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Future of Nuclear Energy

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GW Panel: Aftermath of Fukushima Dai-ichi Accident

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Insight in Economics™

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Future of nuclear energy

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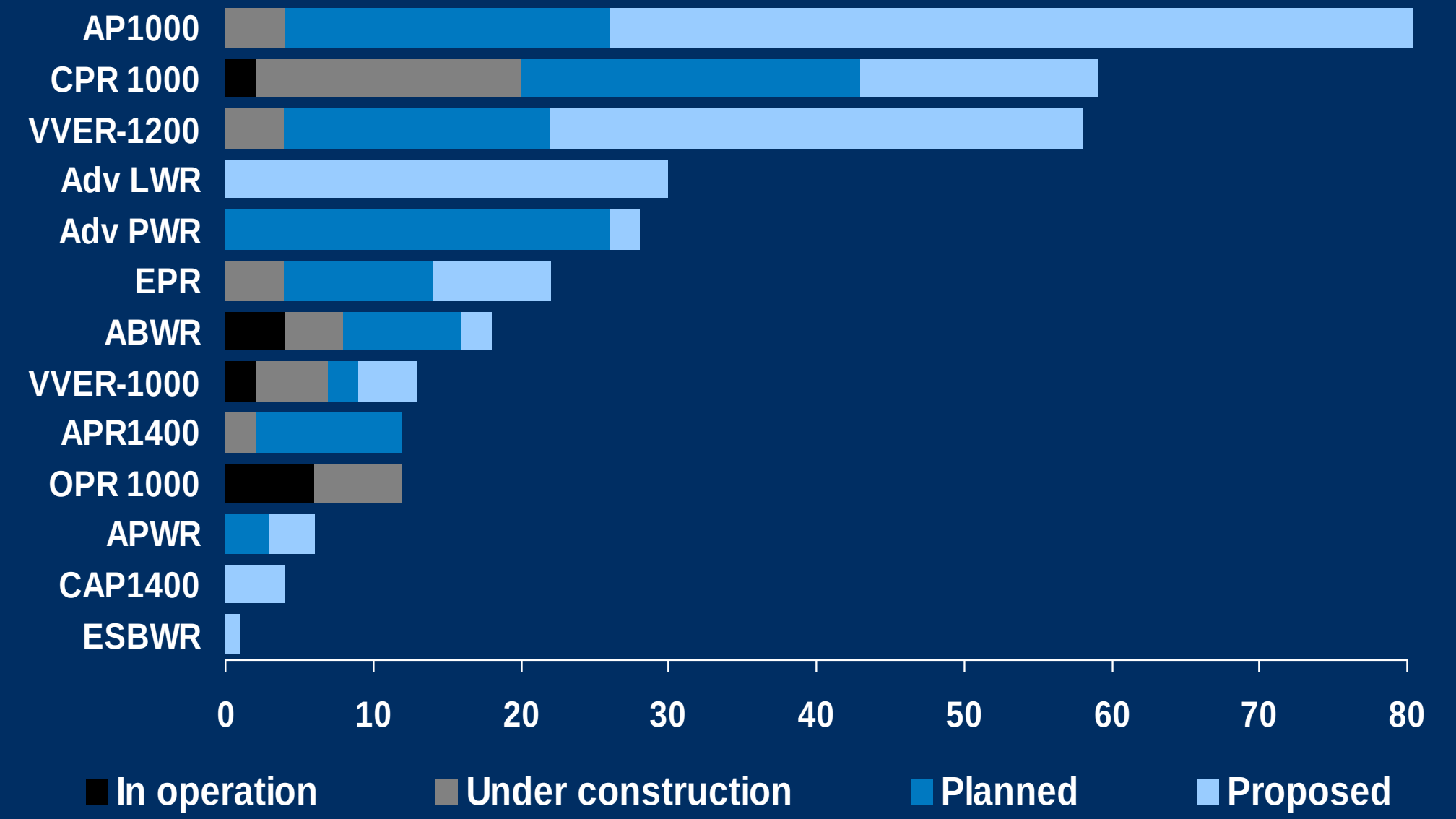
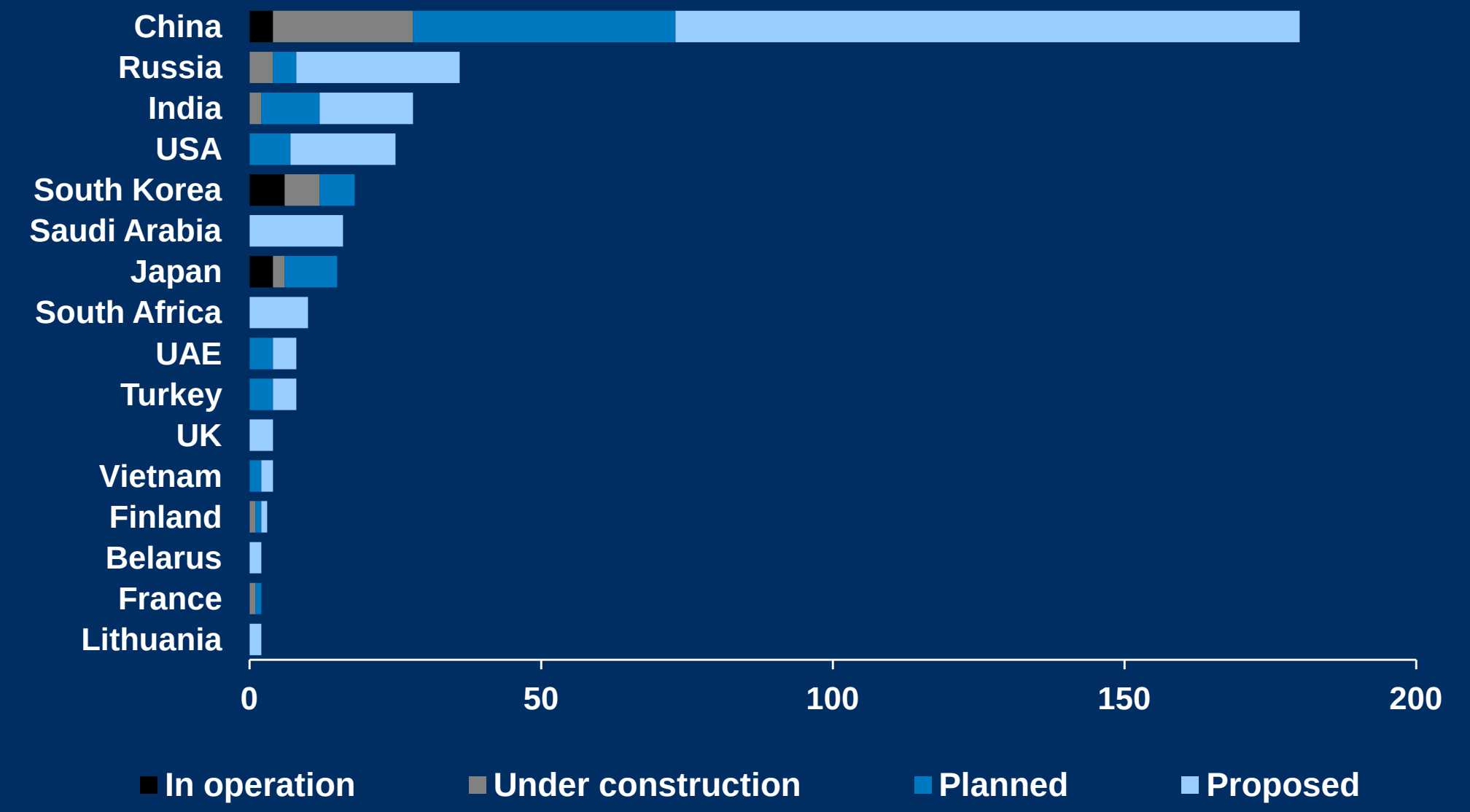
- Global league tables
- Cost
- Nuclear development approach
- Summary

