

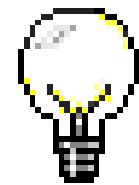
# **Nuclear Energy**

**Economics-Regulations-Challenges**

**Dr. Ugur GUVEN**

# Question of Economic Feasibility

- Main issue with nuclear reactors is not safety anymore but economic feasibility.
- While many advanced and very safe forms of nuclear reactors are viable, they are not economically feasible for now and require research.
- Cost is high due to various reasons described in the next slide.



# Cost of Nuclear Power Plants

- High capital investment, fuel costs, regulatory costs, personnel costs (hiring and yearly training / certification), waste management costs, insurance cost, safety and security costs, decommissioning costs.
- Even for decommissioning in US as per NRC, the power plant has to set aside a minimum of \$ 500 Million dollars for decommissioning at the time of its construction.



# Capital Costs

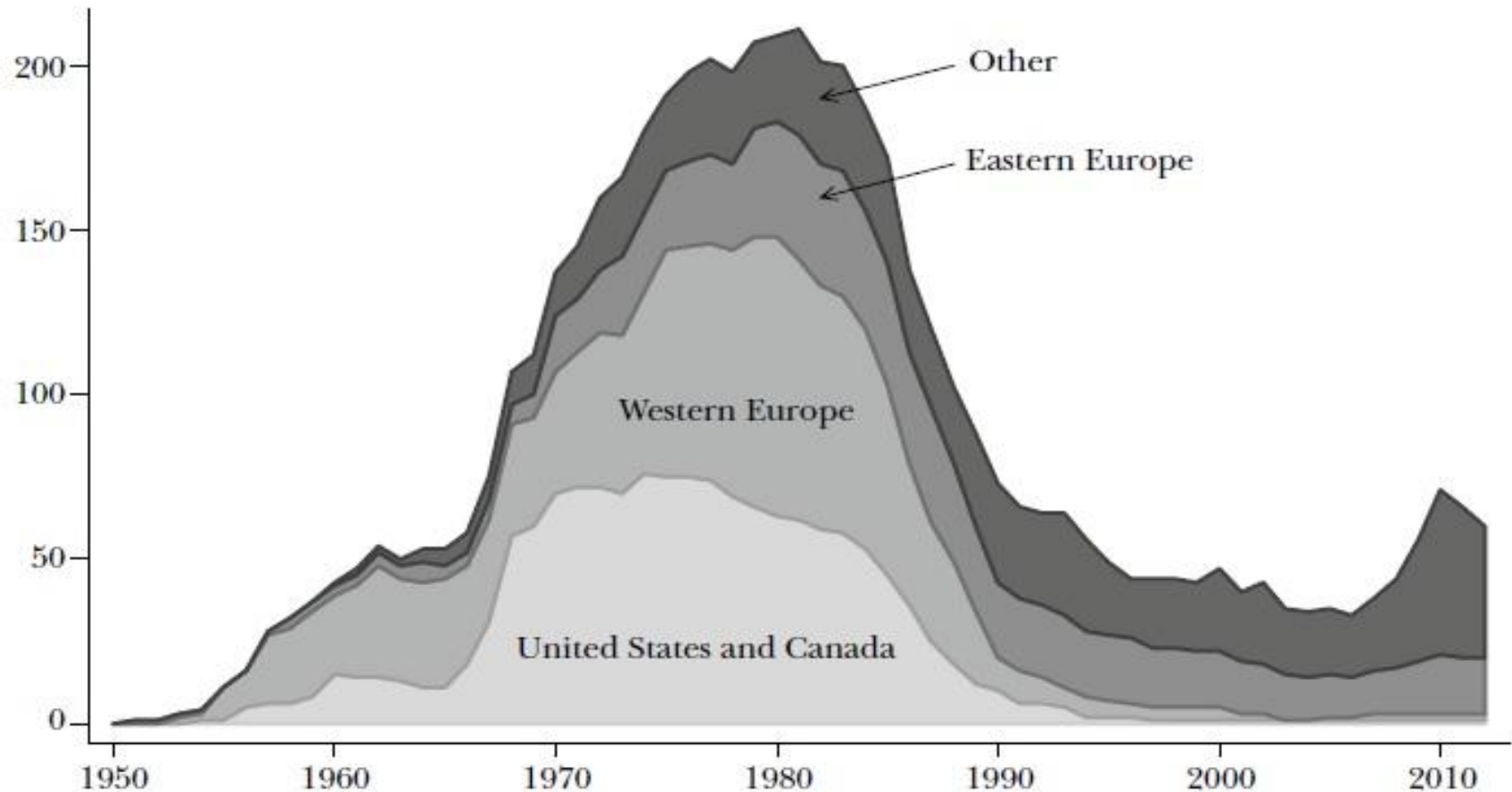
- **Capital costs**, which include the cost of site preparation, construction, manufacture, commissioning and financing a nuclear power plant. Building a large-scale nuclear reactor takes thousands of workers, huge amounts of steel and concrete, thousands of components, and several systems to provide electricity, cooling, ventilation, information, control and communication.
- **Financing costs** will depend on the rate of interest on debt, the debt-equity ratio, and if it is regulated, how the capital costs are recovered. There must also be an allowance for a rate of return on equity, which is risk capital.

