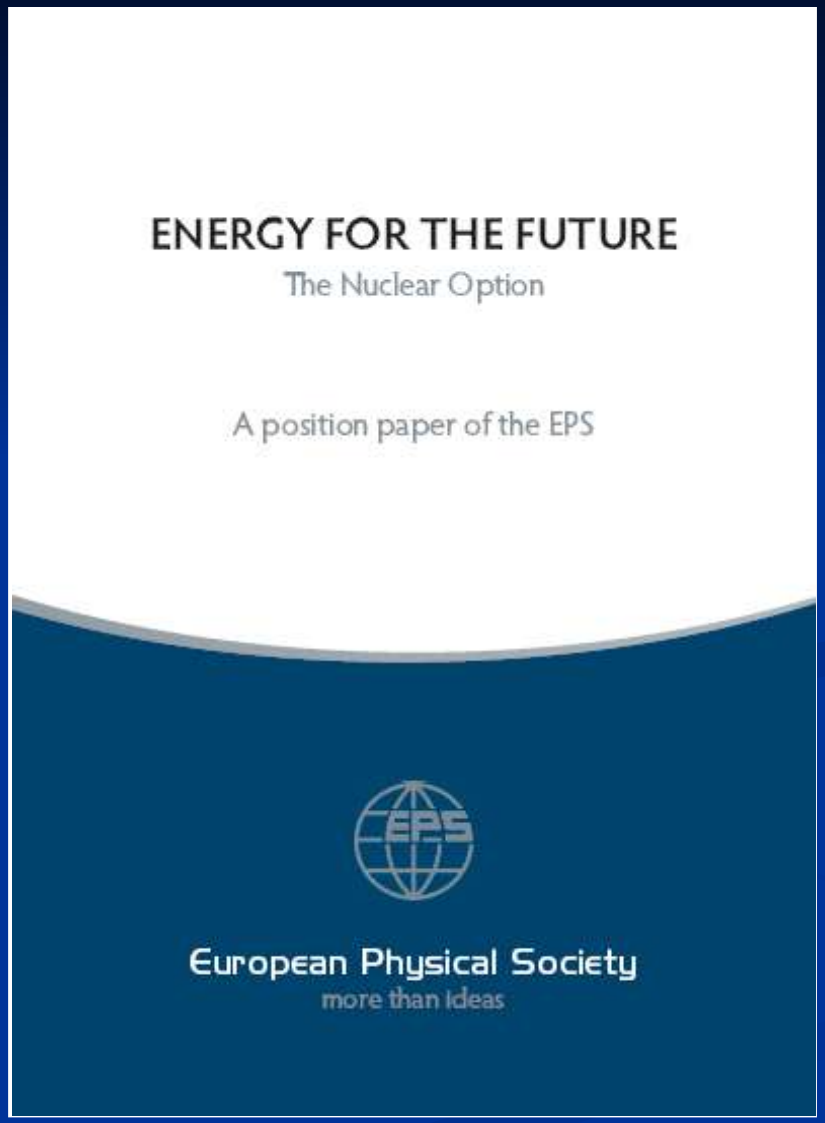

ENERGY FOR THE FUTURE
The Nuclear Option
A position paper of the EPS
EPS
European Physical Society
more than ideas

Authors:
Hartwig Freiesleben (Chair NPB), Technische Universität Dresden, Germany
Ronald C. Johnson, University of Surrey, Guildford, United Kingdom
Olaf Scholten, Kernfysisch Versneller Instituut, Groningen, The Netherlands
Andreas Türler, Technische Universität München, Germany
Ramon Wyss, Royal Institute for Technology, Stockholm, Sweden

