

Overall economics of nuclear power programmes and financing of NPP projects

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International Atomic Energy Agency

Overview

1. Context and (re)emerging interest in NP
2. Operating fleet: improving economic performance
3. New construction: recent cost estimates
4. Externalities and public goods + Tools
5. Financing NP
6. Main messages

1. Context and (re)emerging interest in NP

Reasons – relative importance differs:

- fast growing economies, energy and electricity demand; IEA: all sources/technologies needed
- support development by access to reliable and affordable energy supply
- social objectives: cheap electricity=soc.service
- limited global fossil sources; oil/gas exports
- lack of/running out (cheap) domestic fossil sources: coal, oil

1. Context and (re)emerging interest in NP

Reasons – cont'd:

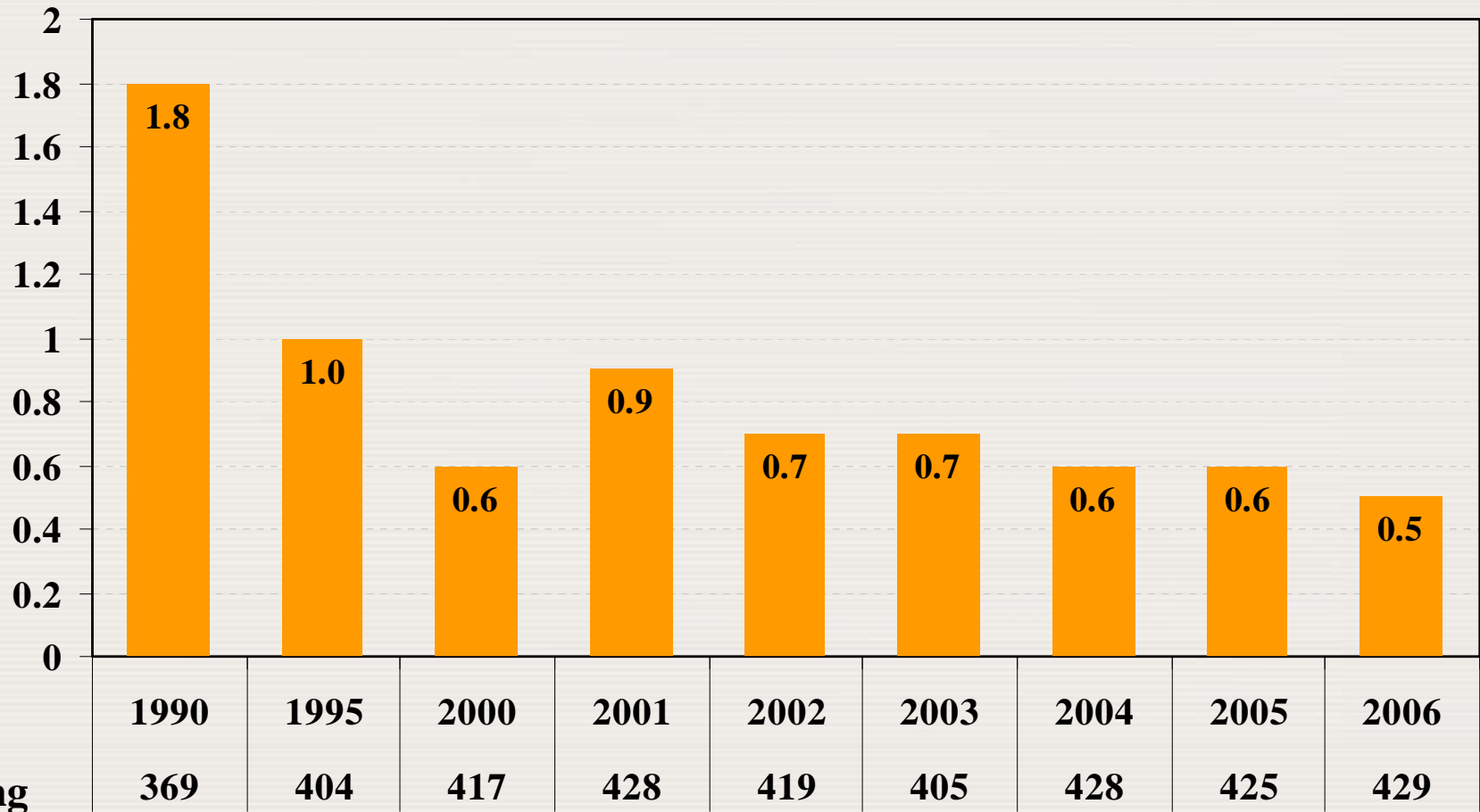
- competitiveness and economic efficiency
- energy supply security
- fossil-fuel prices
- increasing environmental concerns:
 - regional air quality (esp. East/Southeast Asia)
 - party or graduation to climate change mitigation – post-Kyoto agreement
 - towards sustainable (energy) development
 - non-fossil alternatives yet to improve

2. Operating fleet: Improving economic performance

Performance of older generation reactors
steadily improving
despite or due to ever stricter safety regulations:

- more preventive maintenance
- fewer unscheduled stoppages
- increasing capacity factors

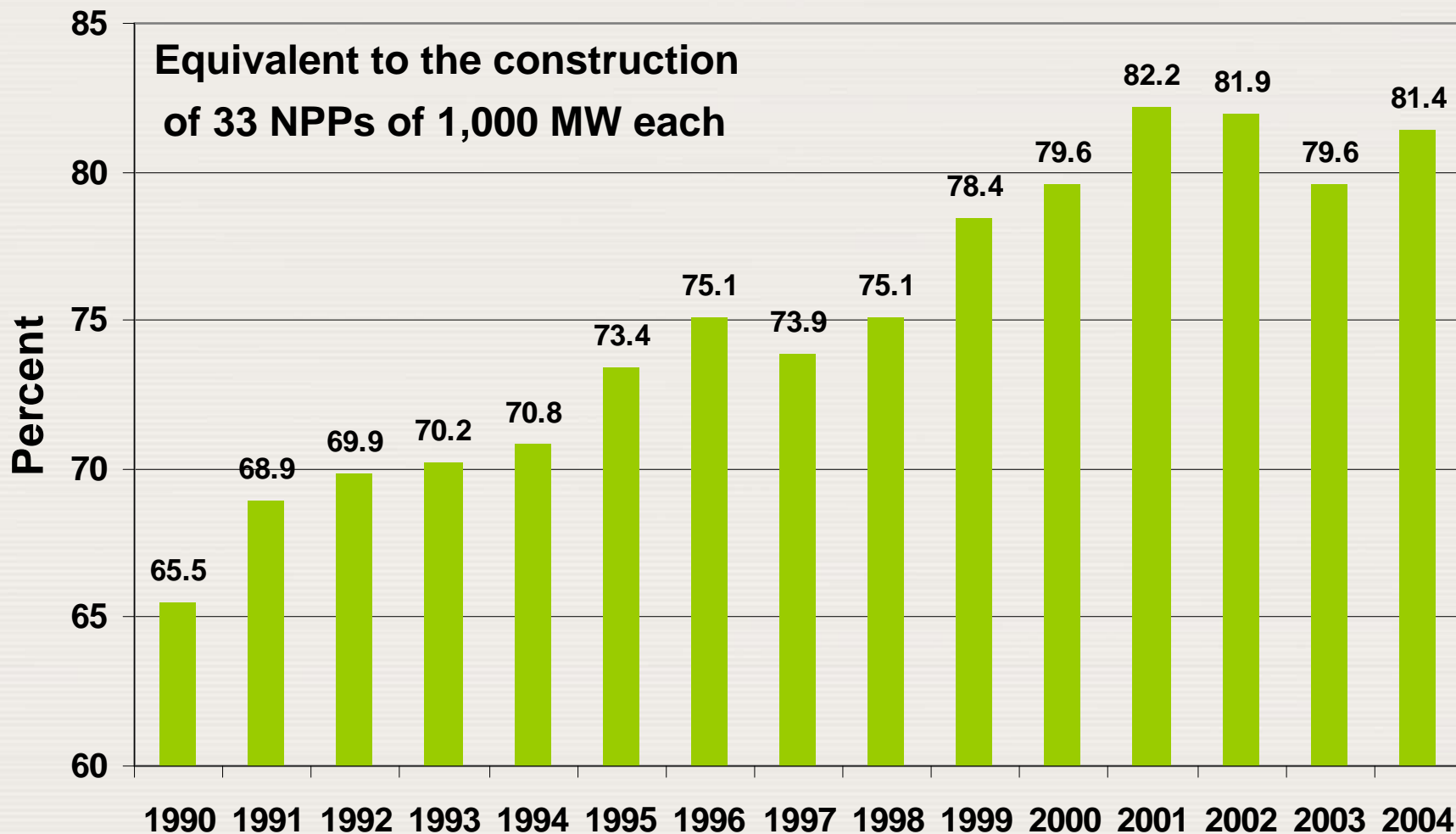
2. Operating fleet: Unplanned scrams per 7000 hours critical



