

## **CSD15 – New York, USA**

# **Nuclear Energy and Sustainable Development** *Economics, Environment, Social*

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# Overview

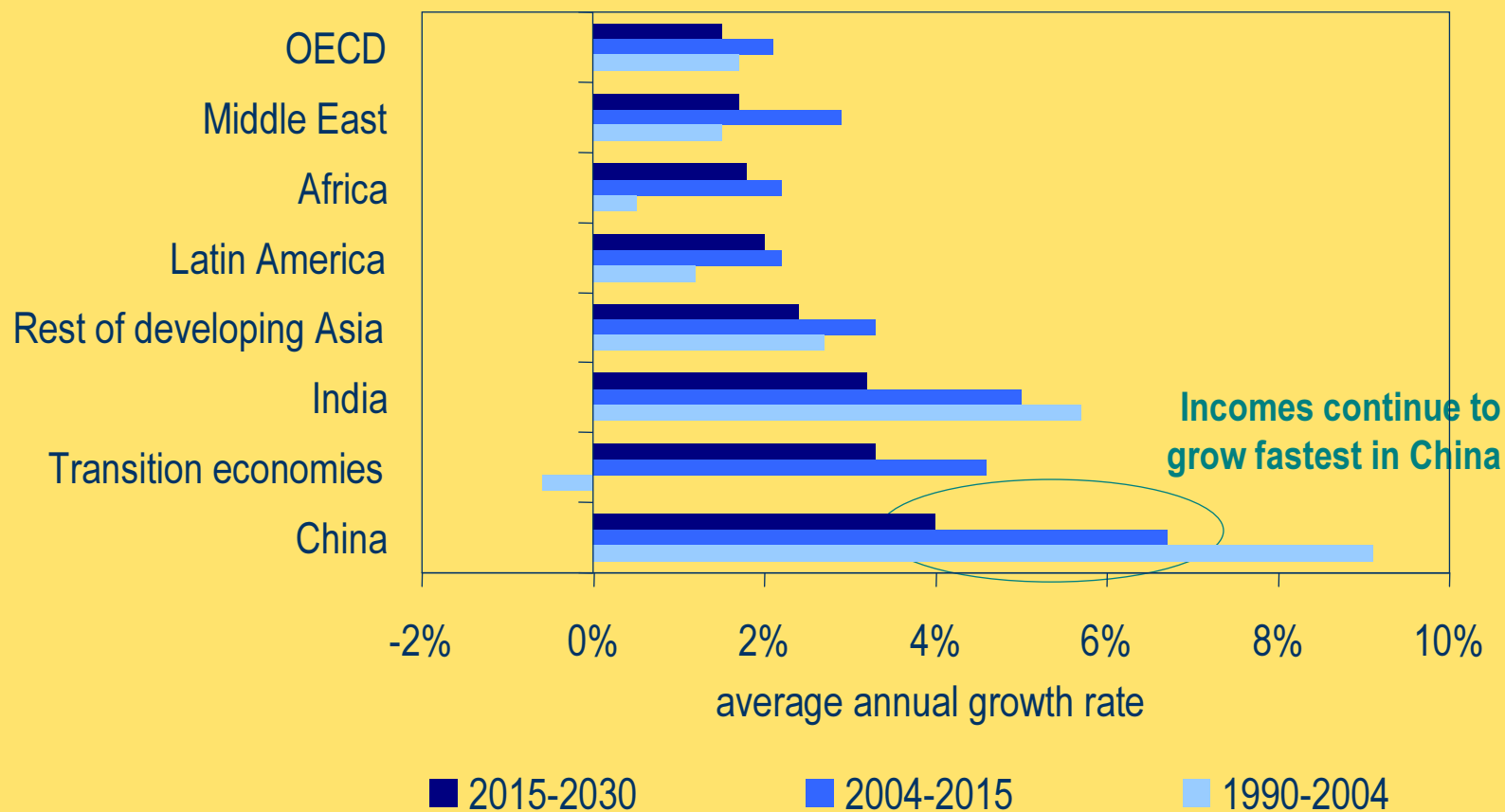
- ◆ **World Energy Outlook 2006 (IEA)**
- ◆ **Nuclear Energy & Sustainable Development**
  - **Economics**
  - **Environment**
    - ❖ **Climate Change**
    - ❖ **Waste**
  - **Social**
    - ❖ **Uranium Resources**
- ◆ **Concluding Remarks**

# World Energy Outlook 2006

## Contents

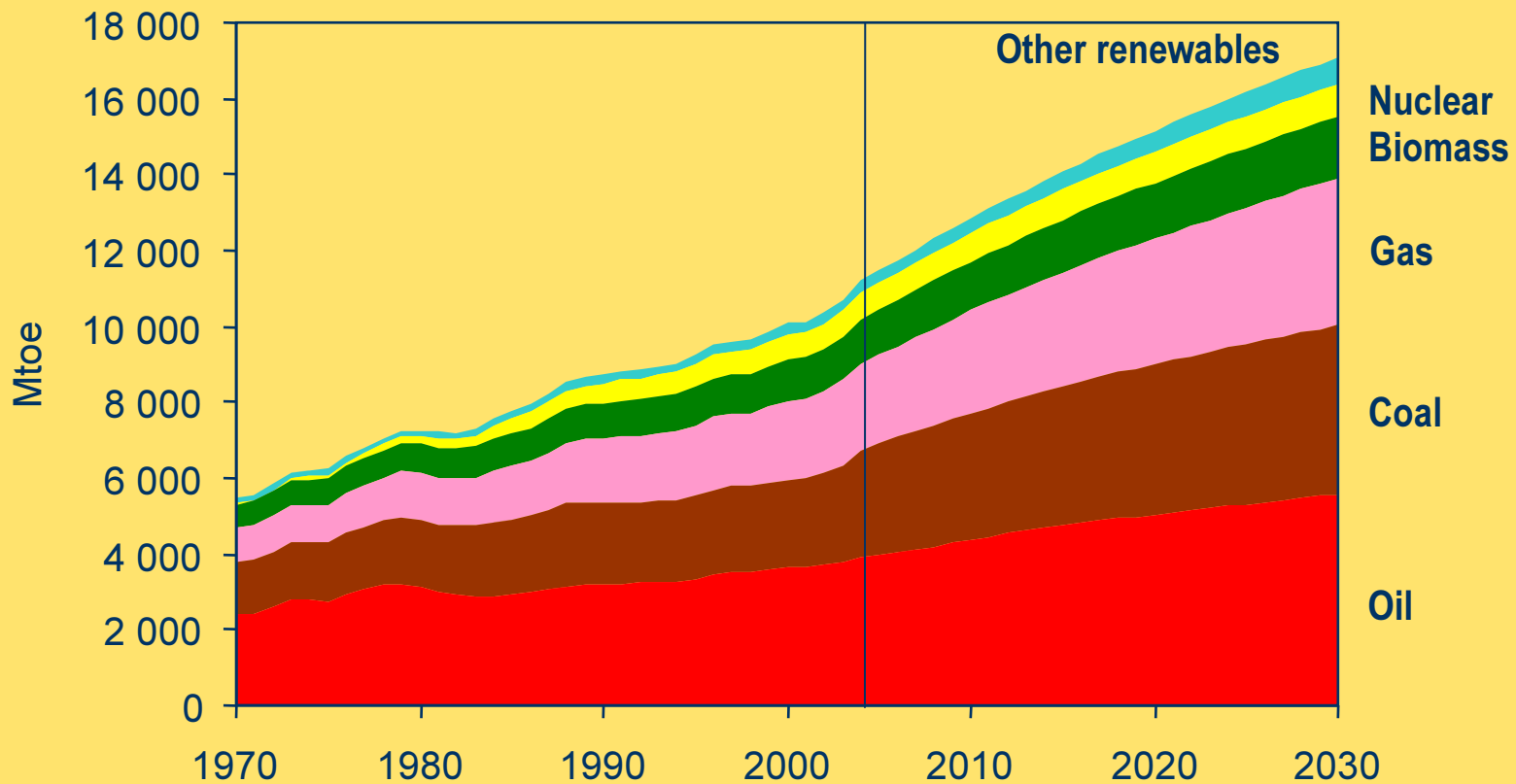
- ◆ **Reference scenario**
- ◆ **Alternative Policy scenario**
- ◆ **Focus on key topics**
  - **Impact of Higher Energy Prices**
  - **Current trends in Oil & Gas Investment**
  - **Prospects for Nuclear Power**
  - **Outlook for Biofuels**
  - **Energy for Cooking in Developing Countries**
  - **Brazil**

