

***International Conference on Non-Electric Applications of  
Nuclear Power: Seawater Desalination, Hydrogen Production  
and other Industrial Applications***

***Oarai, Japan – 16/19 April 2007***

# **NUCLEAR ENERGY OUTLOOK**

***Thierry DUJARDIN***  
**Deputy Director, Science and Development**  
**OECD Nuclear Energy Agency**

# Overview

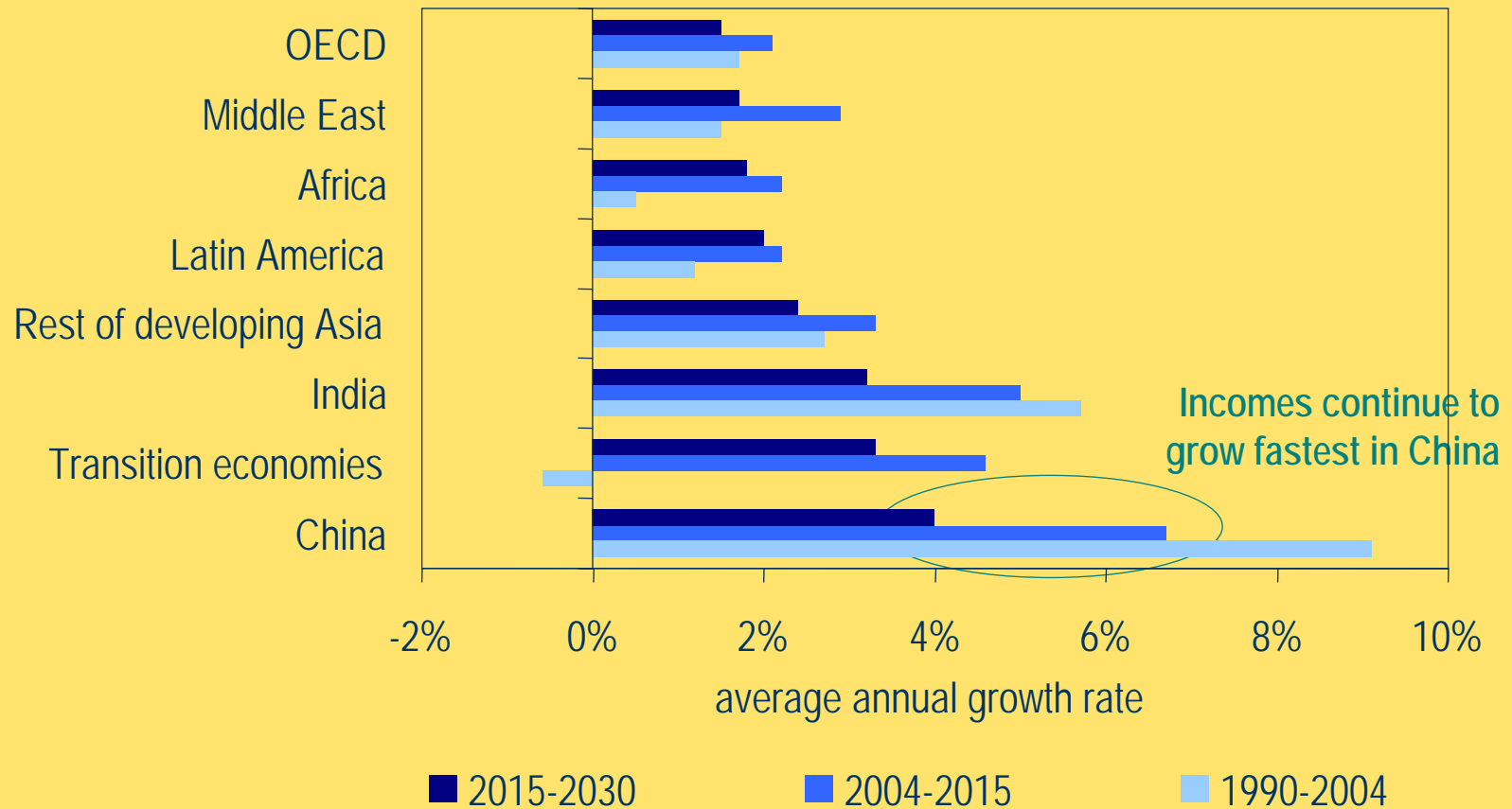
- ◆ **World Energy Outlook 2006 (IEA)**
- ◆ **Nuclear Energy**
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# World Energy Outlook 2006

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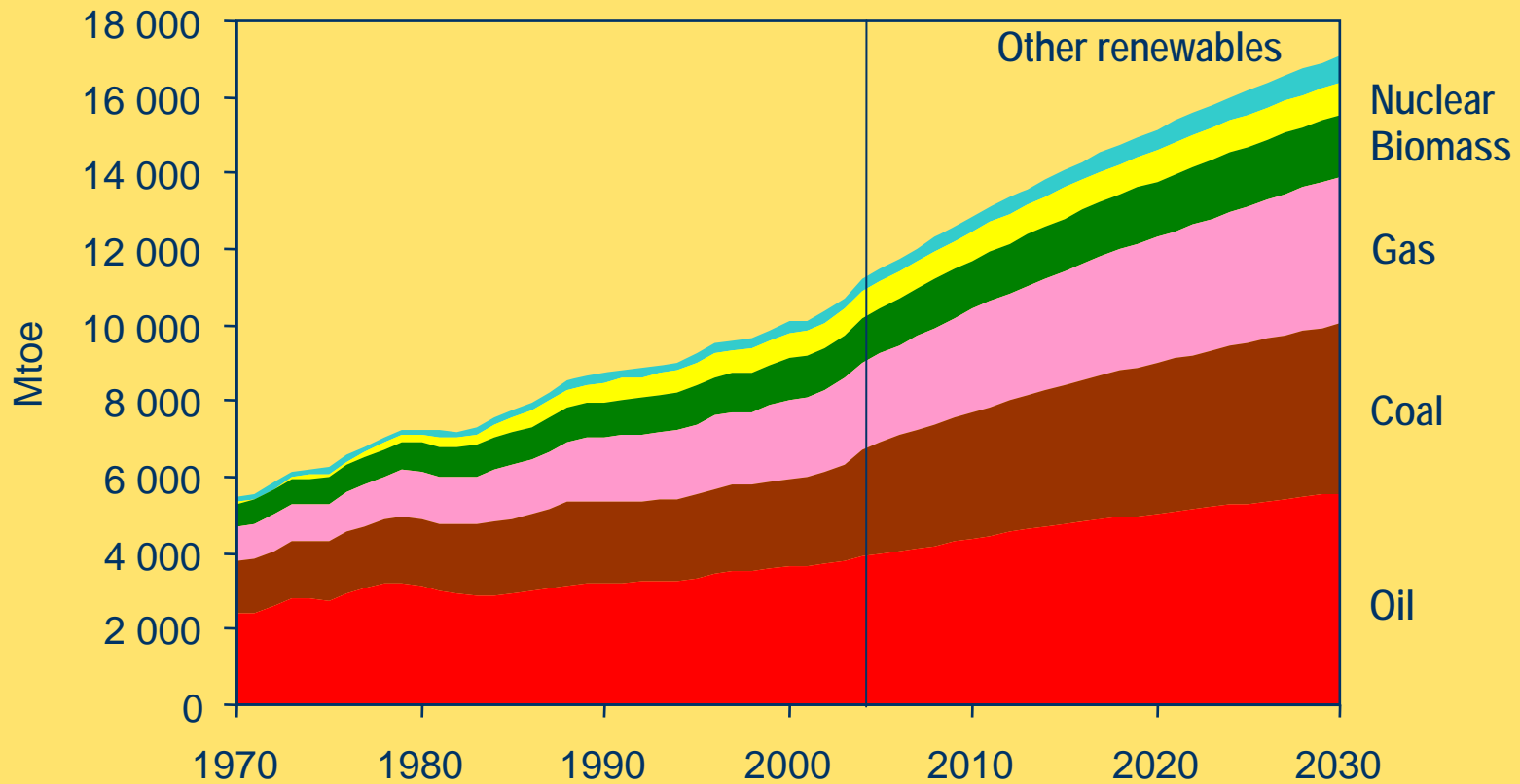
- ◆ **Reference scenario**
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  - **Impact of Higher Energy Prices**
  - **Current trends in Oil & Gas Investment**
  - **Prospects for Nuclear Power**
  - **Outlook for Biofuels**
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## Per-Capita GDP



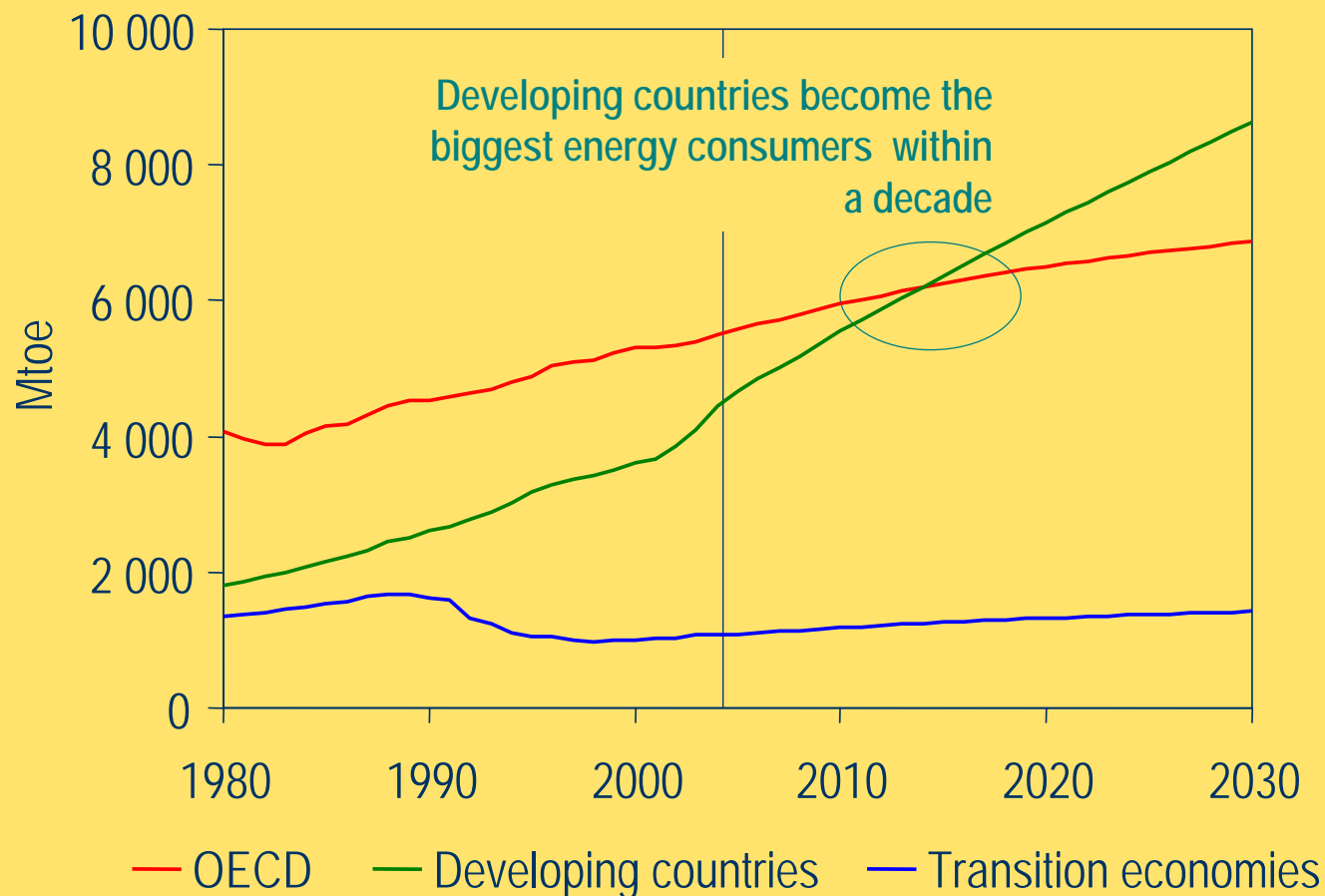
***Incomes in the OECD are still four times higher than in rest of the world in 2030***