Part 1: The EPS position

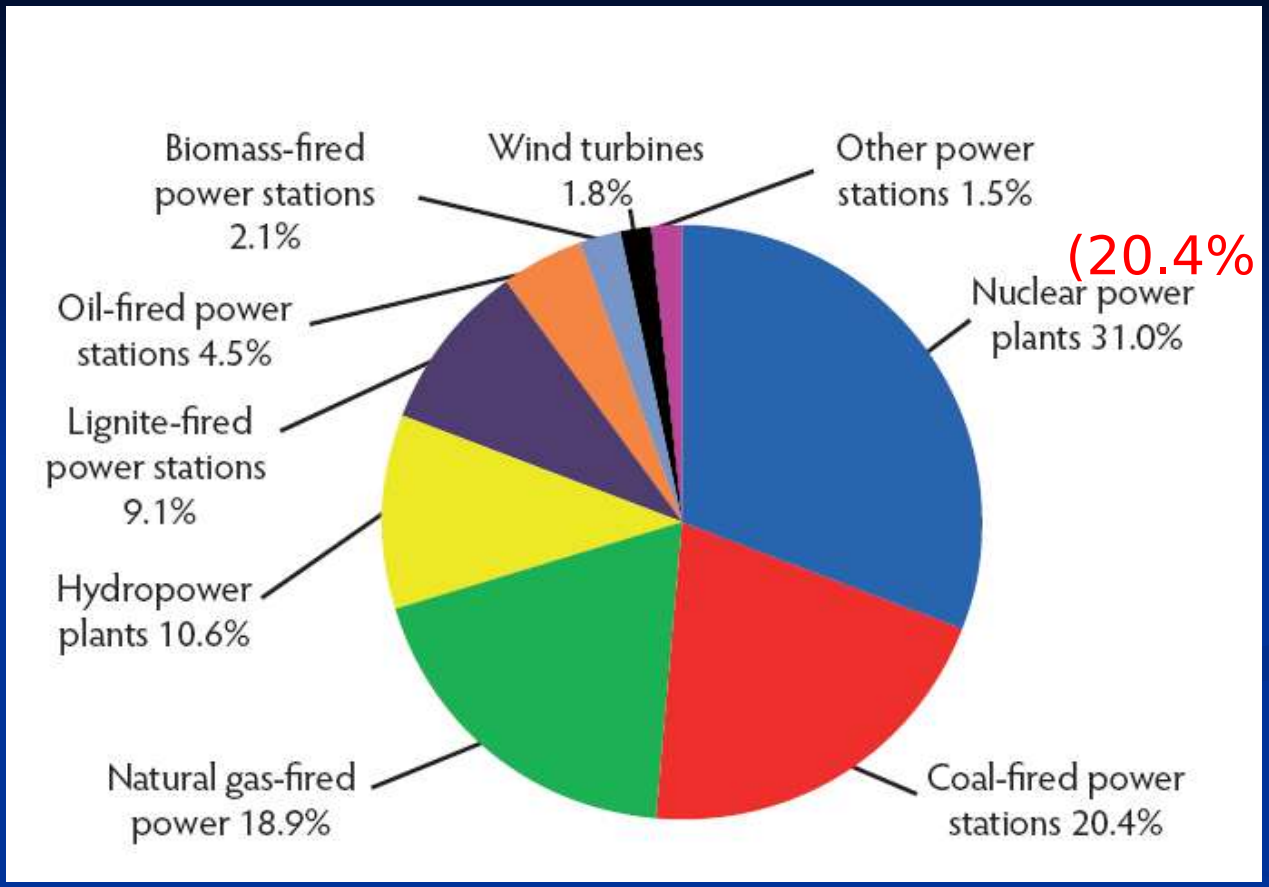
2. The objective of the Position Paper

- Future energy consumption and generation of electricity
- Need for a CO_2 free energy cycle
- Nuclear power generation today
- Concerns
- Nuclear power generation in the future
- The EPS position

Part 2: Scientific/technical part

Containss verifiable facts from various sources (cited)

Generation of electricity



Burning of fossil fuel

(20.4% + 18.9% + 9.1% + 4.5% = 52.9%)