## Per-Capita GDP



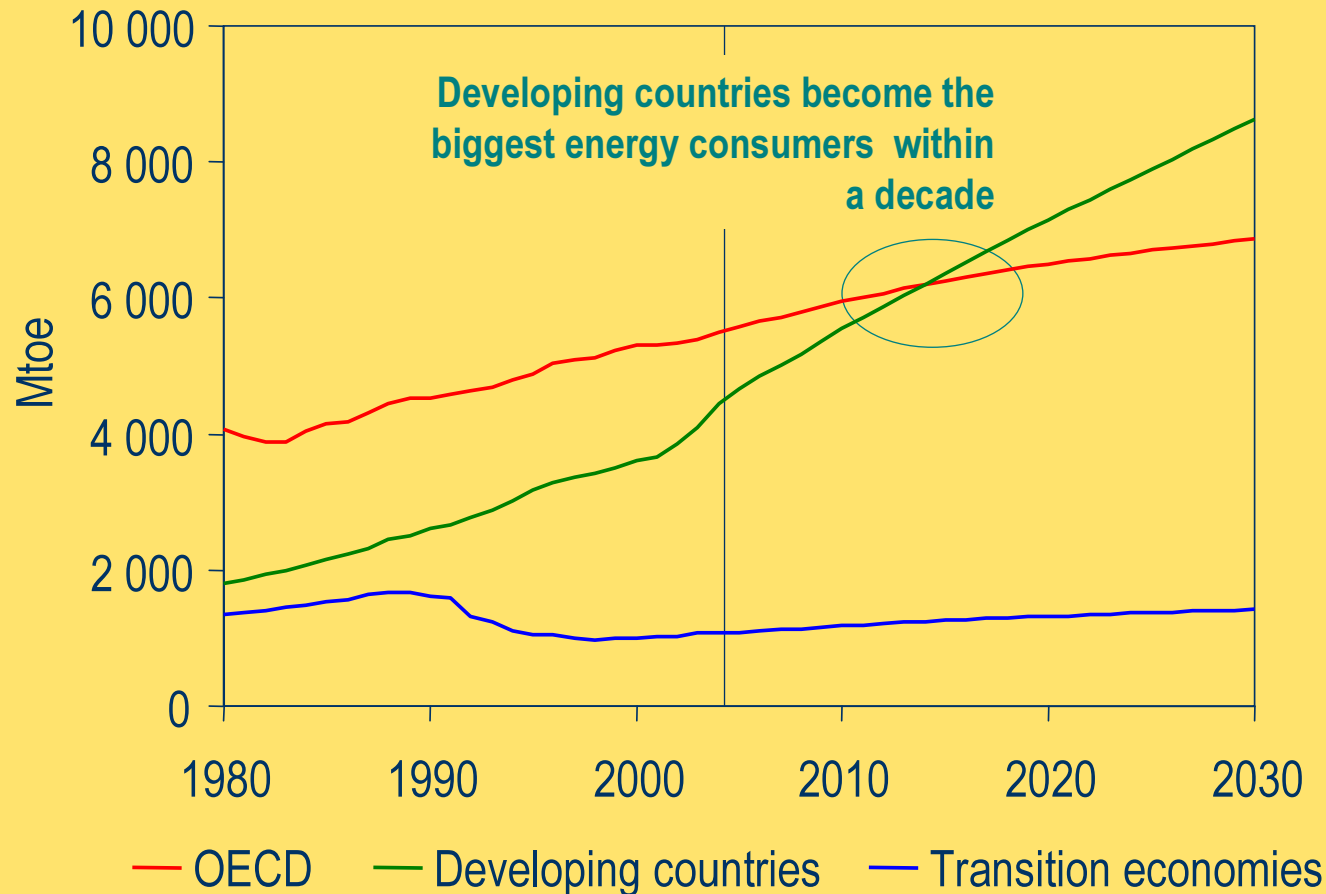
***Incomes in the OECD are still four times higher than in rest of the world in 2030***

# Reference Scenario: World Primary Energy Demand



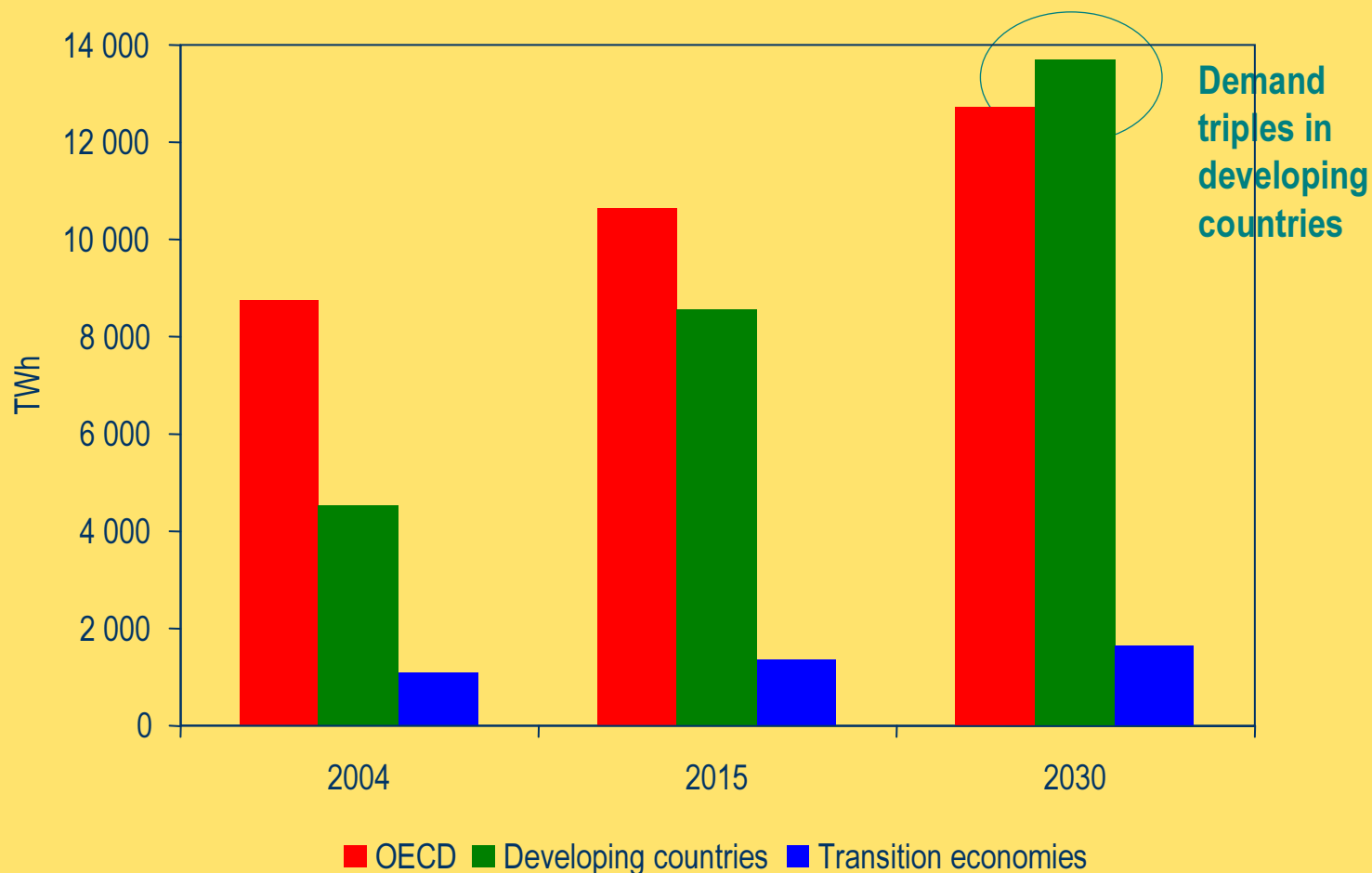
***Global demand grows by more than half over the next quarter of a century, with coal use rising most in absolute terms***

# Reference Scenario: Primary Energy Demand by Region



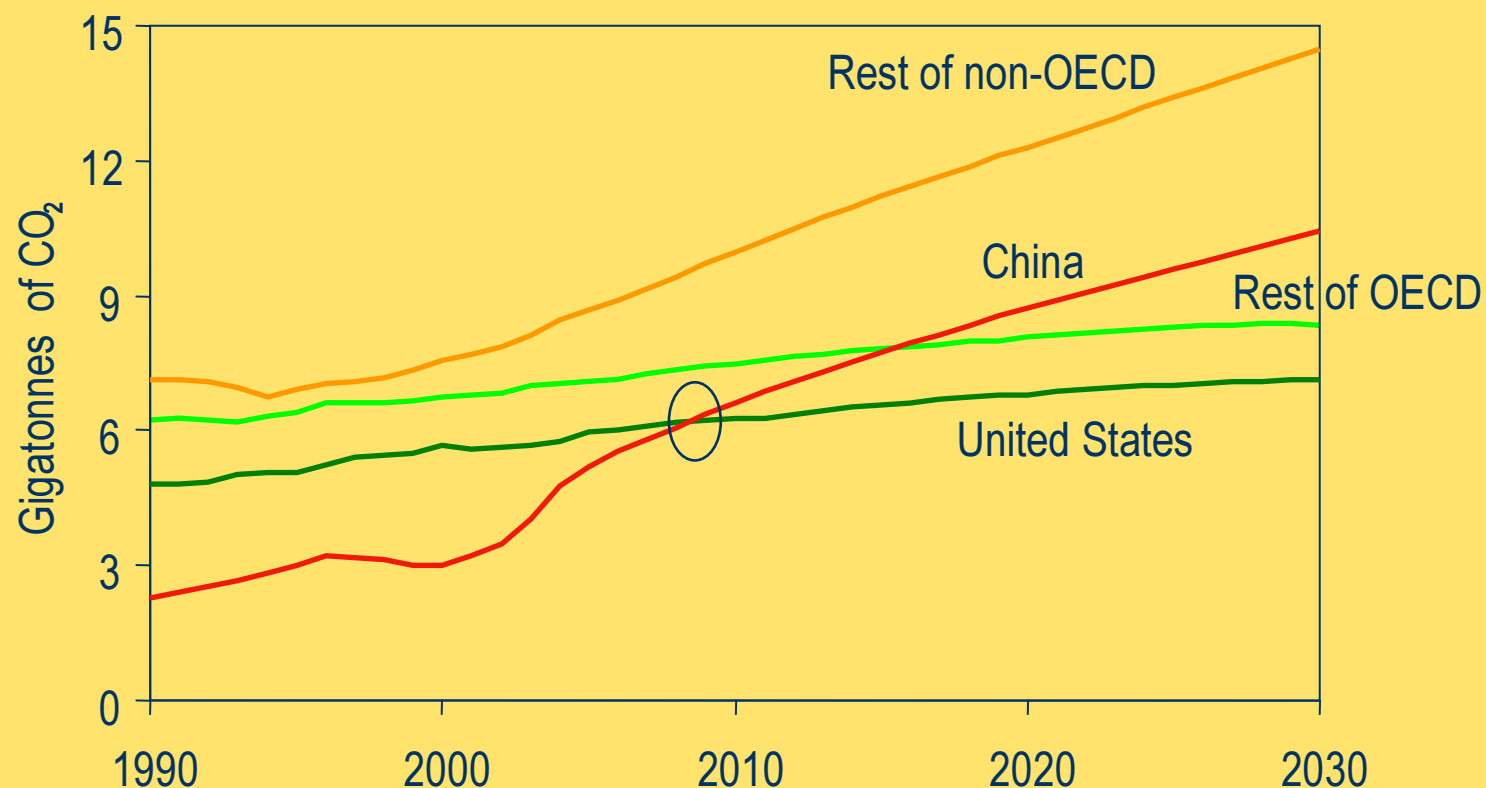
***World oil demand grows by just over half between 2004 and 2030, with 70% of the increase coming from developing countries***

