NERA
Economic Consulting

Global Nuclear Power Seminar

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JOI (Japan Bank for International Cooperation)
Tokyo

Insight in Economics™

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Nuclear Power – 4 Topics

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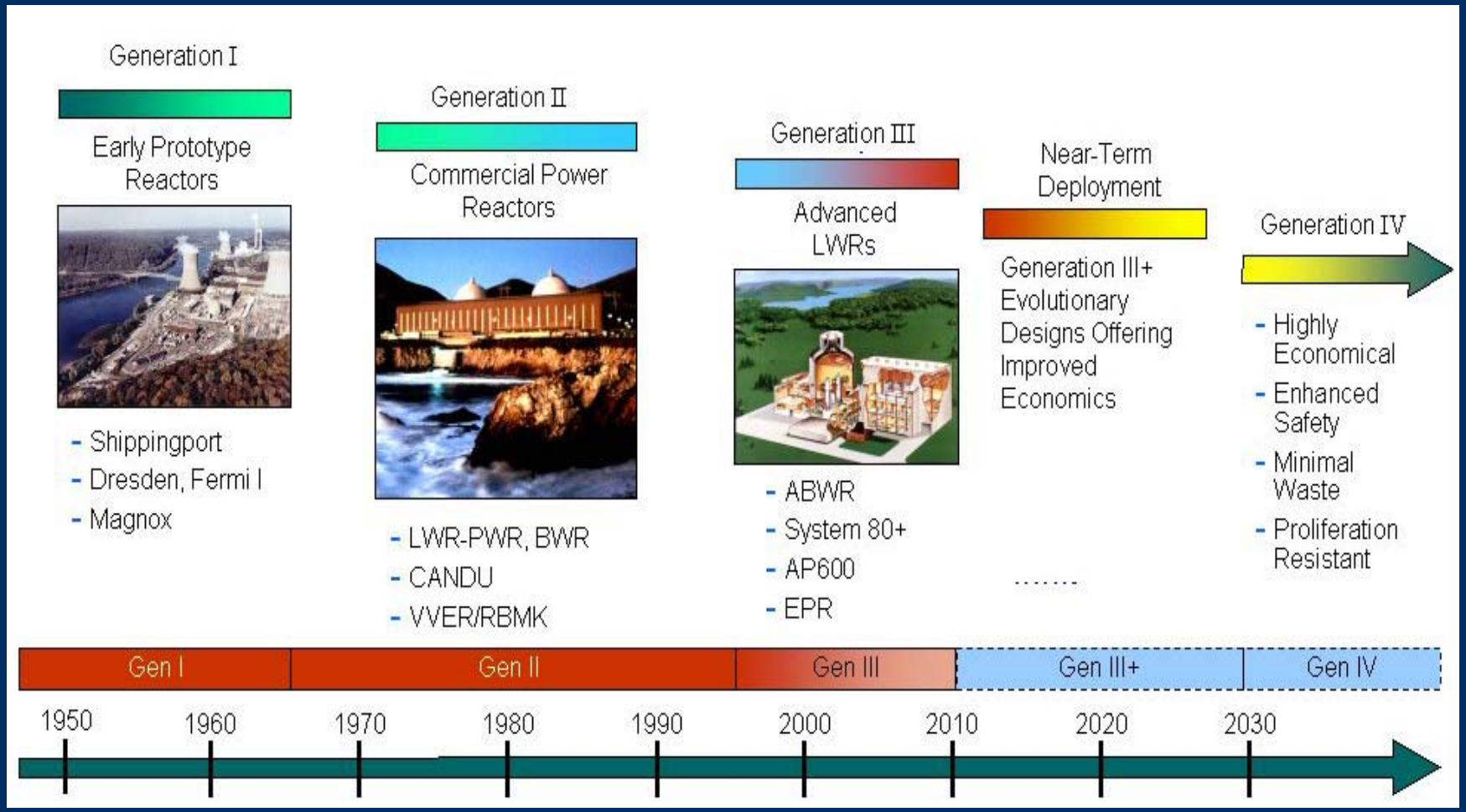
1. Global markets
2. Strategic issues
3. Role of government
4. Small reactors

1. Global markets

- Reactor designs
- Global league tables
- Nuclear costs

1. Global markets
Reactor design evolution



1. Global markets
Gen III. III+ attributes

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- Attributes of Gen III, III+ designs
  - Large size
  - Aircraft crash resistance
  - Lower Core Damage Frequency (CDF)
  - Passive safety (e.g. AP1000, ESBWR)
  - Longer refueling cycle & higher fuel burnup
  - Modular, top-down construction (e.g., ABWR, AP1000)
  - 60 year operating life
  - Load-following & part-load capability