# Reference Scenario: World Primary Energy Demand



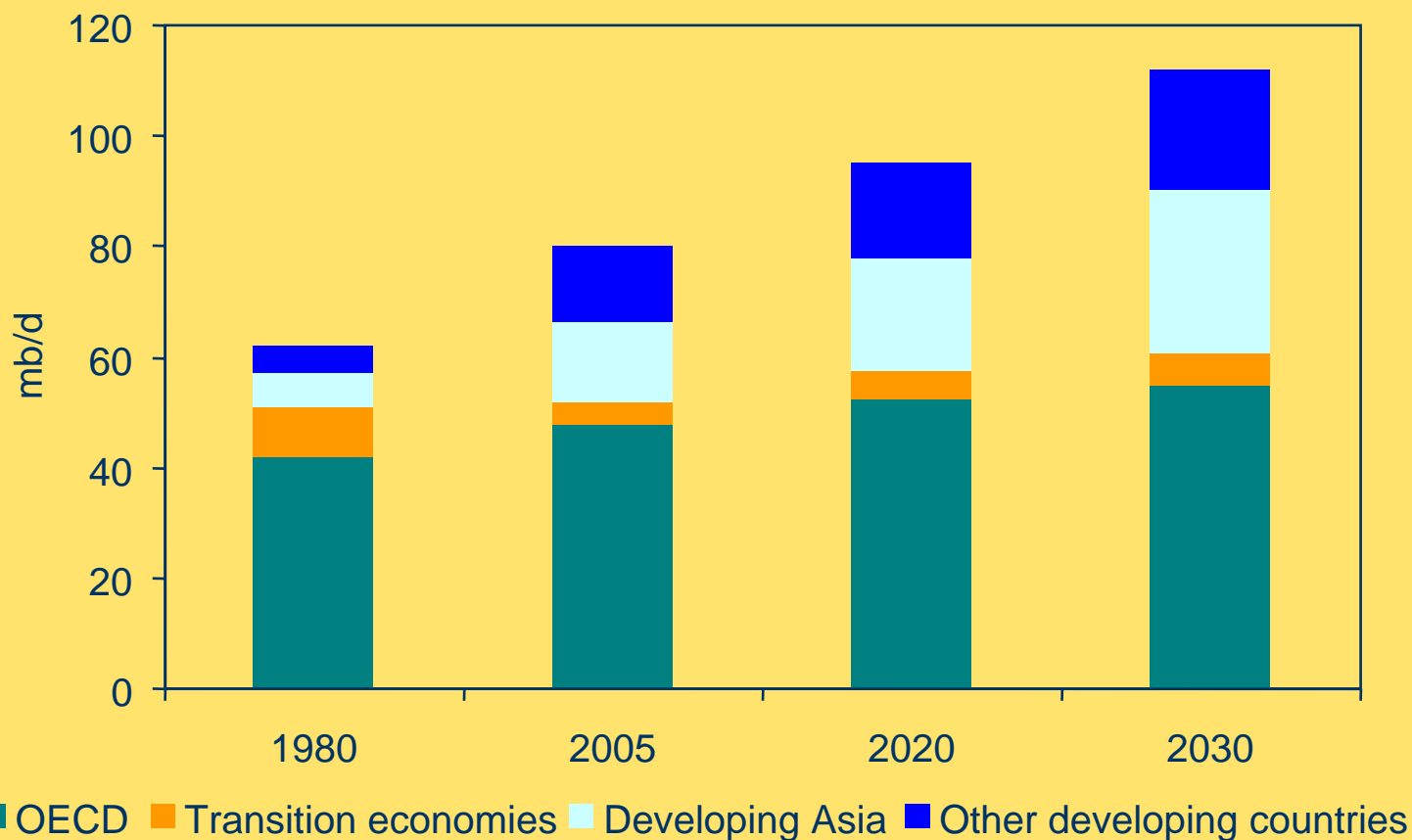
*Global demand grows by more than half over the next quarter of a century, with coal use rising most in absolute terms*

# Reference Scenario: Primary Energy Demand by Region



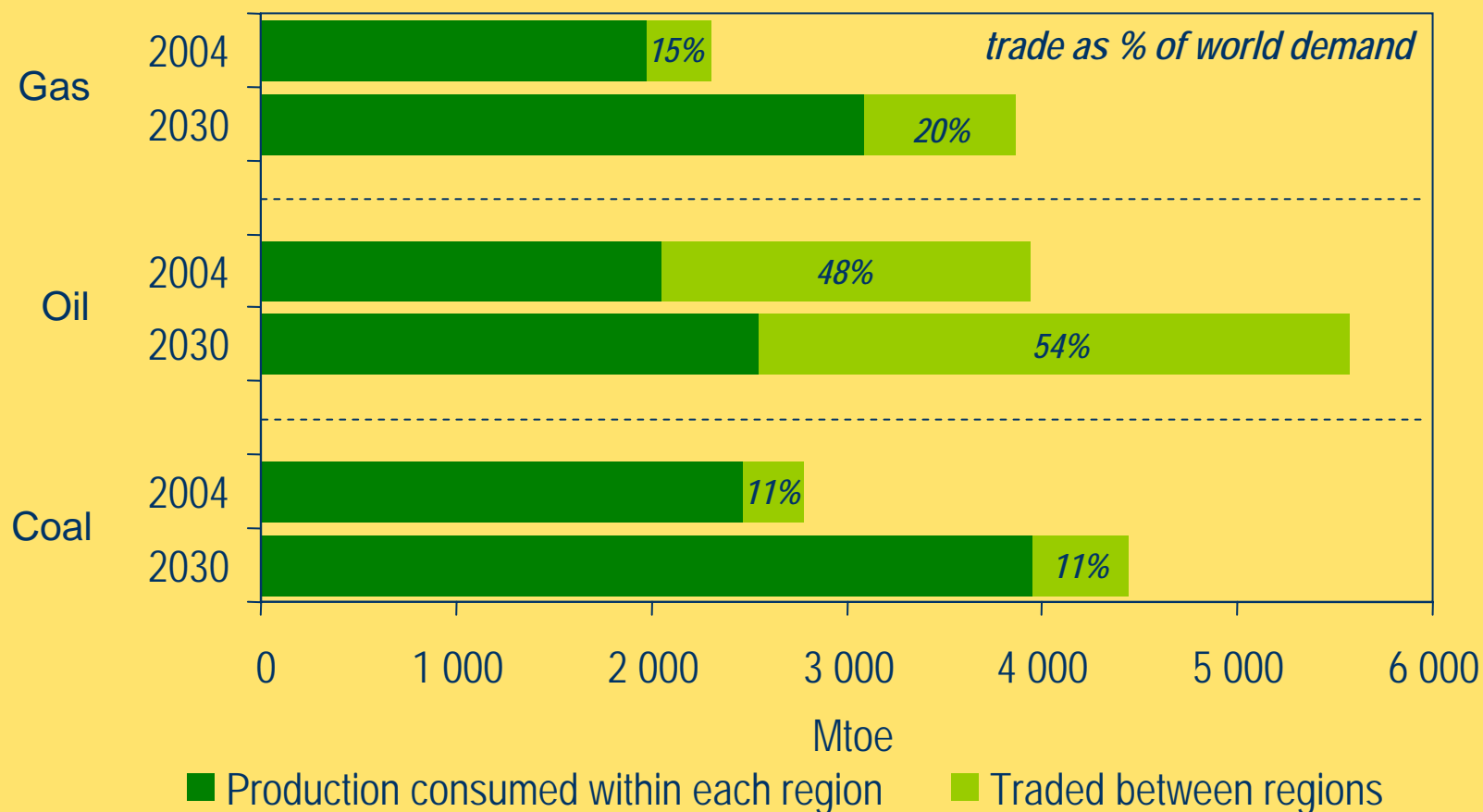
***World oil demand grows by just over half between 2004 and 2030, with 70% of the increase coming from developing countries***

# Reference Scenario: Primary Oil Demand



*Most of the increase in oil demand comes from developing countries, where economic growth – the main driver of oil demand – is most rapid*