Emission of CO_2

Upstream fuel-cycle

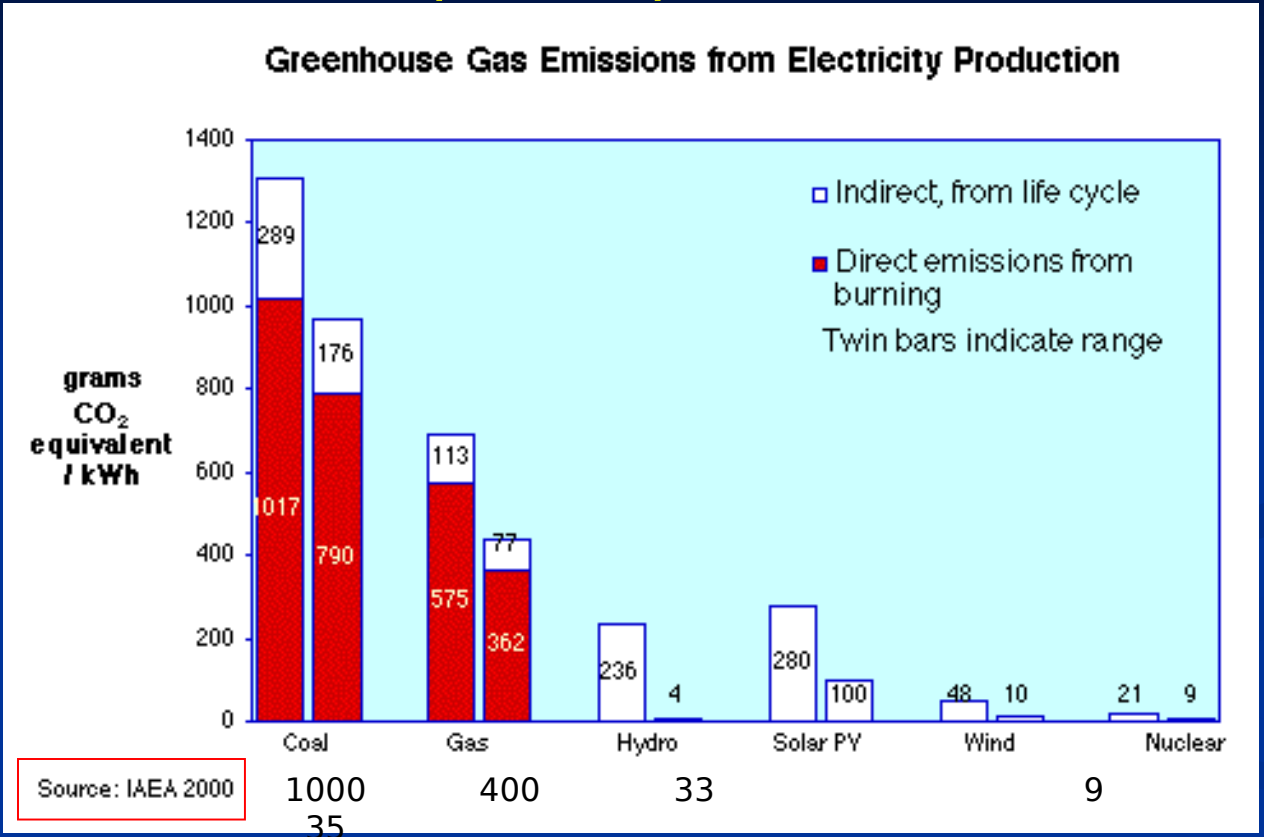
Downstream fuel-cycle

Life-cycle analysis

tricity generation by fuel used in power stations, EU 25, in 2004
al: 3.2 PWh (32.3% of all energy produced)

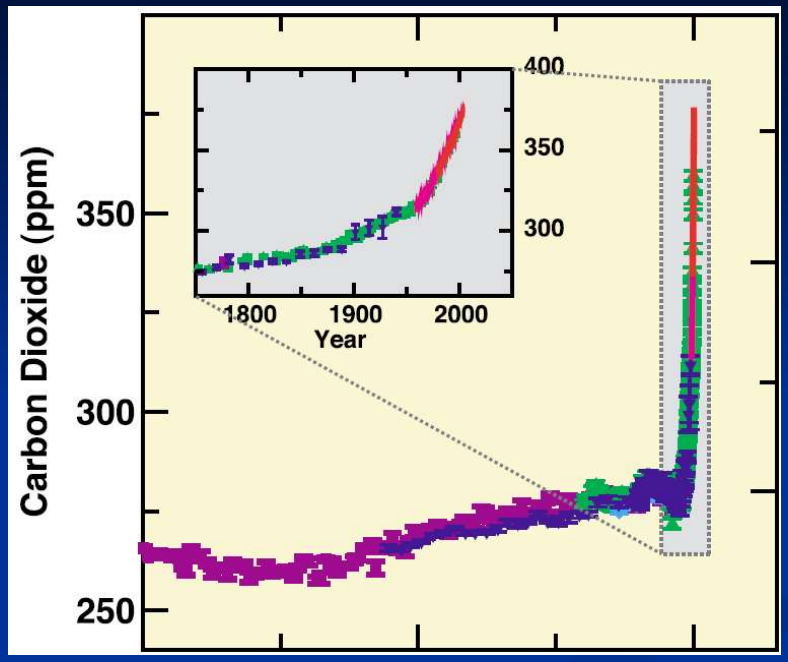
Source: Statistical Office of the European Communities
http://epp.eurostat.ec.europa.eu