1. Global markets
Gen II+, III & III+ reactor designs

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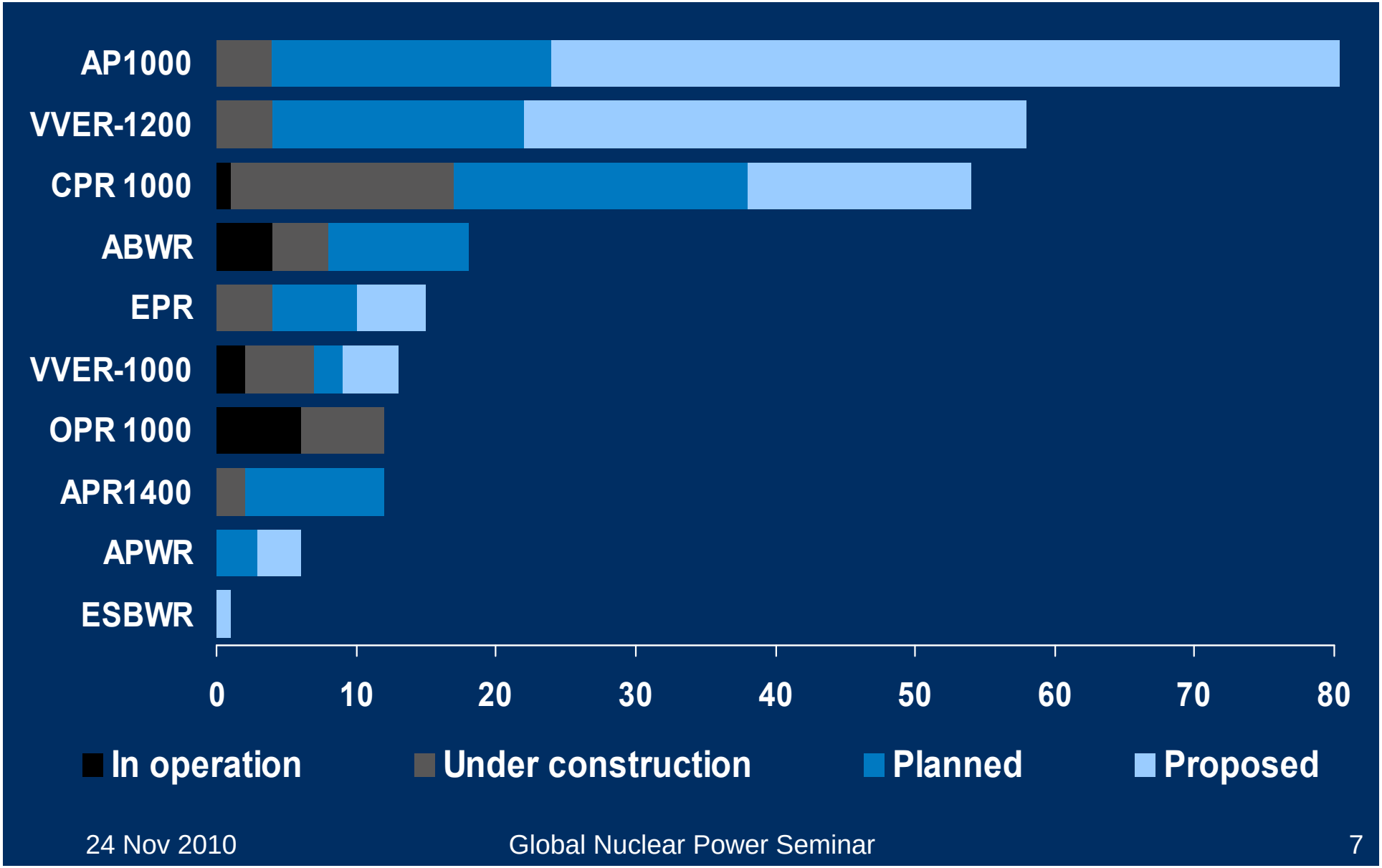
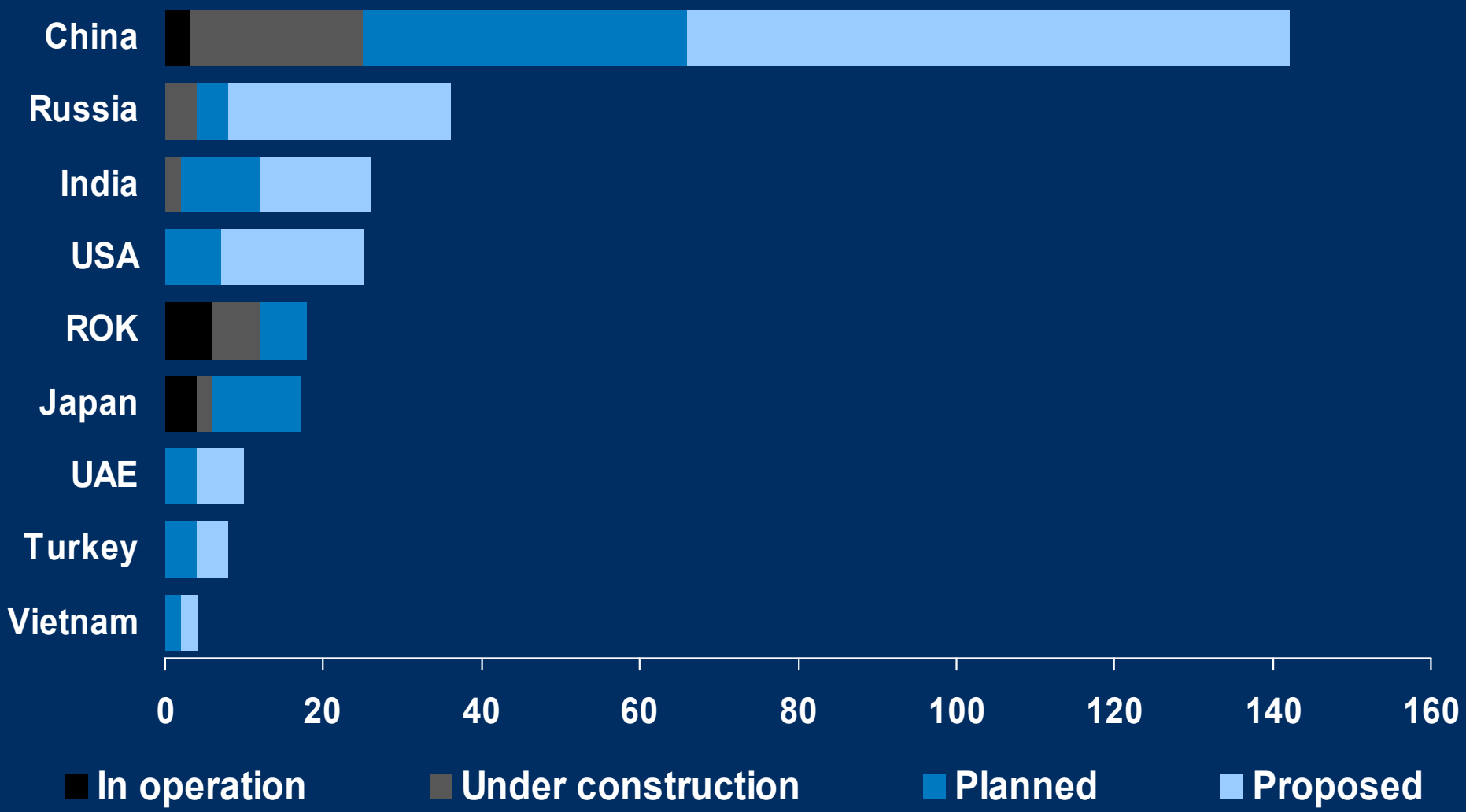
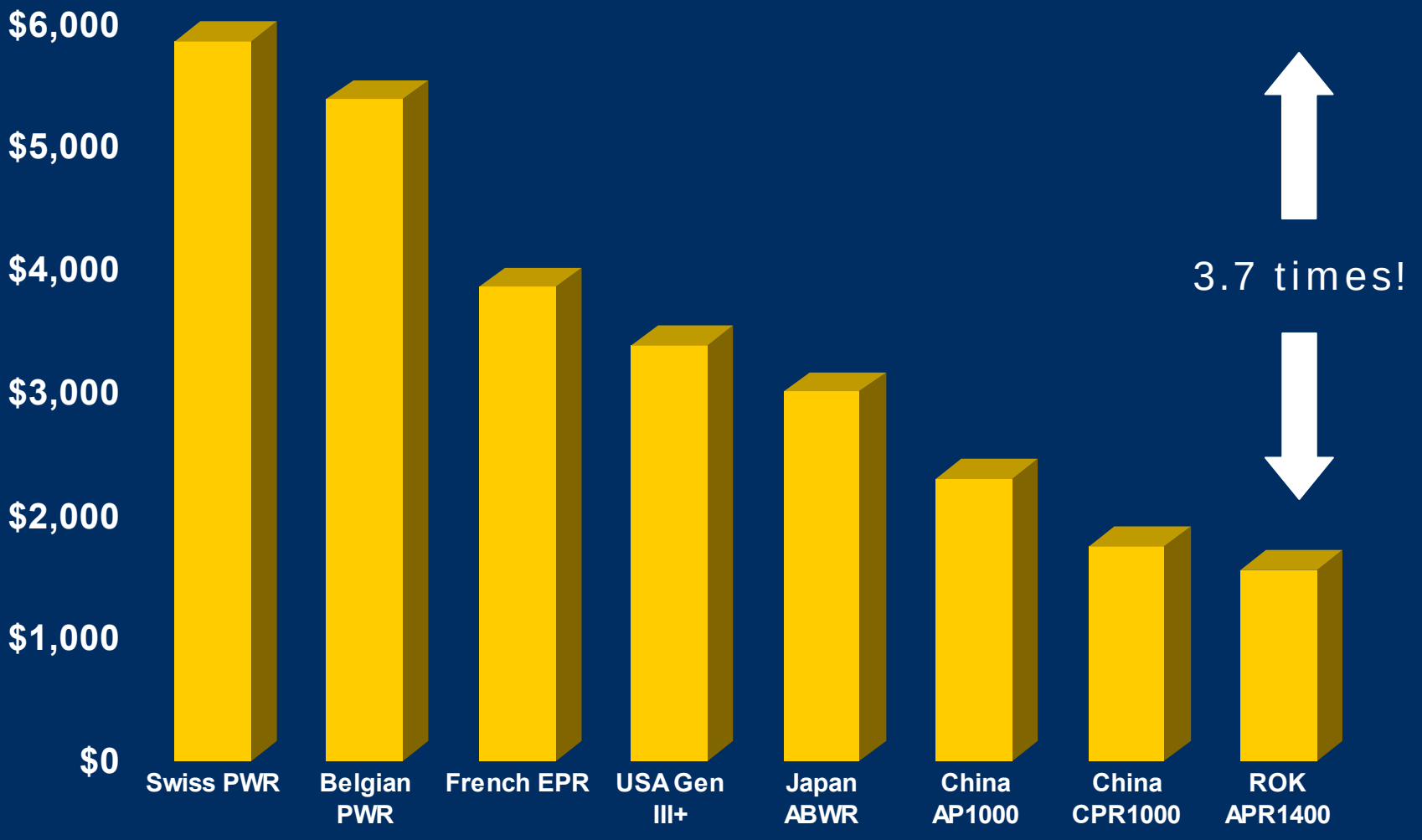


