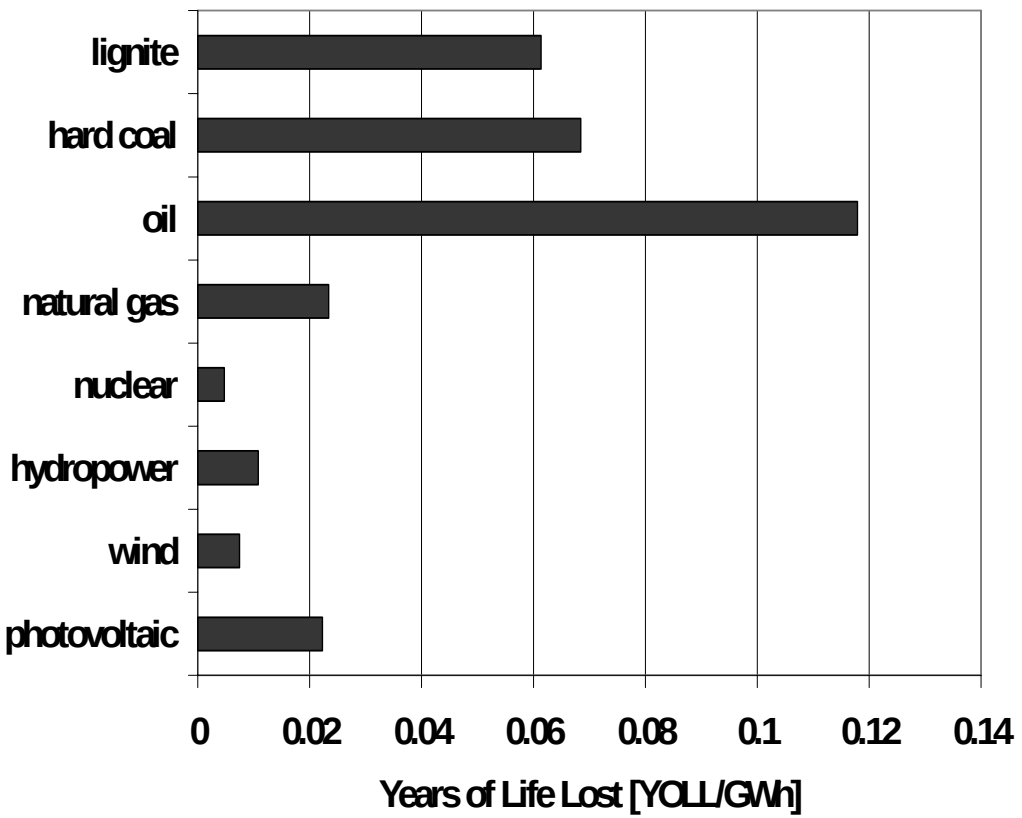
Nuclear energy is a *clean energy*

CO2 emission per GWh



Source: **World Energy Council, London, 2004**

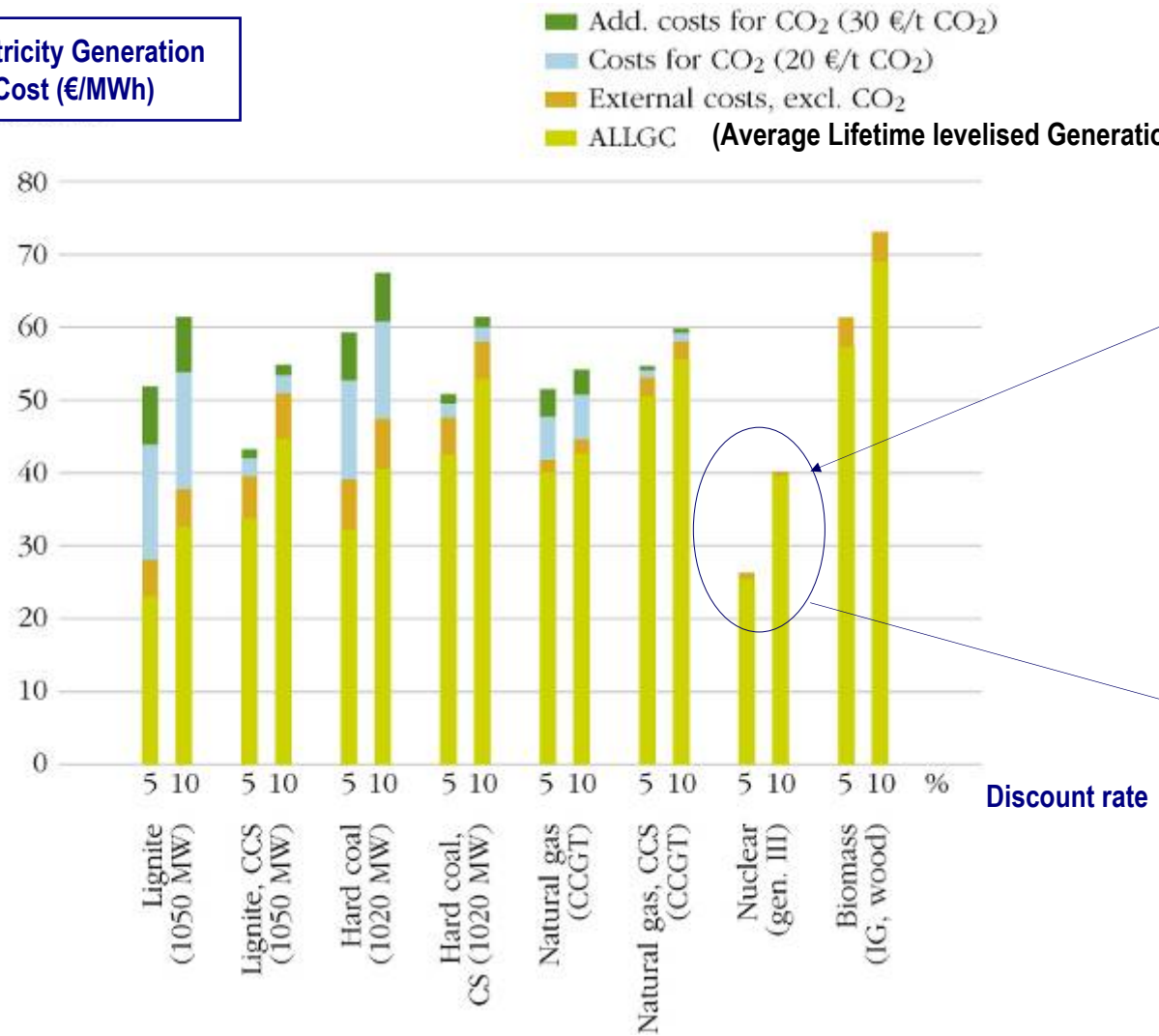
A health & safety record second to none



Source: **Hirschberg, PSI,2004**