■ unplanned scrams per 7000 hours critical

2. Operating fleet:

Energy availability factor



2. Operating fleet:

Improving economic performance

Licence extensions:

- USA: 49 already, 30-35 more
- Western Europe: mixed: extensions-phase-out
- Eastern Europe (Soviet reactors): extension vs shutdowns

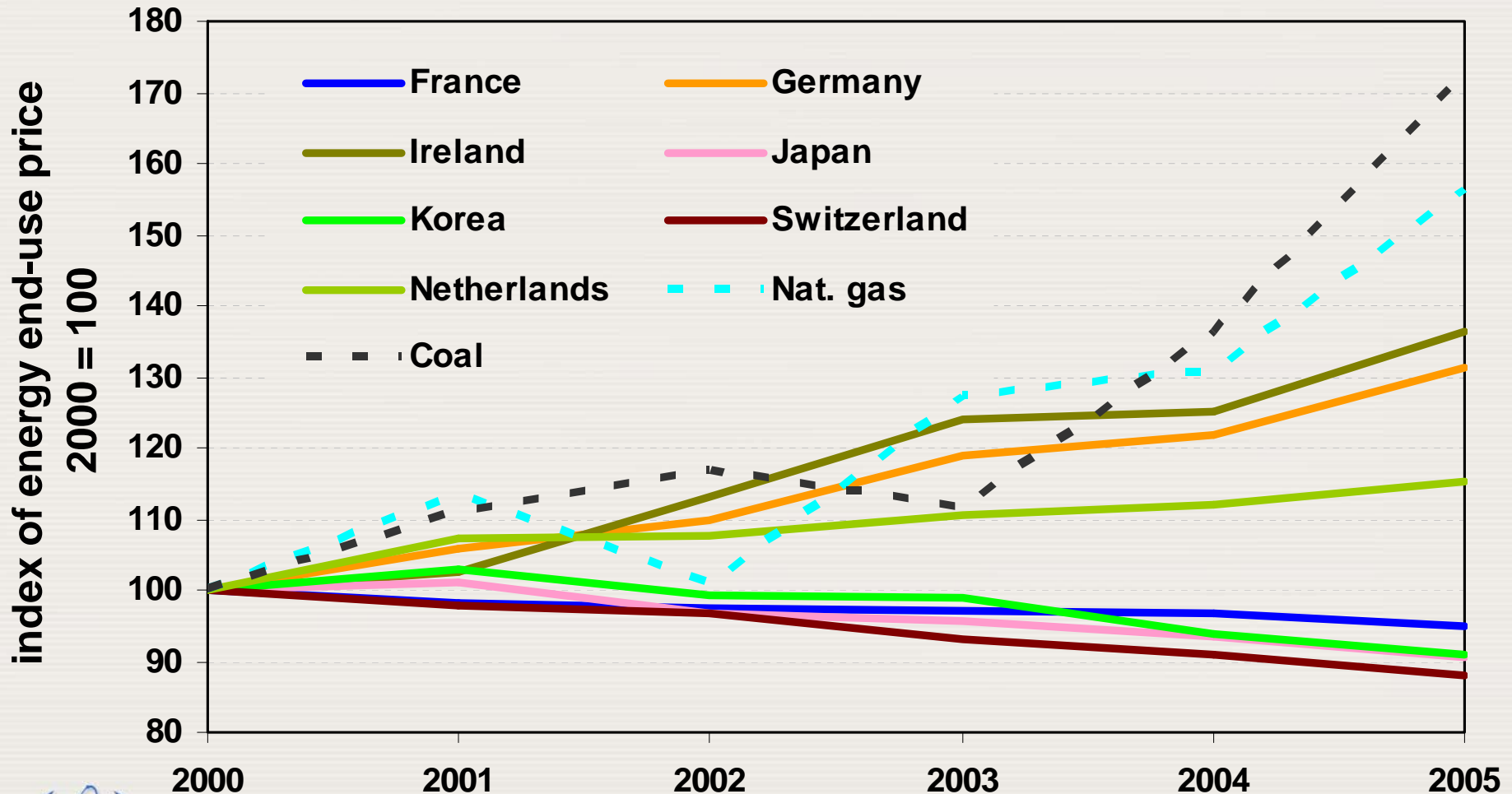
Cost of refurbishing << newly built

Highly competitive: investments amortized

Cash cows: Belgium: €250M special tax for NOs

2. Operating fleet

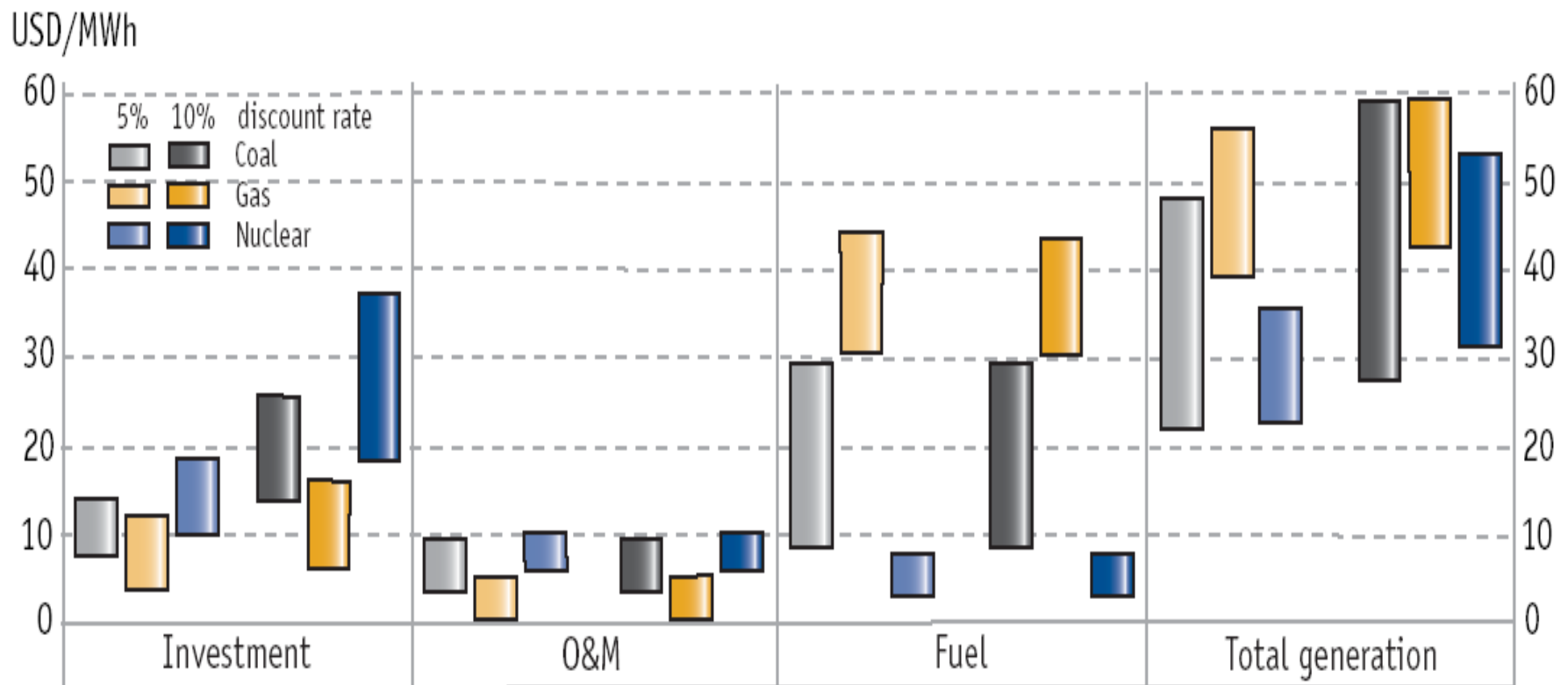
Advantage N?