Life-cycle analysis of electricity producing power plants



Source: Öko-Institut e.V. (Institute for Applied Ecology) Freiburg, Germany
http://www.oeko.de/service/gemis/en/index.htm

Need for a CO_2 free energy cycle



CO_2 concentration (parts per million, ppm) in the atmosphere during the last 10,000 years; inset panel: since 1750

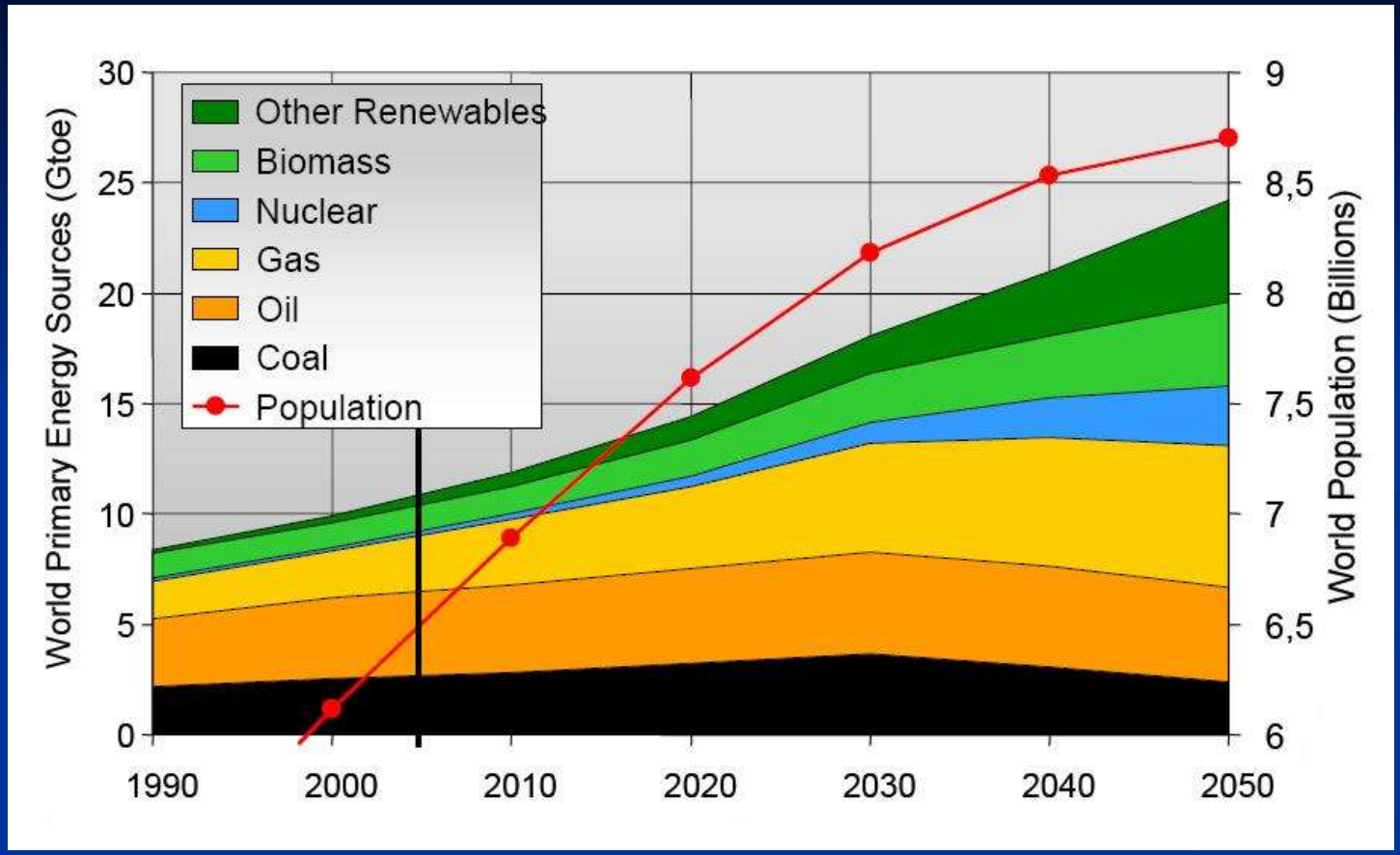
Source: International Panel on Climate Change, IPCC-report 2007, Working group I http://ipcc-wg1.ucar.edu/wg1/ Report/AR4WG1_SPM.pdf