Nuclear energy makes *economic sense*

Electricity Generation Cost (€/MWh)



The cost for nuclear electricity production ranges from 2.5 to 4.0 €cent/kWh

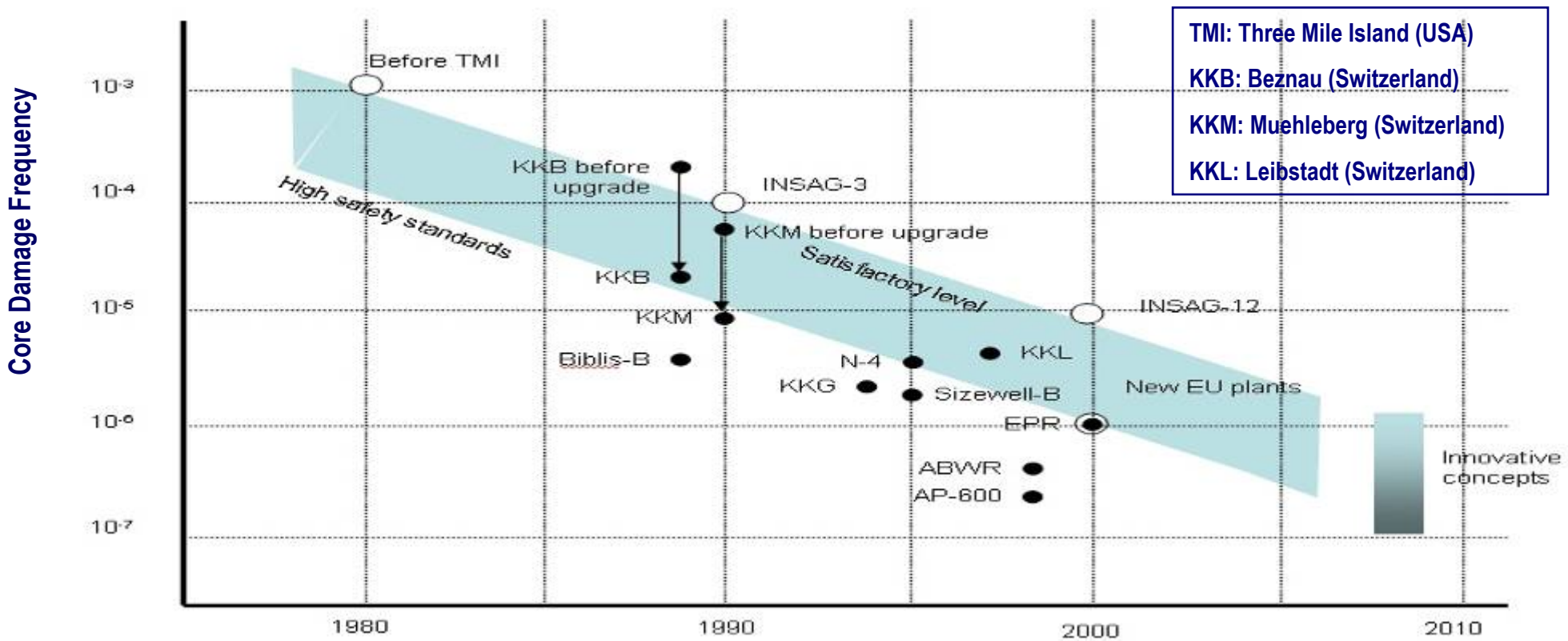
External costs are low because decommissioning and waste management costs are internalised