1. Global markets
Gen II+, III, III+ by country

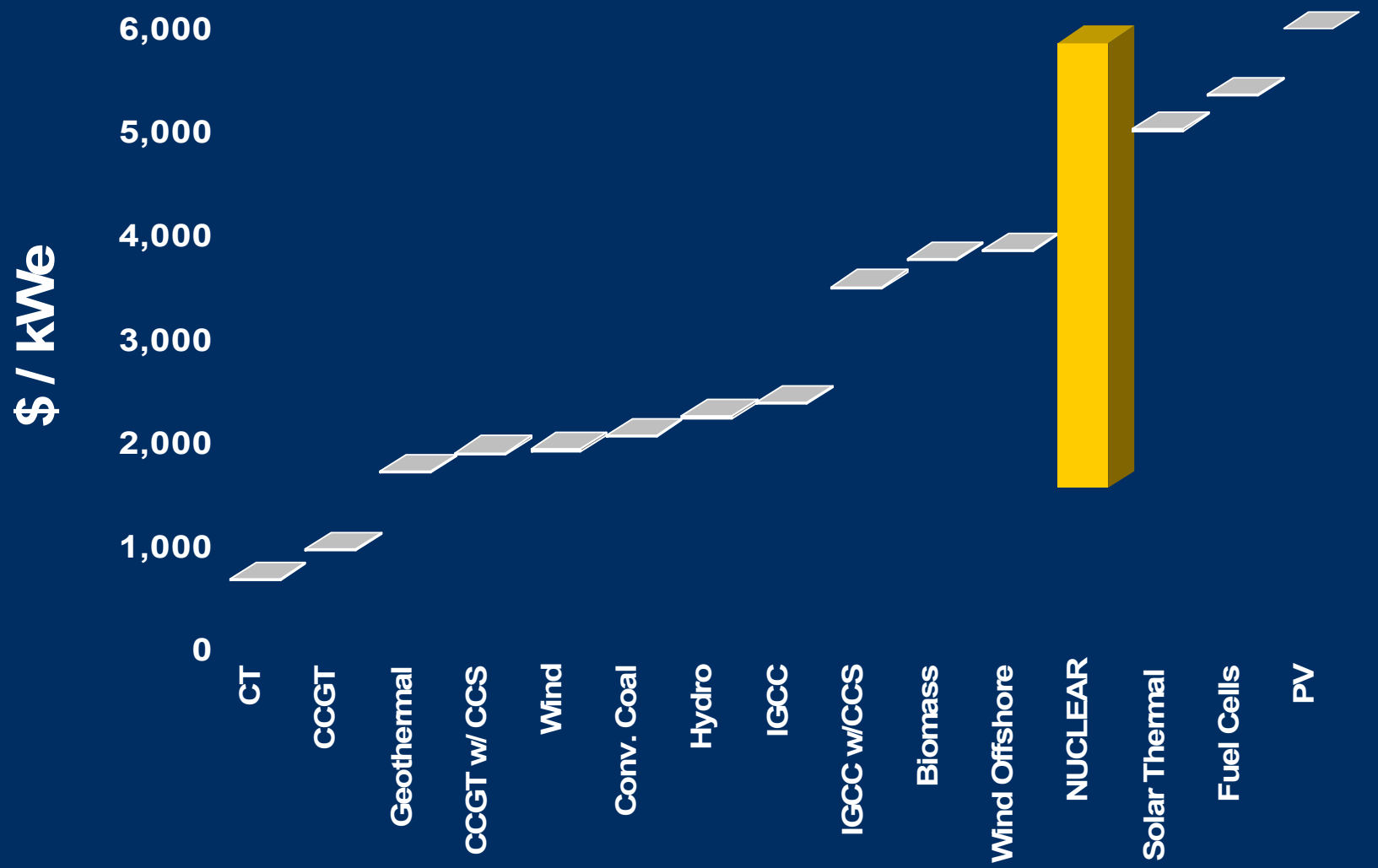


1. Global markets
Overnight capital costs



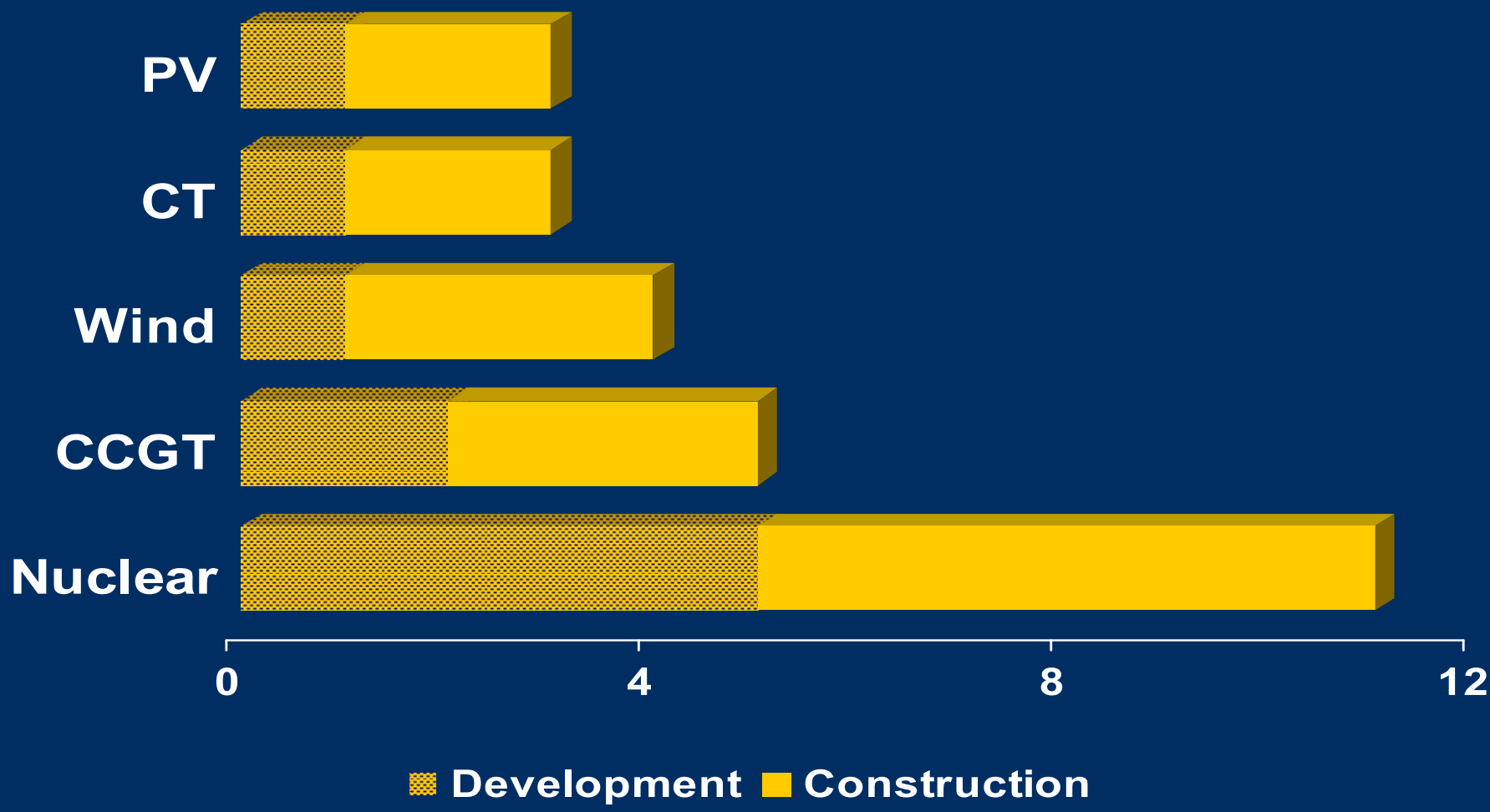
Source: OECD 2010, Table 3.7a, overnight costs in USD/kWe

