



Sharing knowledge across Mediterranean Jordan



Cost factors of nuclear electricity

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6.7 billion people...

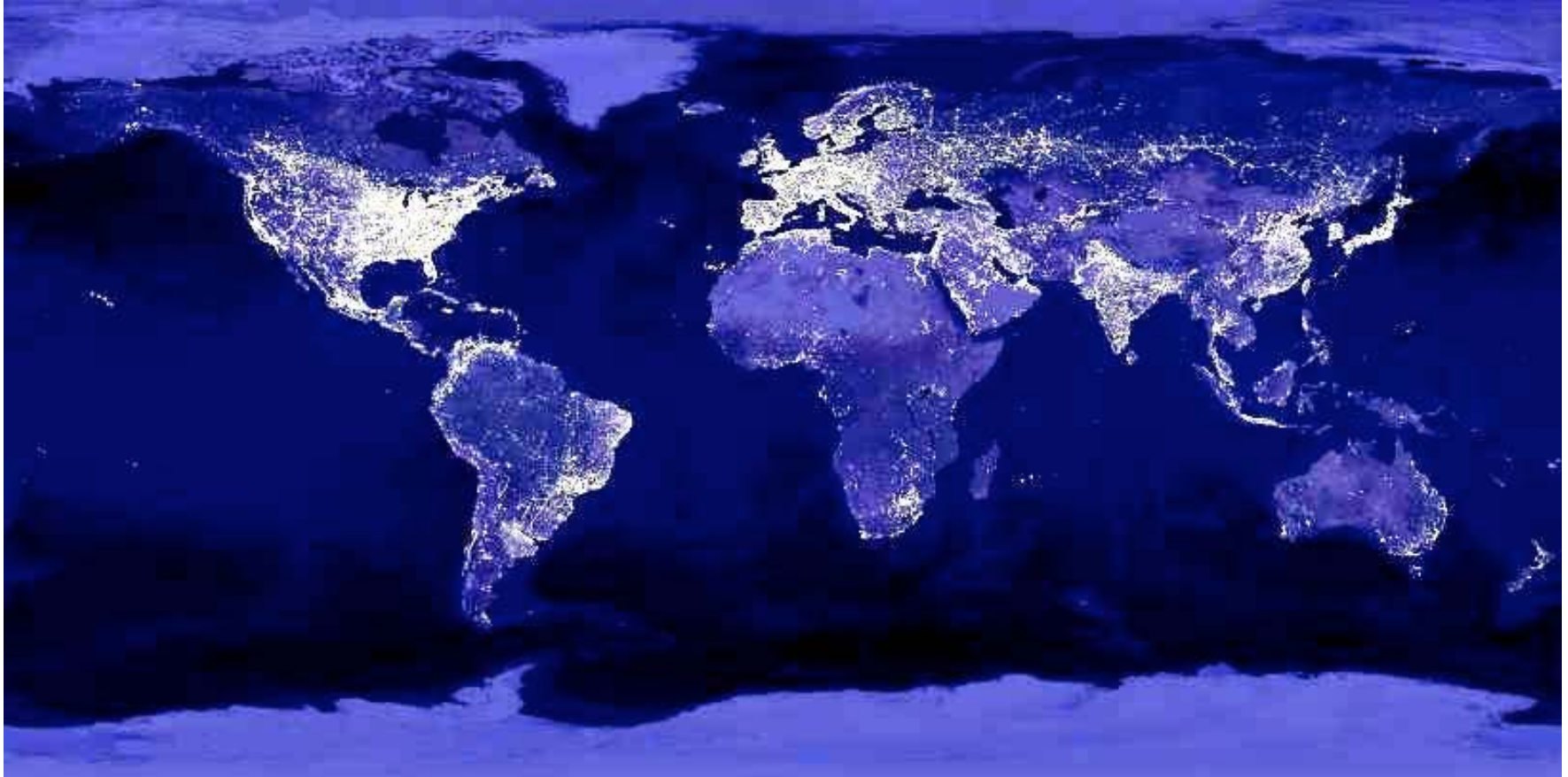


Photo composite NASA sans trucage

6.7 billion people...