# Reference Scenario: World Electricity Demand by Region



***World electricity demand doubles between 2004 and 2030  
Most of the additional demand for electricity is expected to be met by  
coal, which remains the world's largest source of electricity to 2030***

# Reference Scenario: Energy-Related CO<sub>2</sub> emissions by Region

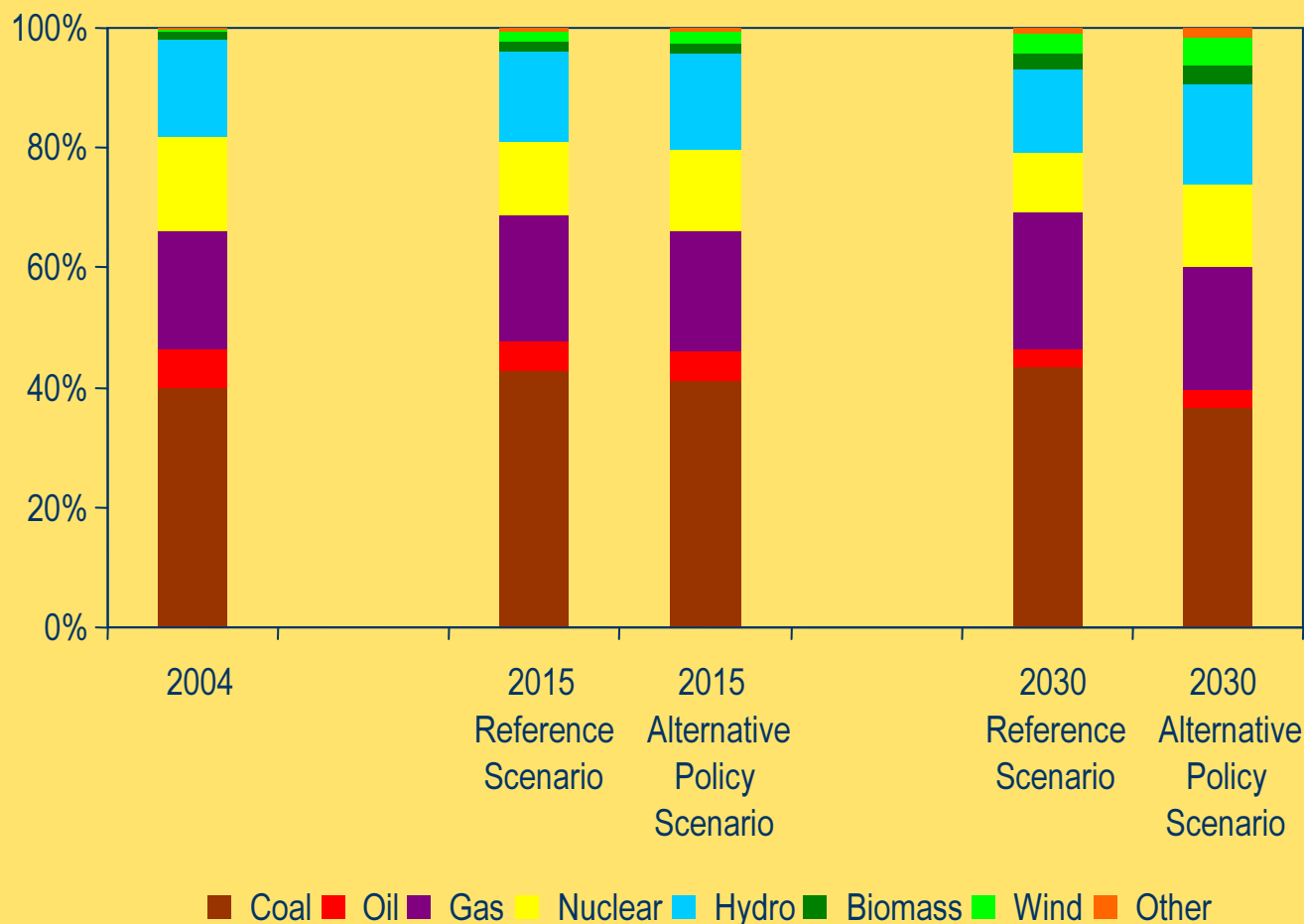


***Half of the projected increase in emissions comes from new power stations, mainly using coal & mainly located in China & India***  
***China overtakes the US as the world's biggest emitter before 2010, though its per capita emissions reach just 60% of those of the OECD in 2030***

# Reference and Alternative Scenarios

- ◆ In short, the reference scenario describes the “*dirty, insecure and expensive*” energy future that the current trends prepare
- ◆ **Alternative scenario**
  - energy efficiency
  - increased use of renewable (>25% of elect. in 2030)
  - increased use of nuclear (~ +25% vs ref. scenario)
  
  - - 10 % in world energy demand (2030)
  - - 15 % in global CO2 emissions

# The Alternative Policy Scenario: Global Fuel Shares in Electricity Generation



***Over a quarter of global electricity comes from renewable energy sources in 2030 in APS***

# Nuclear in the Global Energy Mix

## *The times are changing*

### ◆ Main messages now broadly endorsed

*“Keep all energy options open”*

*“No technology should be idolised or demonised”*

- governments
- industry
- environmentalists

### ◆ International initiatives

- GIF, INPRO, GNEP, ...

### ◆ National programs

- Finland, France, USA, China, India, .... EC

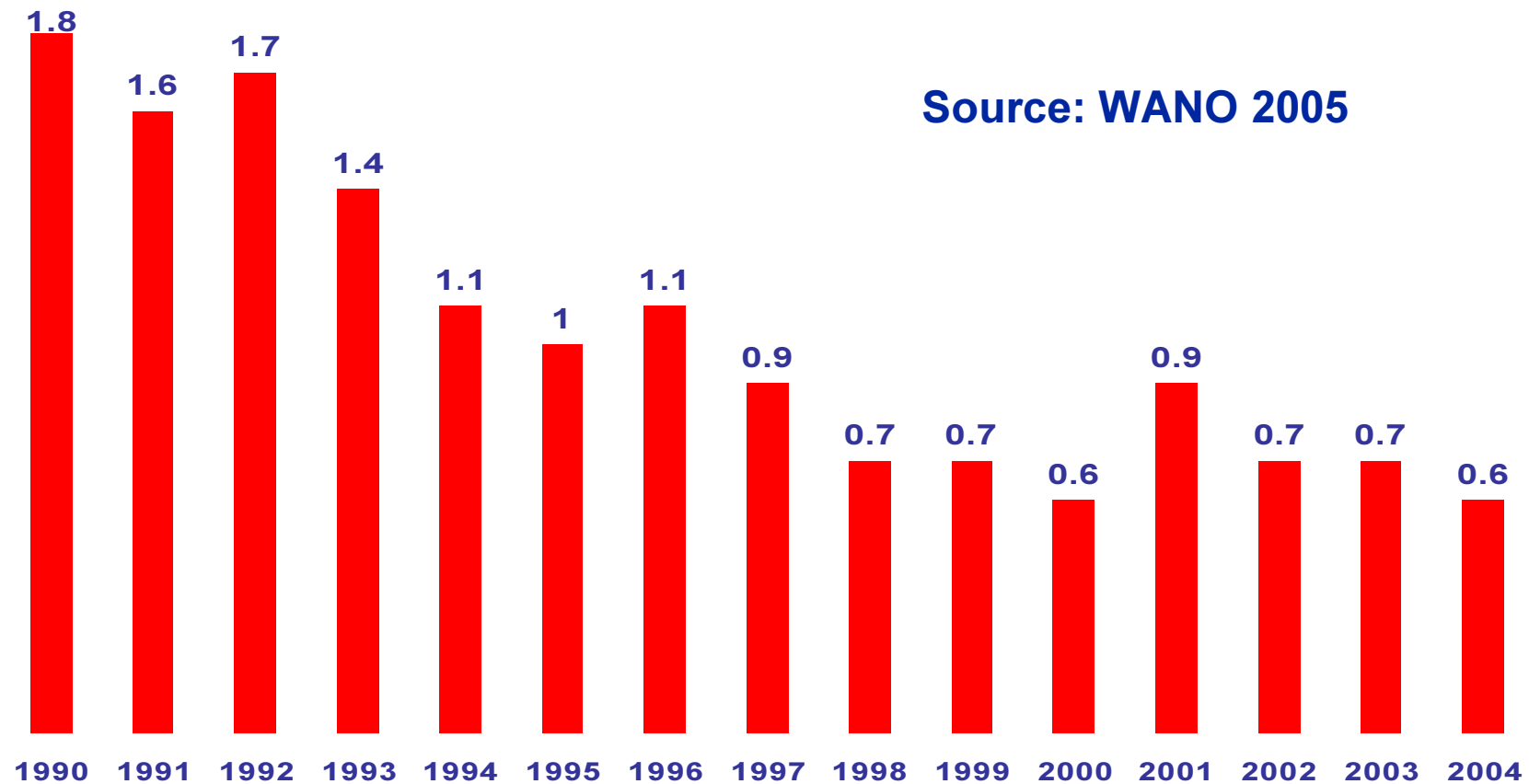
## ***Why times are changing ?***

- ◆ **Rising of fossil fuels prices**
- ◆ **Security of energy supply (and diversity)**
- ◆ **Climate change concerns**