Global nuclear market
Gen II+, III & III+ by reactor design



Global nuclear market
Gen II+, III, III+ by country



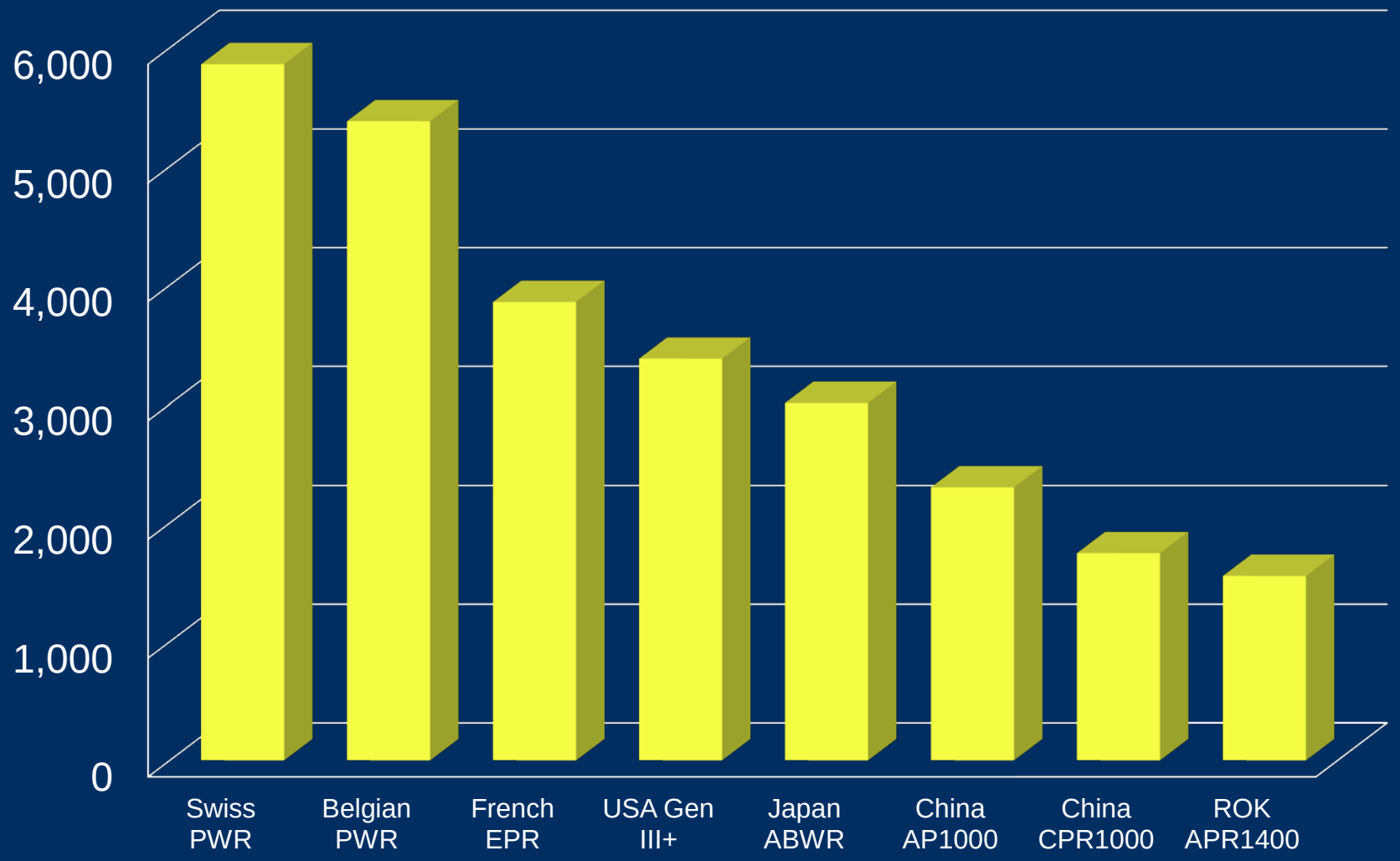
New nuclear

- Vogtle COL issued – construction start soon
- UAE – Braka construction start soon
- Finland - building 1 unit and planning 2 more
- UK - merchant nuclear (more on this)
- South Africa / Eskom - 9,600 MWe of nuclear
- Saudi Arabia / K.A.CARE - 16 new nuclear units
- Other: Russia, Belarus, Turkey, Vietnam, Czech Republic, Jordan, Poland, Lithuania