- ▶ **Need food, water and energy,**
- ▶ **Need reliable and cheap energy and electricity so far,**

Key Factors of electricity generation

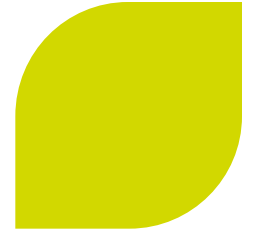


- ▶ **Geographical situation of the country**

- ▶ **Political decision**
 - ◆ **Energy independency**
 - ◆ **Contribution to fight climate change**
 - ◆ **Public acceptance**

- ▶ **Cost factors of nuclear electricity**

Political factors of electricity generation



Government has a key role to play in the energy mix optimization and the deployment of the energy nuclear program

	Dependency of supply	CO ₂ emissions	Impact / Environment	Base-load or follow-up	Regulated / Deregulated
Oil & Gas					
Coal					
Hydro					
Nuclear					
Renewables - intermittent - permanent					

Levelized cost of electricity (LCOE)



- ▶ ***Levelized Cost Of Electricity*** = lifecycle cost considering all expenses from investment and operation to decommissioning. The final cost is obtained after discounting the input and output flows in relation with the discounted amount of generated electricity.
- ▶ ***Marginal cost*** = variable O&M and cycle fuel cost. Controls the decision to operate or not an existing plant.

Levelized cost of electricity (LCOE)



▶ Reactor and fuel cycle features

- ◆ Generation capacity
- ◆ Grid capacity
- ◆ Cooling system
- ◆ Operation & maintenance options
- ◆ Fuel cycle options
- ◆ Life duration
- ◆ Capacity factor
- ◆ ...

Levelized cost of electricity (LCOE)



▶ Financing assumptions

◆ Costs

- Plant investment & decommissioning
- Fuel cycle including transport, interim and final disposal
- Operation & maintenance

◆ Debt/equity ratio

◆ Debt maturity

◆ WACC

◆ Interest for loan

◆ Domestic inflation

▶ Environmental costs

◆ No cost passed through to future generations

When deciding, the power company has to consider risks over the long plant lifetime



➤ **Market risks: fuel prices and electricity price volatility**

- ◆ Decision makers have to assess the fluctuations of fuel prices over the next 30 to 60 years; several scenarios have to be considered
- ◆ Electricity price uncertainty in a liberalized market

➤ **Project achievement and performance risks**

➤ **Regulatory uncertainties**

- ◆ CO₂ emissions and other environmental regulations
- ◆ Nuclear licensing procedures

Influence of market and plant ownership status on project finance conditions



Weighted Average Cost of capital (WACC) before tax, in real value

$$= [\%Equity \times ROE_{real}/(1-tax)] + [(1-\%Equity) \times loan\ rate\ real]$$

▶ Regulated market

- ◆ High security for investors and lenders, lower WACC value (5% real)

▶ Liberalized market

- ◆ High risk to be rewarded: high WACC value (11% real)
- ◆ Request for low debt/equity ratio in project financing

