NERA
Economic Consulting

Global Nuclear Power Developments
Asia Leads The Way

Edward Kee
Nuclear Energy Asia 2010 - Hong Kong

Insight in Economics™

(1400 – 1430) **Global Nuclear Power Developments - Asia Leads The Way**

What is the competitive global position of nuclear power plant designs and vendors?

How will China's large new nuclear build programme impact the global industry?

Implications of South Korea's entry into the nuclear power export market

How will the nuclear power plant industry in Japan, the US and Europe compete with Chinese and South Korean nuclear power plant vendors?

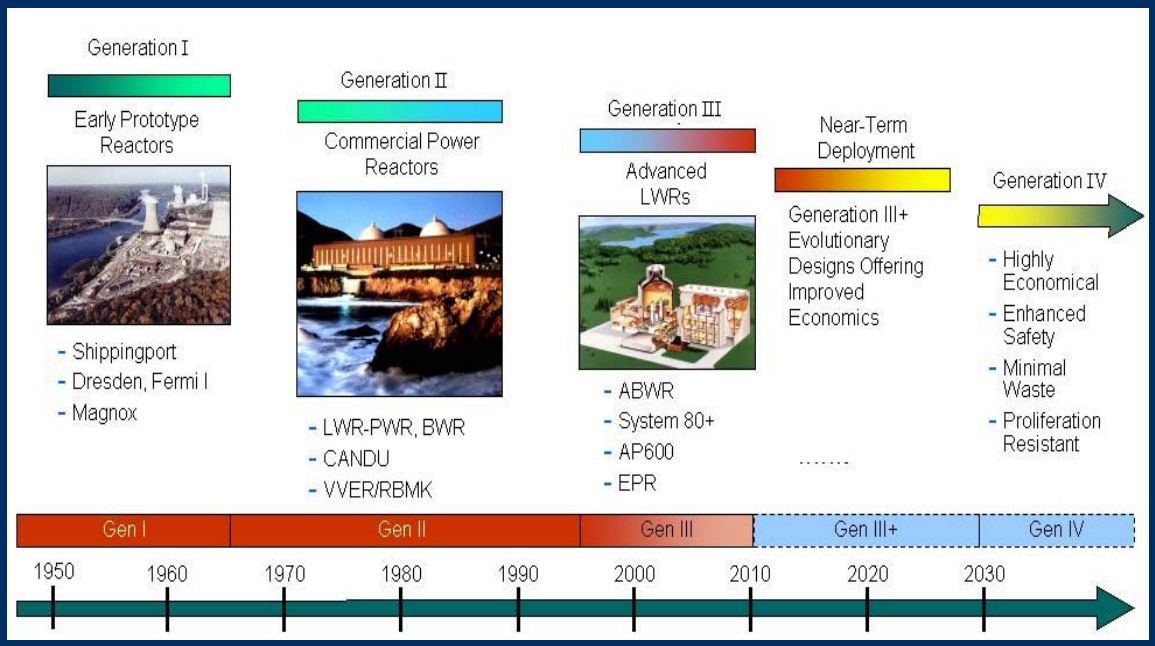
How does the role of government in the Asian nuclear power industry enable nuclear power plant development?

Disclaimer

The slides that follow are not a complete record of the presentation and discussion.

The views expressed in this presentation and discussion are mine and may not be the same as those held by NERA's clients or my colleagues.

Global markets
Reactor design evolution



Gen II (most existing units, these work well); Gen III/III+ (moving to FOAK, size increase); Gen IV (R&D/SMA)

Areva explained the UAE loss - as the result of cheap Generation II reactor design from Korea

However, the Korean APR1400 (based on System 80+) is similar to the EPR, with active reactor safety

No substantive definition of Generation III/III+;

Graphic source: DOE (http://nuclear.energy.gov/genIV/neGenIV1.html**)**

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

This is a list of Gen III attributes;

Key issues:

Who decides if a unit is Gen III? Or something else?