1. Global markets
High overnight capital cost



Source: EIA 2009 Annual Energy Outlook; 2008 overnight cost including contingency in 2007 $/kW; nuclear = OECD Range

1. Global markets
Long lead time for nuclear

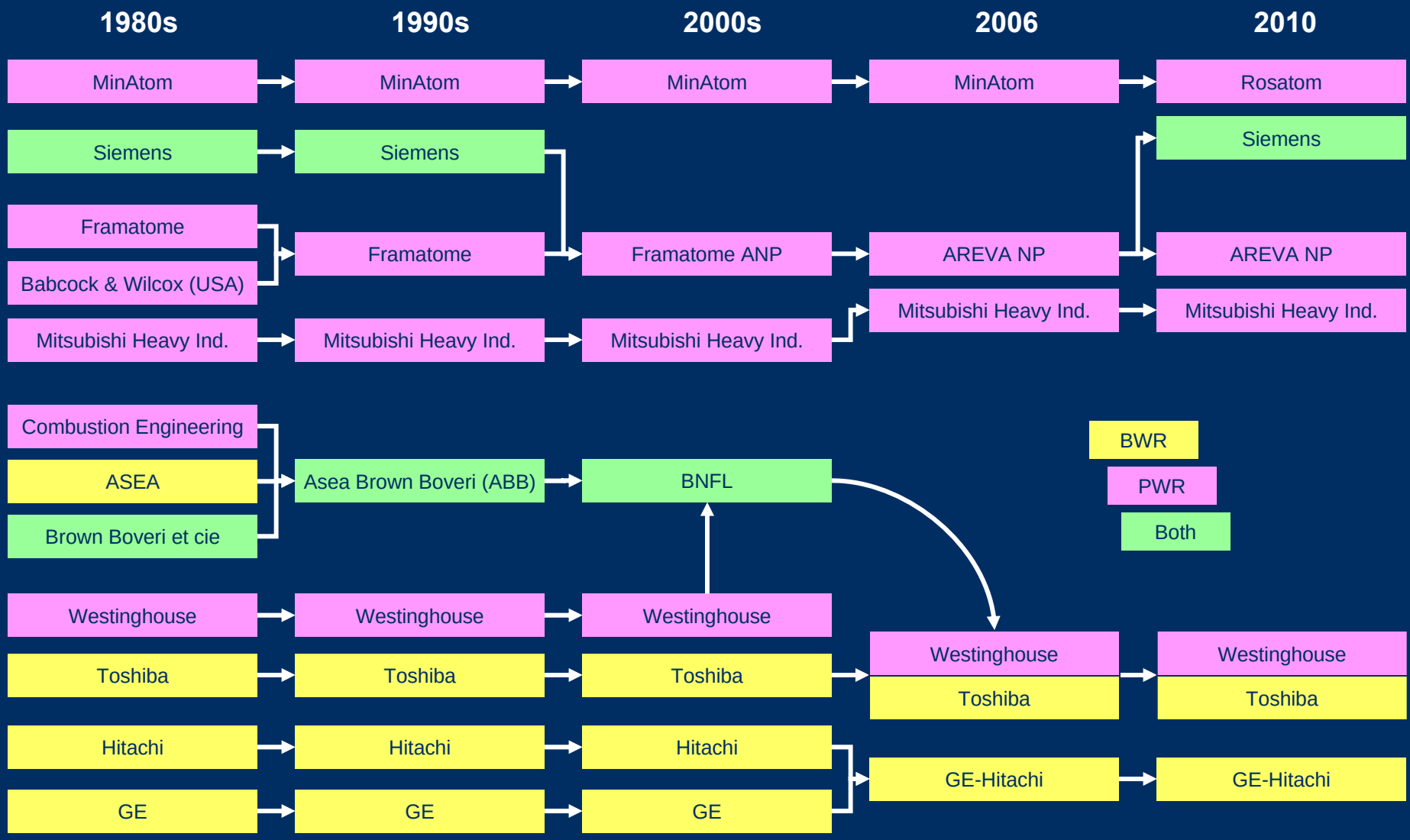


Source: EIA 2009 Annual Energy Outlook input assumptions for construction (lead time); development period is estimate

2. Strategic issues

- Consolidation
- Cost and perception of risk
- Size of nuclear build programs
- Developing countries

2. Strategic issues
Industry Consolidation



2. Strategic issues
New industry competitors

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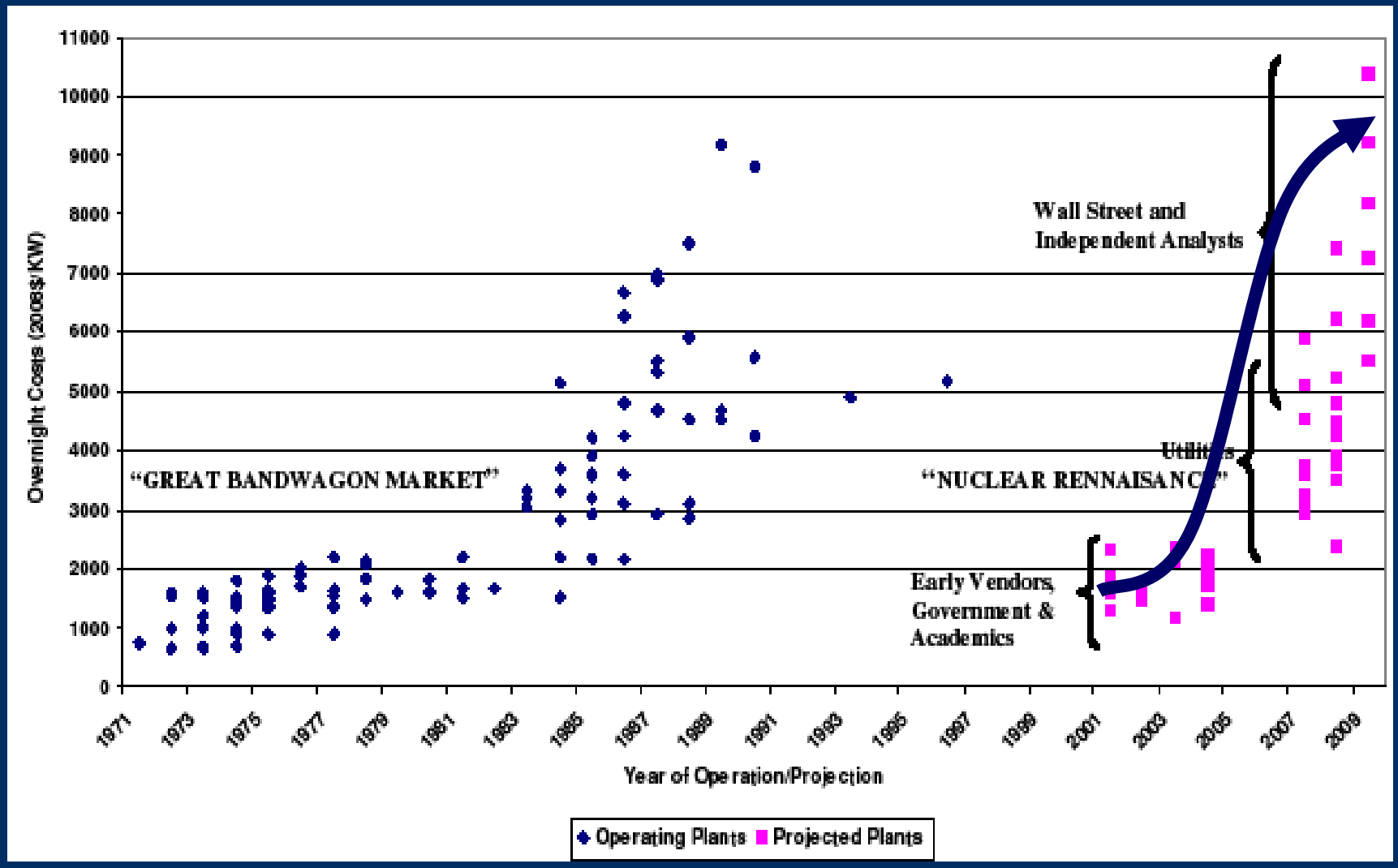
- South Korean companies – offering APR1400 to export market
- Chinese nuclear companies – talking about selling Chinese version of AP1000 and CPR1000 into export market
- India looking to sell its PHWR to smaller countries with new nuclear programs
- New companies with small and innovative reactor designs (e.g., B&W, Hyperion, NuScale)