▶ Hybrid

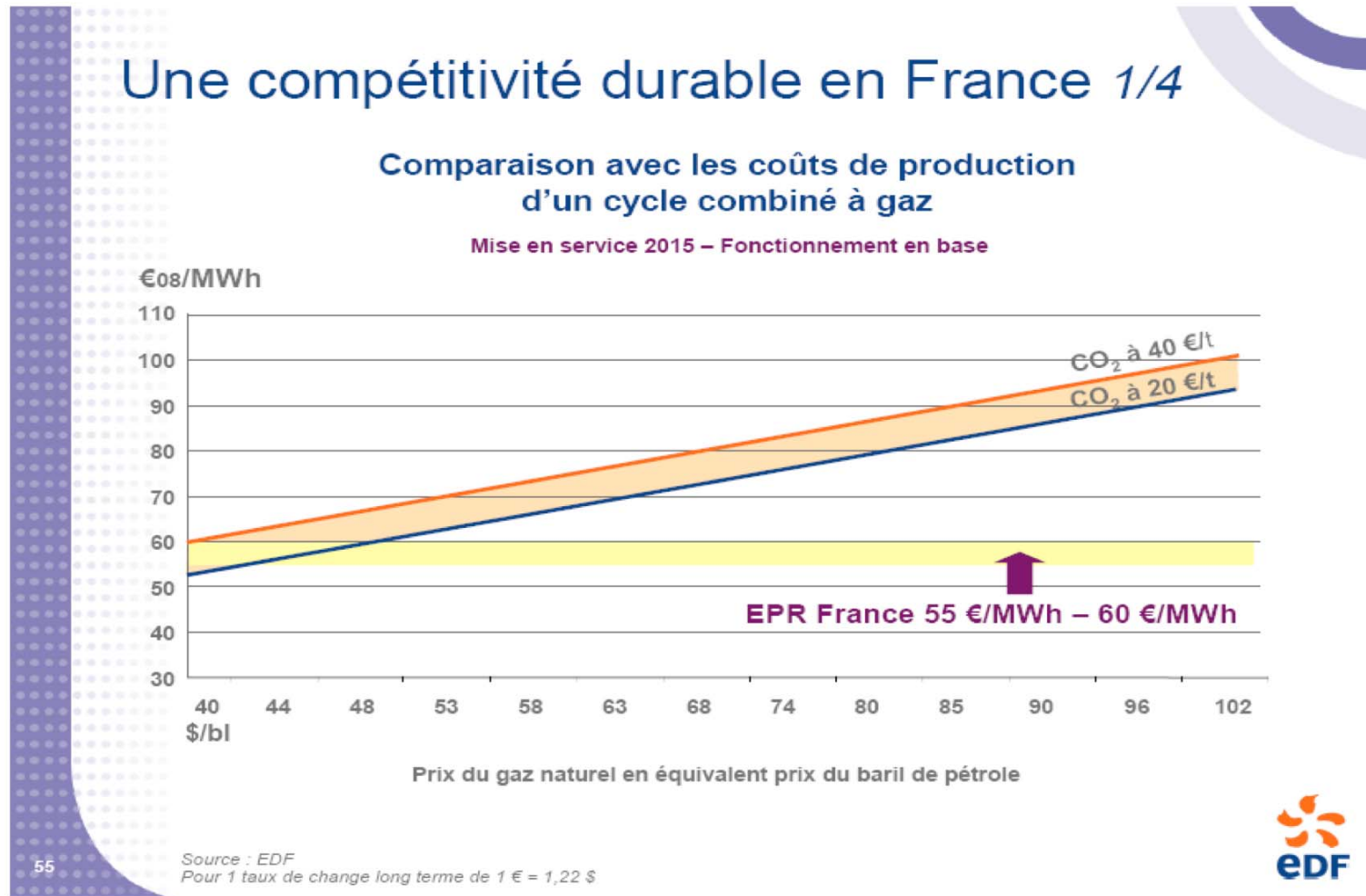
- ◆ Capacity to finance heavy investments on balance sheet
- ◆ High credit rating
- ◆ Moderate WACC value (8% real)

Nuclear new build appears attractive to the European power companies



- ▶ **In 2008, most European power companies have expressed their firm intent to invest into new nuclear capacities: EDF, E.ON, RWE, ENEL, GDFSUEZ, FORTUM, CEZ, ALPIQ, AXPO,...**
- ▶ **Common drivers mentioned: performance of NPPs in service, cost predictability, projected CO₂ price in the context of the European Climate Directive and concerns about gas supply security.**
- ▶ **Some of them have published comparisons of generation costs between nuclear (GenIII+), gas (CCGT) and coal (supercritical) power plants, showing the competitiveness of nuclear power.**