3. New construction: Recent cost estimates

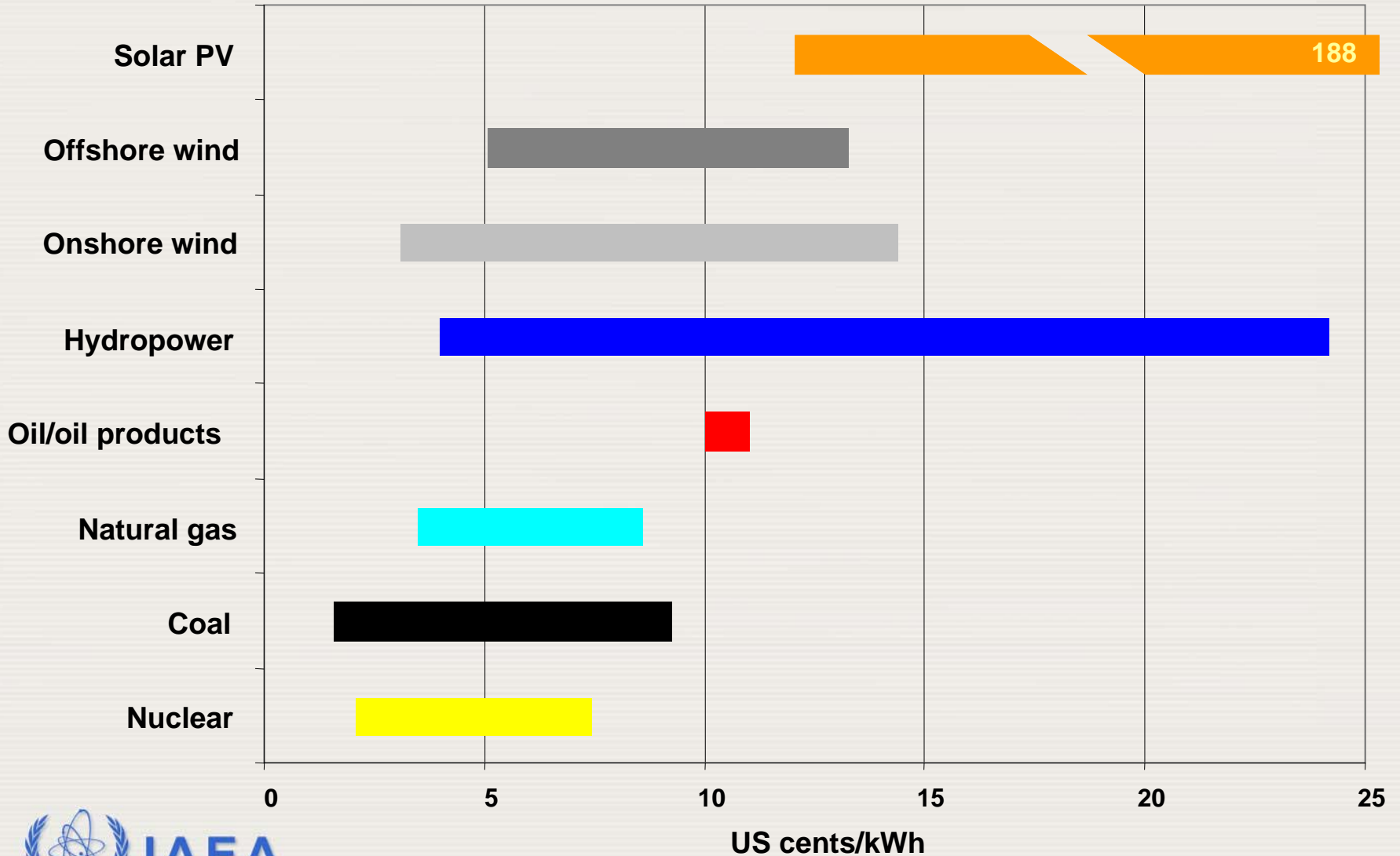
Source: OECD NEA/IEA: 2005 Update

Figure 3.10 – Range of levelised costs for coal, gas and nuclear power plants (USD/MWh)



3. Recent cost estimates

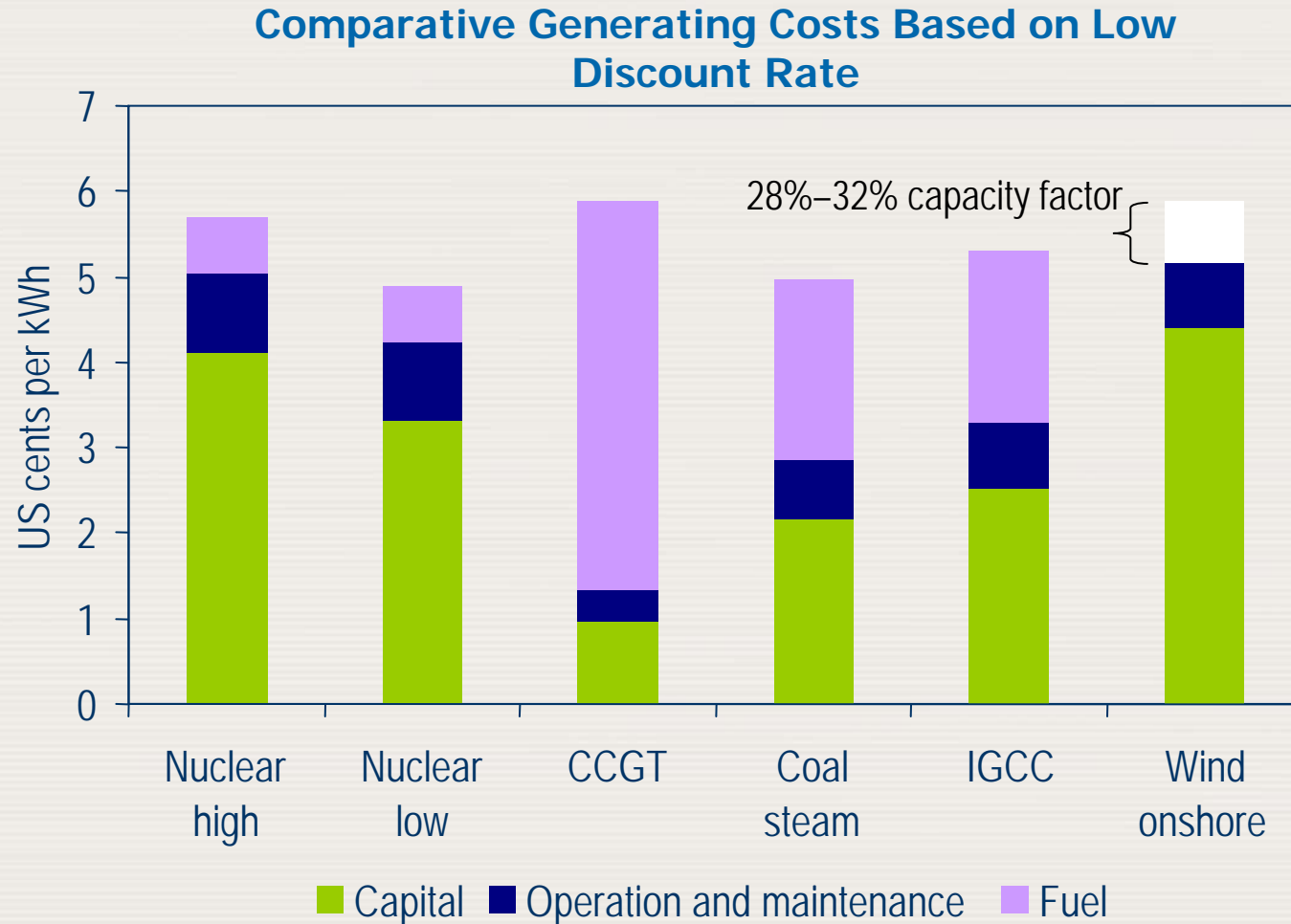
8 studies, IEA



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Source: Adapted from eight recent studies