# Construction Costs

- In general the construction costs of nuclear power plants are significantly higher than for coal- or gas-fired plants because of the need to use special materials, and to incorporate sophisticated safety features and back-up control equipment.
- The OECD Nuclear Energy Agency's (NEA) calculation of the overnight cost for a nuclear power plant built in the OECD rose from about US\$ 1,900/kWe at the end of the 1990s to **US\$ 3,850/kWe** in 2009.
- By way of contrast, China has stated that it expects its costs for plants under construction to come in at less than \$2000/kW and that subsequent units should be in the range of \$1600/kW.

# Nuclear Power Plant Construction Worldwide

Figure 2  
Nuclear Reactors under Construction Worldwide

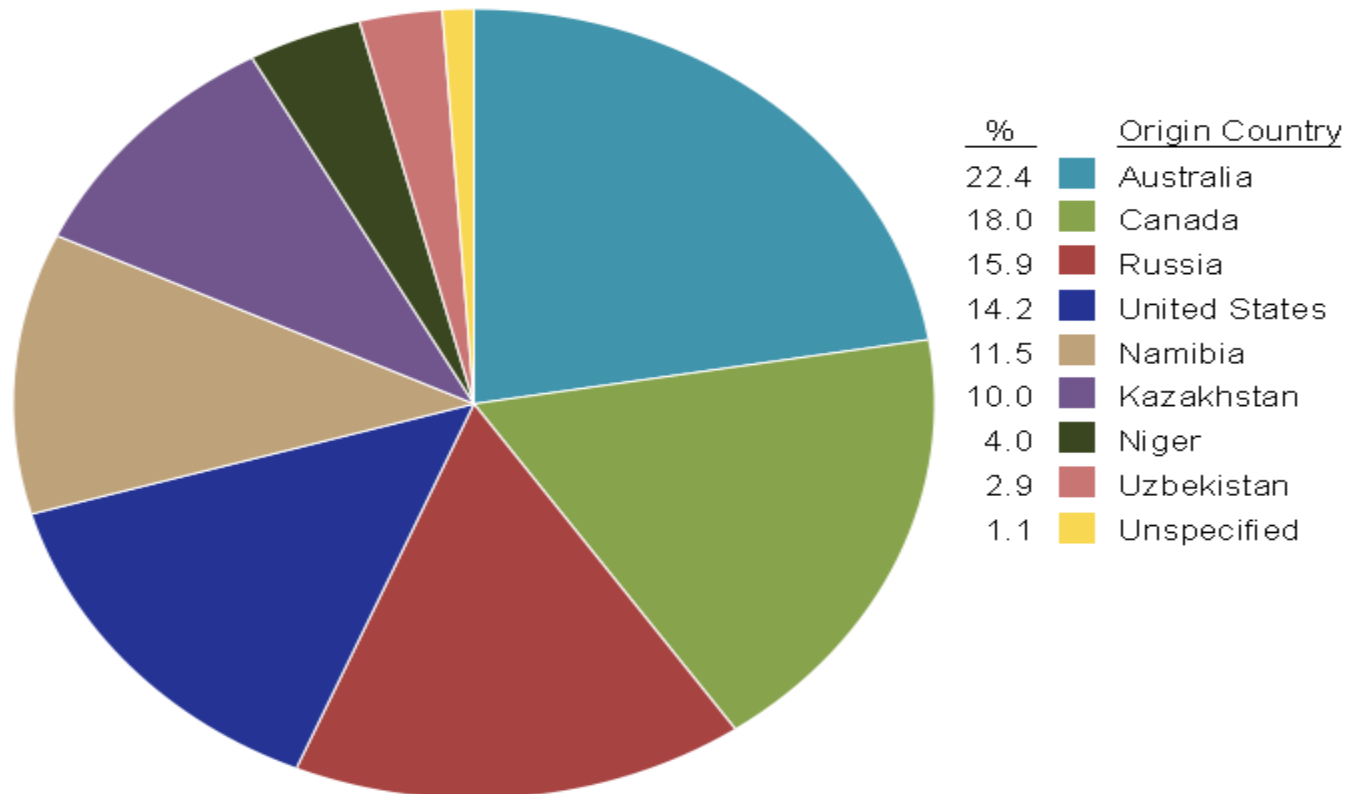