Exemple : EDF Investor Day Presentation 4 décembre 2008

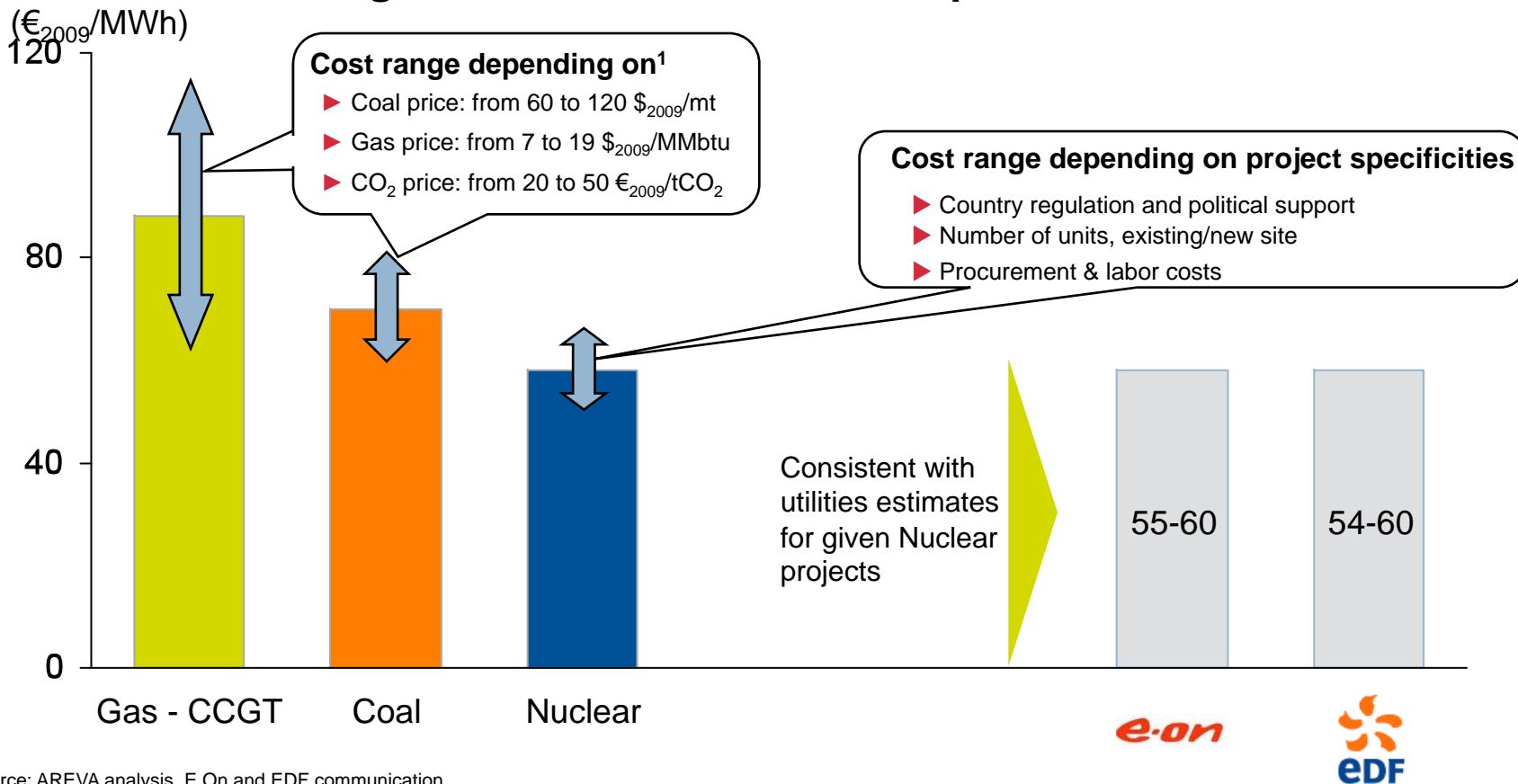


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Nuclear generation costs are forecast to be the lowest on many markets: Europe

Levelized costs of electricity over power plant lifetime, for new build connected to the grid in 2020 in Western Europe