3. Recent cost estimates Compositions



Nuclear could compete effectively with other fuel options, but public concerns over safety, waste disposal & risk of proliferation need to be addressed

4. Externalities and public goods

Externalities: interactions between actors without compensation, positive or negative (Negative: overproduced)

Public good: non-rivalled, non-excludable (underprovided)

Energy: negative externalities – harmful emissions, discharge of wastes into

- soils: degradation (erosion, salinization)

- water: heat, nutrient load

- atmosphere: local – regional – global



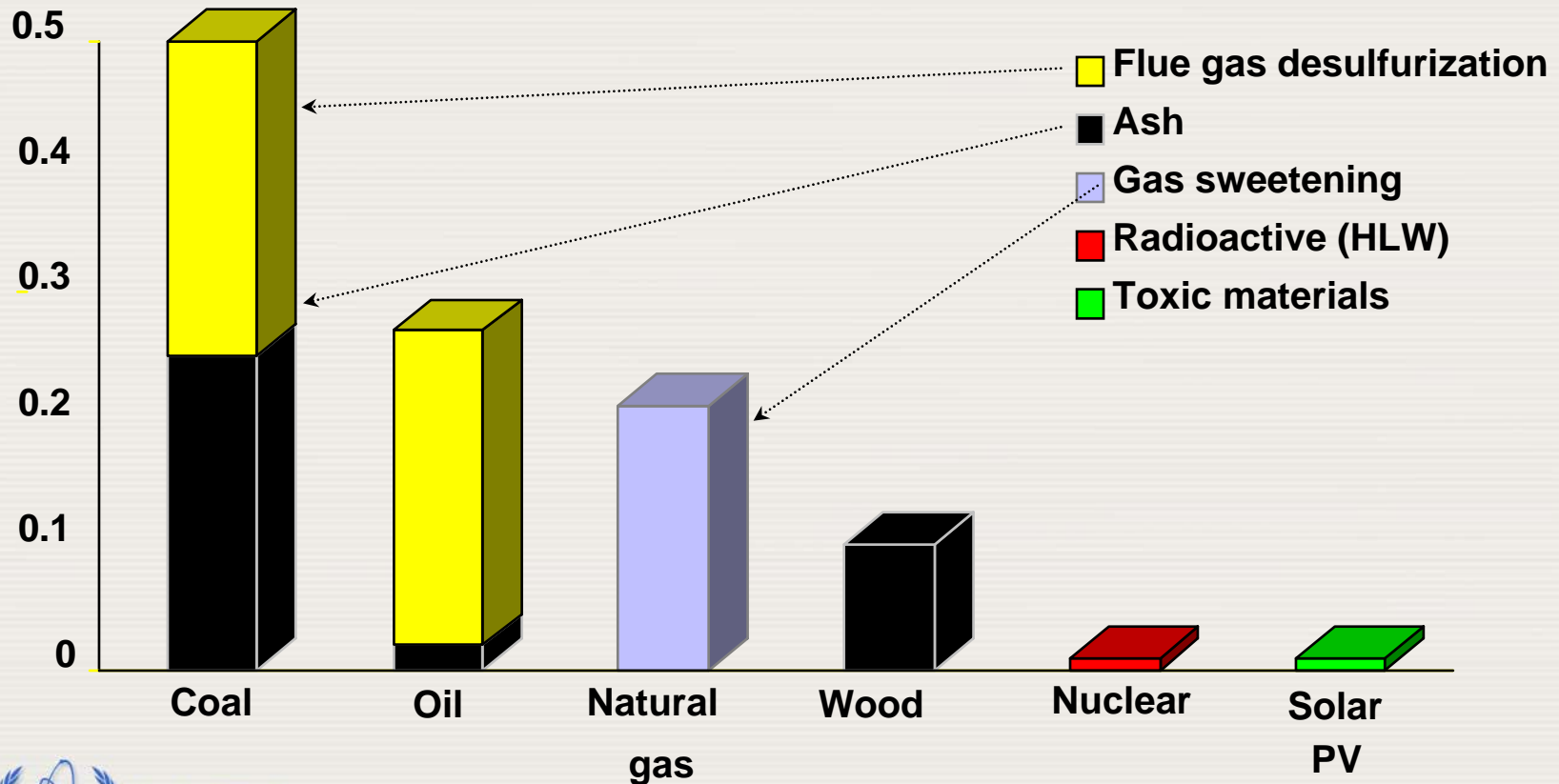
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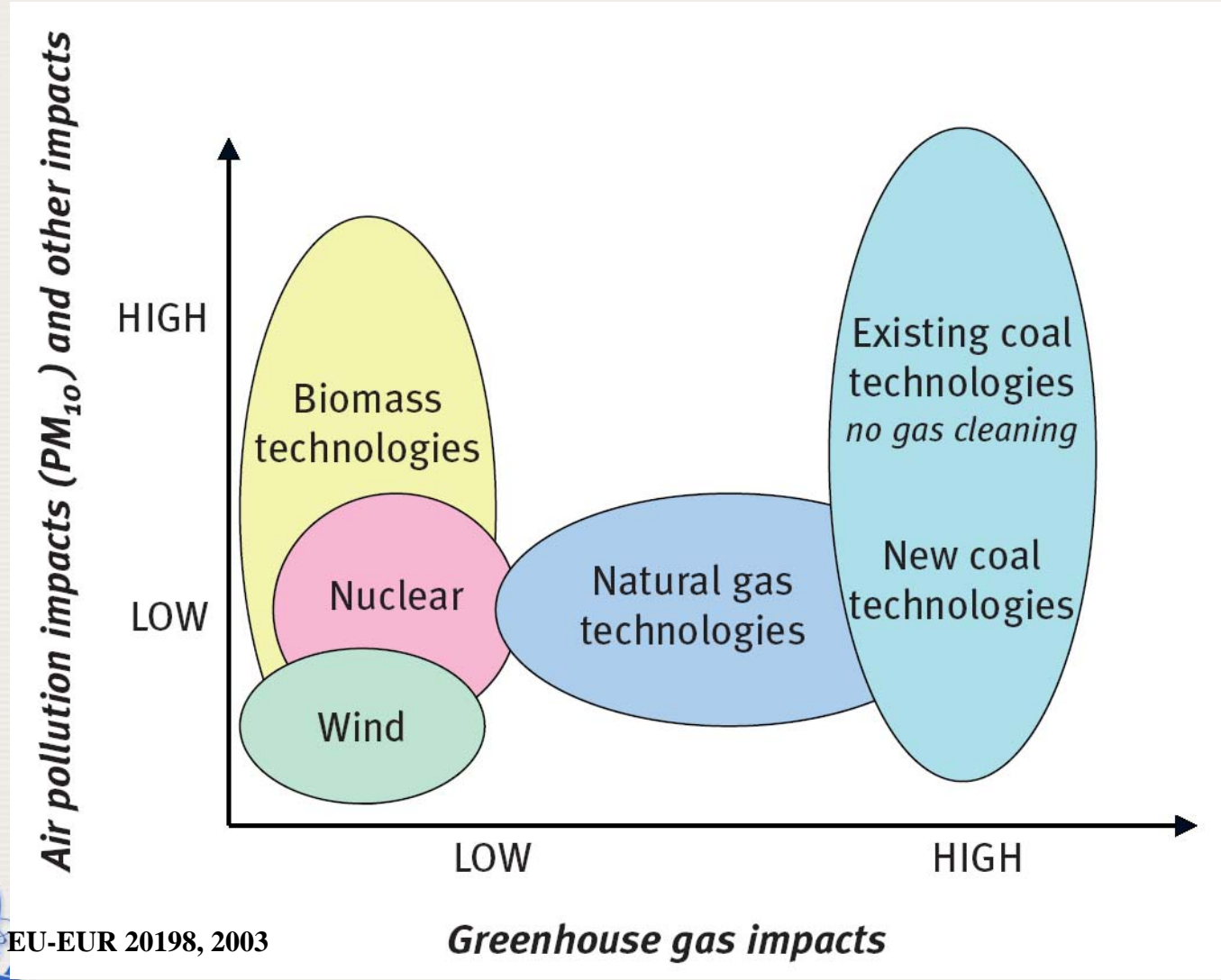
Gap between private cost and social cost