Source: Author based on data from International Atomic Energy Agency (2011).

# Fuel Cost for NPP

- For a typical 1,000 MWe BWR or PWR, the approximate cost of fuel for one reload (replacing one third of the core) **is about \$40 million**, based on an 18-month refueling cycle.
- **Average fuel cost at a nuclear power plant in 2012 was 0.75 cents/kWh.**

Uranium Purchased in 2009 by Owners and Operators  
of U.S. Civilian Nuclear Power Reactors



# Fuel Costs

- In June 2013, the approx. US \$ cost to get **1 kg of uranium as UO<sub>2</sub> reactor fuel** (at current spot uranium price):

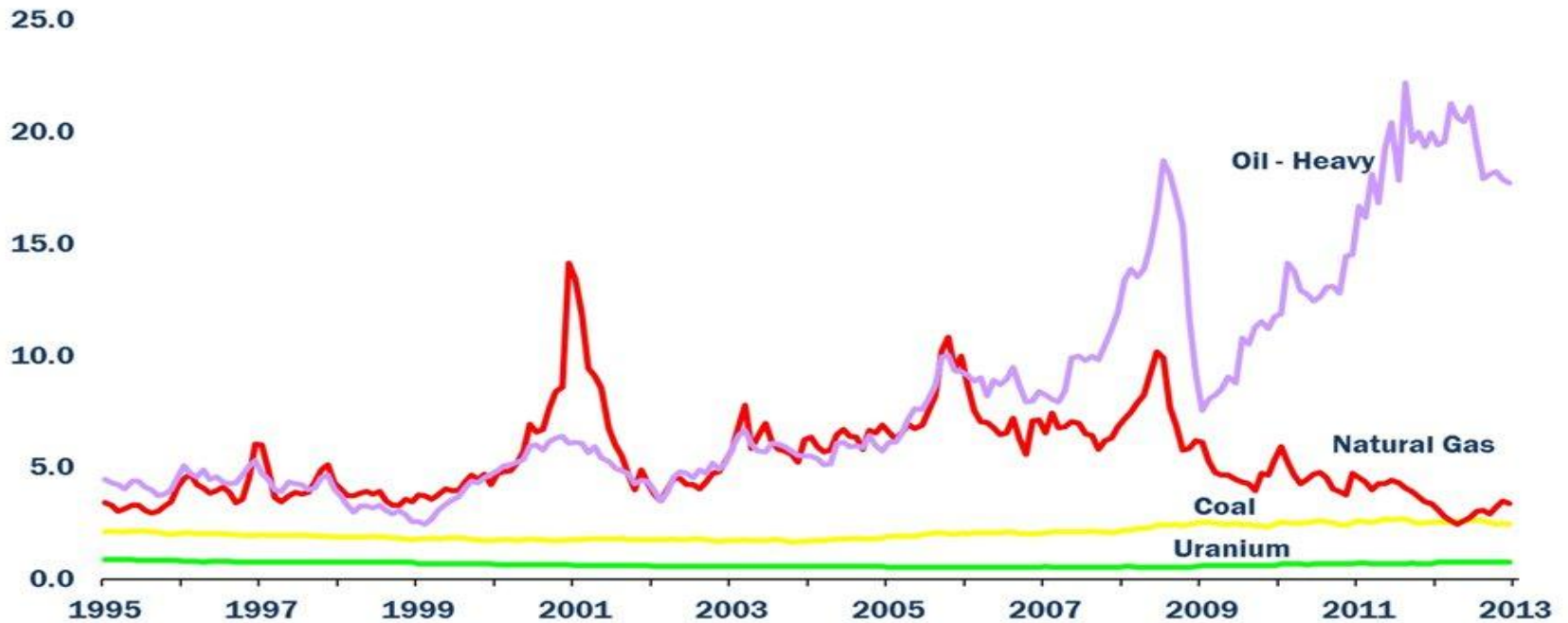
<b>Uranium:</b>	8.9 kg U <sub>3</sub> O <sub>8</sub> x \$130	US\$ 1160
<b>Conversion:</b>	7.5 kg U x \$11	US\$ 83
<b>Enrichment:</b>	7.3 SWU x \$120	US\$ 880
<b>Fuel fabrication:</b>	per kg	US\$ 240
<b>Total, approx:</b>		US\$ 2360