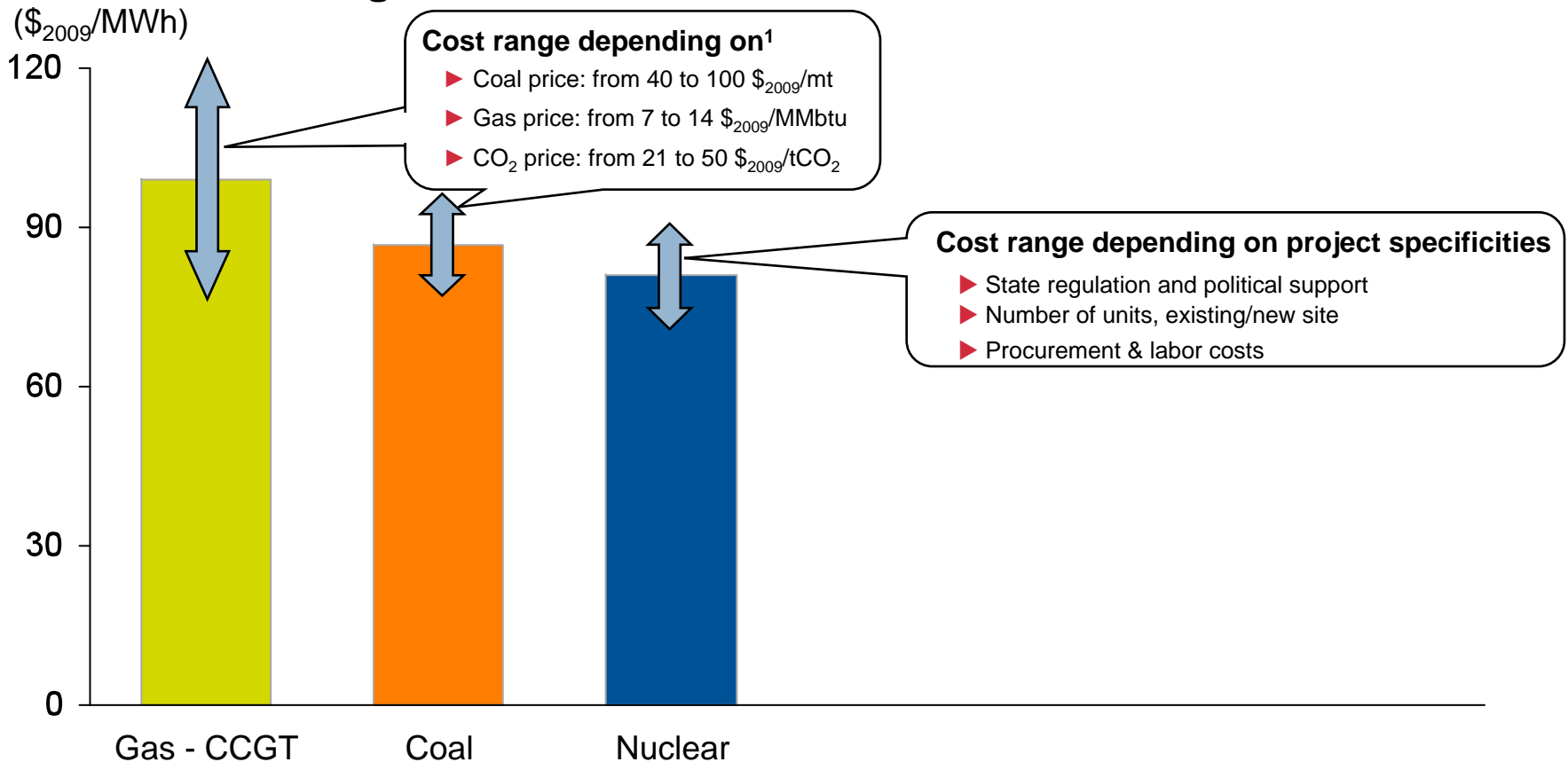


Source: AREVA analysis, E.On and EDF communication
 1. Long term hypothesis (2020 and onwards)

Nuclear generation costs are forecast to be the lowest on many markets: USA



Levelized costs of electricity over power plant lifetime, for new build connected to the grid in 2020 in the US - East coast