Source: EC EUSUSTEL Final Report
www.eusustel.be

Nuclear energy is *safe*

Chernobyl: a lesson well-learned

Safety requirements: the likelihood of one accident in a million years!



Evolution of the core damage frequency requirement for nuclear plants in Europe

Source: Hirschberg PSI 2005

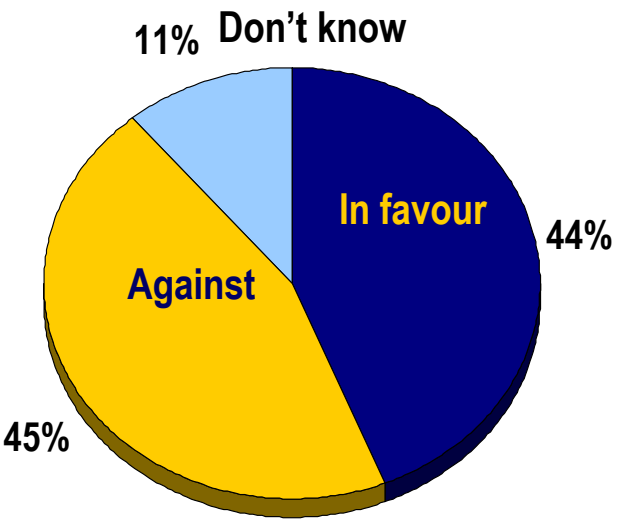
How do Europe's *citizens* see it?

- **Legacy of waste√**
- **Legacy of public opinion√**
- 2008 Eurobarometer Survey on the level of support of EU citizens to nuclear energy:

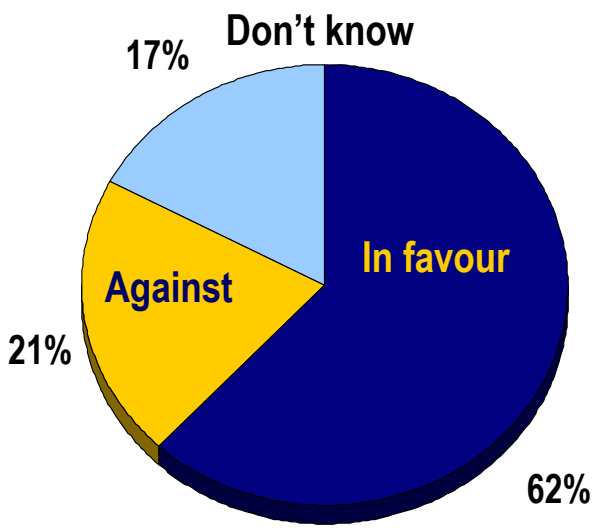
  62% of EU citizens interviewed would favour nuclear energy if safe solutions for waste are implemented