2. Strategic issues
Risk - nuclear cost overruns in USA

Reactor construction starts (units)	Projected overnight cost ($/kW)	Actual overnight cost ($/kW)	% Overrun
1966-67 (11)	$612	$1,279	109%
1968-69 (26)	$741	$2,180	194%
1970-71 (12)	$829	$2,889	248%
1972-73 (7)	$1,220	$3,882	218%
1974-75 (14)	$1,263	$4,817	281%
1976-77 (5)	$1,630	$4,377	169%

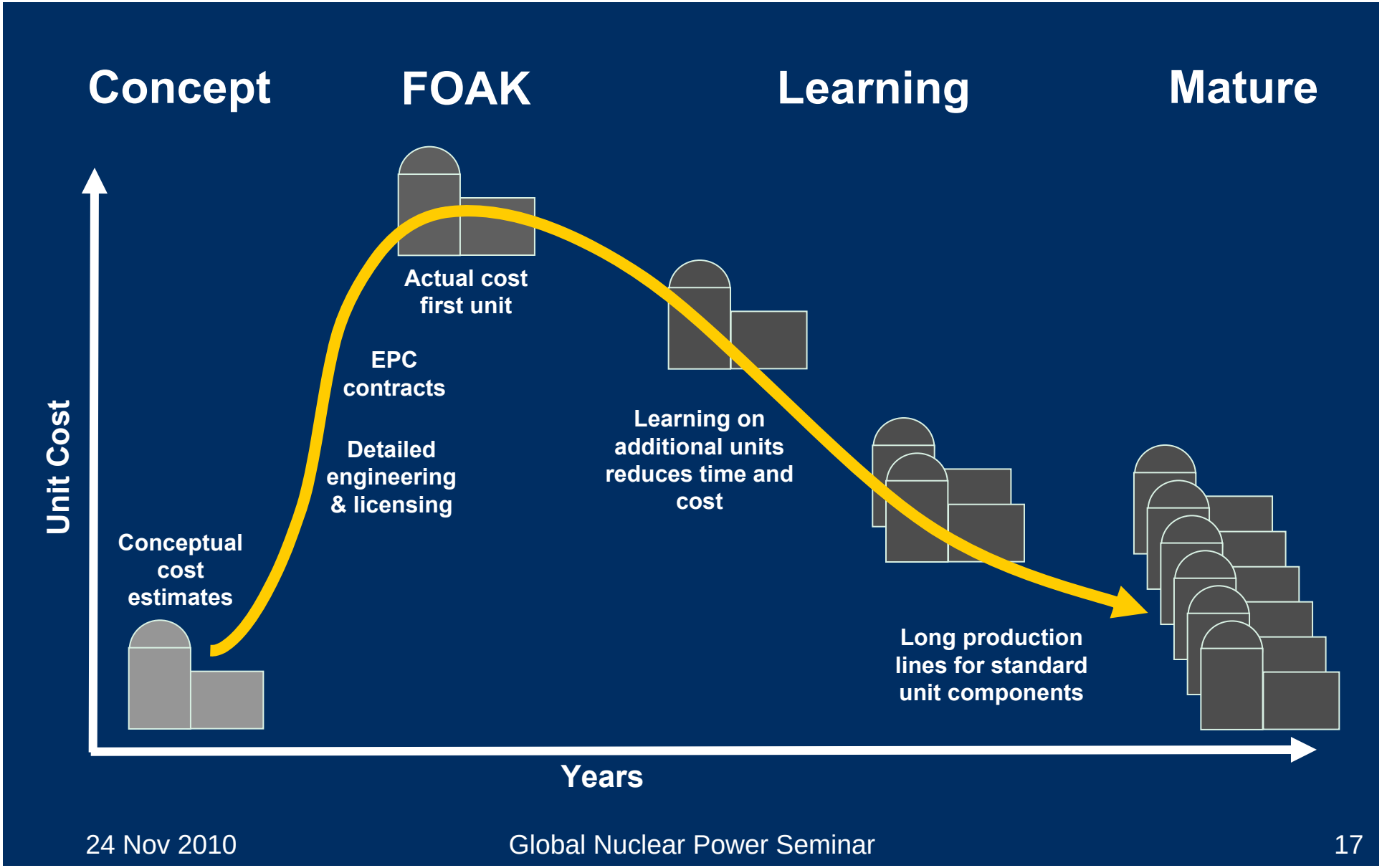
U.S. Congressional Budget Office, Nuclear Power's Role in Electricity Generation, Pub. No. 2986, May 2008, p. 17.