Need for a CO_2-free energy cycle

Pasterze–Glaciertongue with Großglockner (3,798m)

Source: Gesellschaft für ökologische Forschung e.V., München
http://www.gletscherarchiv.de/202006past1.htm

Future energy consumption

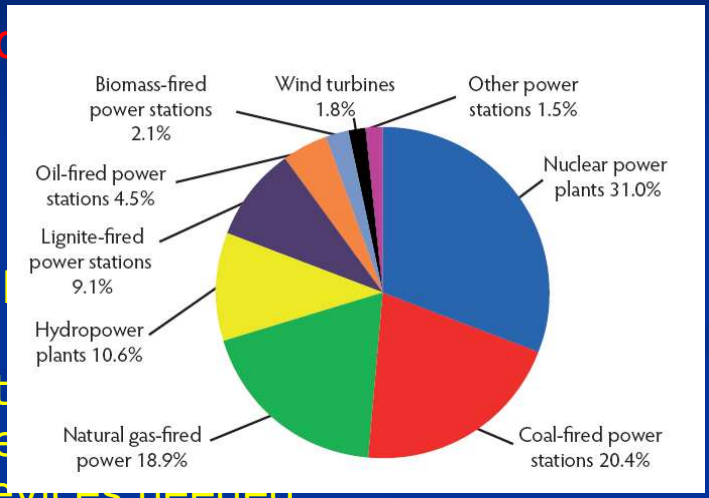


Source: Energy to 2050: Scenarios for a Sustainable Future (2003), International Energy Agency (IEA/OECD) Paris, France

Sustainable development: ….development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on the Environment and Development; Brundtland Commission)

Ambitious plan of the EU:
Reduction of CO_2 emissions by 20% below the level of 1990 by 2020

Necessary prerequisite: economical use of energy
efficient use of fuel for purpose of transport
CO_2 - free electricity generation
from sources witho
burning



Increased use of renewables in Europe:

Hydropower: no significant increase in the foreseeabl
Geothermal: of great, but local, importance
Biomass: substantial, but limited contribut
Photovoltaic: great potential in regions close to the e
electricity network and energy storage devices needed
Wind : electricity output has to be increased by a factor of 17 to draw level with nuclear electricity generation of today by 2020 - 23% annual increase required!
energy storage devices needed to supply a weather- independent load.

Nuclear power: Abandoning of nuclear power results in lacking electricity, replacement by renewables unrealistic in the near future

Realisation of the EU's CO_2-reduction plan depends heavily on the

Summary

Replacing nuclear power plants by coal burning plants is not an option, as it would significantly increase the world's total CO_2 emissions. Renewable energy sources will not grow fast enough to replace nuclear power in the near future.

In order to avoid potentially disastrous climate changes, the choice is not nuclear *or* renewables,

but nuclear *and* renewables

Nuclear power generation today

Nuclear power supplies about 16% of the world's electricity

saves 2.6 – 3.5 Gt of CO_2 emissions

(world wide emission 28 Gt)

435 nuclear power plants world-wide 196 in Europe

Nuclear Power Reactors in Europe *

	Nuclear Electricity Generation 2006		Reactors in Operation May 2007		Reactors under Construction May 2007		Reactors planned May 2007	
	TWh	%e	No.	MWe	No.	MWe	No.	MWe
Belgium	44.3	54	7	5728	0	0	0	0
Bulgaria	18.1	44	2	1906	0	0	2	1900
Czech Rep.	24.5	31	6	3472	0	0	0	0
Finland	22.0	28	4	2696	1	1600	0	0
France	428.7	78	59	63473	0	0	1	1630
Germany	158.7	32	17	20303	0	0	0	0
Hungary	12.5	38	4	1773	0	0	0	0
Lithuania	8.0	69	1	1185	0	0	0	0
Netherlands	3.3	3.5	1	485	0	0	0	0
Romania	5.2	9.0	1	655	1	655	0	0
Russia	144.3	16	31	21743	3	2650	8	9600
Slovakia	16.6	57	5	2064	0	0	2	840
Slovenia	5.3	40	1	696	0	0	0	0
Spain	57.4	20	8	7442	0	0	0	0
Sweden	65.1	48	10	8975	0	0	0	0
Switzerland	26.4	37	5	3220	0	0	0	0
Ukraine	84.8	48	15	13168	0	0	2	1900
UK	69.2	18	19	10982	0	0	0	0
Europe	**1194.4**	**35.4**	**196**	**169966**	**5**	**4905**	**15**	**15870**