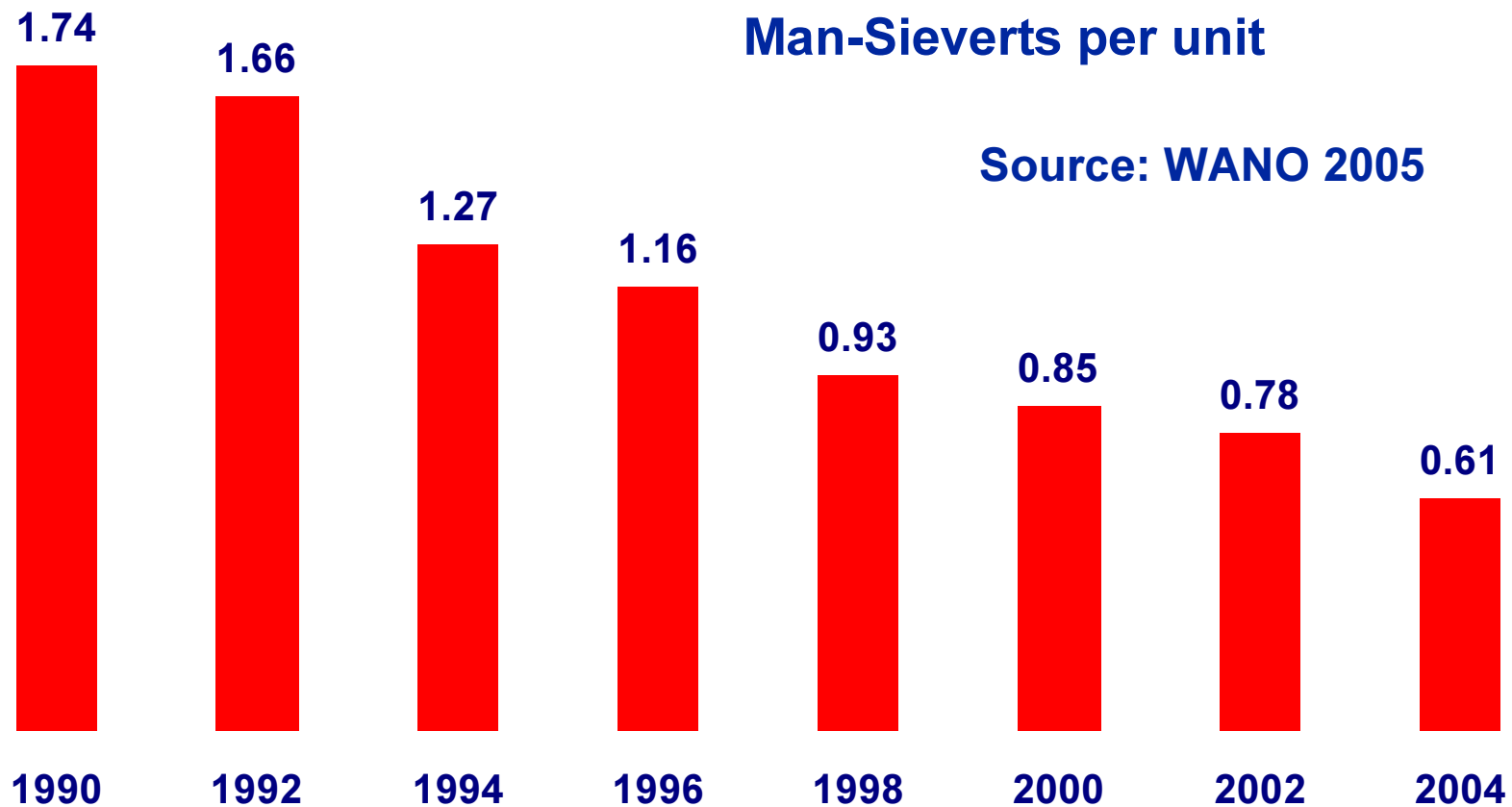
## ***Nuclear energy main features***

- ◆ **Mature technology making continuous progress**
- ◆ **Nearly carbon-free electricity generation source**
- ◆ **Stable cost and low marginal cost**
- ◆ **Geopolitical distribution of uranium resources**
- ◆ **“Domestic” source of energy**

# Unplanned Automatic Scrams per 7000 hours critical



# Collective Radiation Exposure of Personnel in PWRs



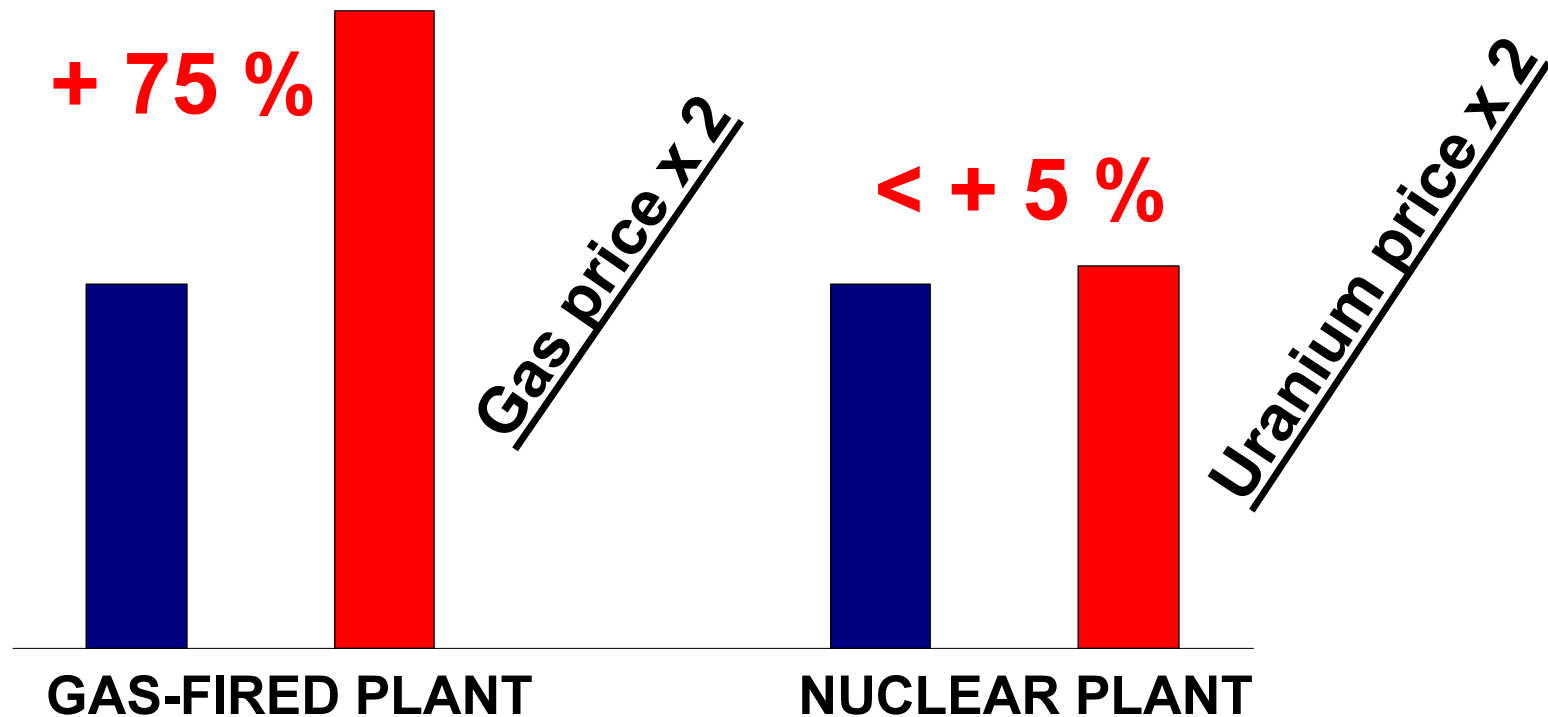
# Nuclear Energy and the Economic Dimension of Sustainable Development

*~ 16% of world electricity generated by nuclear*

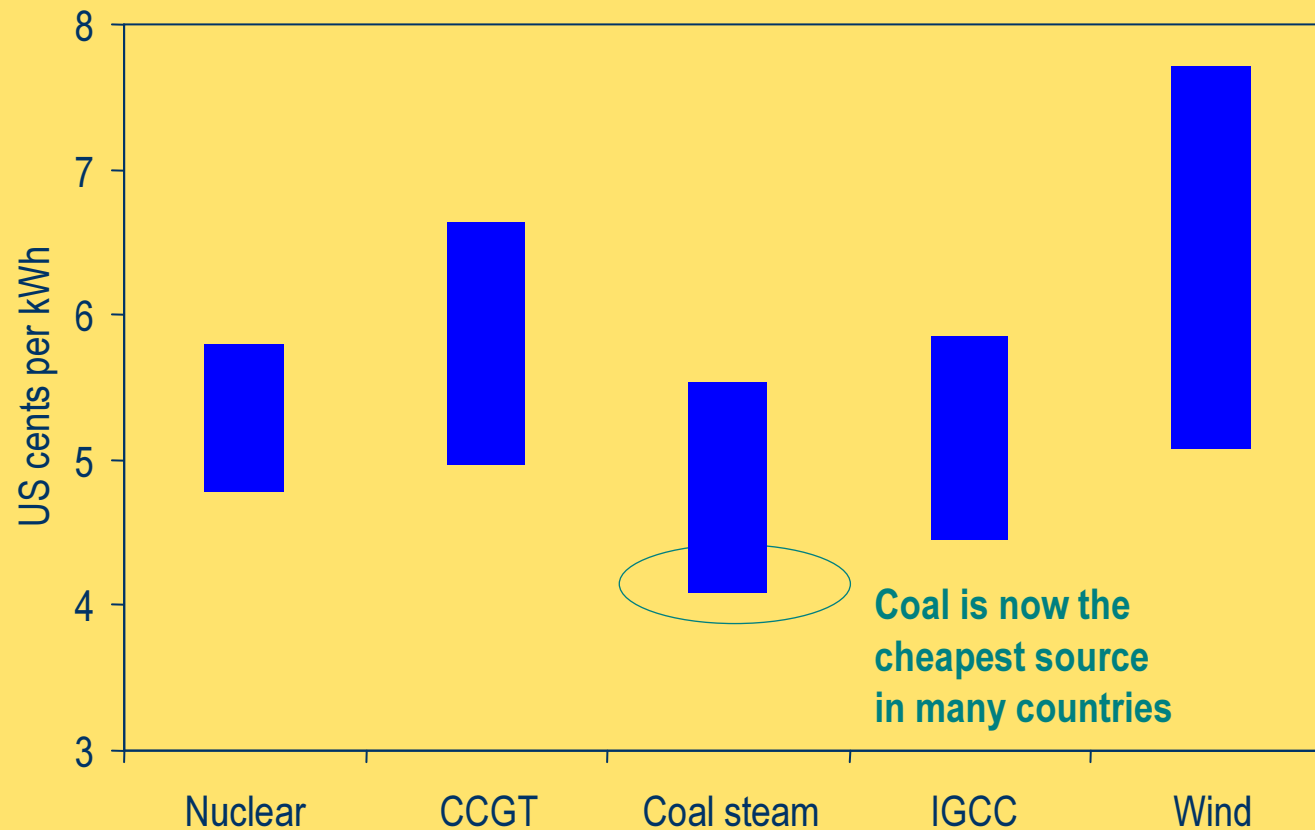
- ◆ Existing power plants are very competitive
- ◆ Low marginal cost of existing nuclear units
  - Increasing load factors
  - Upgrading of plant capacities
- ◆ Low cost of lifetime extension
- ◆ Long term stability of generation costs
- ◆ Very low sensitivity of nuclear KWh to natural uranium cost