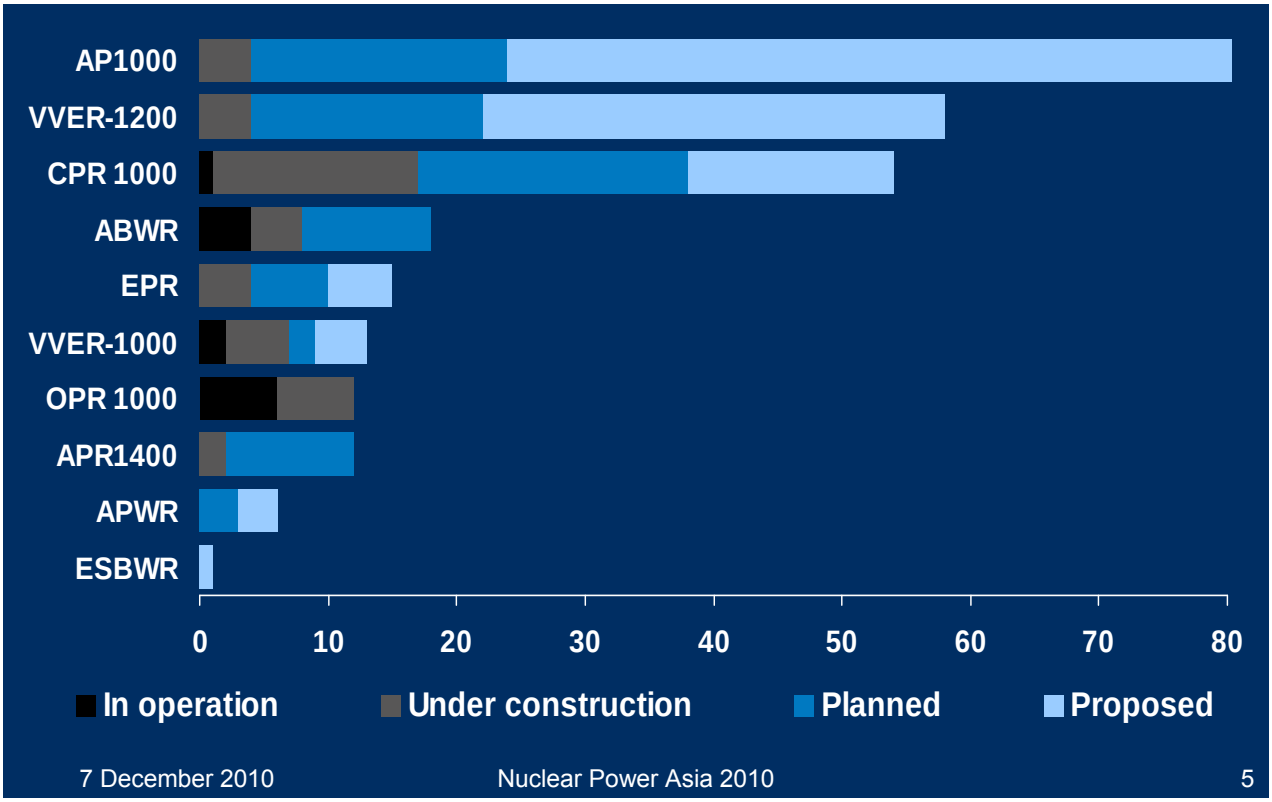
How safe is safe enough?

Are extra safety features (e.g., core catcher) worth the additional cost?

Some Gen II or Gen II+ designs may be much better value for money

Will passive safety designs dominate active safety designs?