4. Externalities and public goods: Wastes in Fuel Preparation & Plant Operation

Million tonnes
per GWe yearly



4. Externalities and public goods: Atmospheric emissions



4. Externalities and public goods

Internalization: incorporating the external costs into private costs →

closing the gap between social and private costs

Fossil sources: regionally diverse picture

Local and regional: OECD internalized

developing countries: some initial steps

GHGs: Kyoto Protocol: most Annex I: initial steps

developing countries: no limitations

CC: GHGs by 2050: +130%; stabilize: -50/-80%

4. Externalities and public goods

Nuclear power:

most externalities internalized:

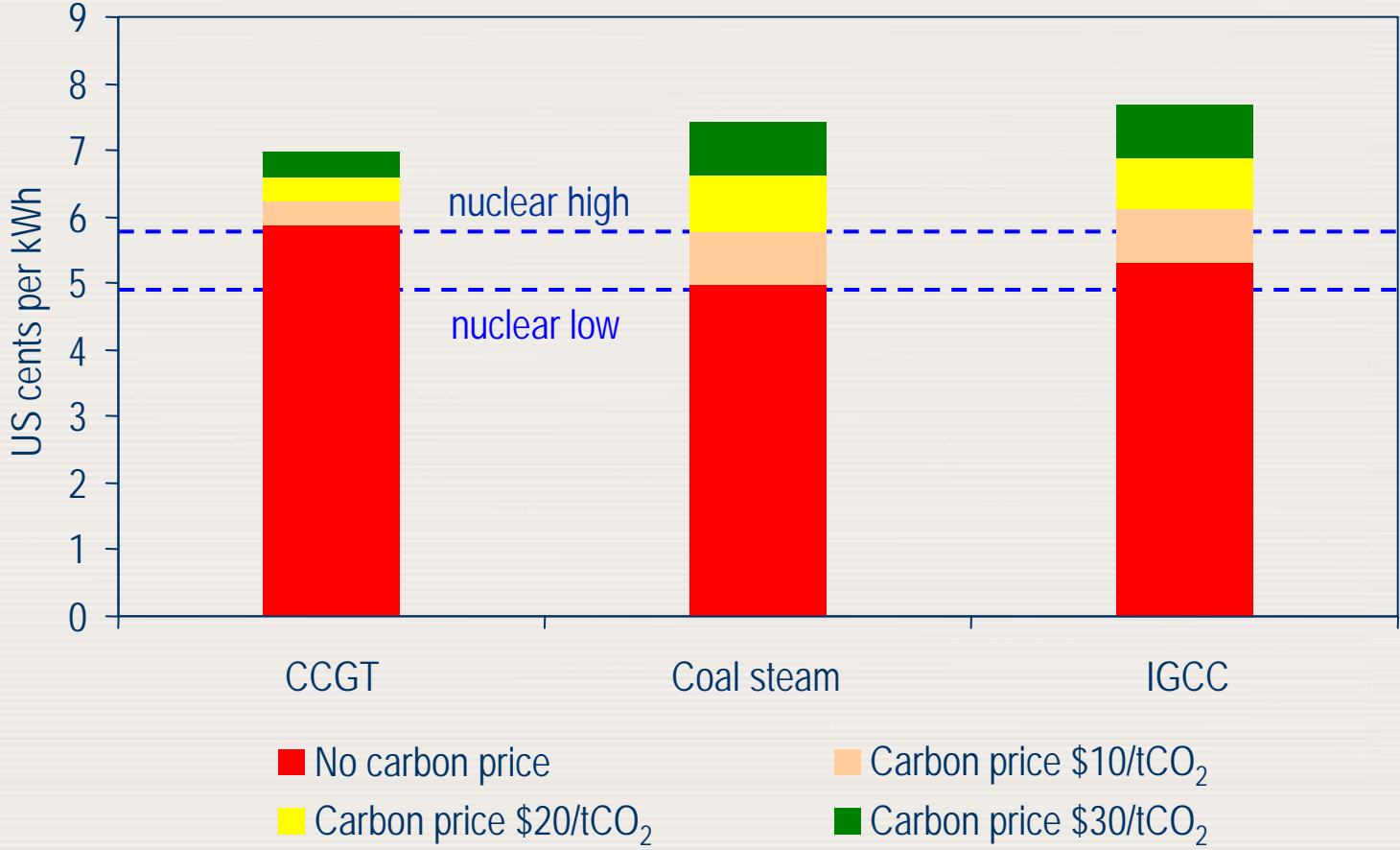
- security and safety measures
- waste management and decommissioning

Public goods remain unaccounted for:

- energy supply security
- foreseeable prices: long-term price level
- stable prices: non-volatility

4. Externalities and public goods: CO2 penalty

Comparative Generating Costs Based on Low Discount Rate



A relatively modest carbon penalty would significantly improve the ability of nuclear to compete against gas & coal

4. Externalities and public goods: Supply security: focus on nuclear

Supply security: many aspects and targets; here:

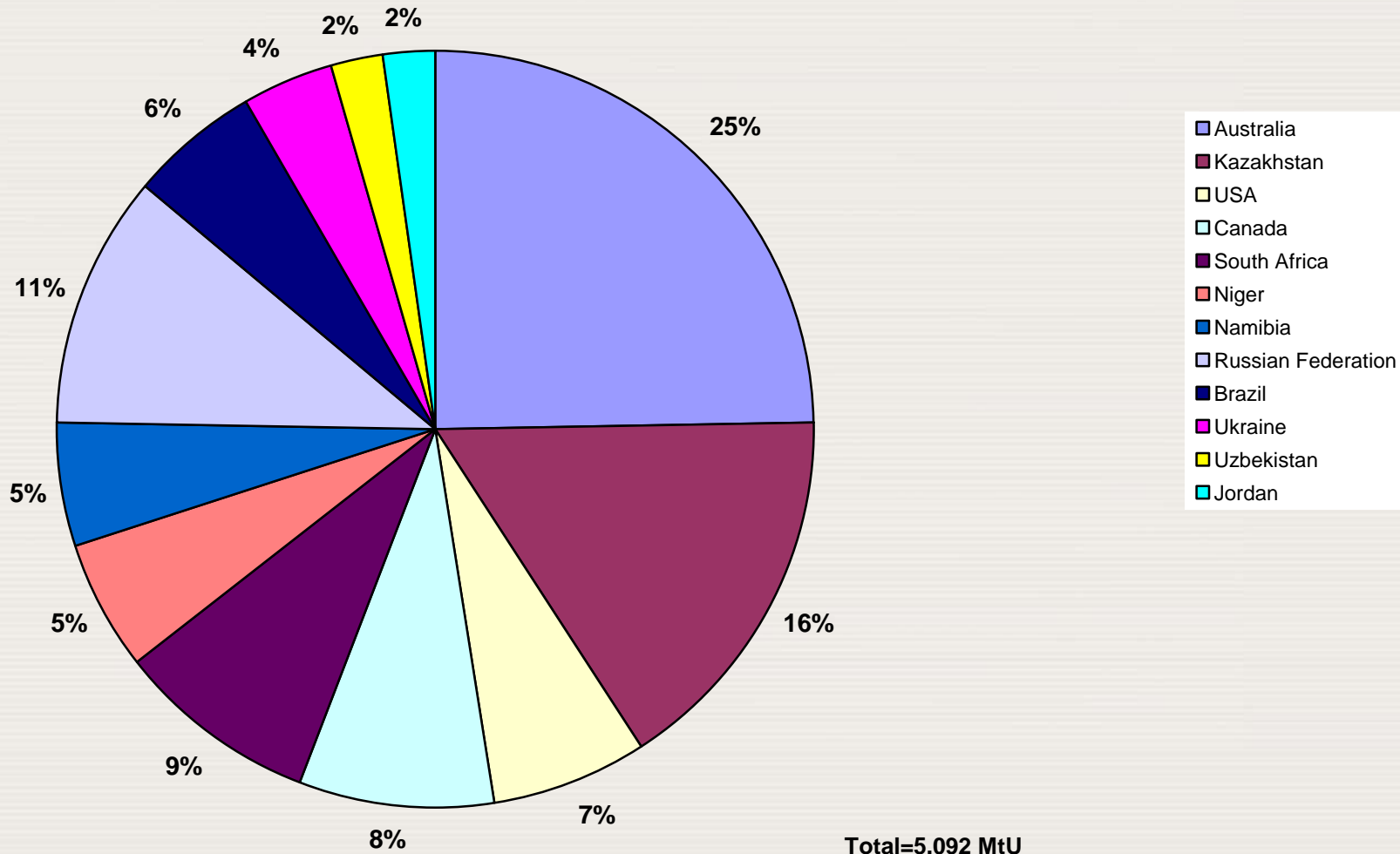
Domestic vs imported energy sources

Self sufficiency - Import dependence:

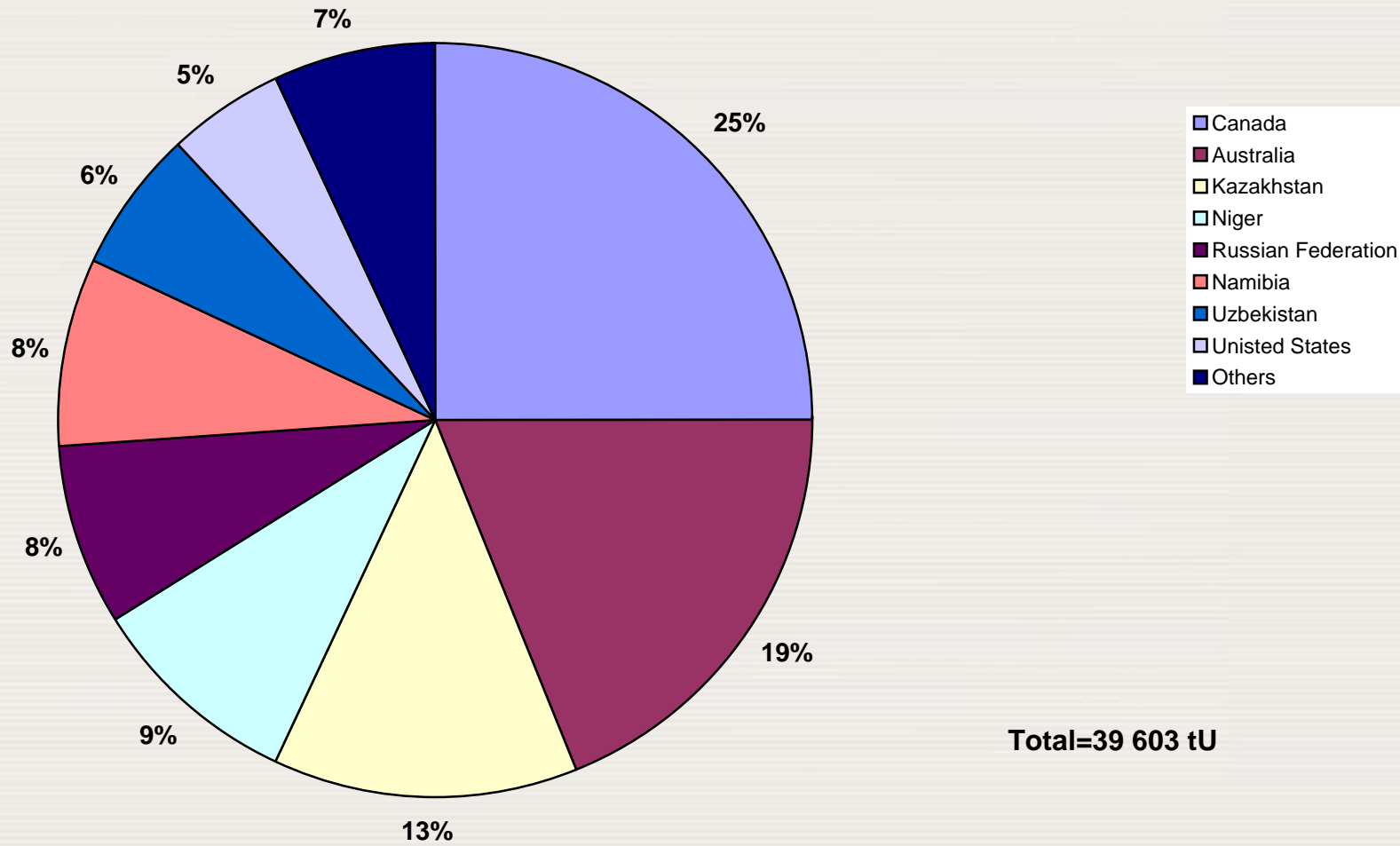
Even if imported: nuclear counts as domestic

- Uranium from many regions
- Competitive fuel market
- Easy to store next load (no short-term risk)

4. Externalities and public goods: Supply security: focus on nuclear



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4. Externalities and public goods: Supply security: focus on nuclear

Fuels price levels

Fossil sources:

competing uses, cheap technologies, fast growing demand:

→ elevated (relative to \$30/b oil) likely to remain and increase over the long term

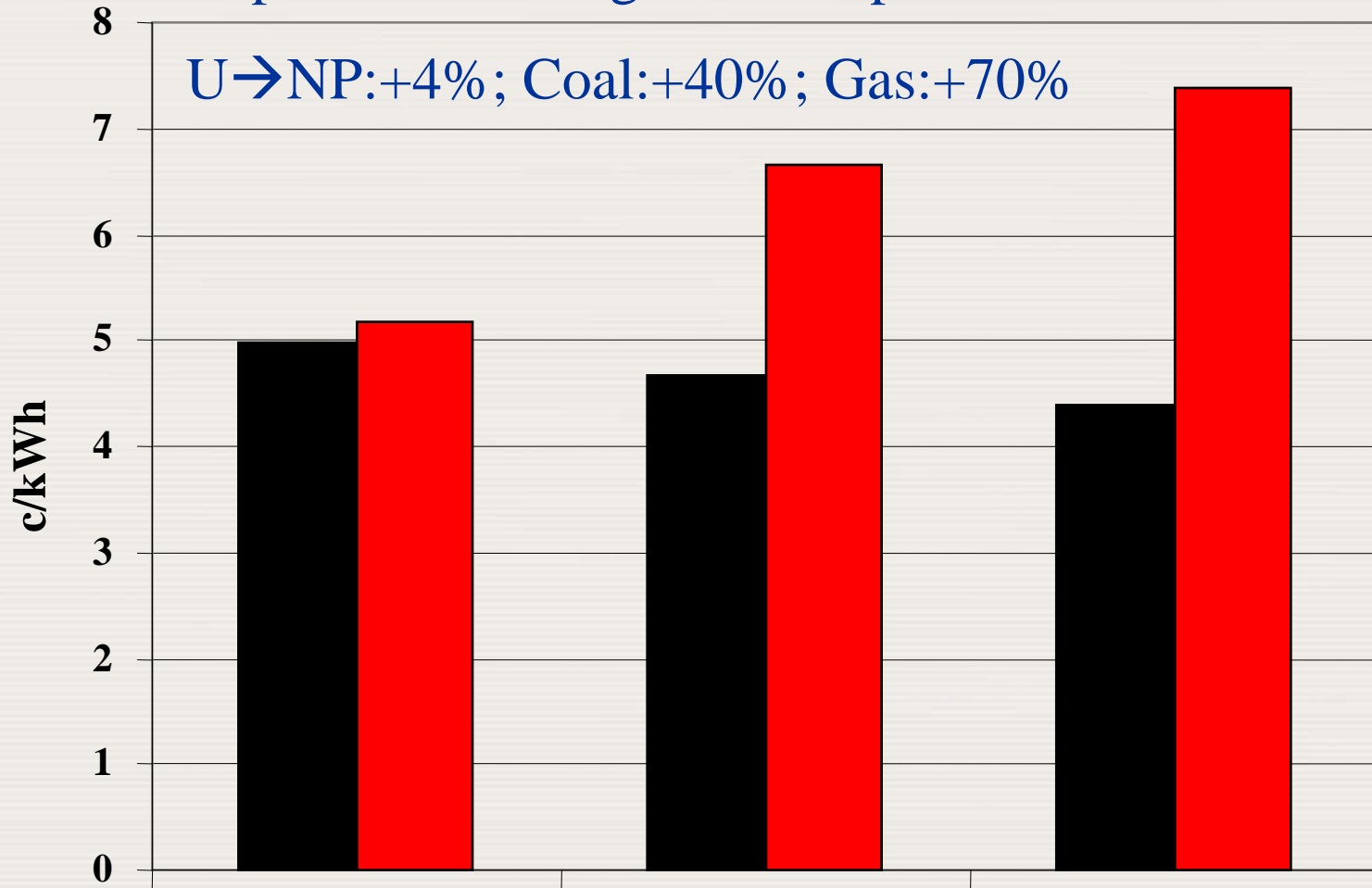
Uranium:

no alternative use, abundant resources

→ low prices (\ll \$130/kg) likely to remain

4. Externalities and public goods: Supply security: focus on nuclear

Impact of doubling resource prices:



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Nuclear

Coal

Natural gas

4. Externalities and public goods: Supply security: focus on nuclear

Nuclear can address several aspects of supply security

- adds to supply mix: new resource/technology
- low-risk fuel supply: disperse, stable regions
- long-term low price: abundant resource base
- low volatility risk: fuel cost small share of electricity price

Currently: these benefits not visible to private investors ← public goods, underprovided

4. Externalities and public goods

Local/regional air pollution and climate change:
tiny emissions from operation;
low emissions on life-cycle basis

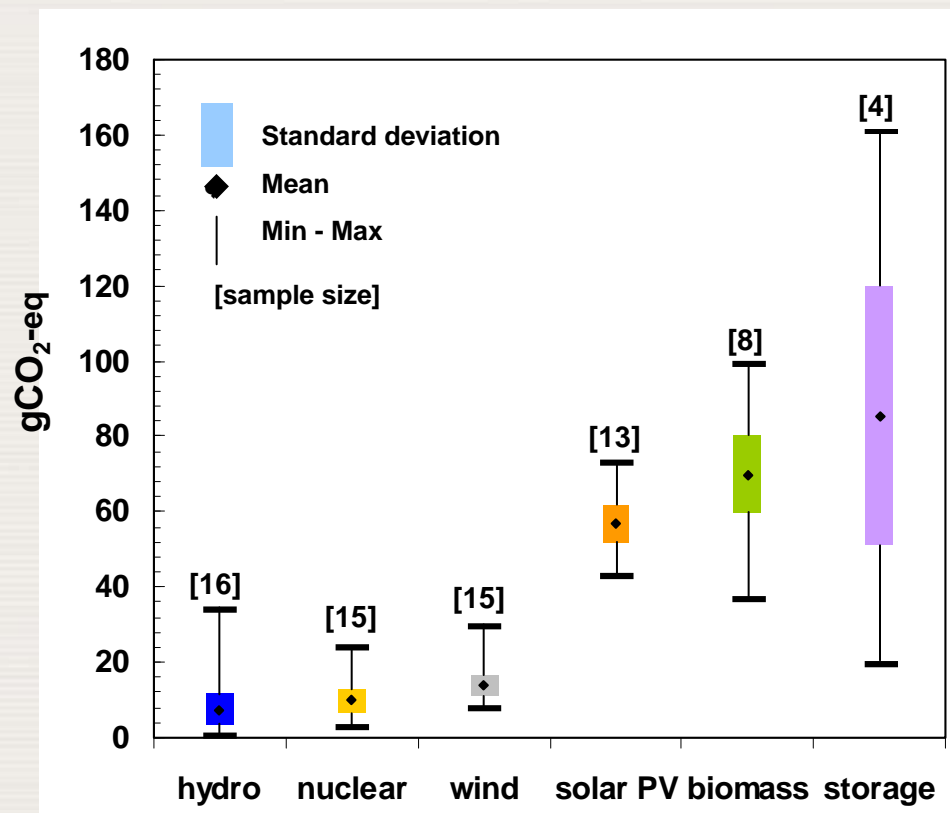
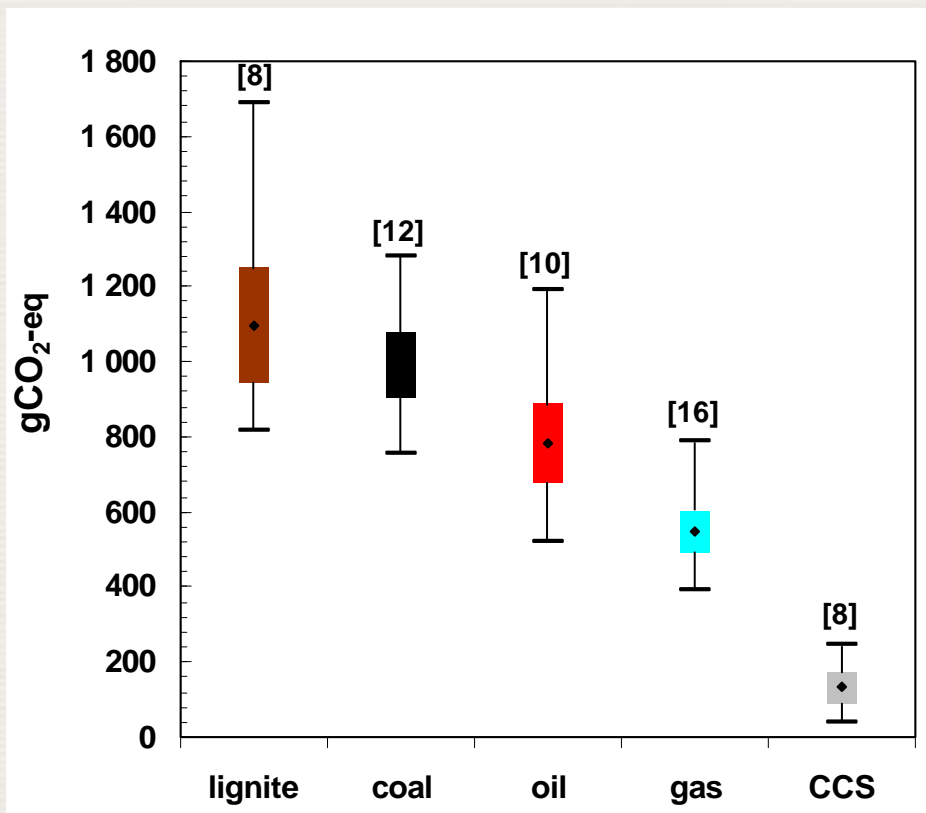
Combining supply security and climate change:

- coal: SS+ (if domestic); CC– (even with CCS)
- gas: SS +/- (dom/imp); CC +/- (replace coal/oil)
- nuclear: SS+ ; CC +

Comparison of life-cycle GHG emissions:

4. Externalities and public goods

Life cycle GHG emissions of different electricity generating options



Nuclear power: Very low lifetime GHG emissions make the technology a potent climate change mitigation option

4b. IAEA assistance to interested MSs

- *Energy system planning* for a national energy strategy:
 - Nuclear power planning must *not* occur *in isolation*
 - *Integrated* energy systems approach
 - Demand and supply – *technology neutral*
 - If nuclear power is part of the *optimal supply* mix:
- Planning for nuclear *infrastructure* is the next logical step

4b. IAEA assistance to interested MSs

➤ **Model for the Analysis of Energy Demand**



➤ **Model for Energy Supply System Alternatives and their General Environmental impacts**



➤ **Financial Analysis of Electric Sector Expansion Plans**



➤ **Simplified Approach for Estimating Impacts of Electricity Generation**



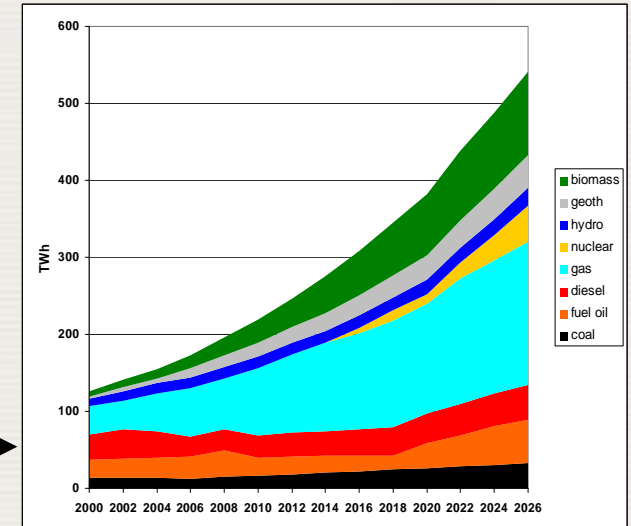
MESSAGE: Model for Energy Supply System Alternatives and their General Environmental Impacts

INPUT

- Energy system structure (including vintage of plant and equipment)
- Base year energy flows and prices
- Energy demand projections (MAED)
- Technology and resource options & techno-economic performance profiles
- Technical & policy constraints



OUTPUT



- Primary and final energy mix
- Emissions and waste streams
- Health and environmental impacts (externalities)
- Resource use
- Land use
- Import dependence
- Investment requirements

4. Costs + Externalities + public goods: Energy planning tools - Optimal portfolios

Putting technical and economic performance data into national energy planning models:

nuclear often part of optimal solution -
especially if CC and SS accounted for

So why difficult to implement?