*Competitiveness is no more a crucial issue*

# Electricity Cost Sensitivity to Fuel Price Volatility

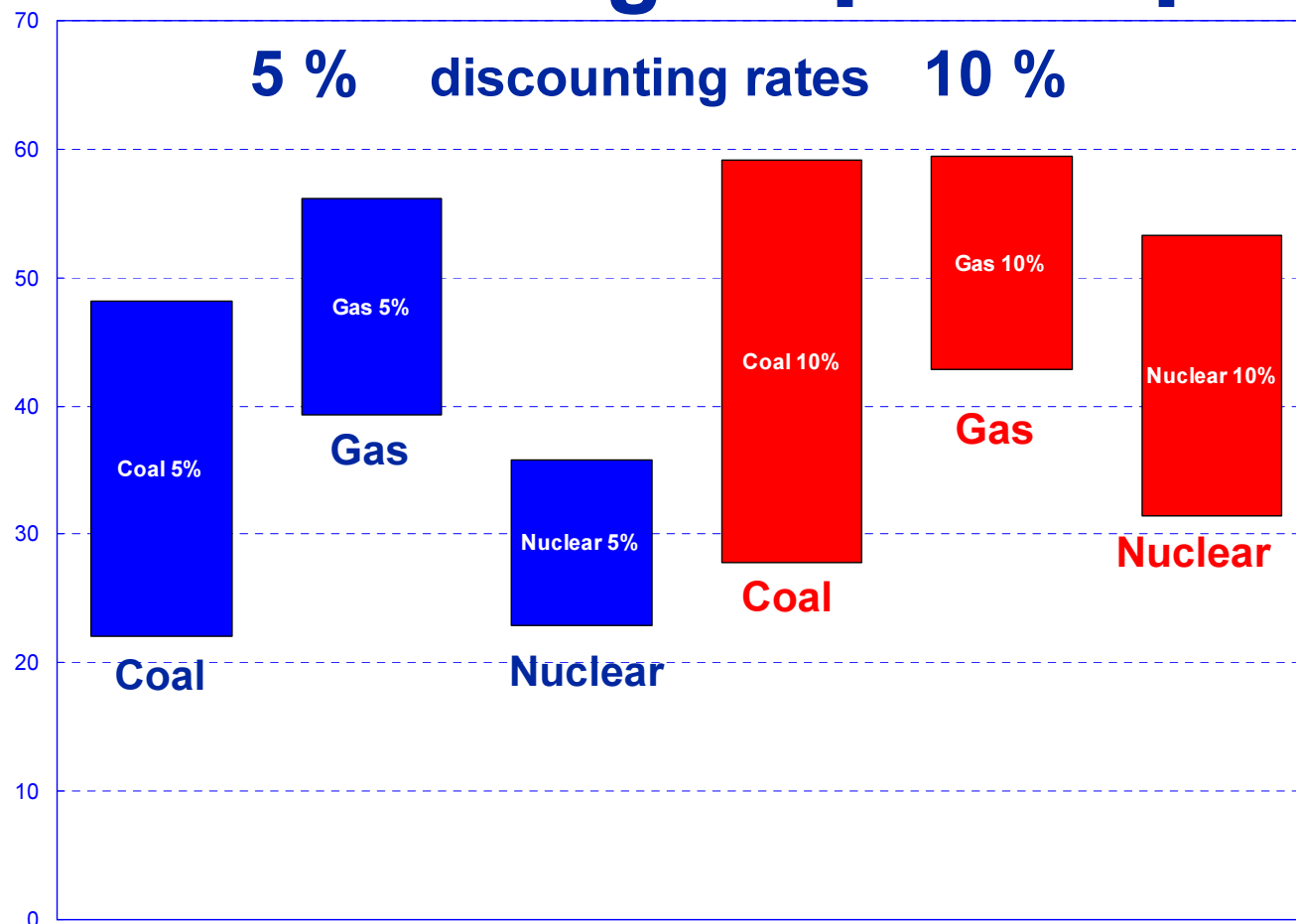


# Electricity Generating Cost Ranges of Main Technologies



***Gas-fired electricity is no longer the cheapest form of generation;  
prices assumed to remain between \$6 and \$7 per MBtu***

# NEA/IEA study (2005) Cost Ranges\* [USD/MWh]



\* Excluding the 5% highest and 5% lowest values

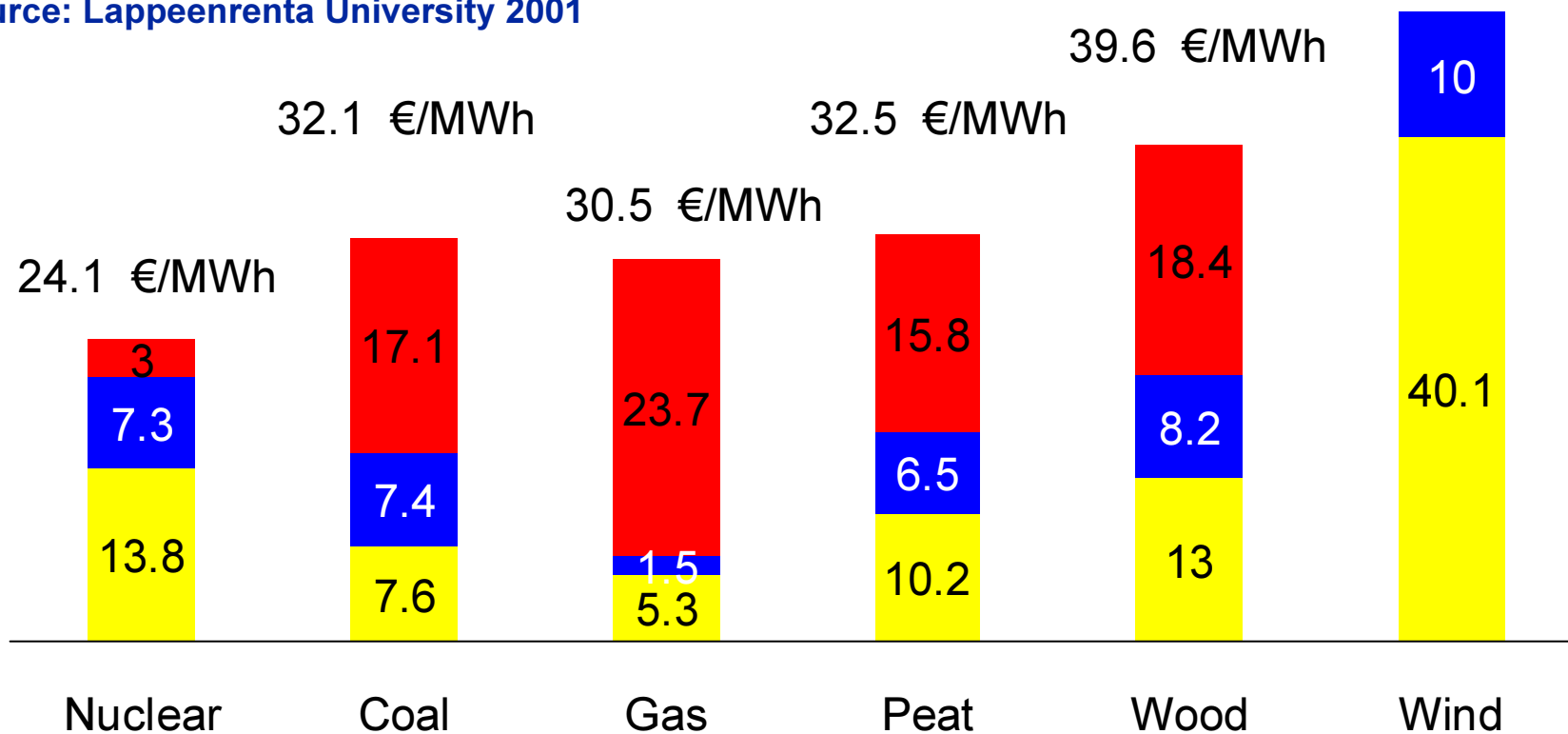
# Projected Costs in Finland

(5% discount rate - €2001)