* Source: World Nuclear Association, http://www.world-nuclear.org

Heavy dependence on nuclear power:
France, Lithuania, Slovakia, Belgium

Gradual phase-out planned:
Belgium, Germany,
The Netherlands, Sweden

Use prevented by law:
Austria, Denmark, Greece, Ireland, Italy, Norway

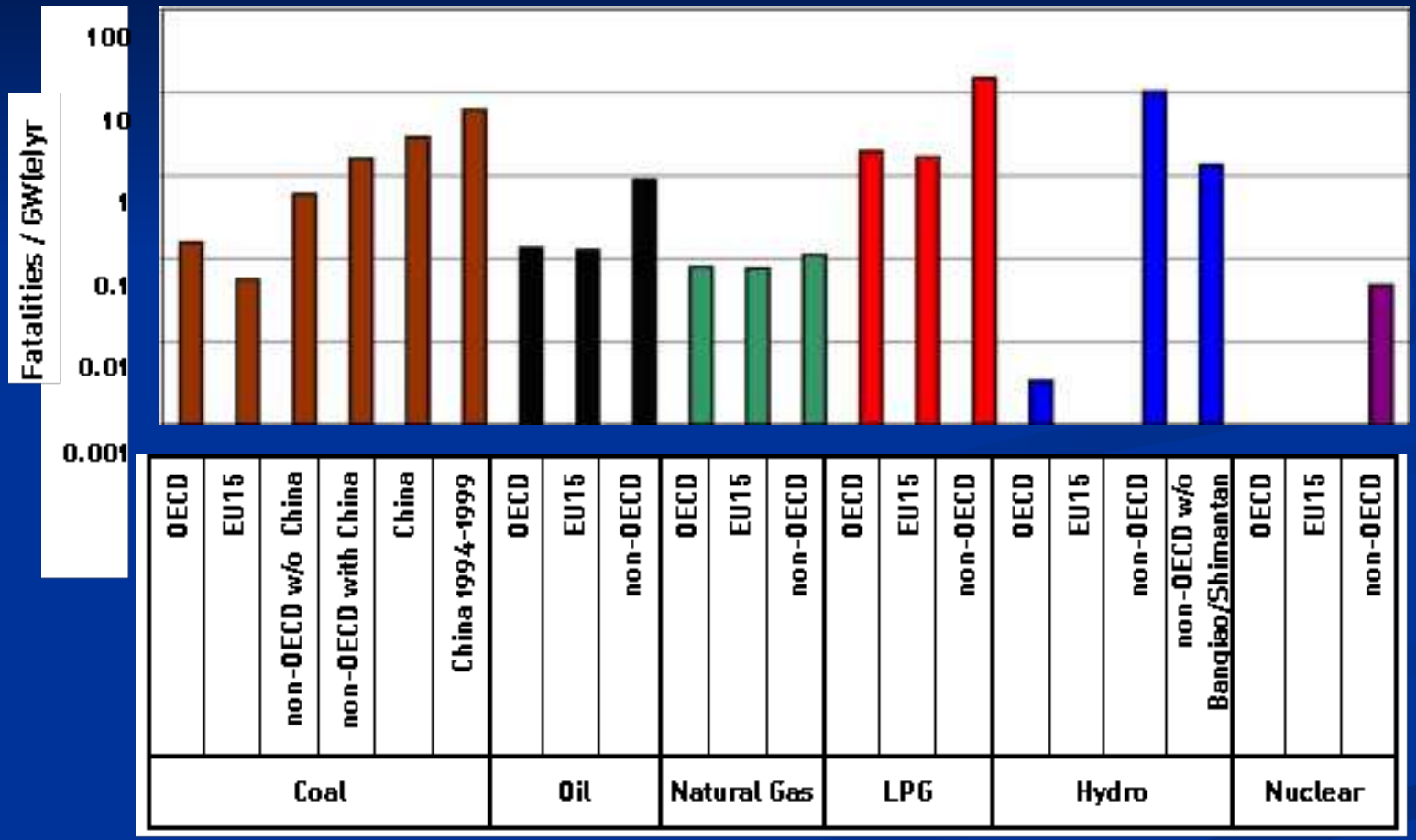
Significant increase in South Asia and Far East