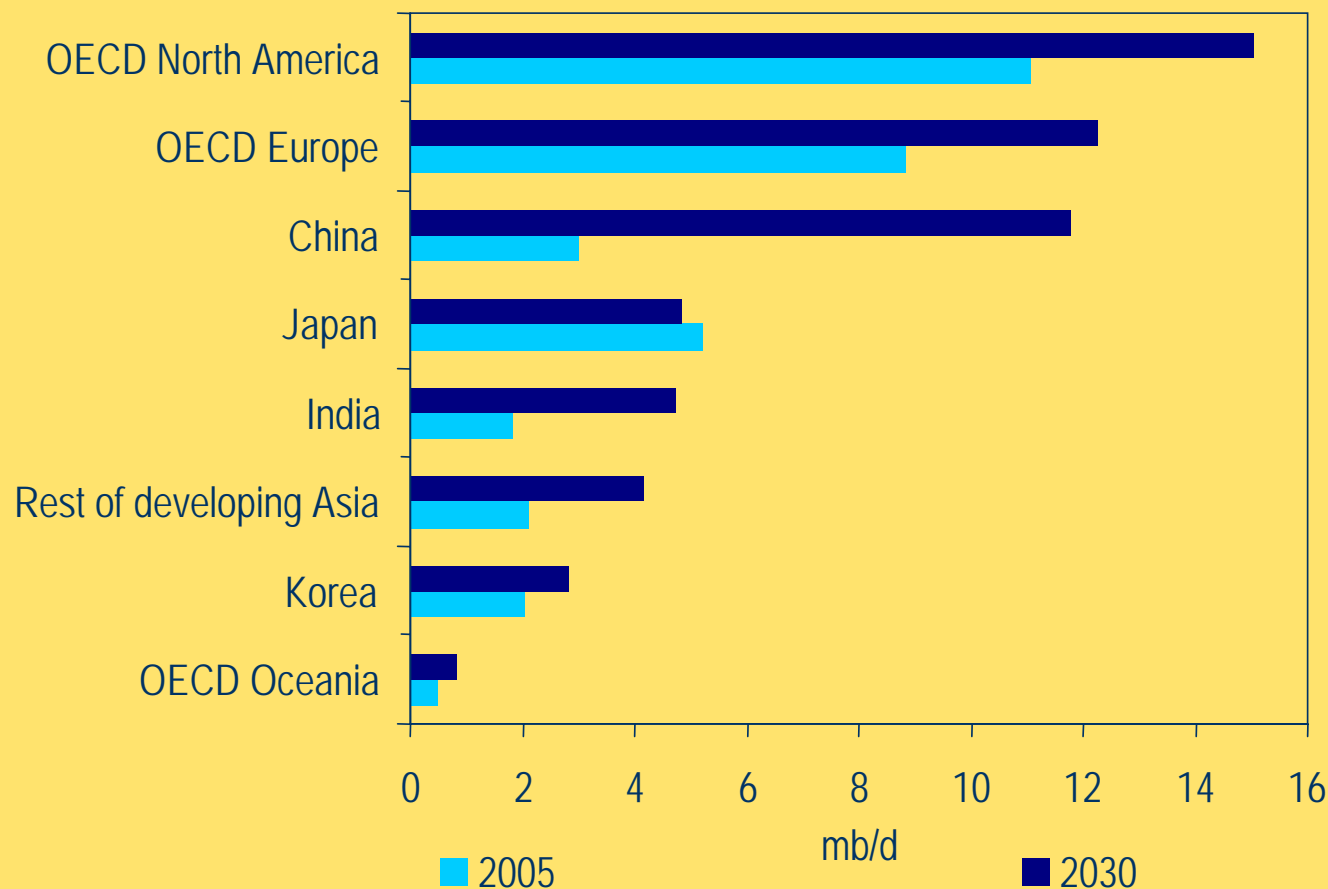
# World Fossil Fuel Supply



***Oil remains by far the most heavily traded fuel, but trade in natural gas expands faster***



# Reference Scenario: Net Oil Imports

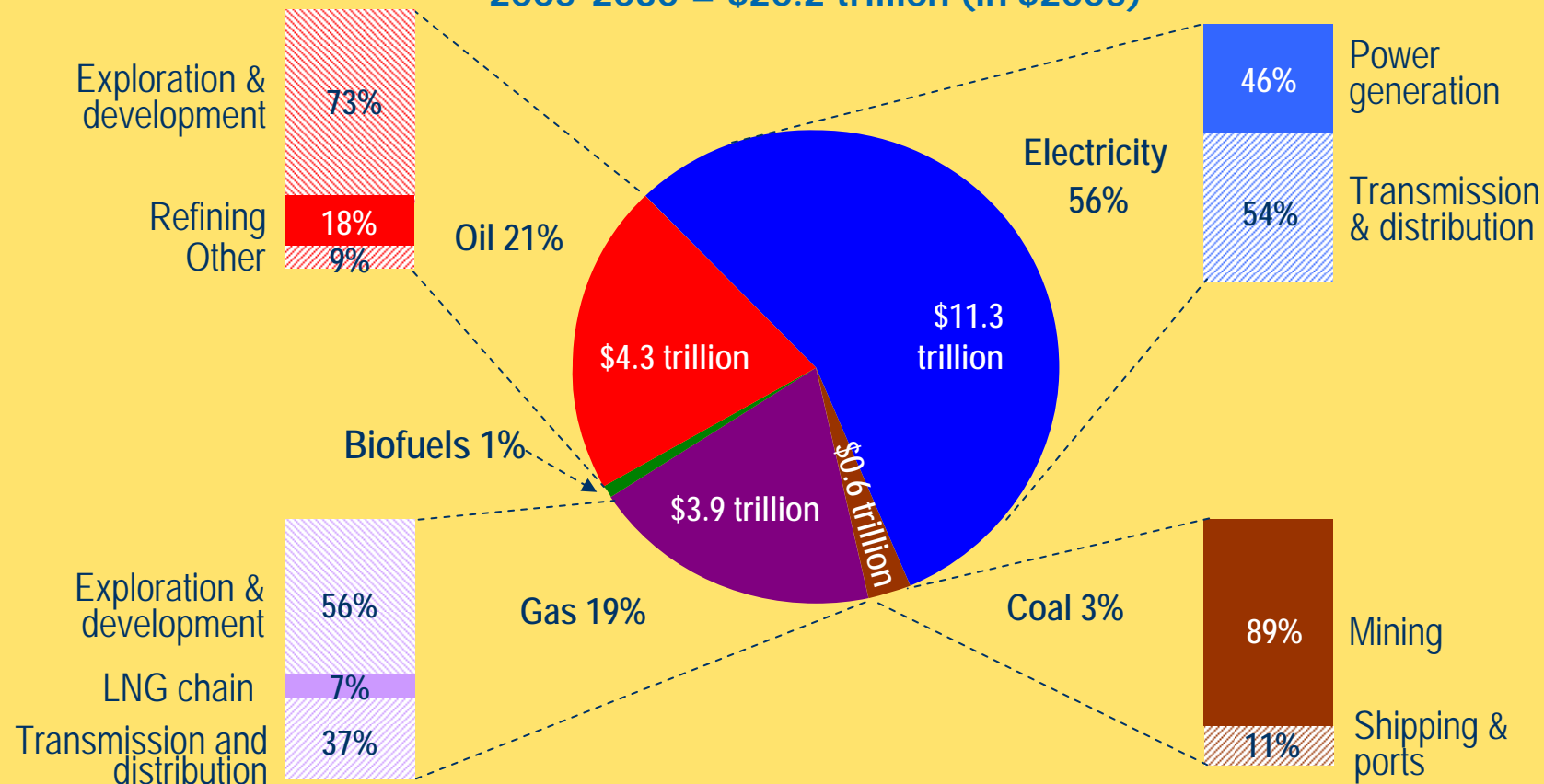


*China sees the biggest jump in oil imports in absolute terms, but North America remains the largest importer*

Reference Scenario:  
**Will the Investment Come?**

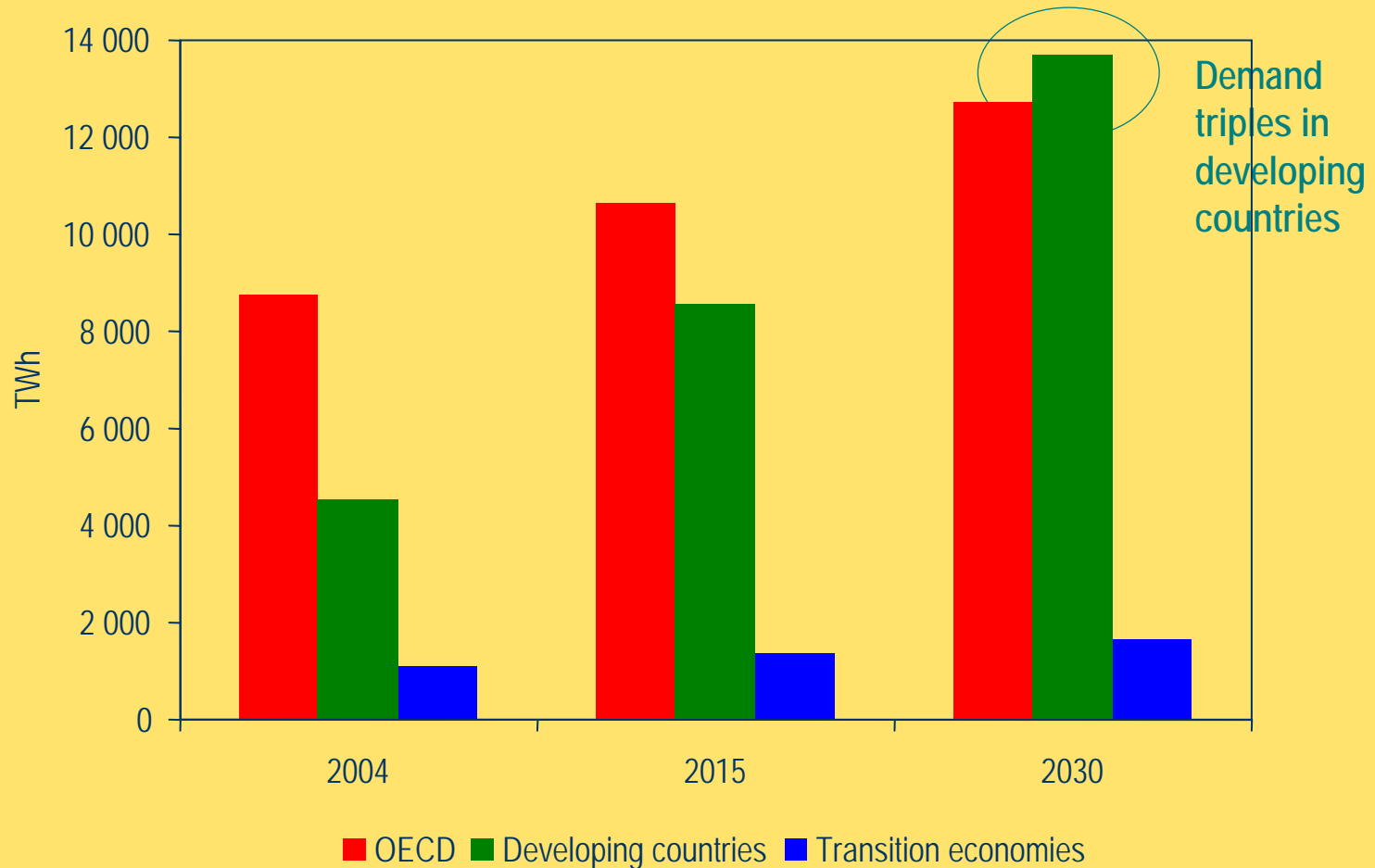


**Cumulative Investment in Energy-Supply Infrastructure,  
2005-2030 = \$20.2 trillion (in \$2005)**



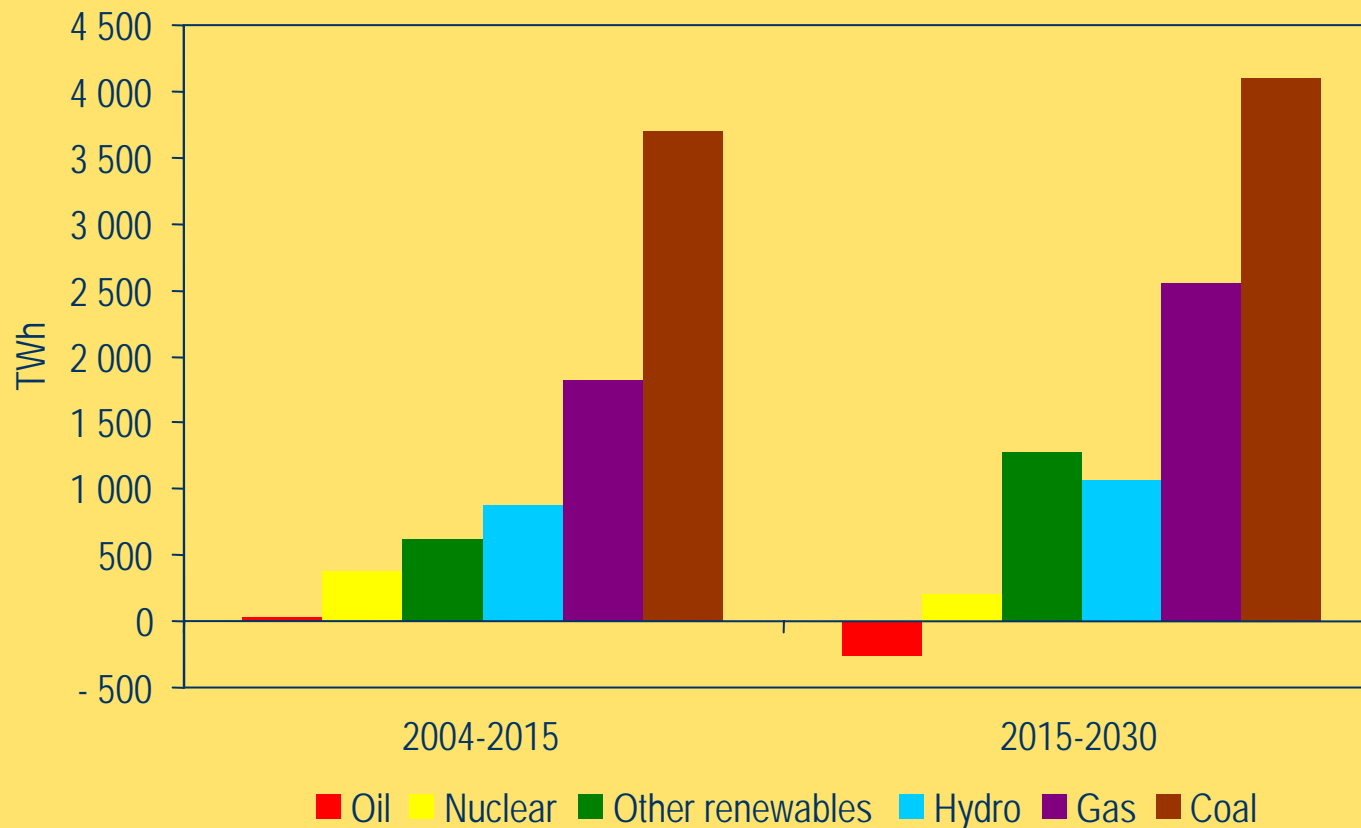
***Just over half of all investment needs to 2030 are in developing countries, 18% in China alone***

# Reference Scenario: World Electricity Demand by Region



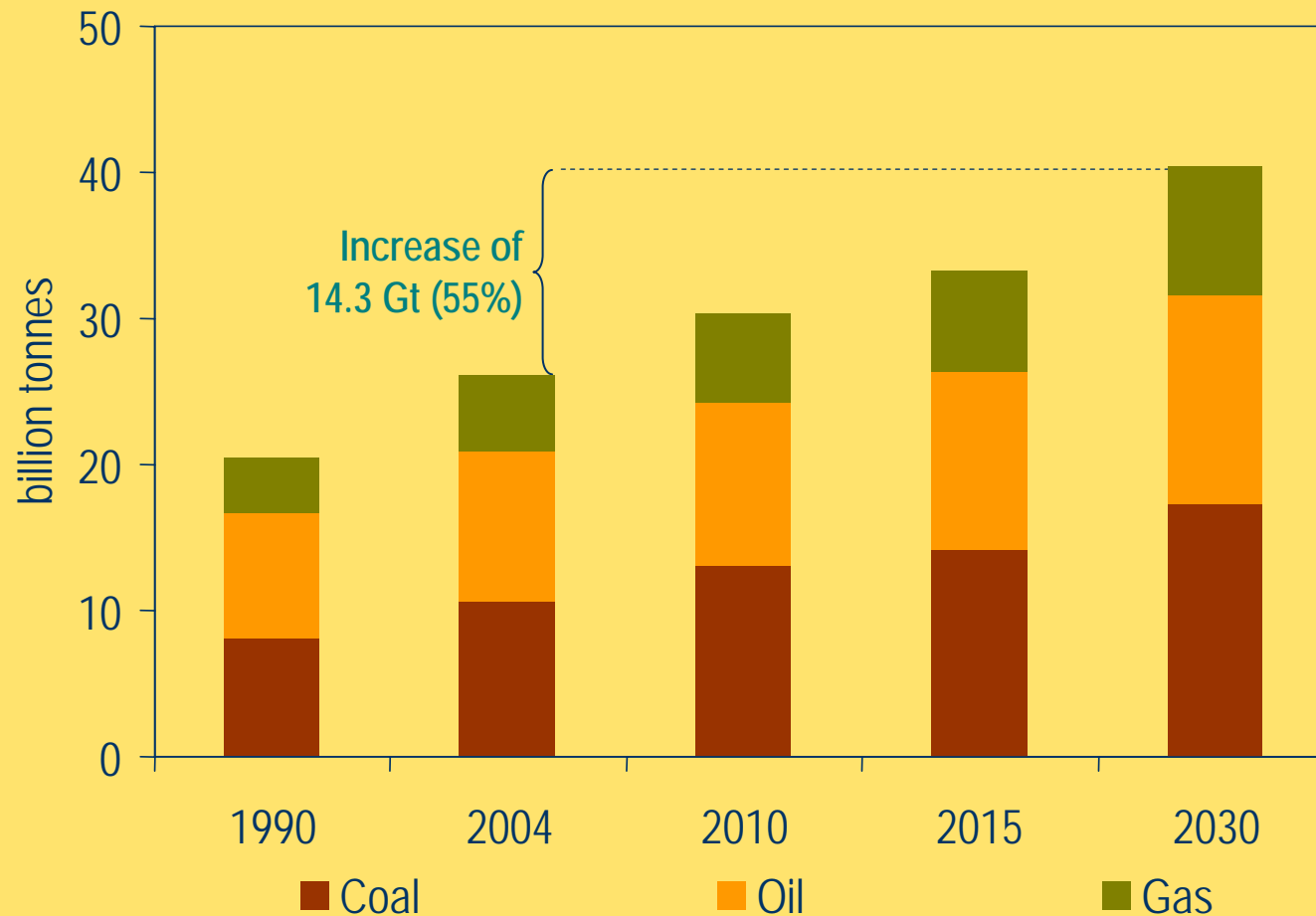
***World electricity demand doubles between 2004 and 2030***