Investment O&M Fuel Cycle

50.1 €/MWh

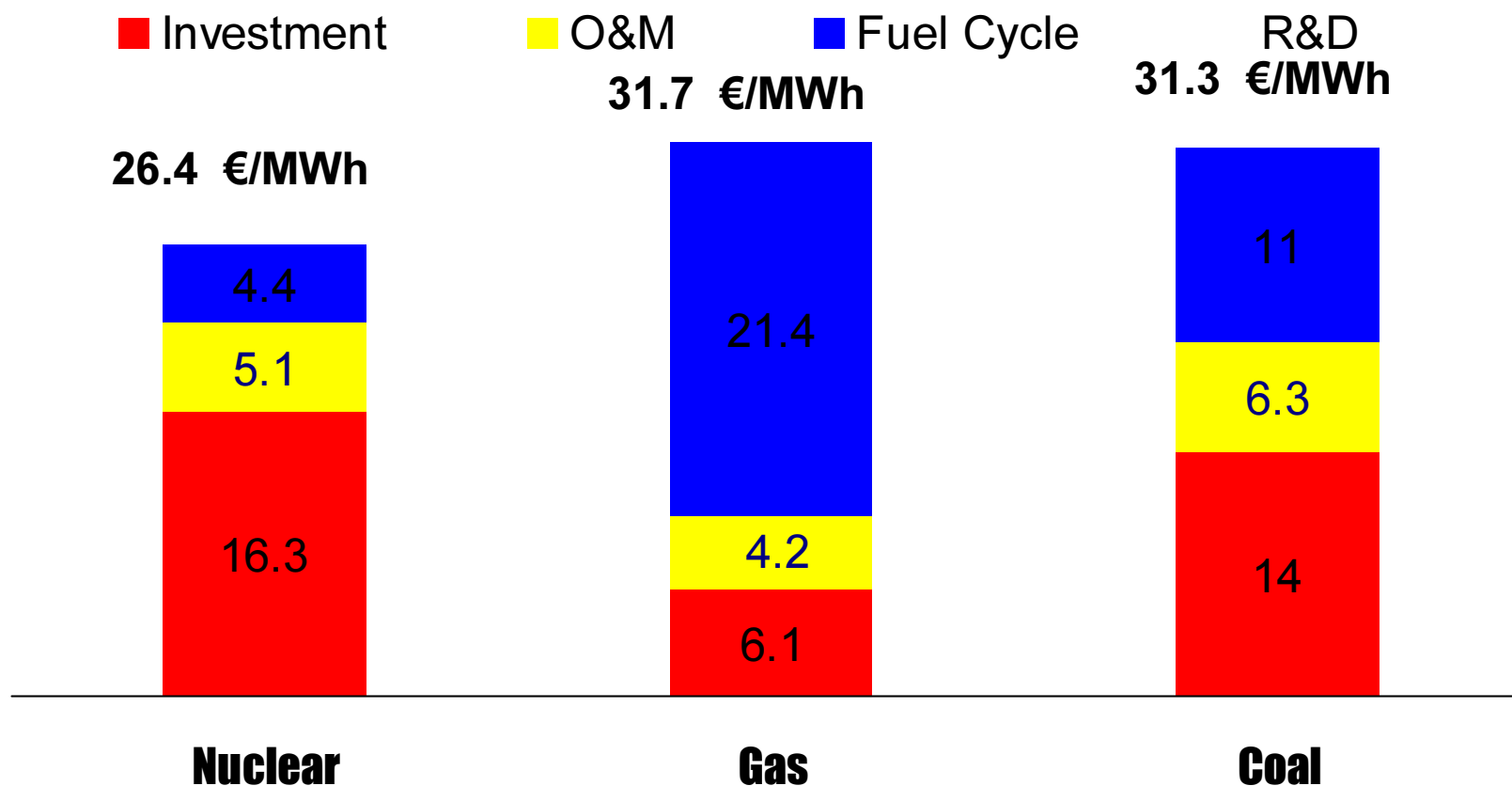
Source: Lappeenranta University 2001



# Projected Costs in France

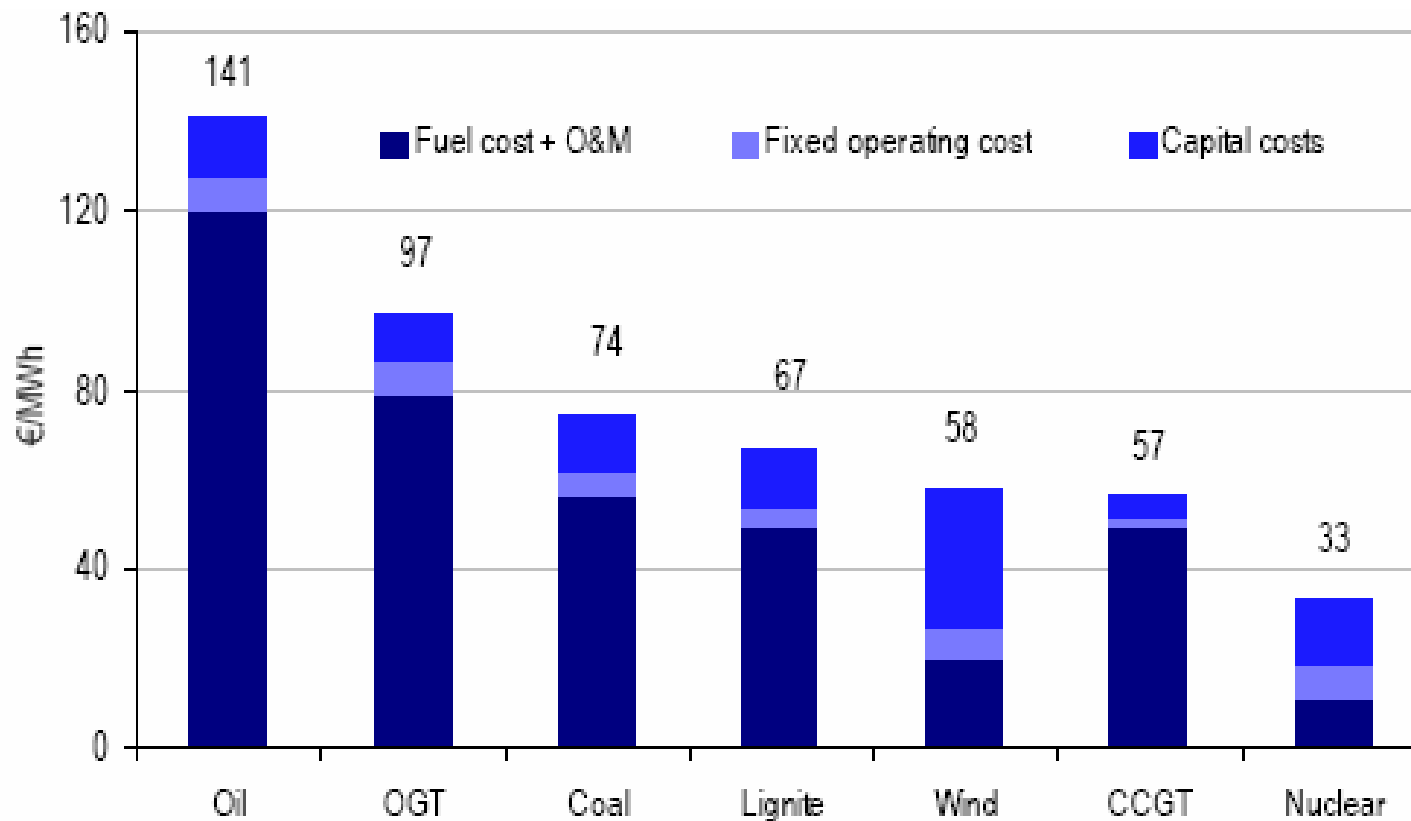
(8% discount rate - €2001)

Source: French Ministry  
of Industry 2003



# Full Cost on New Capacity (€/MWh)

## Source UBS



# Capital market views

- ◆ A remarkable change in capital markets views on nuclear over the last three years
  - “Too much capital intensive” disappeared
- ◆ Capital markets expect new build in Europe (not in all countries)
- ◆ Resources to invest in new NPP are available
- ◆ Competitiveness is no more an issue

## *Paradox ?*

- ◆ Existing nuclear power plants are “cash cows” for most utilities worldwide
- ◆ Decisions to build new plants “future cash cows” are difficult to make (Europe & North Am.)

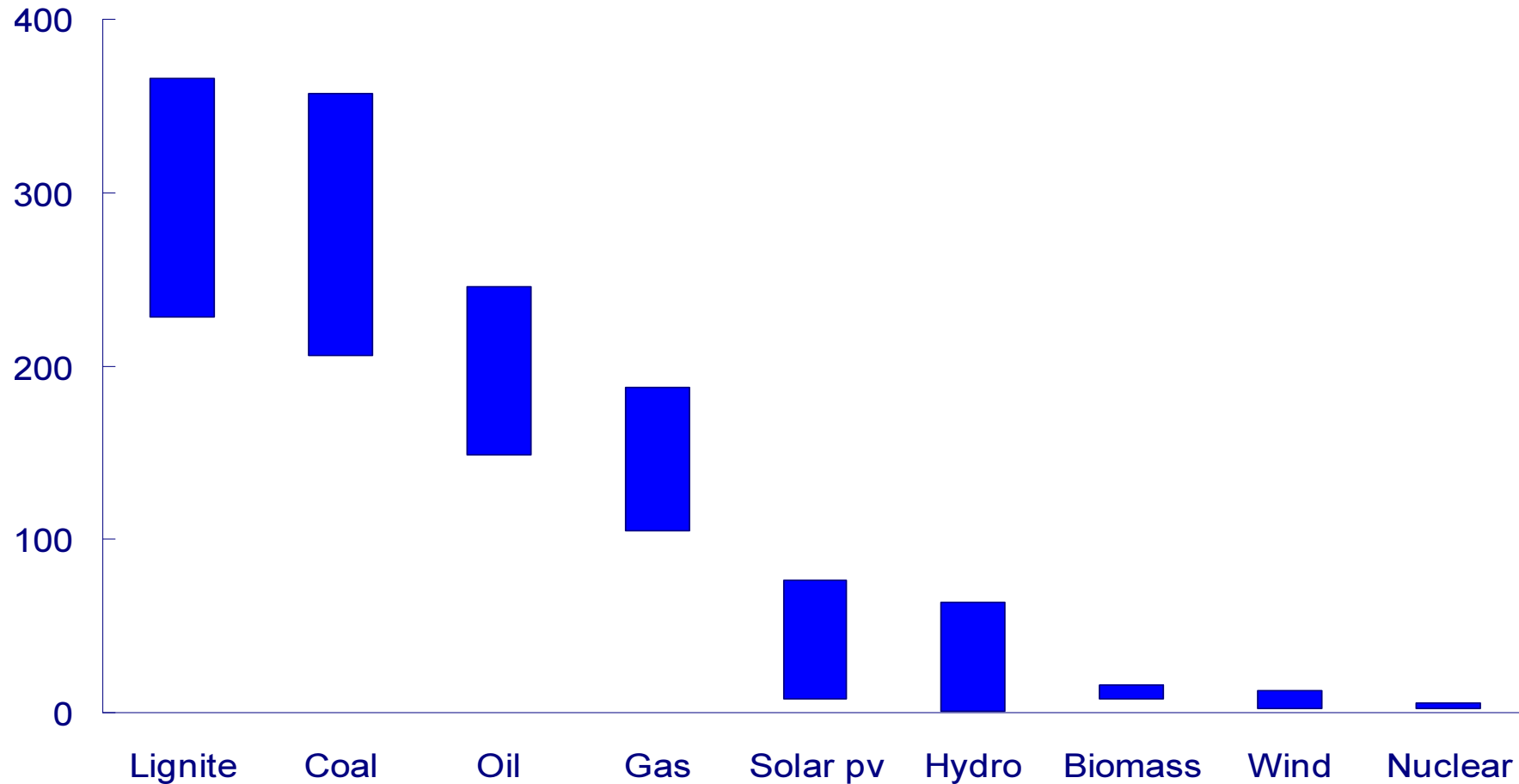
## ***The nuclear case seems good, so where is the problem ?***