New industry competitors

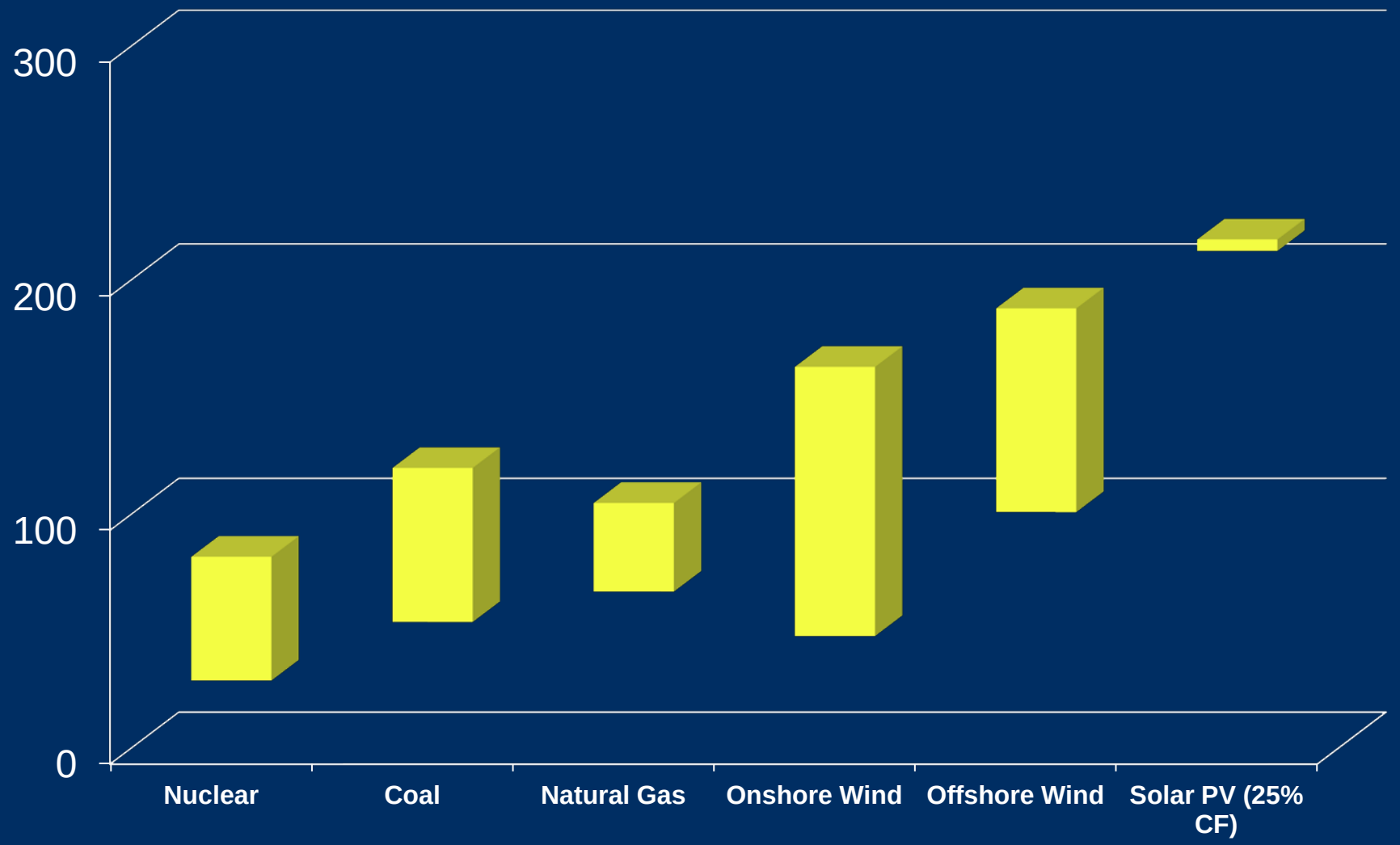
- South Korea
  - Exporting APR1400
  - APR+ design by 2013 (with no US content)
- China
  - CAP1400 to be built in China, then exported
  - ***A***CPR1000 was to be offered to export market
- Only about 60 years (2 or 3 generations) of reactor designs – improvements will come (small, innovative & advanced reactors?)