Reference Scenario:  
World Incremental Electricity  
Generation by Fuel



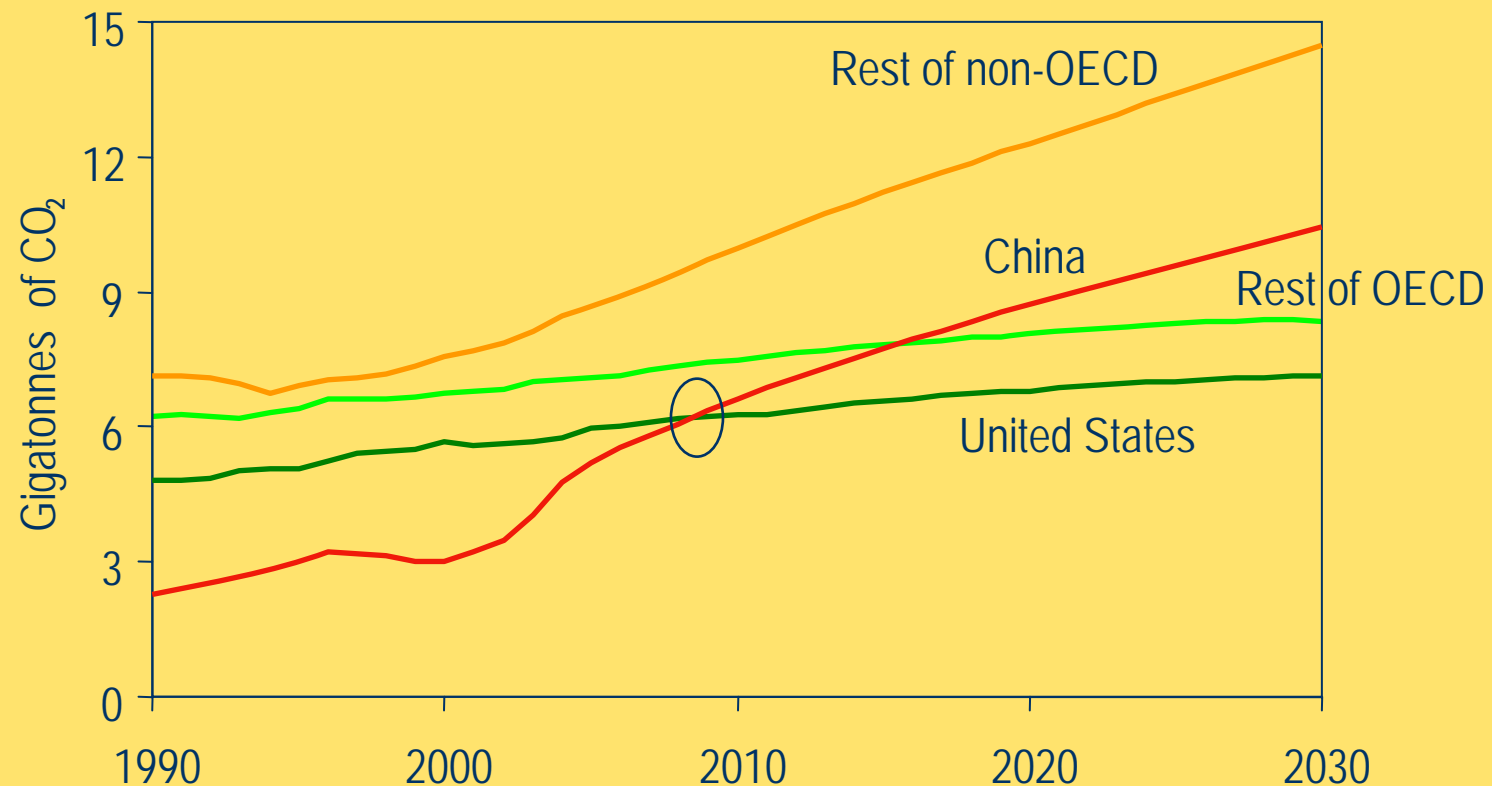
***Most of the additional demand for electricity is expected to be met by coal, which remains the world's largest source of electricity to 2030***

# Reference Scenario: Implications for CO<sub>2</sub> Emissions



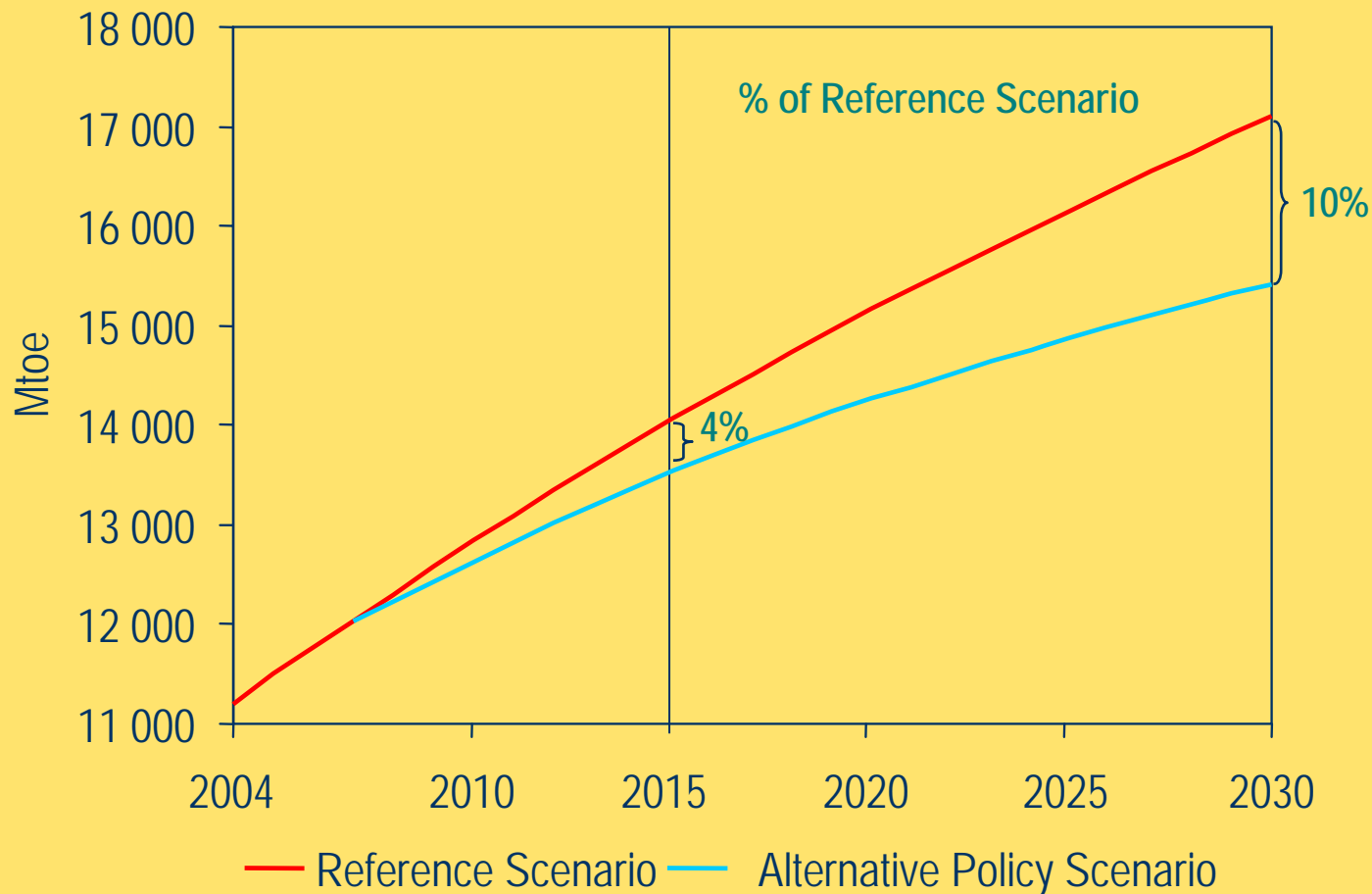
*Half of the projected increase in emissions comes from new power stations, mainly using coal & mainly located in China & India*

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



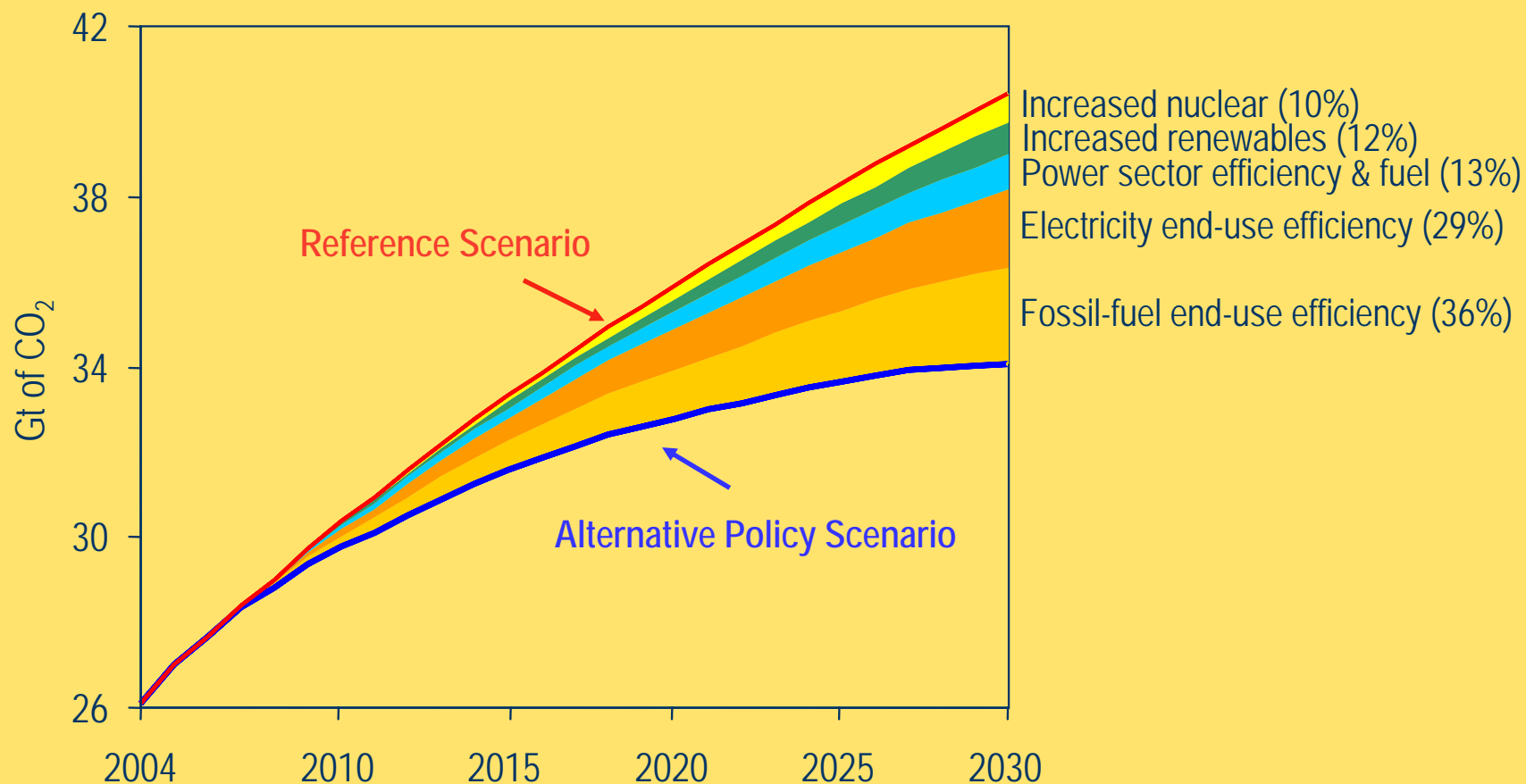
***China overtakes the US as the world's biggest emitter before 2010, though its per capita emissions reach just 60% of those of the OECD in 2030***

# Alternative Policy Scenario: World Primary Energy Demand



*The impact of new policies – though far from negligible – is less marked in the period to 2015 because of the slow pace of capital stock turnover*