- ◆ **Business risks**
- ◆ **Lack of confidence in the stability of the rules**
  - **political stability**
  - **nuclear regulatory stability**
  - **taxation stability (incl. ETS)**
- ◆ **To reduce risks, partnership utilities / large industrials ('the Finnish solution')**
- ◆ **Role of governments**
  - **societal benefits should be recognized**
  - **role to play in reducing the risk, not causing them**

# Nuclear Energy and the Environmental Dimension of Sustainable Development

- ◆ **Efficient use of natural resources**
- ◆ **Practically no greenhouse gas emissions**
- ◆ **Small volumes of solid waste**
  - **Feasibility of final disposals**
  - **Important social concern**
    - ✓ **Technical confidence alone is not enough**
    - ✓ **Acceptance by the broader public needs to be gained**

# Greenhouse Gas Emissions from Electricity Production Chains (g C/kWh – equiv.CO<sub>2</sub>)



# Radioactive Waste

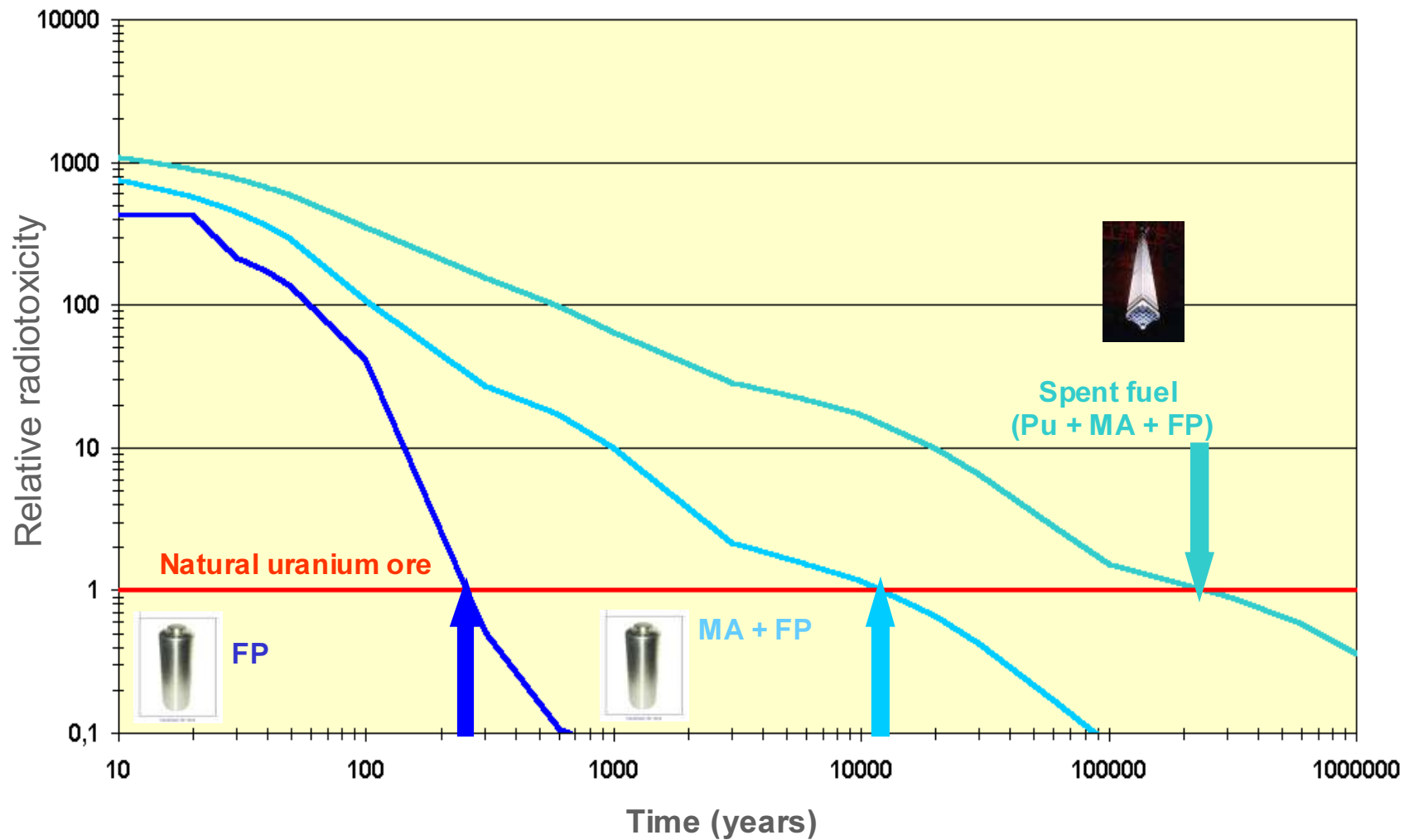
***3 categories : low, intermediate and high level***

- ◆ **Disposal of LLW and most ILW, mature practice**
- ◆ **HLW**
  - **~ 1% of total volume, ~ 99% of total radioactivity**
  - **Deep geological disposal considered as practicable (*viable, reliable and safe solution*) by the scientific and technical community**
  - **Little societal consensus**
  - **Actual risk vs. perceived risk**
  - **Ethical considerations**
- ◆ **Greater involvement of stakeholders and better communication needed**

# HLW Disposal - The Way Forward

- ◆ **Continue high quality technical work**
- ◆ **Pursue dialogue with civil society**
- ◆ **Demonstrate the feasibility of opening and operating a disposal site**
- ◆ **Major steps have been completed**
  - **Olkiluoto in Finland**
  - **Yucca Mountain in the USA**
  - **Others are following (Sweden, France, ...)**

# Radiotoxicity and Spent Fuel Management

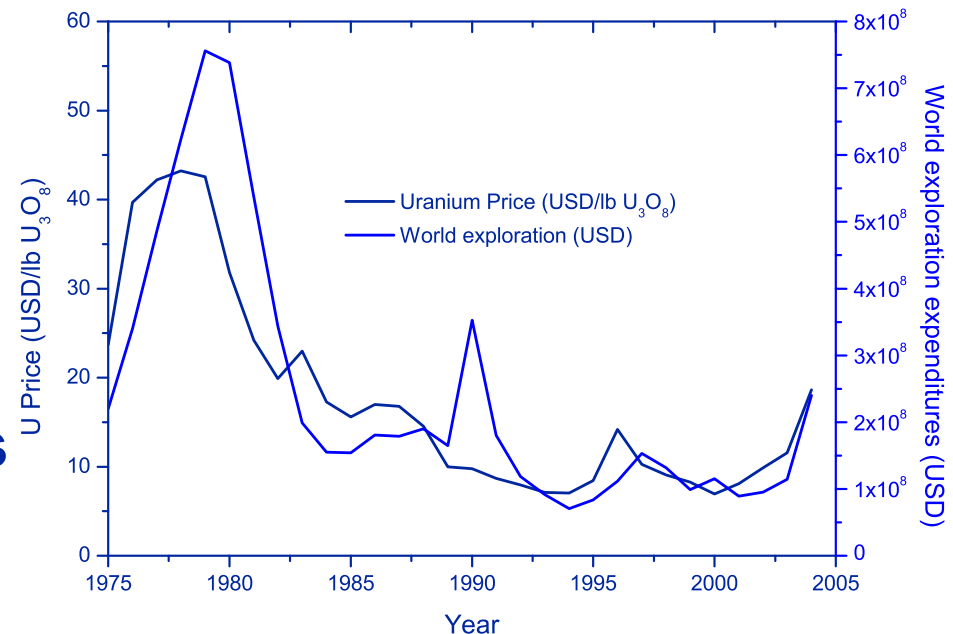


# **Nuclear Energy and the Social Dimension of Sustainable Development**

- ◆ **Human capital, scientific knowledge, highly qualified manpower**
- ◆ **Man-made asset, technology intensive industry**
- ◆ **Institutional framework, comprehensive laws and regulations**
- ◆ **Security of supply**
  - **reduced dependence, especially on oil and gas**
  - **geopolitical diversity of natural resources and technologies**
  - **“domestic” source of energy**

# Uranium Resources

- ◆ **Plentiful ~ 14.8 MT**  
Consumption ~ 60/70 kT/y
- ◆ **Well distributed**  
Australia, Canada
- ◆ **Expandable**  
Unconventional resources
  - ❖ Phosphates ~ 22 MT
  - ❖ Seawater ~ 4000 MT



**Technology exist to improve energy yield (over x 50 )  
with the fast neutrons reactors and closed fuel cycles**  
**Natural uranium ~ 0.7 % U235, 99.3 % U238**

# Lifetime of Uranium Resources

## (years of 2004 nuclear electricity generation)

	<b>IR<sup>1</sup></b>	<b>TCR<sup>2</sup></b>	<b>TCR+Ph<sup>3</sup></b>
<b>Current LWR once through</b>	<b>85</b>	<b>270</b>	<b>675</b>
<b>Fast Reactors</b>	<b>2550</b>	<b>8000</b>	<b>20 000</b>