Nuclear capital cost



Source: OECD Generating Costs 2010, Table 3.7a, overnight capital costs in US$//kWe

Nuclear energy cost



Source: OECD Generating Costs 2010, LCOE in US$//MWh; 5% discount rate; OECD countries only

Nuclear plant cost & learning

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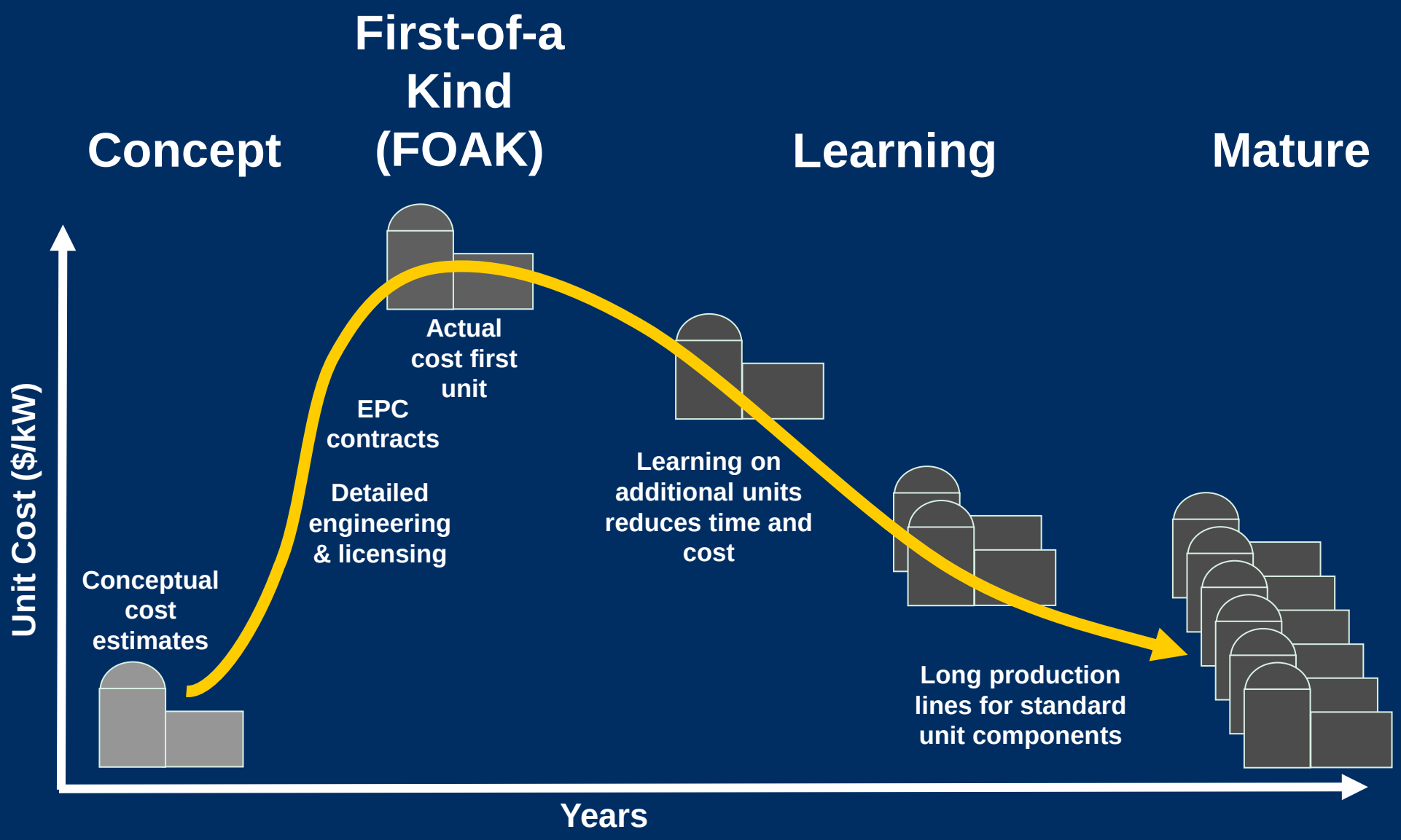