EUROBAROMETER

Current Opinion



If waste issue was solved



Low and medium active waste: *Solutions* are in place

Country	Site	Period
UK	Drigg Dounreay	1959 - 1957
France	Centre la Manche Centre de l'Aube Morvilliers	1969 - 1994 1992 - 2003 -
Germany	Asse Morsleben	1967 - 1981 - 1999
Sweden	Forsmark	1988 -
Finland	Olkiluoto Loviisa	1992 - 1998 -
Spain	El Cabril	1992 -
Czech rep.	Dukovany	1994 -
Norway	Himdalen	1998 -
Slovak rep.	Mochovche	2000 -

Source: Schenkel, ESOF 2006

Simple shallow land disposal

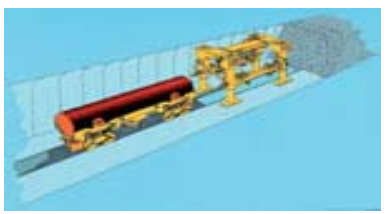
Engineered near-surface disposal

Mined rock cavity

Highly active waste: *Solutions* are being refined

- **Reprocessing and vitrification of fission products plus actinides (France, UK)**
  Status: implemented, glass storage facility

- **Direct interim storage of spent fuel**
  Status: technical solutions exist;
  implemented interim store facilities

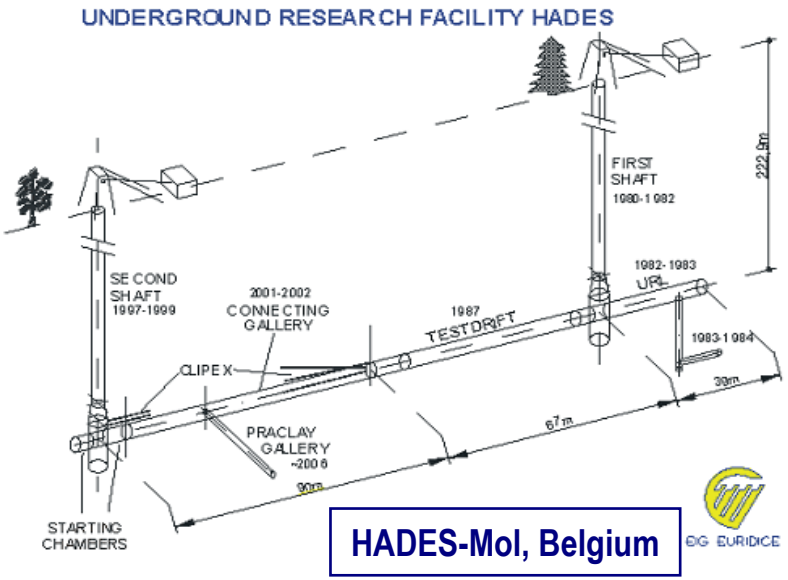


- **Geological repository of vitrified glass / spent fuel**
  Status: technical solutions exist / under test;
  no real pressure for quick implementation, acceptance lacking

- **Partitioning and transmutation of long lived actinides**
  Status: under development

Highly active waste: *Real solutions* are underway

ONKALO Test Site, Finland
Final repository in Olkiluoto in 2020



HADES-Mol, Belgium

Grimsel, Switzerland

Geological disposal: the example of Finland

Spent fuel disposal cost breakdown (Million Euro Dec 2006)
5,500 tU of spent fuel from 5 reactors operating up to 60 years

Construction		630 M€
- above ground facilities	150	
- repository	480	
Site Operation (100 years)		2,140 M€
- encapsulation plant	1,120	
- canisters	530	
- repository	470	
- transports	20	
Decommissioning and sealing		240 M€
- dismantling and waste management	10	
- repository closure and sealing	230	
Total		3,010 M€

Waste management and disposal costs represent 5% of the total electricity production price

0.16 c€/kWh (1,000 tU produce 400 million kWh). Same order as other projects: UK, USA, Spain, Sweden

Ref. Posiva, Euradwaste 2008

Nuclear: a *dual use* technology

Yet, a critical distinction has to be made

Nuclear energy is a dual use technology …
But don't forget … civilian ≠ military use

Are civilian reactors used for weapons production? *No!*

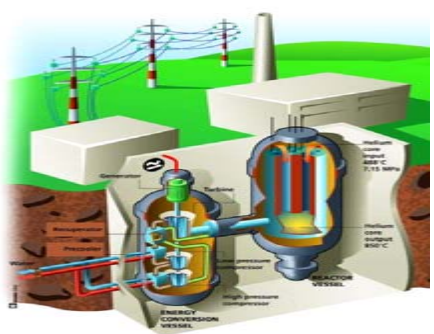
Civilian applications	≠	Military applications
• Low enriched uranium (specific materials/design ≠ criticality) in enrichment and fabrication plants		• High enriched uranium > 90%
• Power reactors, sealed reactor core optimized for electrical production, reactor grade plutonium		• Weapon grade Plutonium Pu-239 > 90%
• R&D programmes aligned to national civil nuclear power programmes		• Short term reactor irradiation (1-3 months)
		• Reprocessing for Pu production and conversion to metal or alloys
		• Weaponisation programme (explosives, dual use items, codes, delivery systems,…)

What does this mean in practice?