Concerns

Risks and safety
Waste
Proliferation and extremists' threats

Risks and safety

Risk-oriented comparative analysis of energy sources:
severe energy-related accidents in the period 1969 -2000



Source: Paul Scherrer Institut (PSI), Villigen, Schweiz, Technology Assessment/ GaBE
http://gabe.web.psi.ch/research/ra/

Most serious energy-related accidents:

Dam failure: 1975 Banqiao/Shimantan, China: 26,000 fatalities

Coal mines: more than 5,000 deaths each year

Chernobyl

According to WHO * study:

50 immediate casualties among emergency workers due to an acute radiation syndrome

9 children died of thyroid cancer

Long term casualties?

Causal chain?

* http://www.who.int/mediacentre/news/ releases/2005/pr38/en/index.html

Quantitative risk assessment

through the measure “ Loss of Life Expectancy (LLE)” *

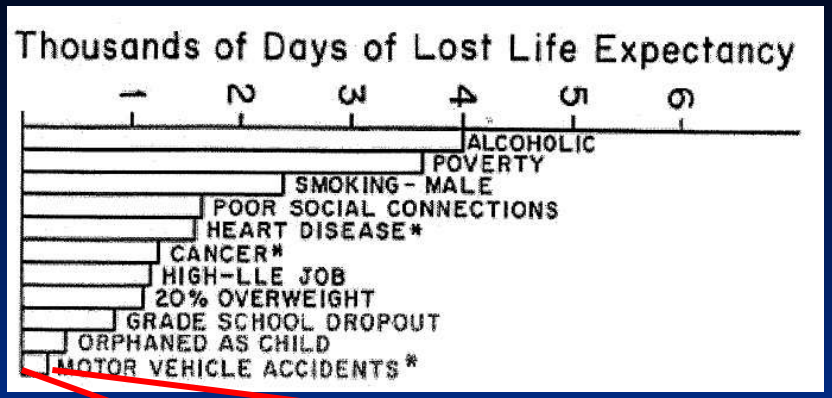
LLE = probability for a risk to cause death
• lost life expectancy, if this risk causes death

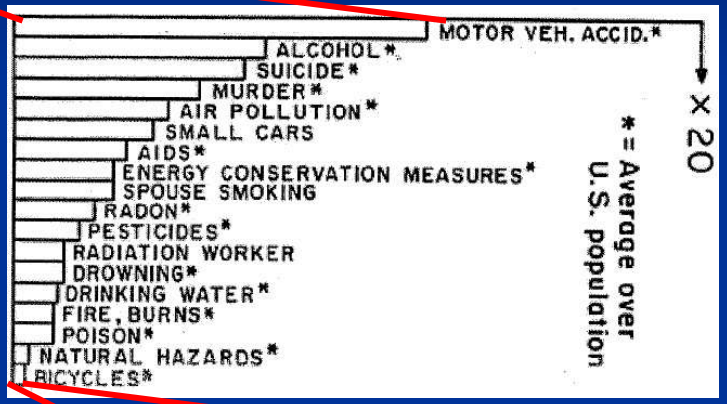
Assumption:
40 y old person with life expectancy of 35 y
takes risk with 1% chance of being immediately fatal

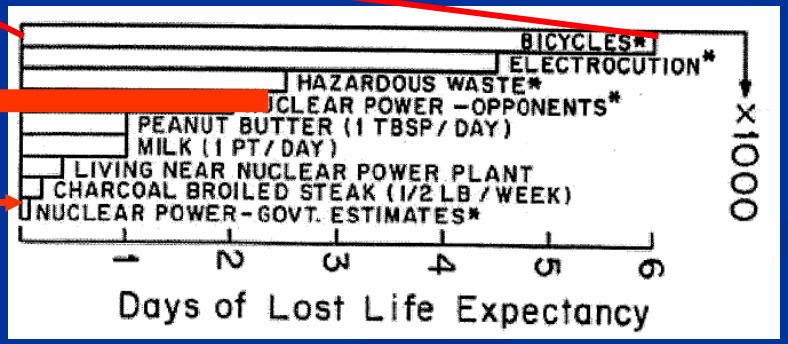
LLE = 0.01 • 35 y = 0.35 y

1,000 persons taking this risk:
10 will die immediately, each having their lives shortened by 35 y
990 do not have their lives shortened at all