At 45,000 MWd/t burn-up this gives 360,000 kWh electrical per kg, hence fuel cost: 0.66 c/kWh.



# Monthly Fuel Cost for US Energy Production

## Monthly Fuel Cost to U.S. Electric Utilities 1995 – 2012, In 2012 cents per kilowatt-hour



NEI

NUCLEAR ENERGY INSTITUTE

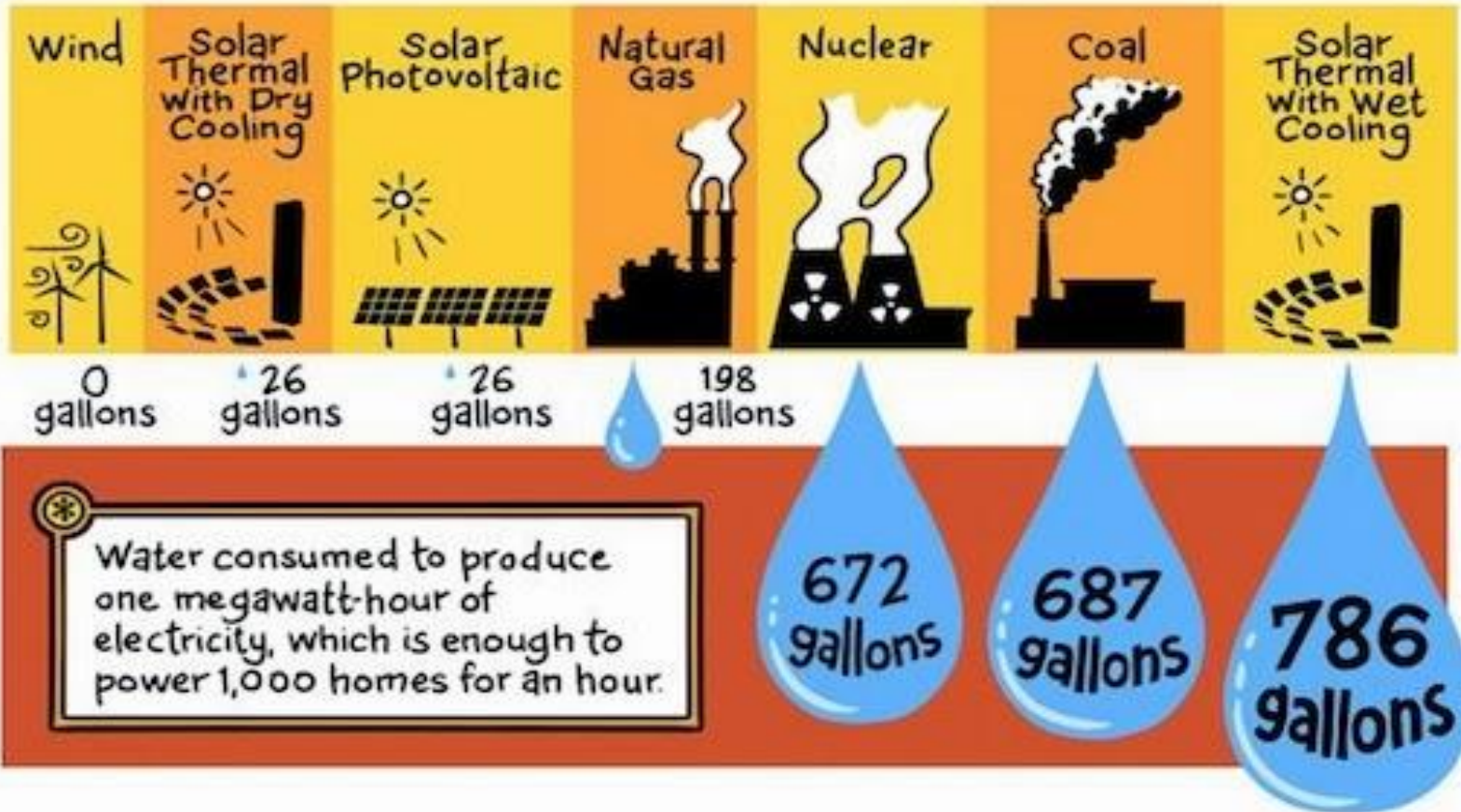
Source: Ventyx Velocity Suite  
Updated: 5/13