2. Strategic issues
Risk - Cost *estimates* seen as escalating



Source: "The Economics of Nuclear Reactors," Mark Cooper, June 2009

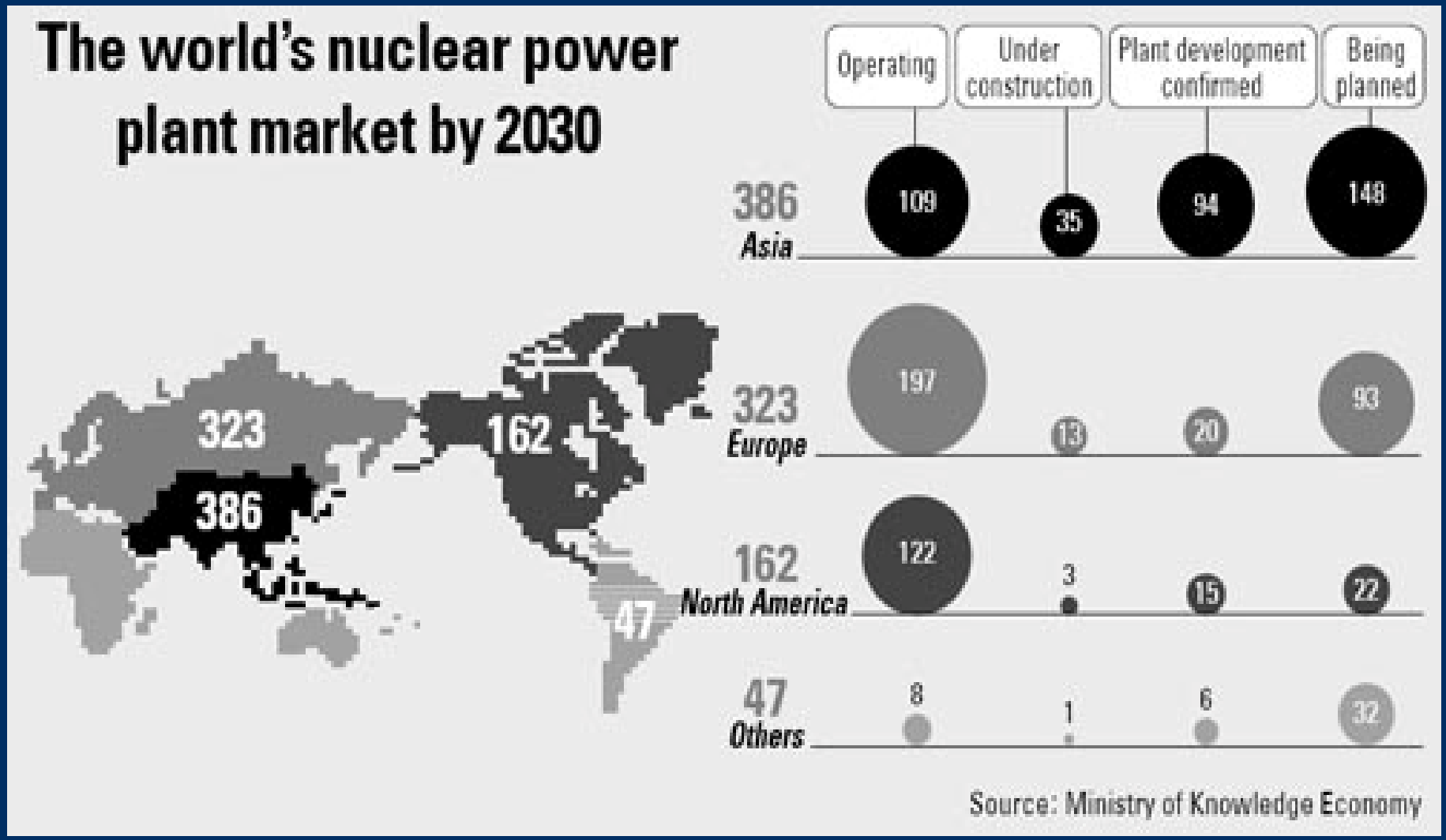
2. Strategic issues
Risk - FOAK & learning curve



2. Strategic issues
Size of Nuclear build programmes

- Low costs linked to large build programme
- High demand growth = high nuclear potential
  - China, India, etc
- Lower demand growth = lower nuclear potential
  - USA, Europe
  - High cost to shift supply to nuclear
    - Shut down existing coal units?
    - Impose significant carbon tax?

2. Strategic issues
South Korean view of world market



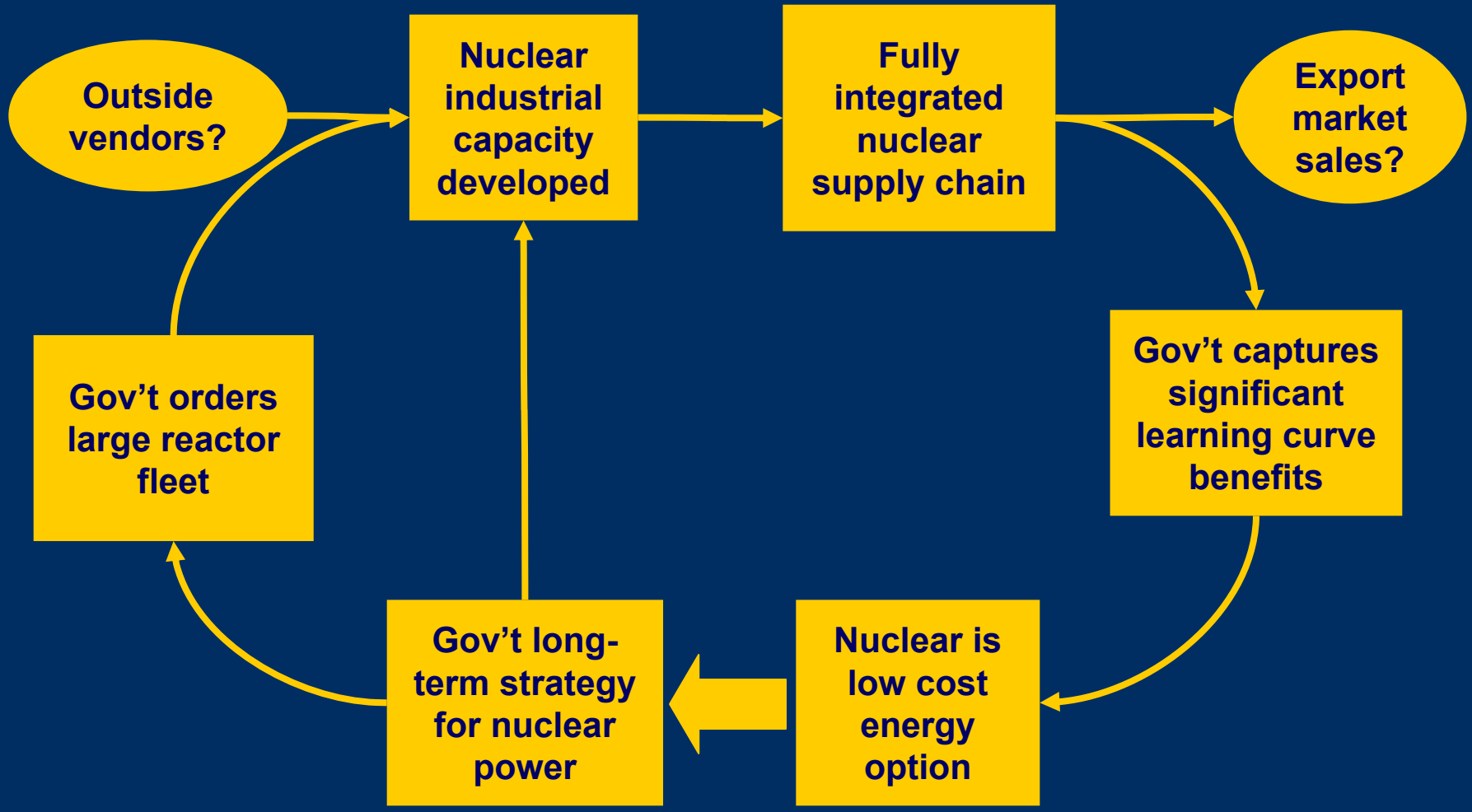
2. Strategic issues
Developing countries

- High growth rate, but some hurdles
  - Multiple smaller countries, multiple sales
  - Lack of physical and administrative infrastructure
  - Financial viability
- Nuclear power development models
  - IAEA – slow - build infrastructure, then NPP
  - UAE – fast - buy infrastructure and build NPP
  - Russia – faster - build and operate nuclear IPP