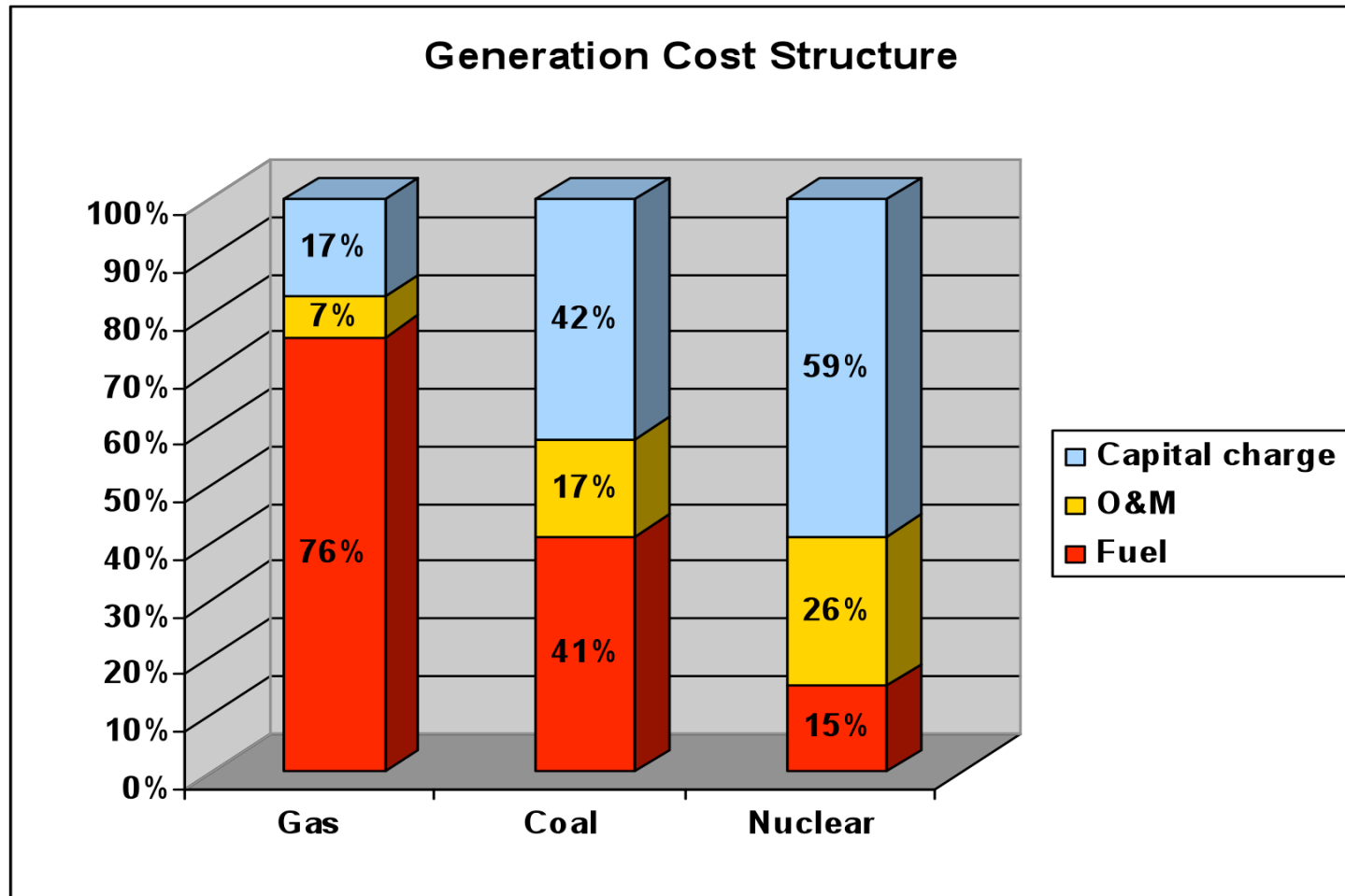


Source: AREVA analysis

1. Long term hypothesis (2020 and onwards)

Quite different generation cost structures (indicative figures)