nuclear. clean air energy.

# Coolant Cost

- Nuclear reactors are made next to water bodies for ready supply of coolant.

## WATER USE BY POWER PLANTS\*



# Operations and Maintenance Cost

- This is the annual cost associated with the operation, maintenance, administration, and support of a nuclear power plant. Included are costs related to labor, material & supplies, contractor services, licensing fees, and miscellaneous costs such as employee expenses and regulatory fees. The average non-fuel O&M cost for a nuclear power plant in 2012 was 1.65 cents / kWh.

# System Costs

- System costs are the total costs above plant-level costs (capital and operating) to supply electricity at a given load and given level of security of supply. They include grid connection, extension and reinforcement, short-term balancing costs and long-term costs of maintaining adequate back-up.
- **Nuclear system cost is \$1-3/MWh.**

# Waste Management Costs

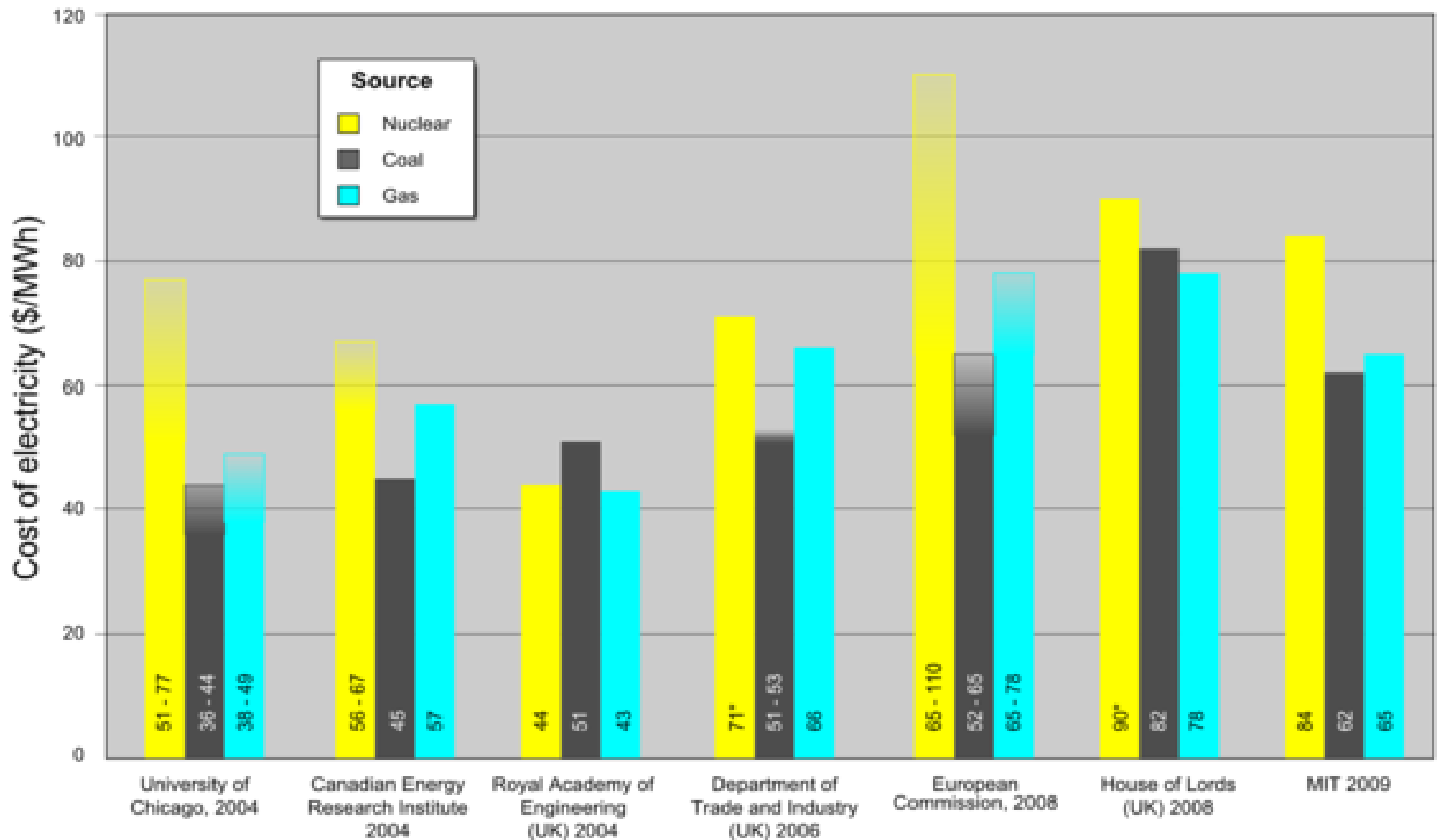
- \$35.8 billion (1/10th of a cent per kWh of electricity generated at nuclear power plants plus interest since 1983). Of the \$35.8 billion, \$10.8 billion has been spent. Payments to the Nuclear Waste Fund are included in the fuel costs.
- **Per Nuclear Plant: \$300 million to \$500 million** —includes estimated radiological, used fuel (\$100 million) and site restoration costs (about \$300 million).