- Countries with nuclear weapons capabilities use separate, dedicated facilities to produce the special nuclear materials needed for weapons applications
- The shutdown of say, existing or future EU, American or Japanese civil nuclear reactors would have zero impact on the ability of another country to obtain nuclear weapons
- Nuclear know-how cannot realistically be confined, effective political and technical instruments have to be implemented within the scope of the Non-Proliferation Treaty
- Security infrastructure in the EU has been developed over decades and reinforced following Sept. 11, 2001 while all new reactors have built-in proliferation resistant features

Will Gen. IV Systems be even safer?
Yes!

- **Gen. IV systems are designed with safeguards in mind and will be inherently more proliferation resistant**
- **Existing safeguards technologies can be adapted to future Gen. IV reactor systems. They will benefit from experience gained operating existing fast reactors and reprocessing technologies. Nevertheless, new safeguards technologies will need to be developed**
- **New and better verification technologies for fabrication and reprocessing plants is required for the recycling of minor actinides: dry reprocessing will require a substantially higher development effort than currently used by aqueous reprocessing technology**



Political, institutional and technical challenges ahead

Political Action

- Adherence to Non-Proliferation Treaty with additional protocol the norm
- Clear consequences for non adherence or withdrawal
- Nuclear Weapons States to foster disarmament rather than modernization of their weapons arsenal
- Creation of regional/global security systems for regions with strong tensions
- Nuclear Weapons States to accept safeguards for their own sensitive facilities
- Develop regime to assure fuel supply and fuel cycle services on non-discriminatory basis; e.g. Global Nuclear Energy Partnership (GNEP)
- Preserve adherence/implementation of Test Ban and Fissile Material Cut Off Treaty
- Support design of future nuclear systems: no weapons usable materials, ease of safeguardability, early provision of information

Institutional (Legal Action)

Strengthening the IAEA is in everybody's interest

- Extend International Atomic Energy Agency's responsibility to cover Weaponization Programs
- Increased role of IAEA in export/import control (at least better exchange on, for example, rejected exports)
- Strengthen the role of the IAEA in assurance of supply
- Whenever the IAEA's Board of Governors and the UN Security Council act in a unified manner the IAEA has clear authority and receives the best results
- Maintain the integrity and impartiality of the IAEA's verification system

Technical Action

Robust science is needed for verification systems & technological issues: the role of the JRC

- **Foster establishment and make maximum use of independent regional systems** ("neighbours watching neighbours" – a powerful concept and excellent confidence building measure)
- **Detection of clandestine activities remains a major challenge**
  Toolbox needs to be strengthened: wide-area monitoring, environmental sampling, satellites, open and other sources etc
- **Nuclear knowledge and technology less confined, technical barriers to enrichment, reprocessing even weapons design have eroded**
  → export control is more complex and challenging

Conclusion

Nuclear is a key part of Europe's energy mix *today* and will continue to help keep the lights on in the *future*

But a lot needs to be done to inform European citizens that:

- **Nuclear energy plays the *leading role* in Europe's energy supply: it is a viable low carbon option supplying 31% of our current electricity needs with an economic model that takes full responsibility for all its wastes.**
- **Nuclear energy is a *competitive* energy that makes economic sense: climate change, security of supply issues and the current economic slowdown make this even more apparent. Launching new nuclear projects is inevitable and is gathering pace in Europe.**
- **Nuclear fission reactors have a safety & environmental track record that is second to none.**
- **Waste management solutions exist while new developments hold great promise.**
- **Measures to counteract security threats are in place and credit has to be given to the nuclear industry and scientific community for the proliferation resistant features they have developed.**
- **Taking a longer-term view → the key to success is a real Community approach!**

Thank you for your attention!

Now what do you think?

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Director-General
European Commission, Joint Research Centre

'Supporting Legislation, Serving Society'

Please visit us at the European Research Booth (No 1019)

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