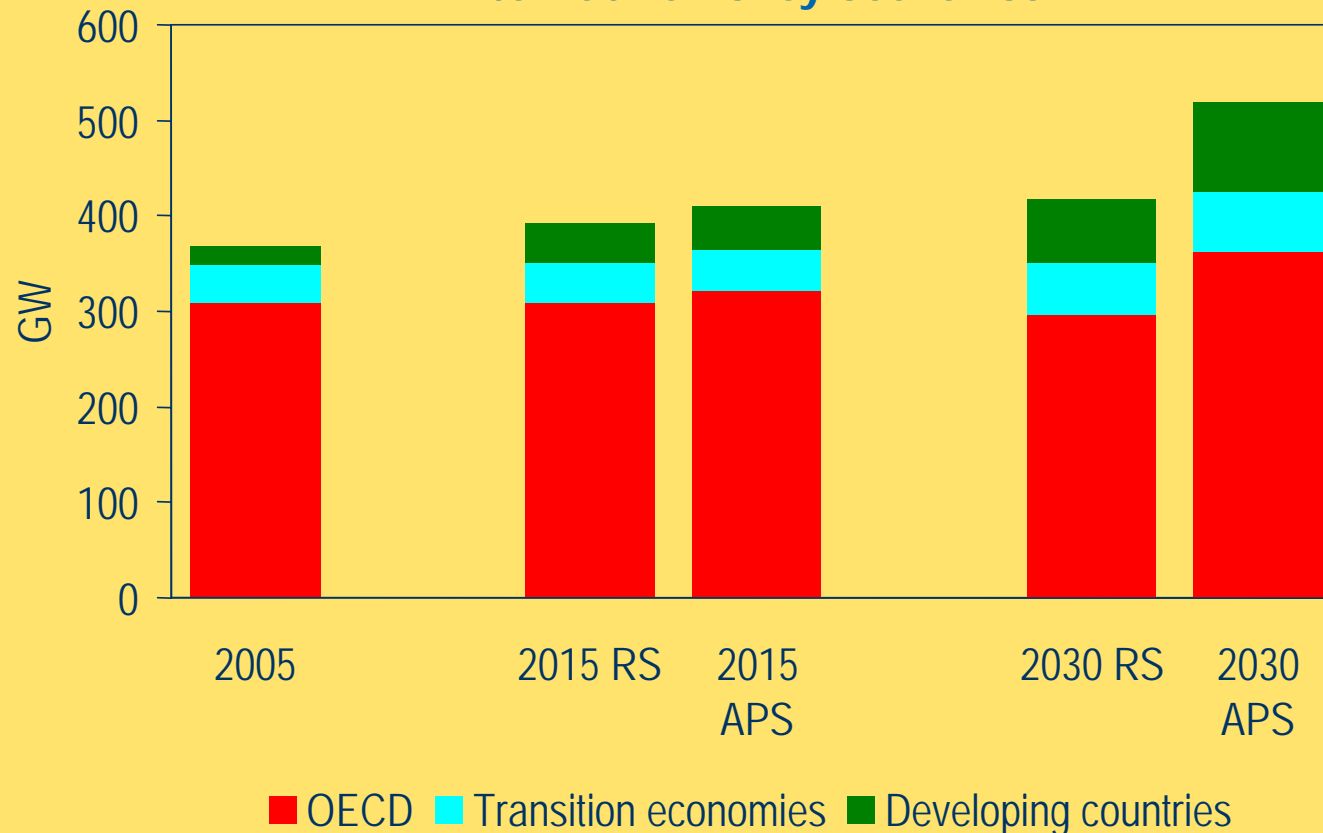
# Alternative Policy Scenario: Global Savings in Energy-Related CO<sub>2</sub> Emissions



***Improved end-use efficiency of electricity & fossil fuels accounts for two-thirds of avoided emissions in 2030***

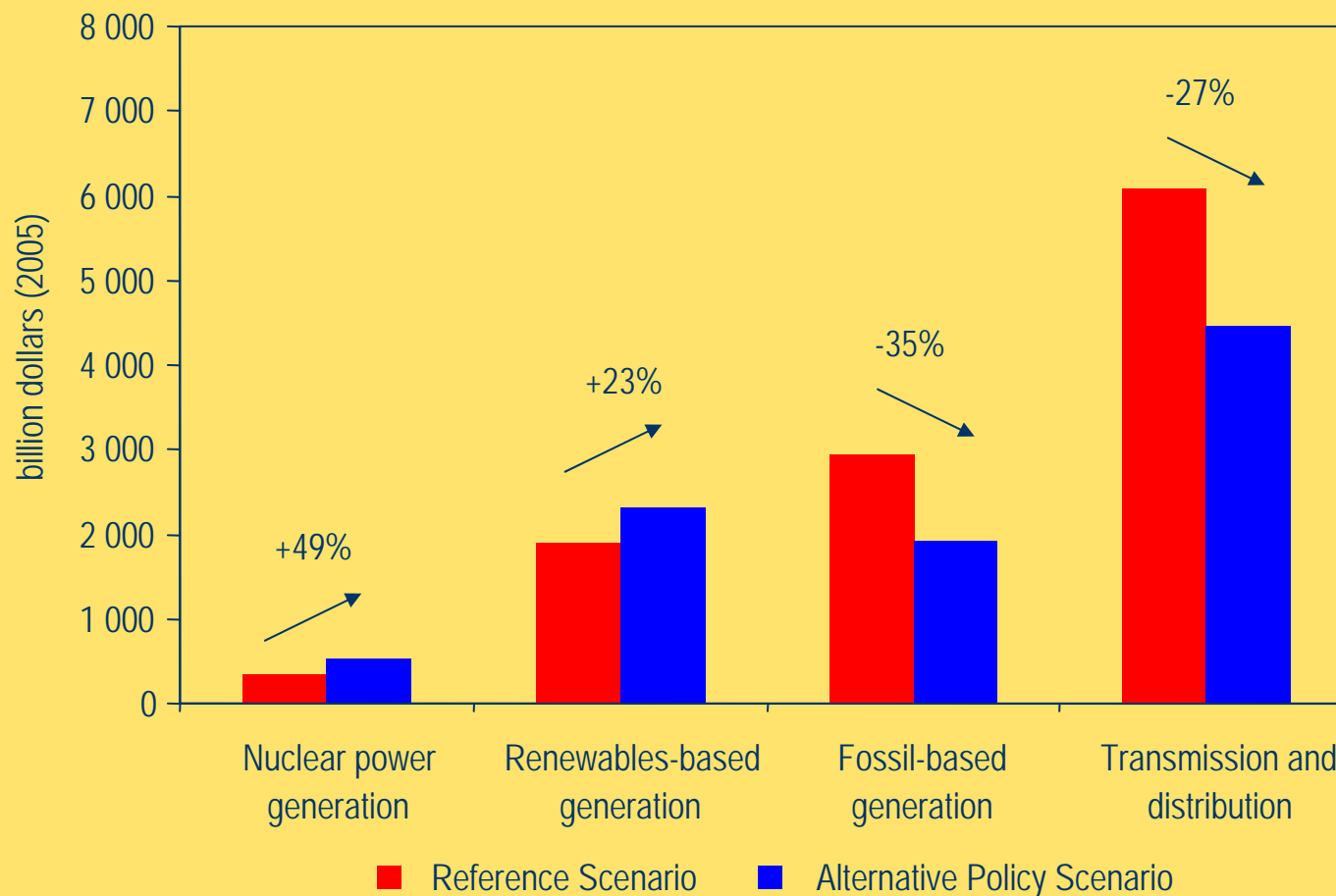


World Nuclear Capacity in the Reference and Alternative Policy Scenarios



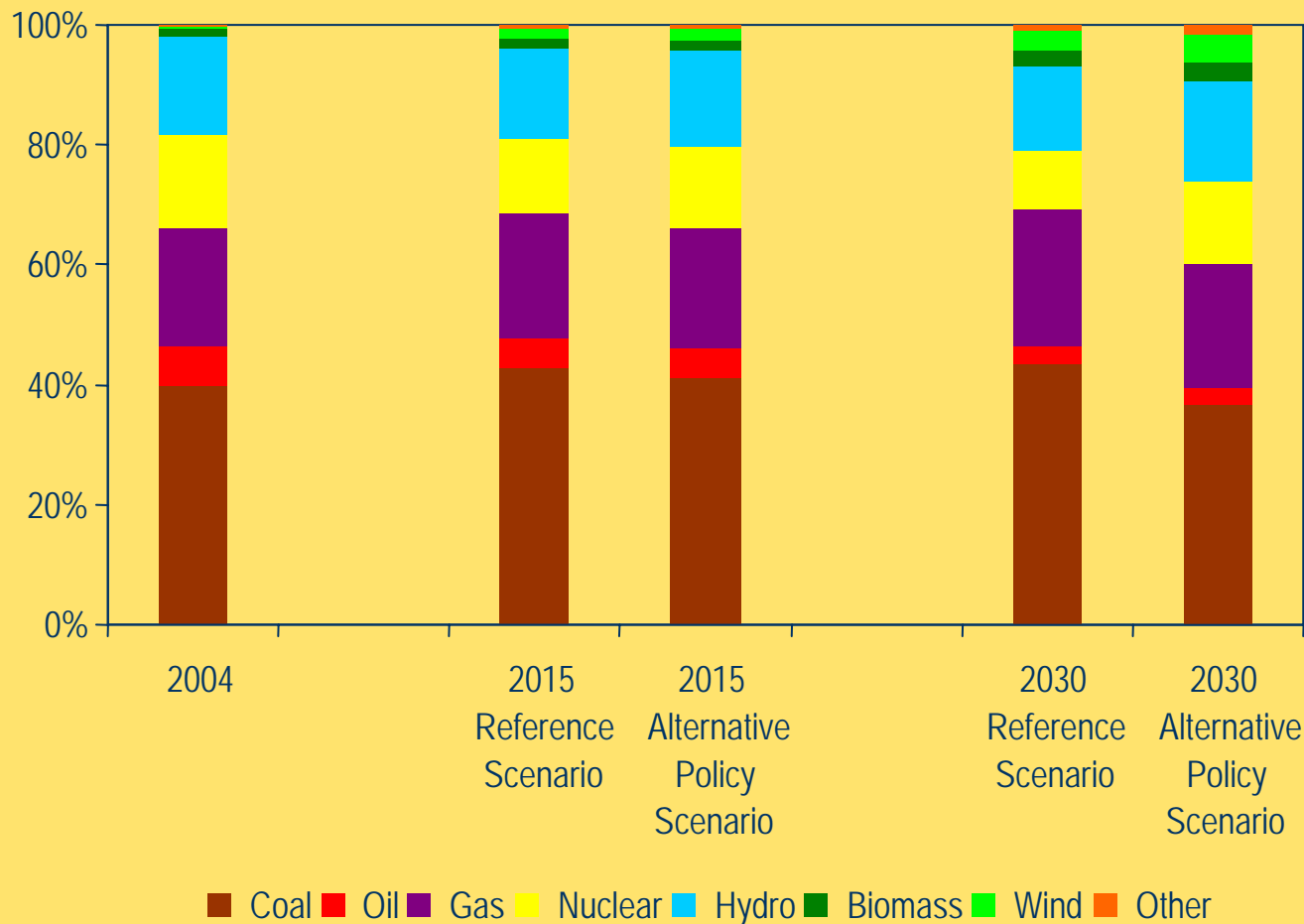
*More favourable policies on nuclear could significantly accelerate the growth in global capacity – especially in OECD countries*

# The Alternative Policy Scenario: Electricity-Supply Investment, 2005-2030



***Electricity-supply investment are \$2.1 trillion lower than in RS, but renewables and nuclear investment are higher***