# Cost of Electricity Production

Energy source	Costs of electricity production in euros per megawatt hour
Nuclear Energy	107.0 – 124.0
Brown Coal	88.0 – 97.0
Black Coal	104.0 – 107.0
Domestic Gas	106.0 – 118.0
Wind Energy Onshore	49.7 – 96.1
Wind Energy Offshore	35.0 – 150.0
Hydropower	34.7 – 126.7
Biomass	77.1 – 115.5
Solar Electricity	284.3 – 391.4

# Studies in Energy Cost

Levelised costs of electricity for different studies



(\*) does not include waste disposal.

# Education of the Public on the Facts

- There should be a widespread education of the public through the school system as well as through the public media of the real facts of the nuclear energy.

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"I BASE ALL  
MY DECISIONS ON



SCIENCE..."

"BUT WITH NUCLEAR POWER  
AND URANIUM MINING..."



...I TAKE AN  
ALTERNATIVE  
APPROACH"





# New Regulations Needed

- New Regulations are needed to make sure that necessary training is given to nuclear sector workers.
- Nuclear Energy should be supported by laws and regulations to make it more competitive. Newer and safe reactor designs should be supported for initial investment cost.
- Regulations on 3<sup>rd</sup> party equipment for nuclear reactors would have to fulfill national and international standards.