Nuclear development

- Ownership & commercial development approach is key issue for nuclear power
- All existing nuclear power plants (and those under construction today) built by
  - Regulated utility, or
  - Government or government utility
- New merchant nuclear only with government assistance (e.g., US DOE Loan Guarantees; UK ~~subsidies~~ market reforms; Turkish PPAs)

Merchant nuclear - *really hard*

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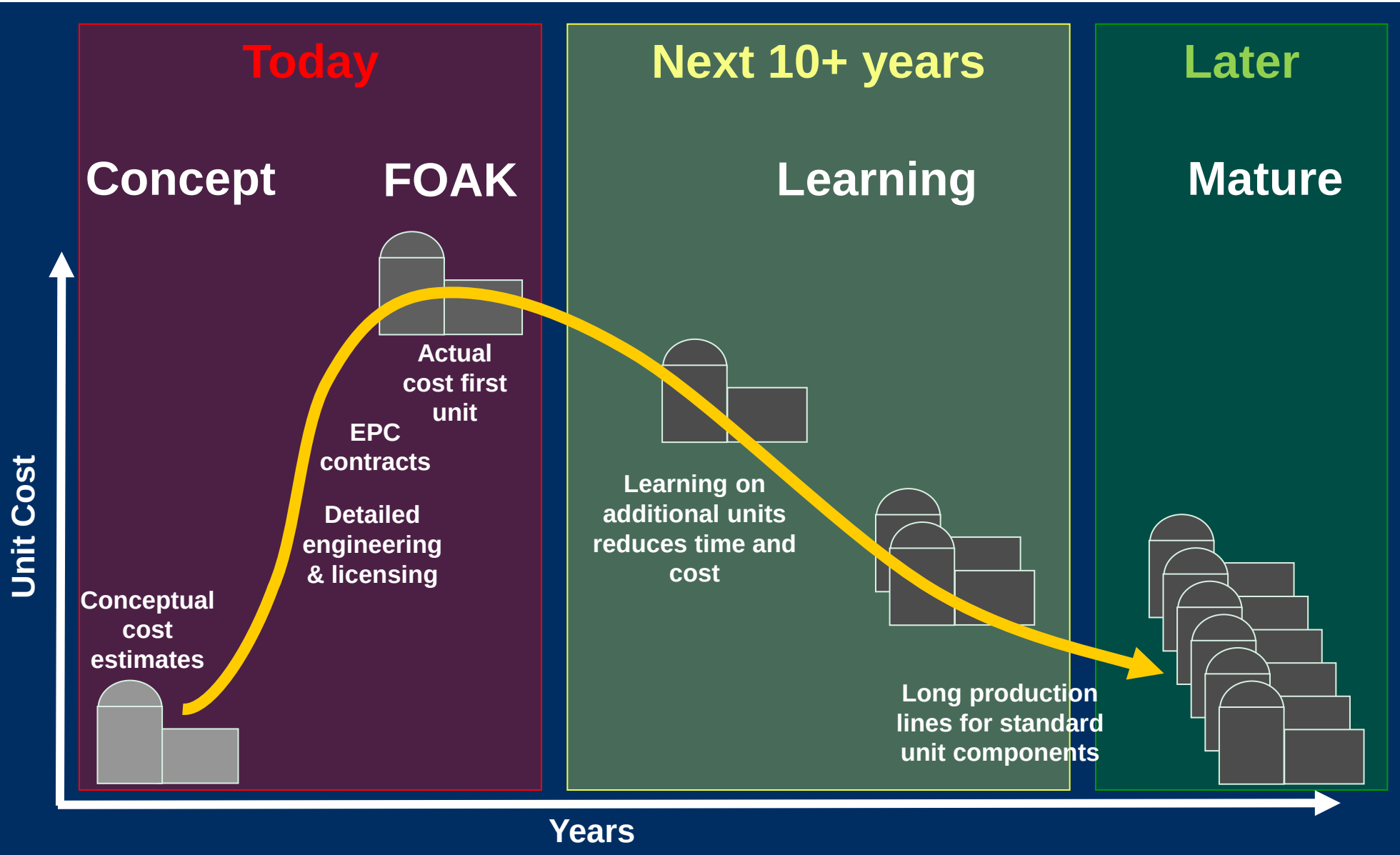
- No merchant nuclear plant has ever been built
- Project ***and*** market risk assumed by developer
  - Large project risk before commercial operation (COD)
  - Some project risk after COD (e.g., prolonged outage)
  - Market risk from volatile electricity markets
- Project finance approach strained by
  - High capital intensity & large project size
  - Long development and construction period
  - Lack of revenue certainty