5. Economics to financing

Positive spillovers of NP:

- low GHG emissions
- energy supply security
- price stability and predictability
- externalities already internalized
- towards sustainable energy
- synergies with intermittent sources

5. Economics to financing

Make visible to investors:

- negative externalities of other sources
- public-good benefits of nuclear

Feasible policy instruments:

depend on electricity market characteristics

Easier for state-owned or regulated monopolies

Possible for deregulated: C-tax, auctioned

emission permits, auctioned import permits

Fixing these: finance easier but still challenge



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large asset at risk for a long time

5. Financing NP

IAEA report

2006: GC request for report on *financing* nuclear power as an option in meeting the energy needs of interested *developing countries*

NE task force:

- literature search,
- consultancy mtg involving reps of financial institutions, vendors, nuclear sector experts
- peer review of draft paper
- published revised report in 2008

5. Financing NP

Issues and non-issues

Main conclusions:

Non-issue: capacity for investment:


2006: US\$ 4.2 trillion raised in the *global capital markets*; of which

5% or US\$230 billion invested in power industry

The issues: *economic, political and operational factors* including *regulatory and licensing* certainty, plants being built *on time and on budget*, and, most importantly, **revenues covering costs**

Usual sources for debt and equity (some precluded for LDCs):

- *Internal funding from government* budgetary allocations, government grants, collection of revenues, and fees
- *Domestic and international capital market* issues of financial instruments

- *Soft loans, grants, or other type of directly allocated development funds from international aid organizations and development banks, and/or other government sponsored aid programs*
- *Funds provided under Export Credit Agencies (ECAs) insurance schemes or institutions like OPIC (US: Overseas Priv Inv Corp) and MIGA (WB: Multilat Inv Guarantee Agency), although these only insure the supplier of exported equipment; project sponsors do not get paid in case of delays or default*
- *Equity investments and commercial loans (eg.  IAEA Finland)*

Innovation in financing at the practical level means:
packaging existing financial instruments in new and different ways, such as public-private partnerships (ppp),
tailored to the needs of the case, with
risks identified and contractually allocated to parties best suited to manage such risks (including governments)

Three major concerns in financing nuclear:

- regulatory certainty
- lack of recent experience (on the part of investors and financiers)
- degree of government involvement (political, back-end of fuel cycle, proliferation, liability)

Addressing these concerns and properly allocating the risks is the key to successful financing

2008 financial crisis: dust settles, rearrangements, tighter regulations, revised/new hedging tools (e.g., CDS: credit-default swap)

6. Main messages

Economics improving:

- operating fleet: better managed, high availability, amortized
- license extensions: uprates, low-cost
- new NPPs: economically competitive, but not all advantages visible to investors
- new constructions: relearning
- Gen III+ reactors: inherently safe features → simpler = safer = cheaper
- Gen IV: key objective to reduce costs
- more new builds=learning: 1 to 5: 30-35%

6. Main messages

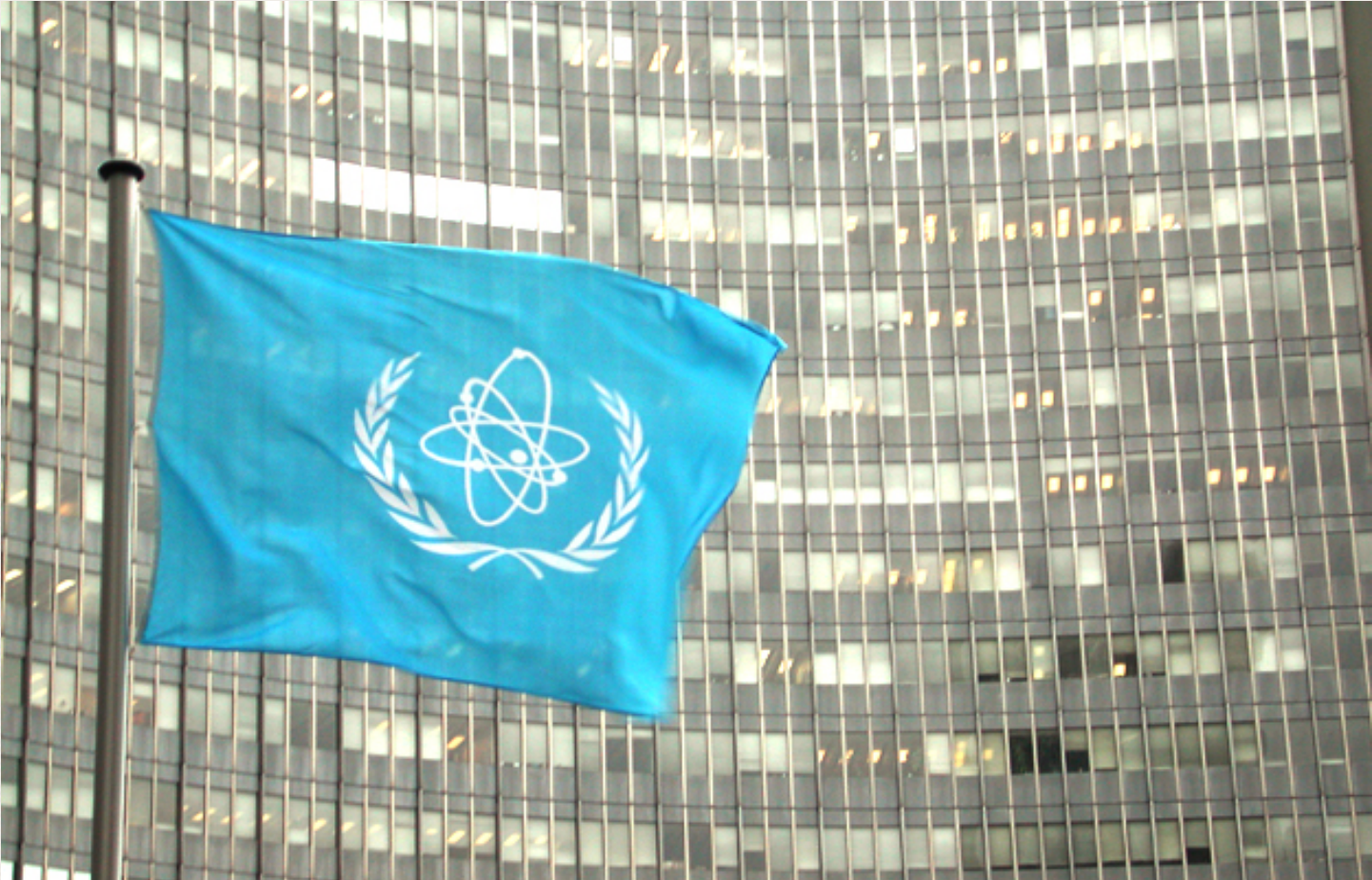
Financing prospects improving:

- *NP* investors *learning* risk allocation and suitable *financing* schemes
- *finance* industry *learning* nuclear power:
state of technology and risks

Will need to get together to reap benefits of NP

Public policy (governments) to play a role to foster socially optimal energy supply for the benefit of all

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...atoms for peace.