1. Identified Resources = Reasonably Assured Resources + Inferred Resources = 4.74 MtU

2. Total Conventional Resources = (Reasonably Assured + Inferred + Prognosticated + Speculative) Resources = 14.80 MtU

3. Phosphates = Uranium contained in phosphates = 22 MtU

Source: NEA/IAEA 2006

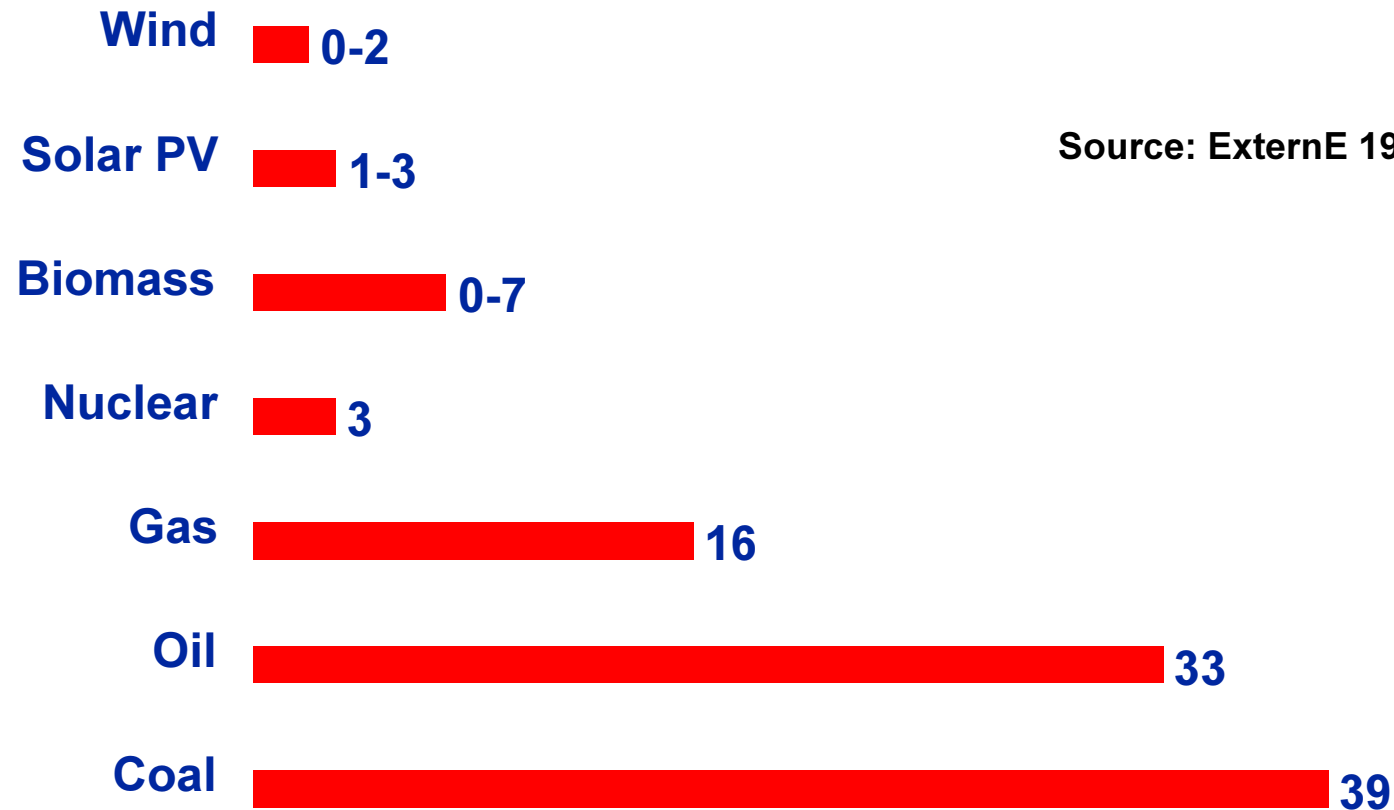
# Externalities

***Costs that are born by the society as a whole rather than by consumers***

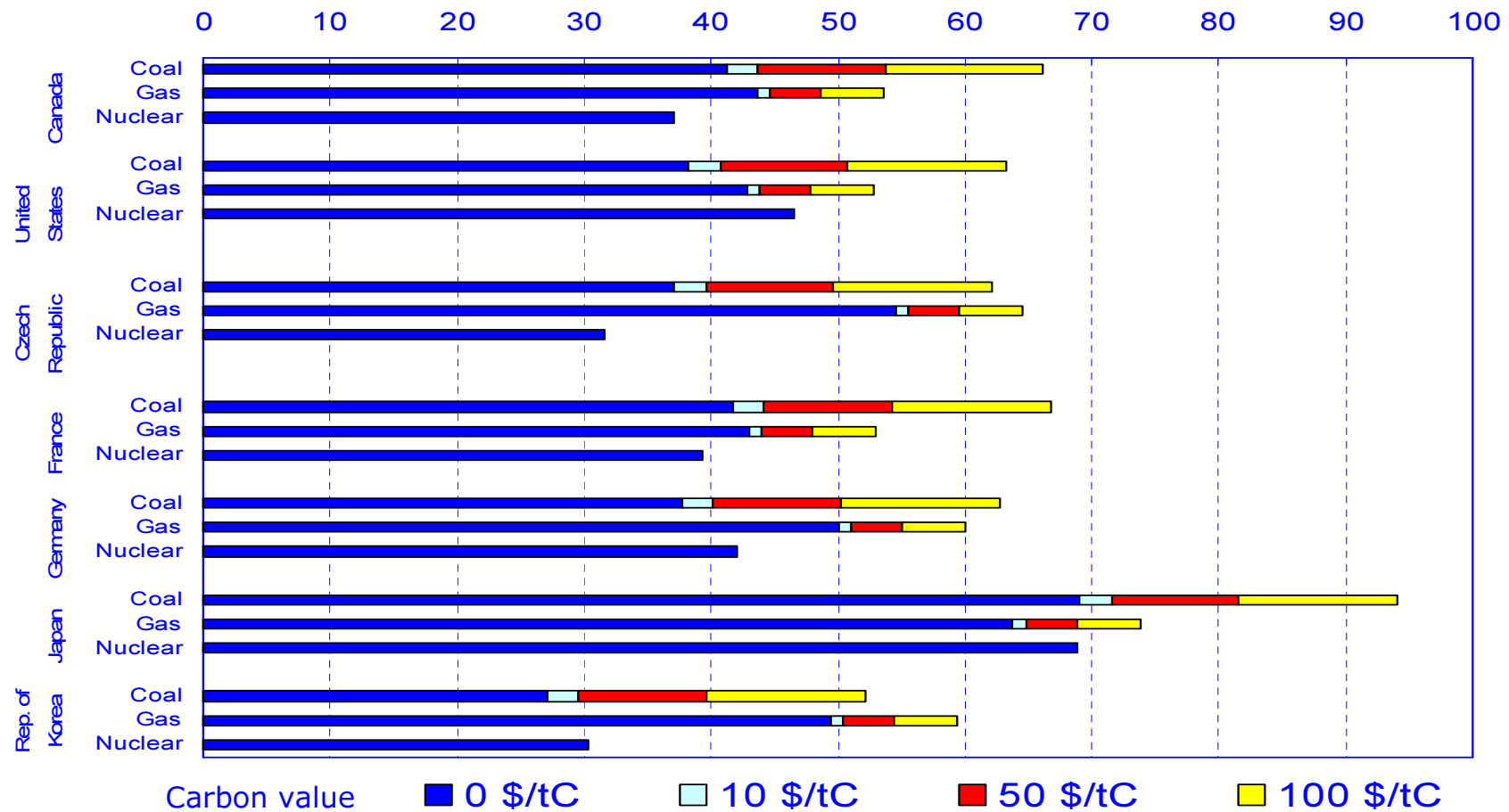
***Detrimental to global economic, social and environmental optimisation***

- ◆ **Health and environmental impacts of release of waste - CO<sub>2</sub>, radioactive waste**
  - **Routine operation**
  - **Decommissioning & dismantling (*included*)**
- ◆ **Insurance (severe accidents)**
- ◆ **Policy factors not reflected in market prices**
  - **Security of supply**
  - **Social acceptance**

# External Costs of Electricity Generation (m€/kWh)



# Impact of Carbon Values on Generation Costs at 10% discounting rate [USD/MWh]



## Concluding Remarks (1)

- ◆ **Energy needs are huge, especially in developing countries**
- ◆ **No ideal or magic solution to avoid the “*dirty, insecure and expensive*” energy future that the current trends prepare**
- ◆ **All technologies will be needed**
  - **A mix of sources will be needed to meet demand at affordable cost while protecting the environment**
  - **No opposition between renewable and nuclear energy**

## Concluding Remarks (2)

### ◆ Economics

- **No technology/source is always cheaper for base load electricity generation**
- **Electricity generation costs are decreasing owing to technology progress and competition**
- **Nuclear competitiveness increases greatly and is no more a crucial issue**
- **“Internalising externalities” such as carbon value will enhance competitiveness of nuclear energy even more**

# Concluding Remarks (3)

## ◆ Environment

### ➤ Waste

- ❖ Disposal of low level and most intermediate level waste, mature practice
- ❖ Deep geological disposal of high level waste  
Not a technical issue - No social consensus

### ➤ Climate change

- ❖ Without nuclear energy GHG emissions from the power sector would be ~16% higher
- ❖ In the long term, nuclear energy has the potential to alleviate the risk of global climate change
- ❖ The nuclear option deserves to be considered by policy makers in the post-Kyoto period
  - ✓ Kyoto II – to reintroduce nuclear in CDM & JI

# Concluding Remarks (4)

## ◆ Social aspects

- Security of energy supply
- Uranium resources are available
- Diversity of energy supply & price stability
- Innovative advanced technology are under development
  - to improve economics,
  - to minimize waste and to make the best use of natural resources
  - to produce hydrogen, ...
- Existing infrastructures (equipment and teams) are valuable assets

## Concluding Remarks (5)

**From a sustainable development perspective, nuclear energy has a major contribution to offer**

- **reduction of CO2 emissions**
- **security of energy supply**
- **diversity of supply & price stability**

***Dealing adequately with the societal concerns is a key issue***

***Role of governments key to provide stability***

***Thank you for your attention***