FOAK cost issues add difficulty



Regulated nuclear plants

- General approach is that ratepayers take project ***and*** market risks, with oversight by regulator
- But maybe not all risk - in 1980s, *ex post* reviews placed project and market risks on owners
  - Prudence reviews and disallowances
  - Large negative impact on investor-owned utilities
- Approaches to manage ratepayer risk
  - IRP processes & regulatory oversight of project
  - EPC contracts & cost caps to shift project risk

Government nuclear plants

- Government assumes project and market risk
- Lower cost of funding (i.e., all debt)
- Deep pockets + large purchase = strong buyer negotiating position (e.g., UAE and China)
- Nuclear projects have non-electricity objectives
  - Local employment and skills development
  - Local industrial development
  - Energy or climate change policy

Government edge in nuclear

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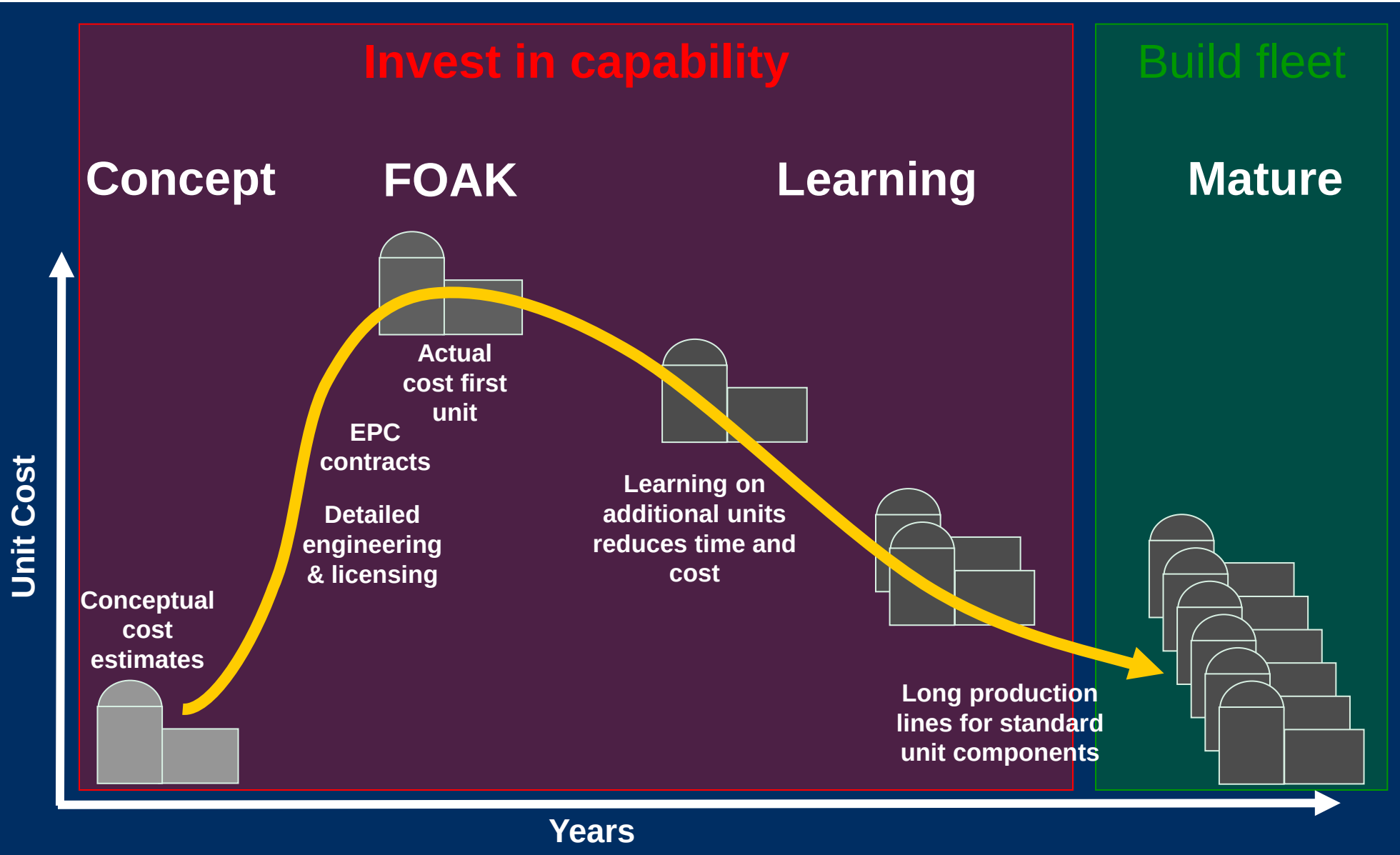
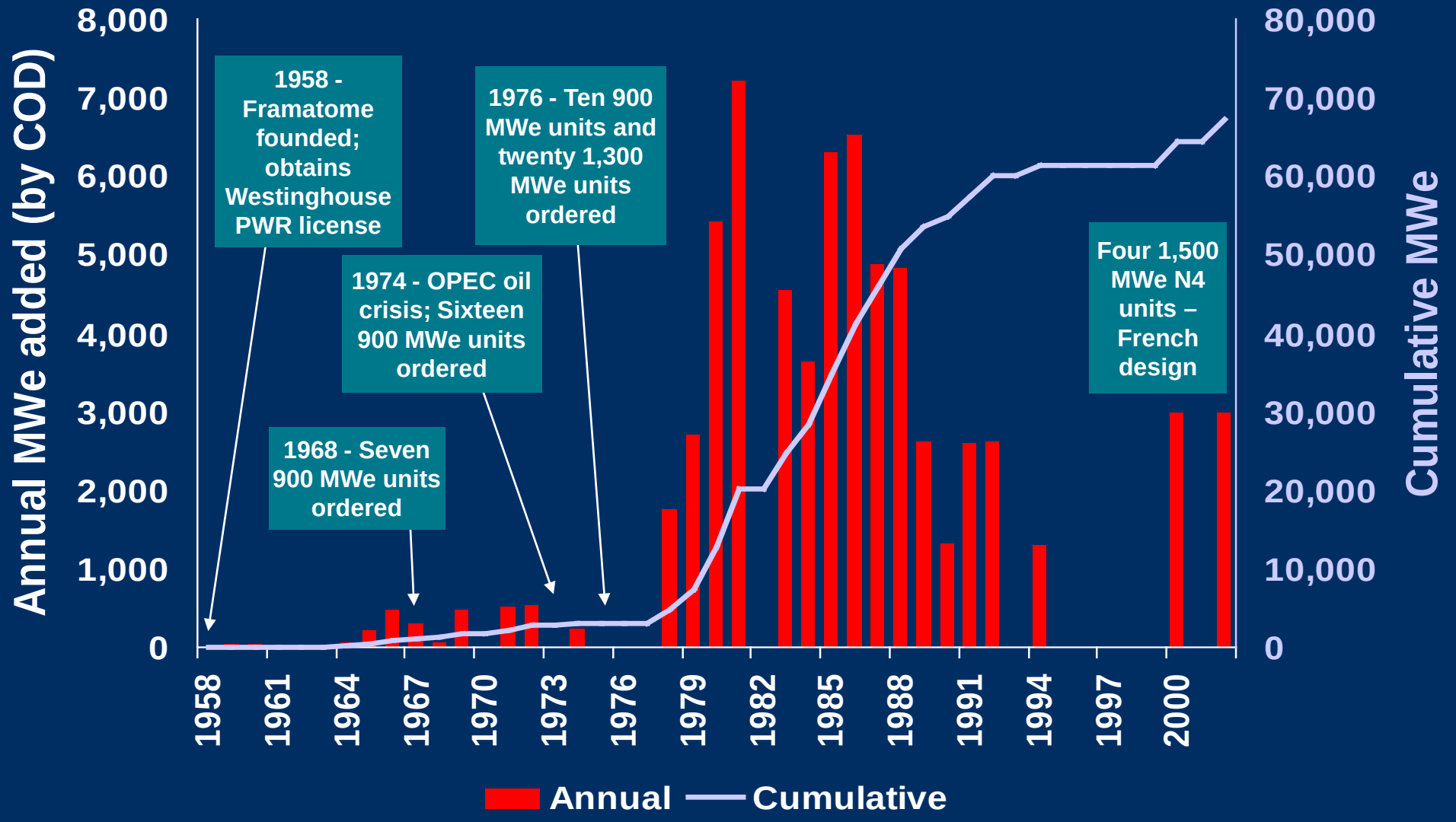
- Key factor is number of nuclear units built
- Only governments can build large nuclear fleets
- Large government nuclear fleet brings
  - Learning curve and fleet benefits
  - National nuclear vendor & integrated supply chain
  - Lower and less volatile electricity costs
  - For some countries, less reliance on imported fuels