# 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***

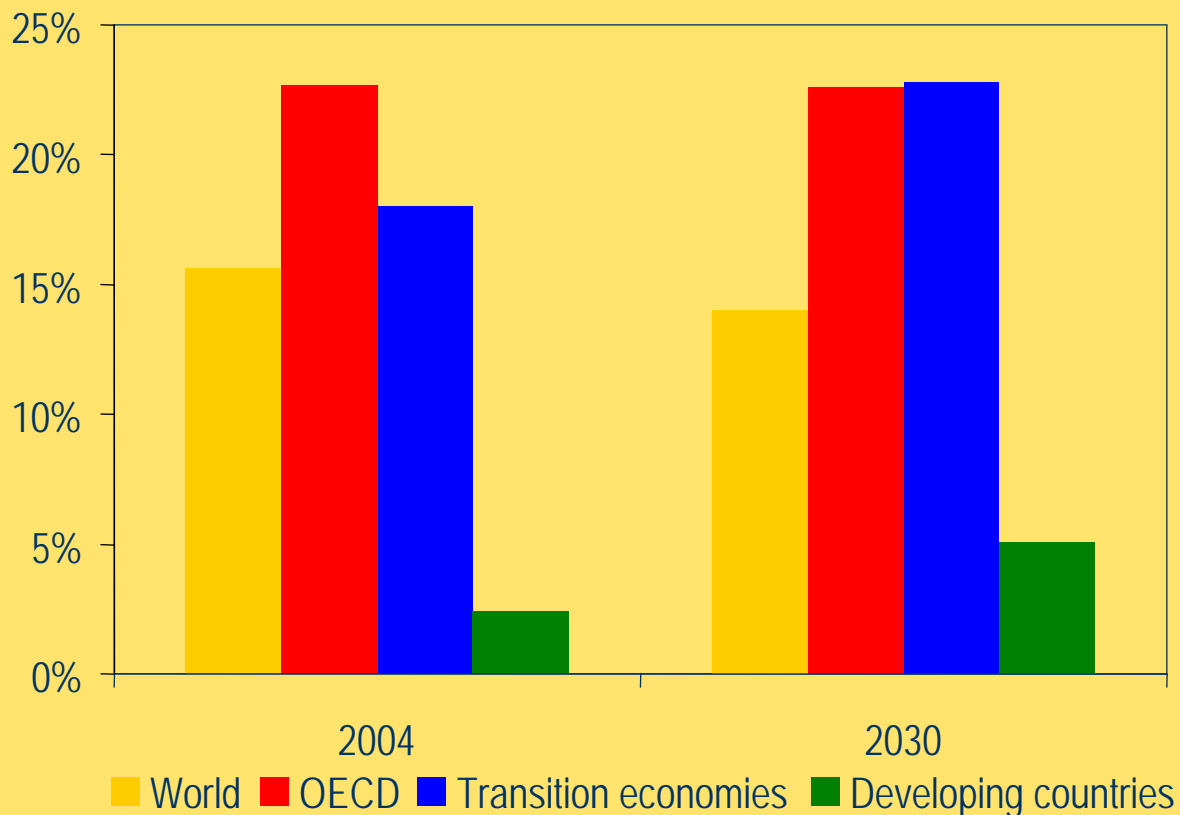
# The Alternative Policy Scenario : Key policies that Make a Global Difference



	<i>Energy efficiency</i>	<i>Power generation</i>
<b>US</b>	<ul style="list-style-type: none"> <li>● Tighter CAFE standards</li> <li>● Improved efficiency in residential &amp; commercial sectors</li> </ul>	<ul style="list-style-type: none"> <li>● Increased use of renewables</li> </ul>
<b>EU</b>	<ul style="list-style-type: none"> <li>● Increased vehicle fuel economy</li> <li>● Improved efficiency in electricity use in the commercial sector</li> </ul>	<ul style="list-style-type: none"> <li>● Increased use of renewables</li> <li>● Nuclear plant lifetime extensions</li> </ul>
<b>China</b>	<ul style="list-style-type: none"> <li>● Improved efficiency in electricity use in industry</li> <li>● Improved efficiency in electricity use in the residential sector</li> </ul>	<ul style="list-style-type: none"> <li>● Increased efficiency of coal-fired plants</li> <li>● Increased use of renewables</li> <li>● Increased reliance on nuclear</li> </ul>

*A dozen policies in the US, EU & China account for around 40% of the global emissions reduction in 2030 in the Alternative Policy Scenario*

## Alternative Policy Scenario: Share of Nuclear Power in Electricity Generation by Region



*The share of nuclear power drops much less than in the Reference Scenario, helping to curb emissions growth*

# Nuclear in the Energy World Scene

## *The times are changing*

- ◆ WEC – Sydney (9/04)  
*“Keep all energy options open”*  
*“No technology should be idolised or demonised”*
- ◆ IAEA Ministerial Conference - Paris(3/05)  
*with OECD & NEA*
- ◆ Greenpeace Co-Founder Calls N-Power  
*“Environmentally Safe and Sound”* (4/05)  
US Senate Energy and Natural Resources Committee
- ◆ Finland, France, USA, China, India, .... EC
- ◆ GIF, INPRO, GNEP, ...

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

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

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

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

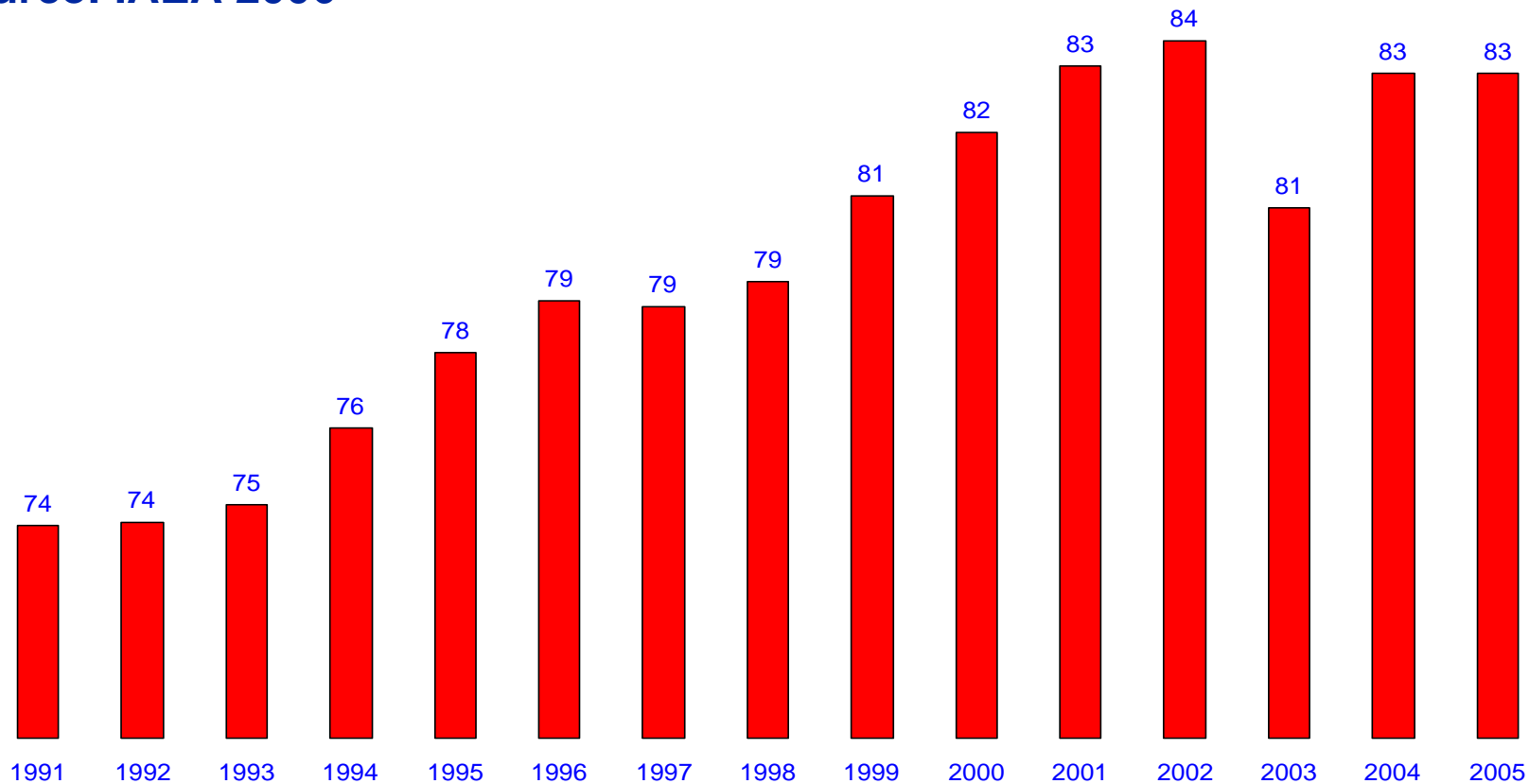
# Nuclear Energy Today

- ~ ***16% of world electricity generated by nuclear  
(24% in OECD countries)***
- ◆ **442 power plants in 33 countries  
(352 in 17 OECD countries)**
  - **existing power plants are very competitive**
  - **increasing load factors**
  - **upgrading of plant capacities**
  - **low cost of lifetime extension**
- ◆ **Mature technology**