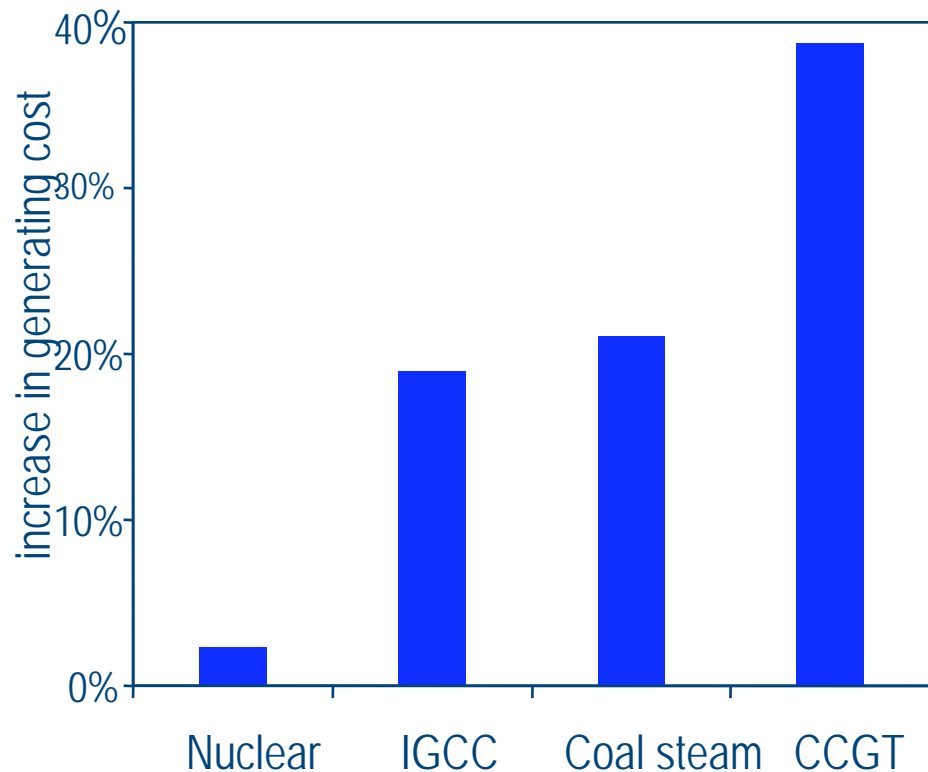
Réf OCDE/AEN 2005



Nuclear generating costs are far less sensitive to fuel price increases than gas & coal plants

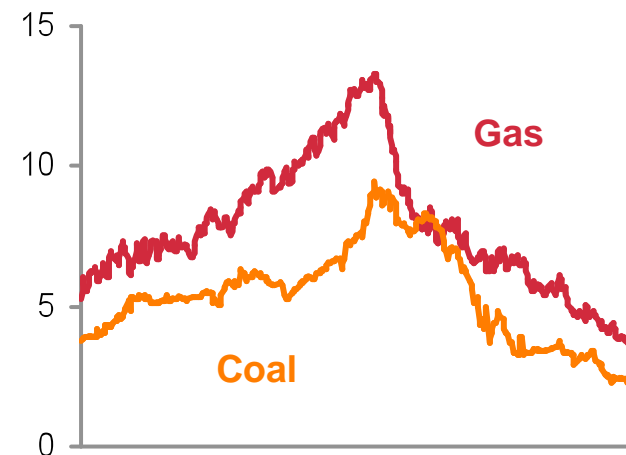


Impact of a 50% increase in fuel price on generating costs (IEA WEO 2006)



Observed volatility of fuel prices

Coal & Gas prices (\$/mmbtu)