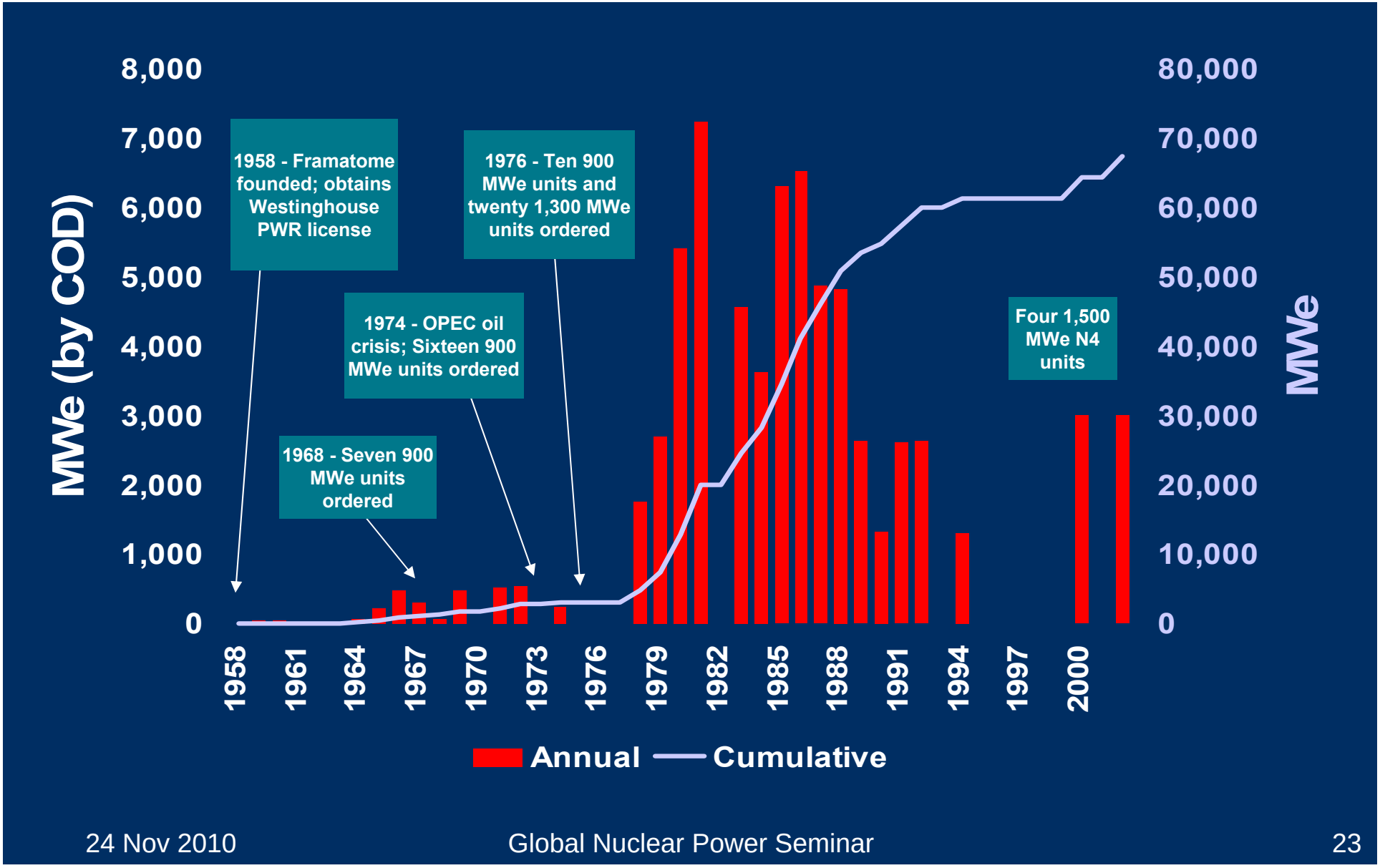
3. Role of Government

- State capitalism & national nuclear champions
- Potential roles for Japanese government
- International nuclear initiatives

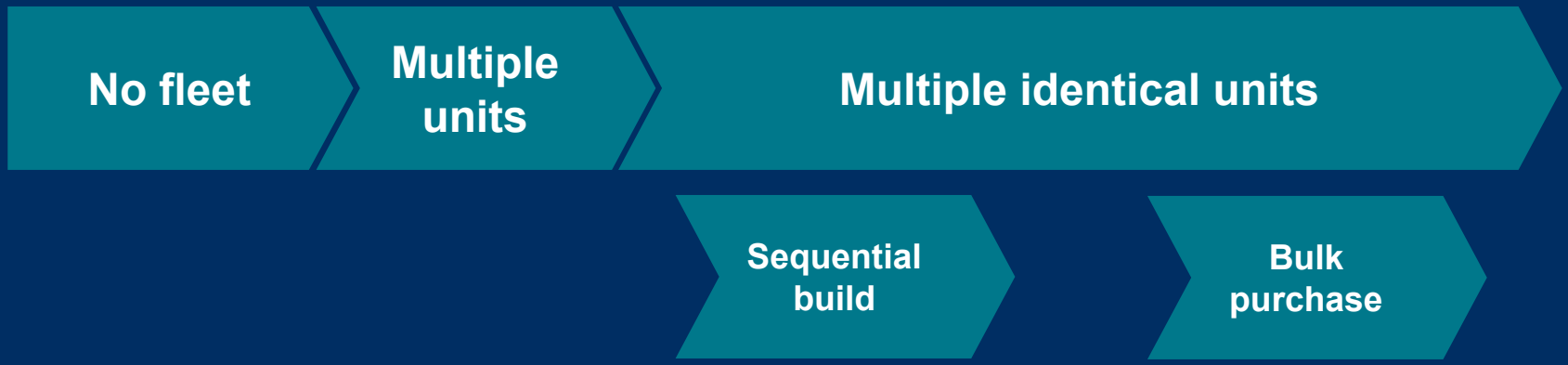
3. Role of Government
State capitalism & nuclear power



3. Role of Government
French nuclear fleet



3. Role of Government
Nuclear fleets



3. Role of Government
Nuclear fleet benefits

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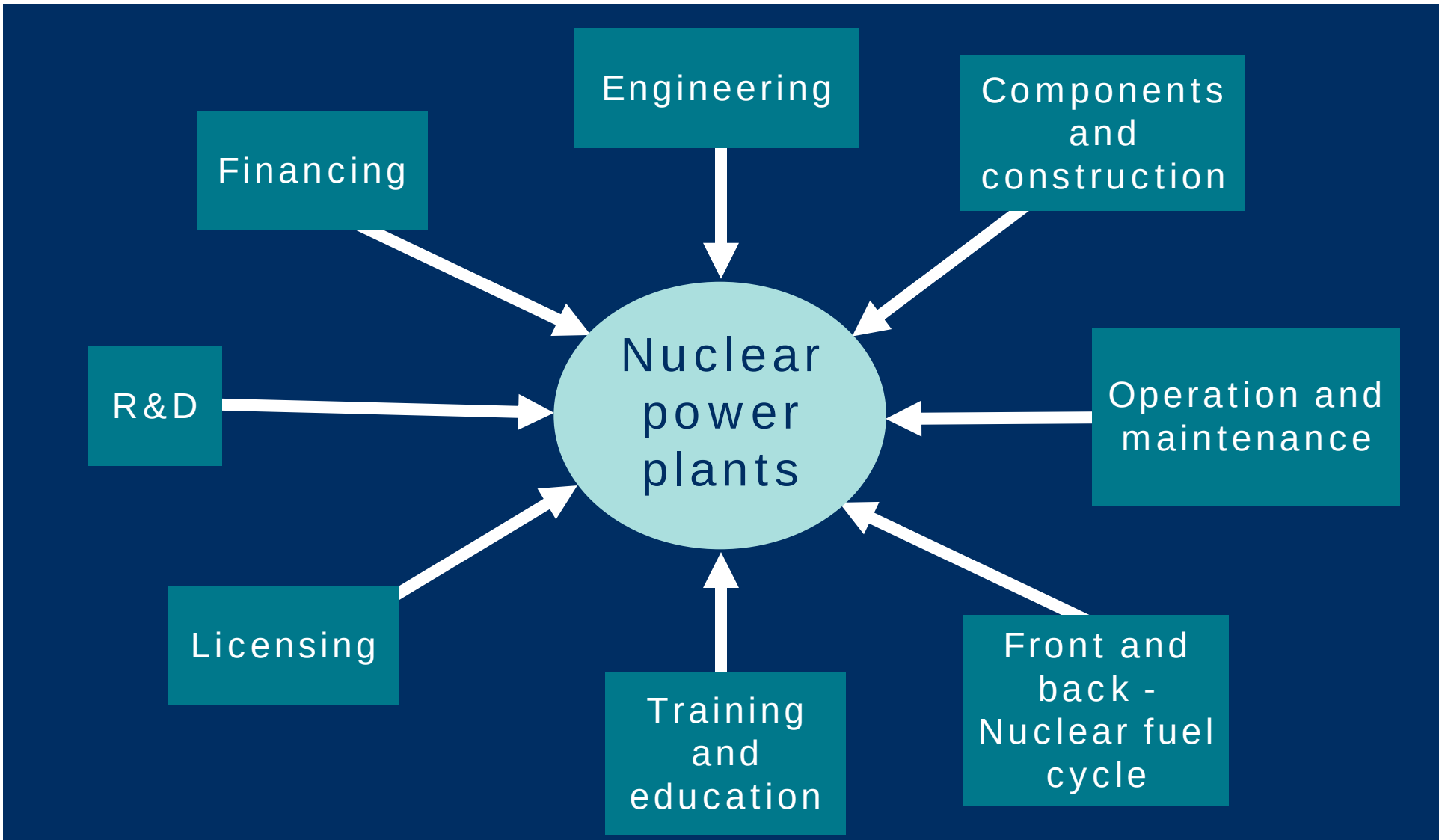
Organization & Management	Multiple Identical Units	Learning Curve Effects	Volume Orders	Mobilize Teams	Industry & Employment
A single organization with a unified approach and economies of scale to accomplish: • Training • Purchasing • Management • Engineering • Regulatory affairs	• Training • Simulator • Operators and management • Refueling outage skills & equipment • New procedures & equipment modifications • Shared spare parts, special tools, and strategic spares	Learning from: • People involved in construction and operation of multiple units • Modification of the design or the construction approach and schedule • Documenting and sharing lessons learned • Vendors build in learning for later bids	Volume orders may allow upstream component suppliers to invest in longer production lines due to bulk procurement Volume orders may bring discounts from NPP vendors that reflect *expected* learning curve benefits and upstream component savings	Sequencing of construction is key Teams move from one project to the next without interruption (also may allow simultaneous work on multiple units) Teams could work on similar tasks for many units, allowing significant commitment to hiring & training	French nuclear industrial development is model Investment in new production facilities Over time, such local suppliers should be able to use their experience (and their own learning curve benefits) to become competitive suppliers in the export market