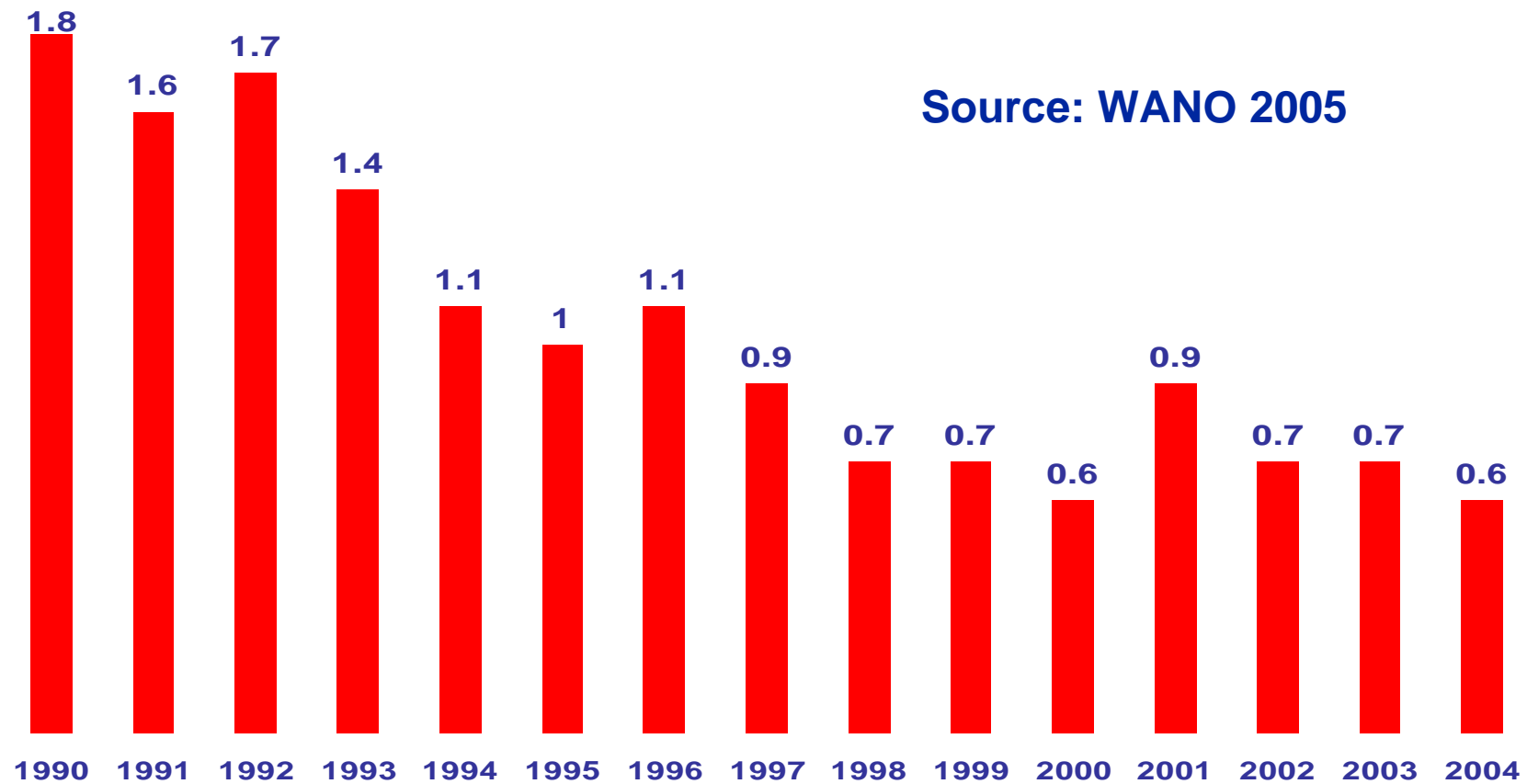


# World Average Nuclear Power Plant Availability Factor (%)

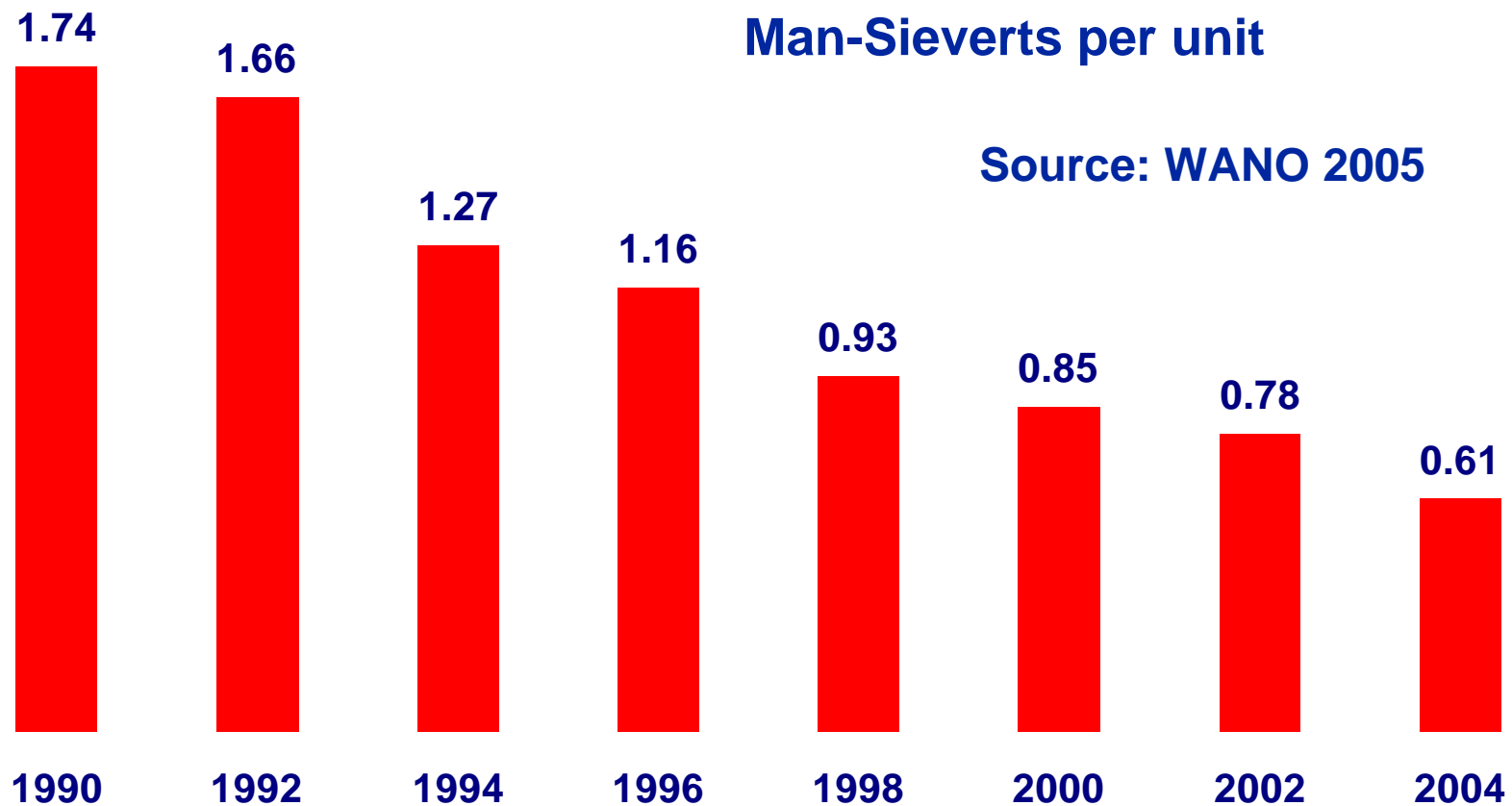
Source: IAEA 2006



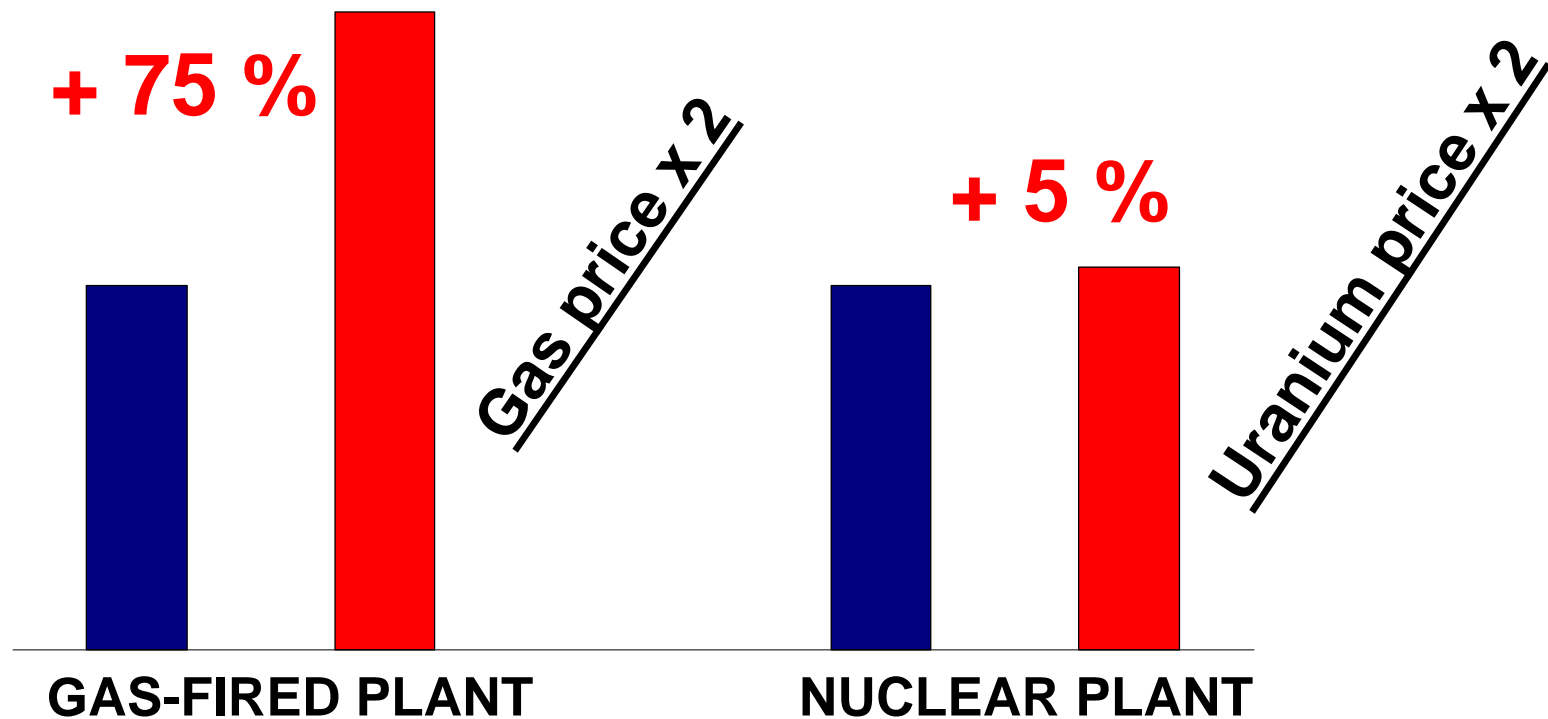
# Unplanned Automatic Scrams per 7000 hours critical



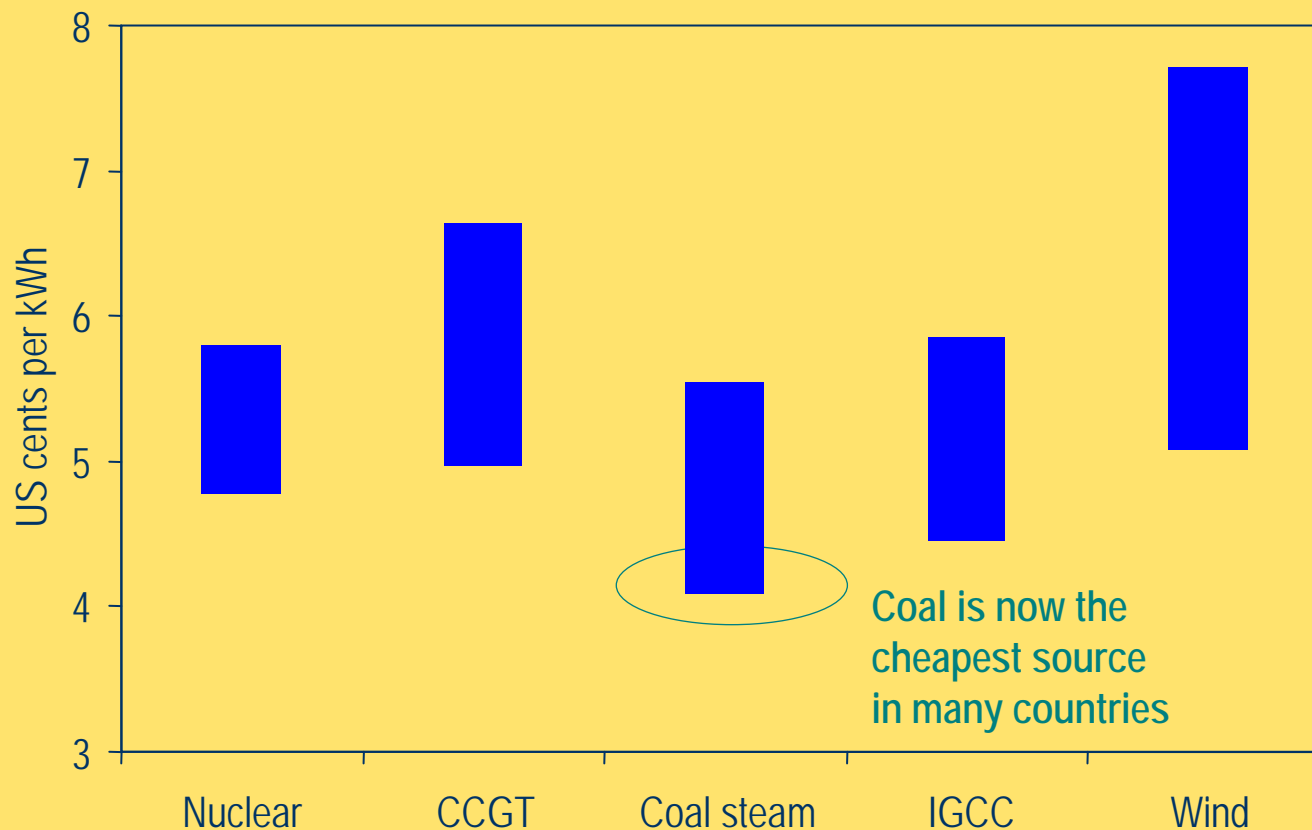
# Collective Radiation Exposure of Personnel in PWRs