Jan 2007 July 2008 Jan 2009

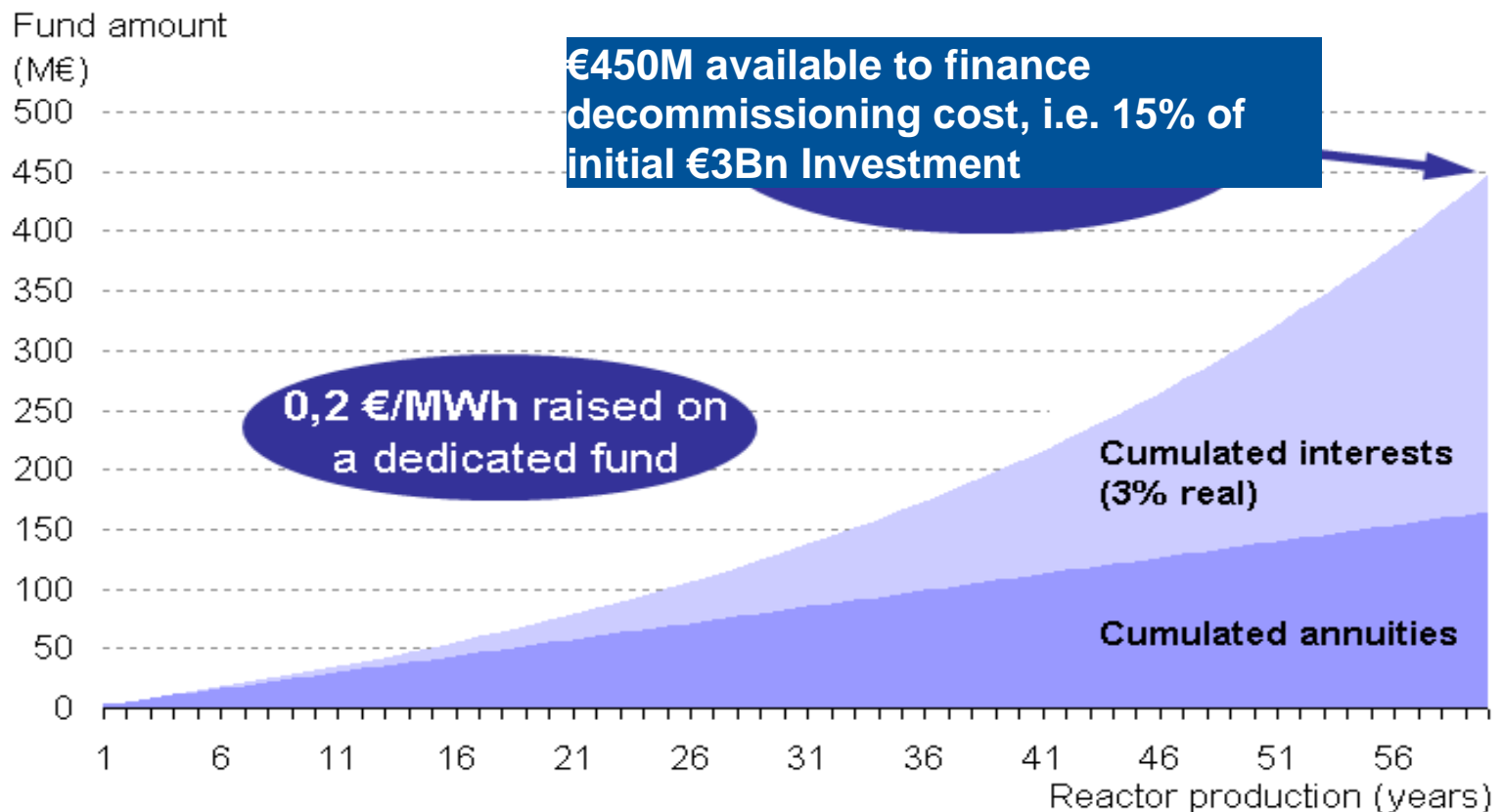
Gas: Henry Hub price, Coal: CIF ARA price

Source: Bloomberg

Decommissioning does not significantly alter nuclear competitiveness



- ▶ **Exemple: saving €3 M/year on a risk free account over 60-years' life → 0.2 €/MWh impact**



Sources: *Revue Générale du Nucléaire* (décembre 2004) + OECD NEA (2003) *Decommissioning nuclear power plants*

The Role of Government: framing, ruling and enabling



- ▶ **Long Term Energy Policy:** combining security of supply, environmental protection and competitiveness
- ▶ **Electricity Market Design:** aiming at reliable and cost efficient supply, encouraging long-term investment
- ▶ **Climate Change Policy:** penalizing carbon emissions
- ▶ **Licensing and Local Planning System:** towards predictable, streamlined processes
- ▶ **Nuclear Liability:** legal framework defining the respective insurance responsibilities
- ▶ **Safety Regulation of Operations**
- ▶ **Radioactive Waste Management and Used Fuel Management:** deciding radwaste disposal policy, used fuel recycling or not
- ▶ **Decommissioning:** regulating and enforcing timely funding by plant operators