3. Role of Government
Integrated nuclear power industry



3. Role of Government
South Korea in UAE

- My personal view of factors leading to UAE selection of South Korea
  - Low price (made possible by South Korea's nuclear fleet, integrated supply chain, learning curve)
  - Recent and current nuclear construction experience (OPR1000 & APR1400 units in South Korea)
  - National commitment to deliver on time
  - High credibility as a result of South Korea's role in earlier UAE energy and engineering projects

3. Role of Government
South Korean projects in UAE

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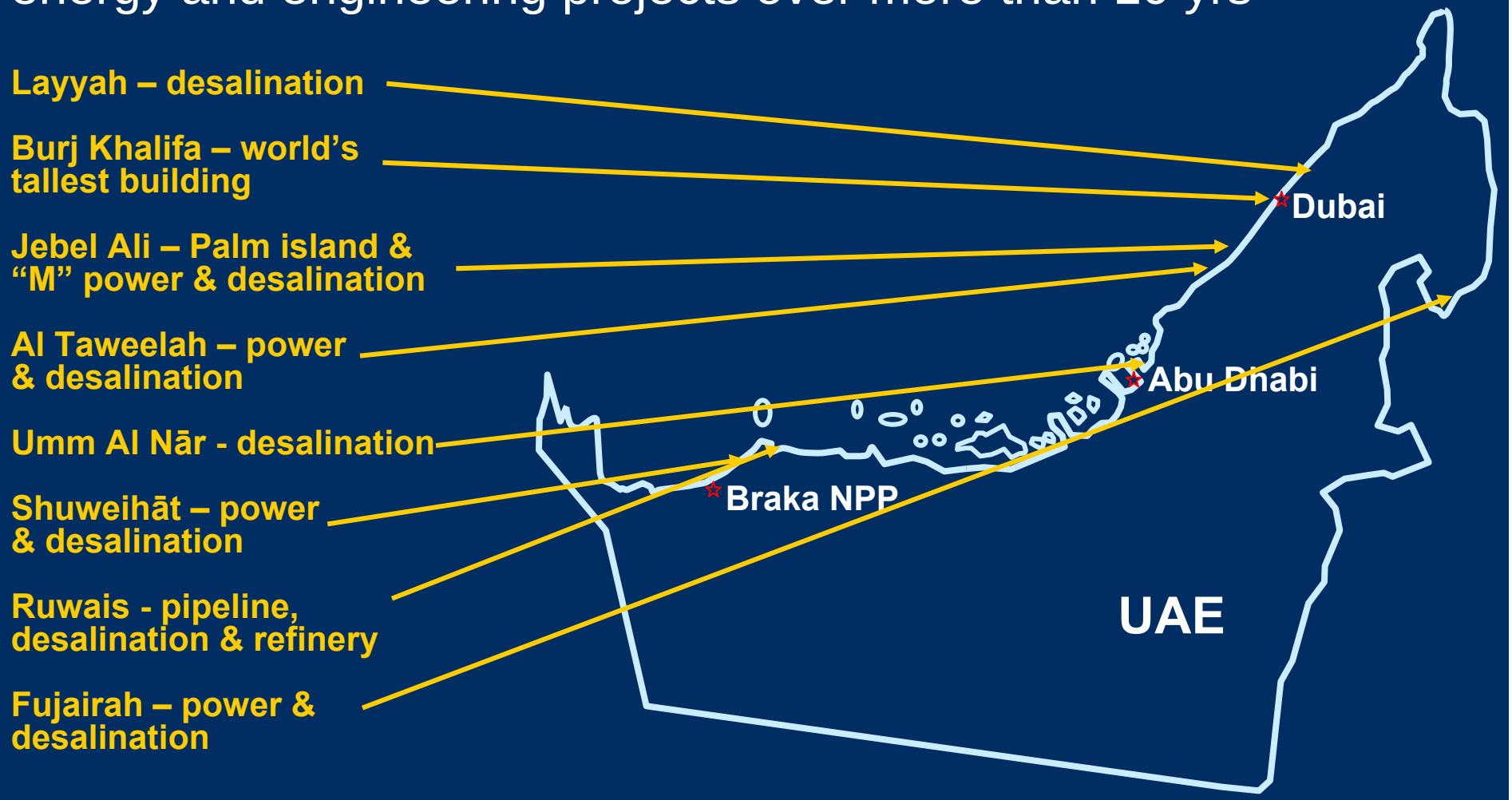
High credibility and strong commercial relationship based on energy and engineering projects over more than 10 yrs



3. Role of Government
Multi-national nuclear initiatives

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- Nuclear Fuel Cycle
  - Front end – effective markets + proposals for international nuclear fuel bank (IAEA, NTI)
  - Back end – difficult issues, multiple approaches proposed (e.g., IFNEC/GNEP)
- NPT & Nuclear Suppliers Group
  - Trade may be eroding purpose (India, Pakistan)
  - Iran sanctions may set precedents elsewhere
- Nuclear Liability

4. Small Reactors
Potential benefits

- Lower total plant cost – easier to fund
- Shorter construction time – easier planning
- Smaller size & dispersed locations (less transmission, lower single shaft risk)
- Higher thermal efficiency (He Brayton cycle, supercritical CO2 cycle)
- Longer fuel cycle – exotic reactor concepts
- Safer – lower accident and proliferation risk

4. Small Reactors
Key issues

- Licensing in LWR-focused nuclear regulatory regimes
- Timing and cost of commercial product
- Will benefits overcome lost scale economies?
- Operational issues and exotic BOP
- Size of market needed for “mass production” business approach

Conclusions – 4 Topics

1. Global markets – Competition and market share
2. Strategic issues – Cost, risk and new markets
3. Role of government - State Enterprises are strong
4. Small reactors – promising, but far from certain

Questions?

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