# Electricity Cost Sensitivity to Fuel Price Volatility

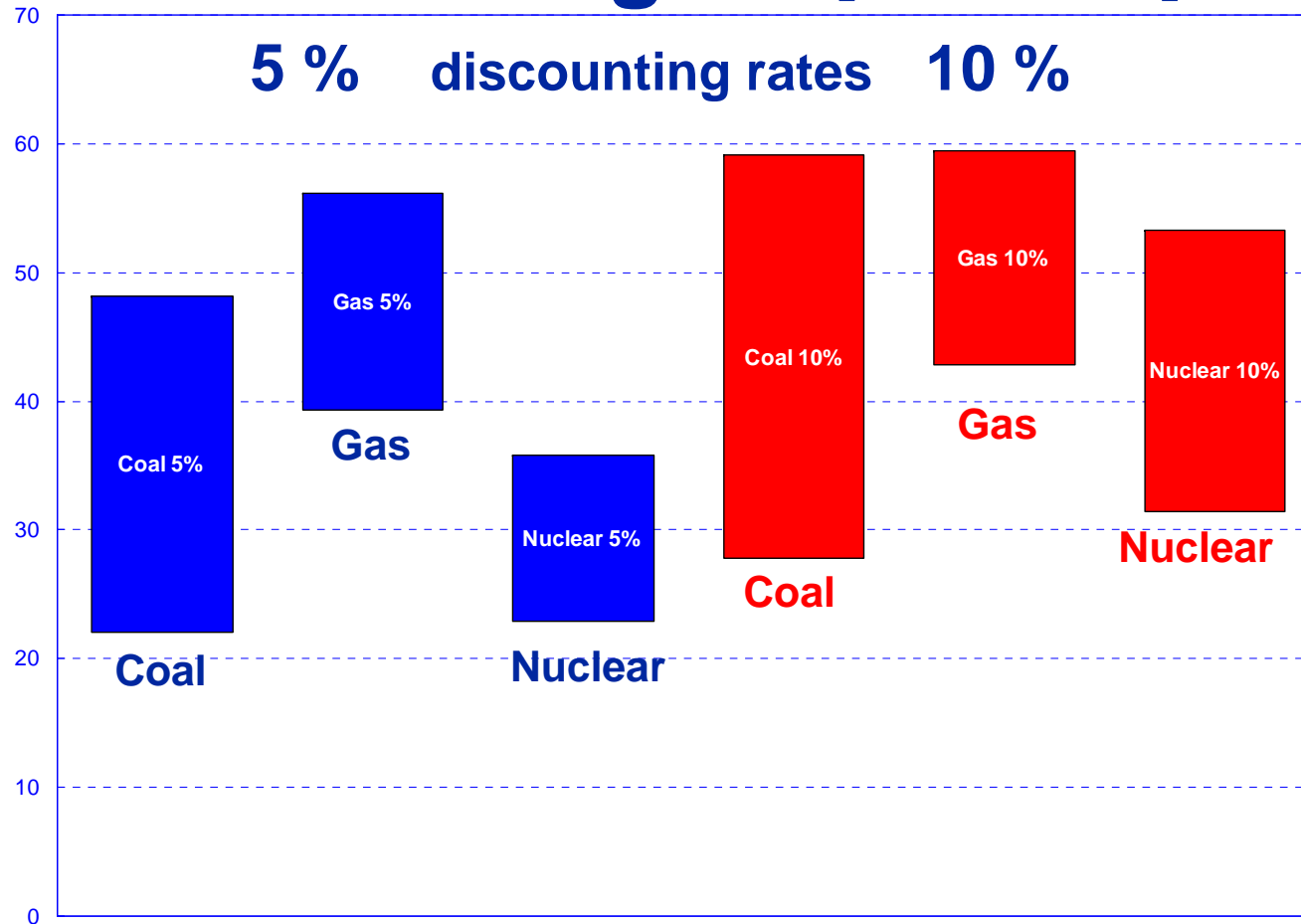


# Electricity Generating Cost Ranges of Main Technologies



***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

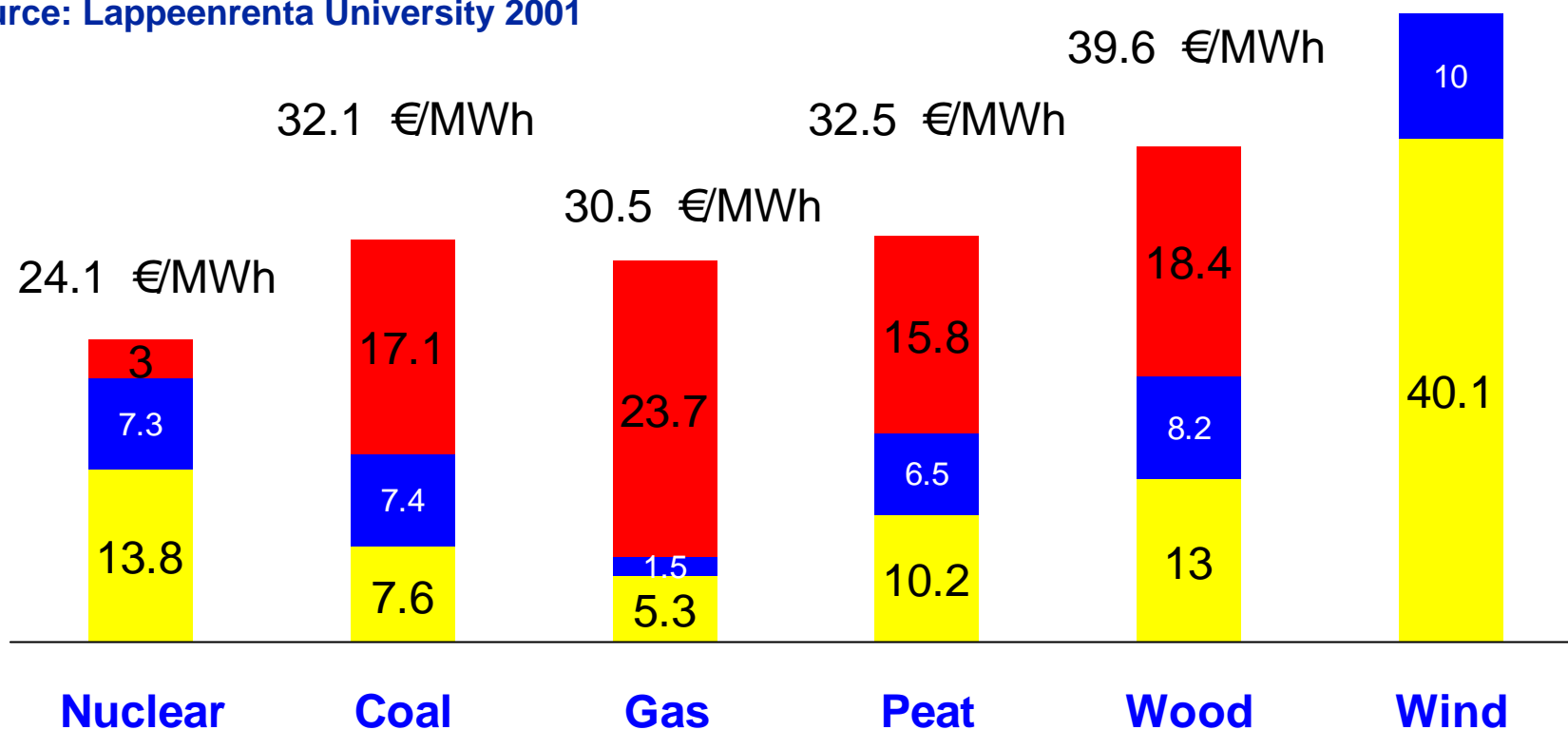
# Projected Costs in Finland

(5% discount rate - €2001)

Investment O&M Fuel Cycle

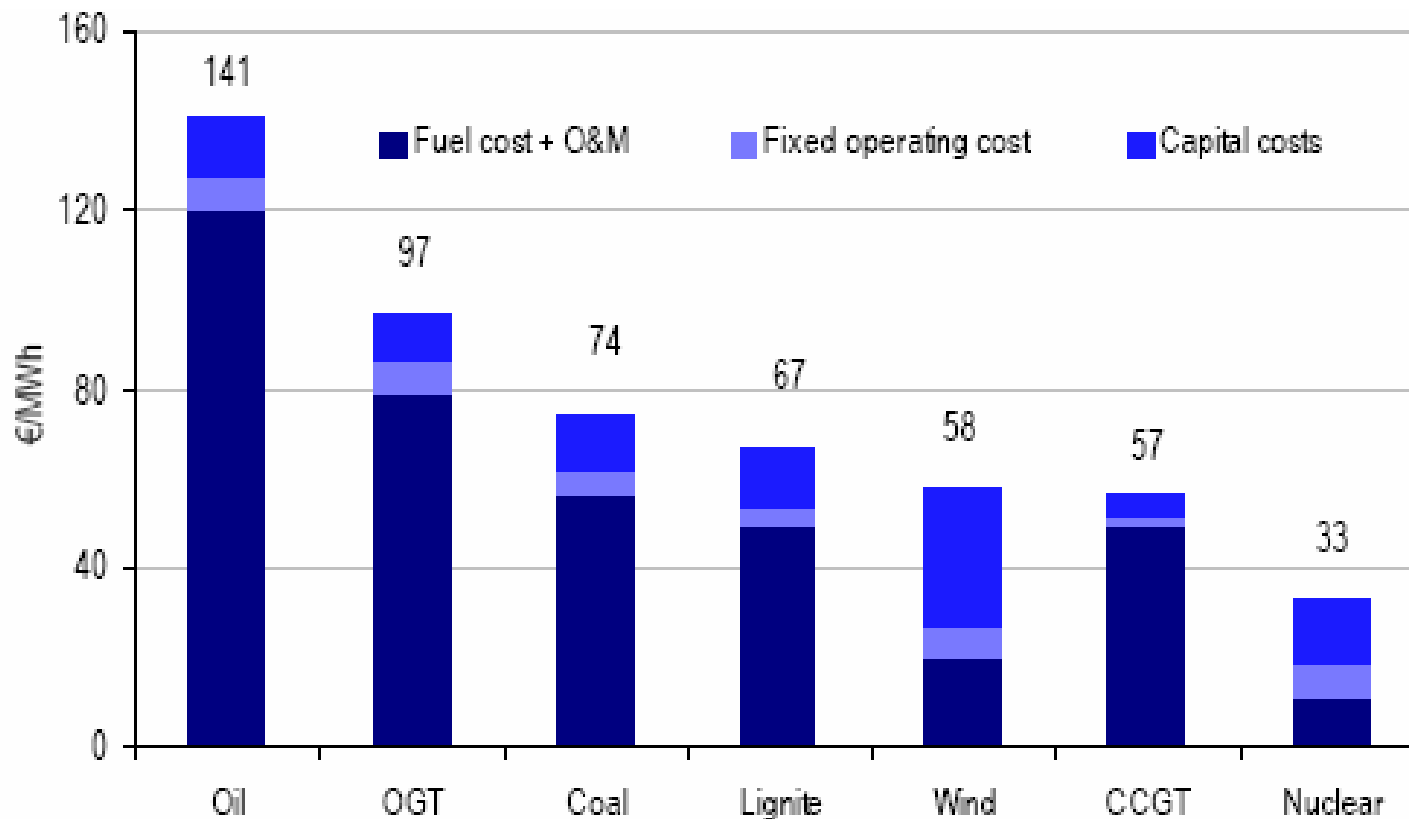
50.1 €/MWh

Source: Lappeenranta University 2001



# Full Cost on New Capacity (€/MWh)

## Source UBS





# Capital market views

- ◆ A remarkable change in capital markets views on nuclear over the last two 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

## *Paradoxe ?*

- ◆ Existing nuclear power plants are “cash cows” for most utilities worldwide
- ◆ Decisions to build new plants “future cash cows” are difficult to make

## ***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**

## Concluding Remarks on Energy Policy

- ◆ No ideal or magic solution to avoid the “*dirty, insecure and expensive*” energy future that the current trends prepare
- ◆ All energy technologies will be needed
- ◆ Uranium resources are available
- ◆ Advanced nuclear technologies are developed
- ◆ From a sustainable development perspective, nuclear energy has a major role to play
  - reduction of CO<sub>2</sub> emissions
  - security of energy supply
  - diversity of supply & price stability
- ◆ Role of governments key to provide stability

# NEA activities on non-electric applications

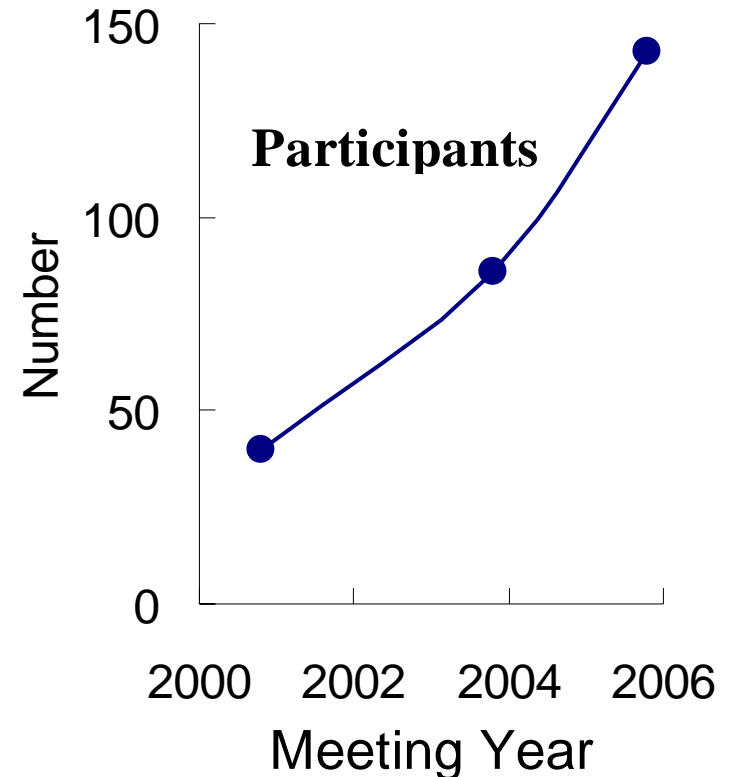
# Information Exchange Meetings on Nuclear Production of Hydrogen

## ◆ Objectives

- exchange information on scientific & technical issues
- identify possible international collaboration

## ◆ Past meetings

- 1<sup>st</sup> meeting, France in 2000
- 2<sup>nd</sup> meeting, USA in 2003
- 3<sup>rd</sup> meeting, Japan in 2005



# Information Exchange Meetings on Nuclear Production of Hydrogen

- ◆ **Topics and papers at the 2005 meeting**
  - **The prospects for hydrogen in future energy structures and nuclear power's role (3 papers)**
  - **The worldwide status of R&D (7)**
  - **Technologies and design concepts (5)**
  - **Integrated nuclear hydrogen production systems (13)**
  - **Basic and applied science (7)**
  
- ◆ **Next meeting will be held in USA, 2008**

# Isotope Production

- ◆ **A series of state-of-the-art reports on “Beneficial Uses and Production of Isotopes”**
  - **carried out jointly by the NEA and the IAEA**
  - **released in 1998, updated in 2002 and 2004**
  - **to provide**
    - ❖ **information on production capabilities and use of radioactive isotopes**
    - ❖ **analysis of trends in supply and demand**

## Generation-IV International Forum (GIF)

- ◆ **NEA acts as technical secretariat for GIF**
- ◆ **Hydrogen production :**
  - **R&D activities and exchange of information are performed with the VHTR system project**
  - **Processes applicable to systems other than VHTR are also included**
  - **6 (and possibly 7) organisations participate in the project**



# Generation-IV International Forum (GIF)

## ◆ Hydrogen production objectives:

- developing and optimising the thermochemical water splitting processes of the sulphur family
- advancing the high-temperature electrolysis process
- evaluating alternative processes
- defining and validating technologies for coupling reactors to process plants

# Generation-IV International Forum (GIF)

## ◆ GIF Economic Modelling Working Group

- Study of hydrogen production cost by modular helium cooled reactor vs. steam methane reforming
- “Allocating Costs for Non-electricity Products from GIF Nuclear Energy Systems”  
(to be presented at this meeting)

***Thank you for your attention***