National nuclear fleet



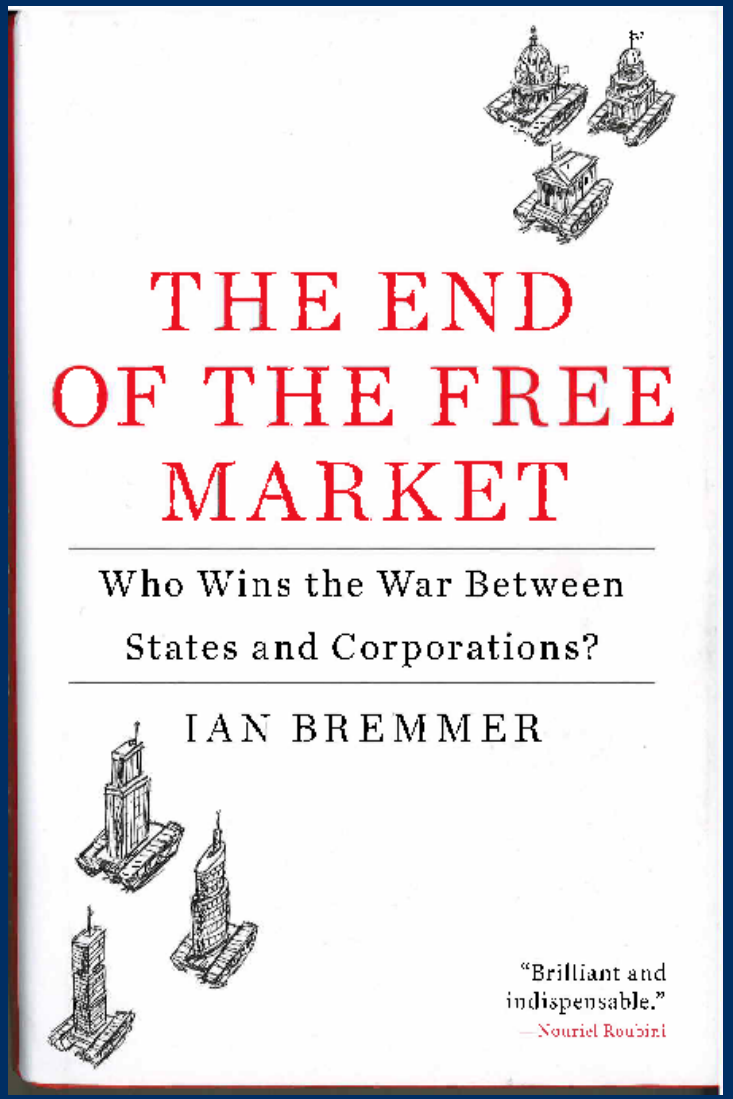
National nuclear fleet (France)



National nuclear program

- National nuclear power program
  - Government electricity industry is captive buyer
  - Nuclear industrial champion based on internal build, with internal supply chain and proven experience
  - Ready to compete in global market
- Facilitate Gov't - to - Gov't nuclear deals
  - Prices/terms unlinked from project economics/profits
  - May be no commercial contracts or transactional rigor

State Capitalism



- Strategic long-term state domination of markets
- National Corporations & State-Owned Enterprises
- Strategic goals (inside and outside country) above profits
- China and Russia leading examples

Published by Portfolio/Penguin in May 2010

Nuclear power future

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- Electricity use will continue to increase
- Burning stuff to make electricity not sustainable
  - Run out of stuff to burn, eventually
  - Stop dumping combustion waste into environment
- Wind, water, solar, geothermal - limited, expensive, and not reliable/controllable
- Nuclear - significant electricity generation source

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