* Bernard L. Cohen: *Before it’s too late*; Springer 1983, ISBN-13: 978-0306414251, and http://www.ecolo.org/documents/documents_in_english/Bernard.Cohen.rankRisks.htm







Government estimates

Source:

http://www.ecolo.org/documents/

documents_in_english/

Bernard.Cohen.rankRisks.htm

Numbers from 1993

This science-based analysis shows that the risk from electricity generation by nuclear power plant is far less than other risks of daily

Emission of radioactive material

Occurance of leukaemia lose to nuclear power plants

Physical safety

Waste

Uranium resources

liferation and extremists' threat

iferation is the clandestine spread of material and/or technology that can be d for the manufacturing of nuclear weapons

Warhead production by states from
highly enriched uranium (HEU >20% U-235) or weapons grade plutonium
Prerequisite: enrichment facilities or special purpose reactors and extraction facilities

Use of fissile material by extremists?

Diversion of Pu/U during/after PUREX ?
effectively impeded by IAEA surveillance and safeguarding
wrong isotopic composition → effective warhead production excluded
difficult handling due to high radiotoxicity

Diversion of a rod of spent fuel?
effectively impeded by IAEA surveillance and safeguarding
reprocessing facilities needed

Possibility: conventional bomb used for vapourisation

Not to be ignored: acquisition of nuclear weapons directly from the dismantling of nuclear weapons arsenals

Summary

Nuclear energy generation is not free of risks. How
far the associated risks, which are in different forms
also present in other energy sources, can be considered acceptable is a matter of judgment.
It must be made rationally on the basis of research and open discussion of evidence and in comparison with the hazards of other sources of energy.

Nuclear power generation in the future

Further perspective for the handling of spent fuel

Alternative to storage:

Transmutation of long-lived isotopes in short-lived ones by

Accelerator Driven Systems (ADS)

or

Incineration of spent fuel in dedicated reactors (GEN IV reactors)

Both processes require partitioning of U/Pu as well as MAs

Don‘t forget fusion as alternative to fission → ITER

ADS vs GEN IV

Design of a first experimental facility to demonstrate the feasibility of transmutation with ADS launched within 6th Framework Programme

In parallel: conceptual design for a modular industrial-level realisation

Although research is still required, some of these systems are expected to be operational by 2030.

Comparative studies on safety issues are performed by the Joint Research Centre of the European Commission, Institute for Energy, Petten, The Netherlands

It is too early to make a final judgement about the relative merits of ADS and GENIV reactors as energy producing and waste incinerating/transmutating systems.

The overall favourable properties are obvious.

Summary

reactor concepts (GENIV) will meet stringent criter
sustainability and reliability of energy production, ar
e for safety and non-proliferation.

lear fission and fusion have the potential for a
stantial contribution to meeting future electricity ne

The EPS position

Given the environmental problems our planet is presently facing, the present generation owes it to the future generations not to forgo a technology that has the proven ability to deliver electricity reliably and safely without CO_2 emission. Nuclear power can and should make an important contribution to a portfolio of sources having low CO_2 emissions. This will only be possible if public support is obtained through an open democratic debate that respects people's concerns and is informed by verifiable scientific and technical facts.

Since electricity production from nuclear power is opposed in some European countries and research into nuclear fission is supported in only a few, the number of students in this field is declining and the number of knowledgeable people in nuclear science is likewise decreasing. There is a clear need for education in nuclear science and preservation of nuclear knowledge as well as for long-term research into both nuclear fission and fusion and methods of waste incineration, transmutation and storage.

Europe needs to stay abreast of developments in reactor design independently of any decision about their construction in Europe. This is an important subsidiary reason for investment in nuclear reactor RD&D and is essential if Europe is to be able to follow programmes in rapidly developing countries like China and India, that are committed to building nuclear power stations, and to help ensure their safety, for instance, through active

Thank you for your attention.