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



Big stories here:

•AP1000, selected by China, has potential to be the most popular design in the world

•Russians are also moving fast on market, according to announcements

•Big reactor vendors, including Areva and GE and Japanese, are trailing

•South Korea was NOT in the export market until the end of 2009

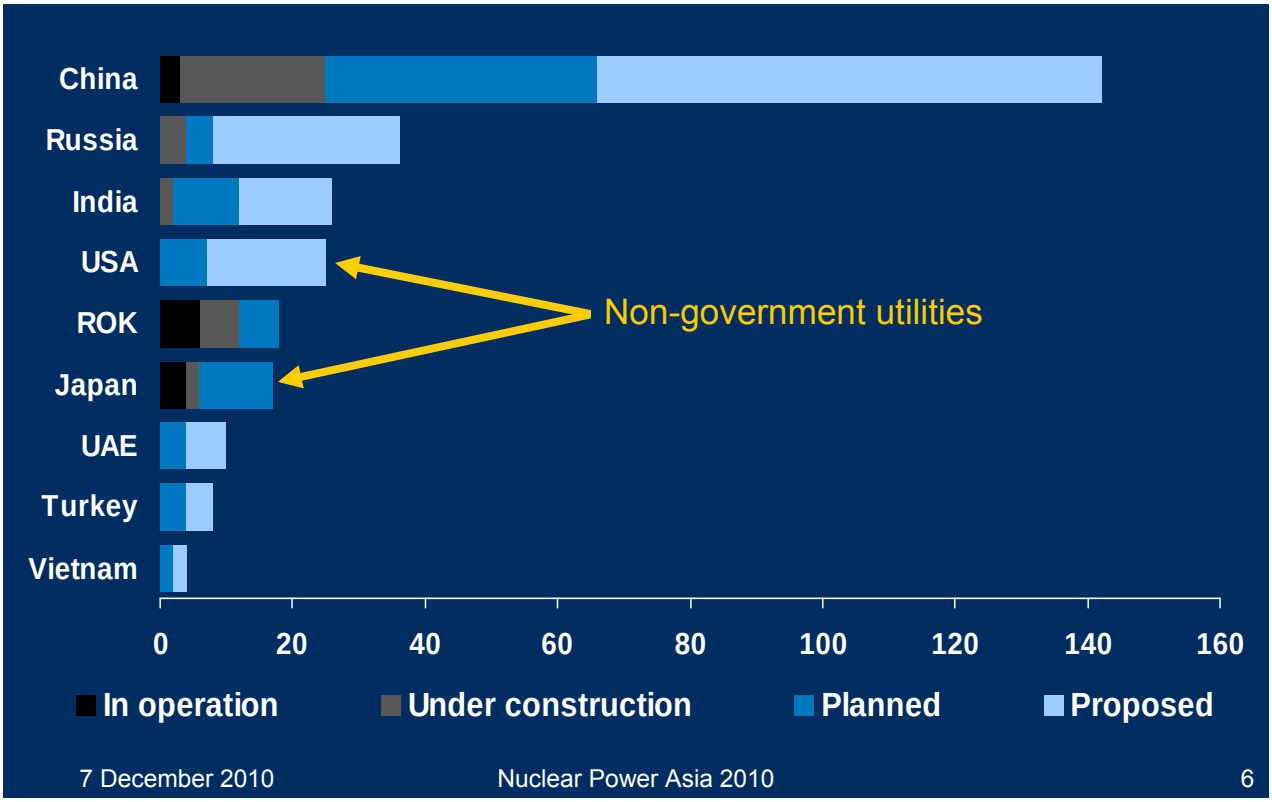
In operation = connected to grid and producing power

Under construction = at first nuclear concrete pour

Planned = units that typically have vendor, site, and other details firmed up; range from pre-construction to only a little more advanced than proposed unit

Proposed = units that have been mentioned, but not yet planned; ranges from detailed project plans to press release/news story

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



Big stories here:

•China's nuclear build programme is huge – has the potential to shape world nuclear industry for many decades

•Russia internal build of VVER designs will build credibility for export market

•India's potential buy of imported LWR designs may change the competitive picture, if EPR, ESBWR, or ABWR (or all of these) get orders

•As new nuclear countries make selections, the aggregate world league table will be important

- countries will look for proven designs with real experience and low costs
- will seek a range of support from vendors (government vendors have edge)

In operation = connected to grid and producing power

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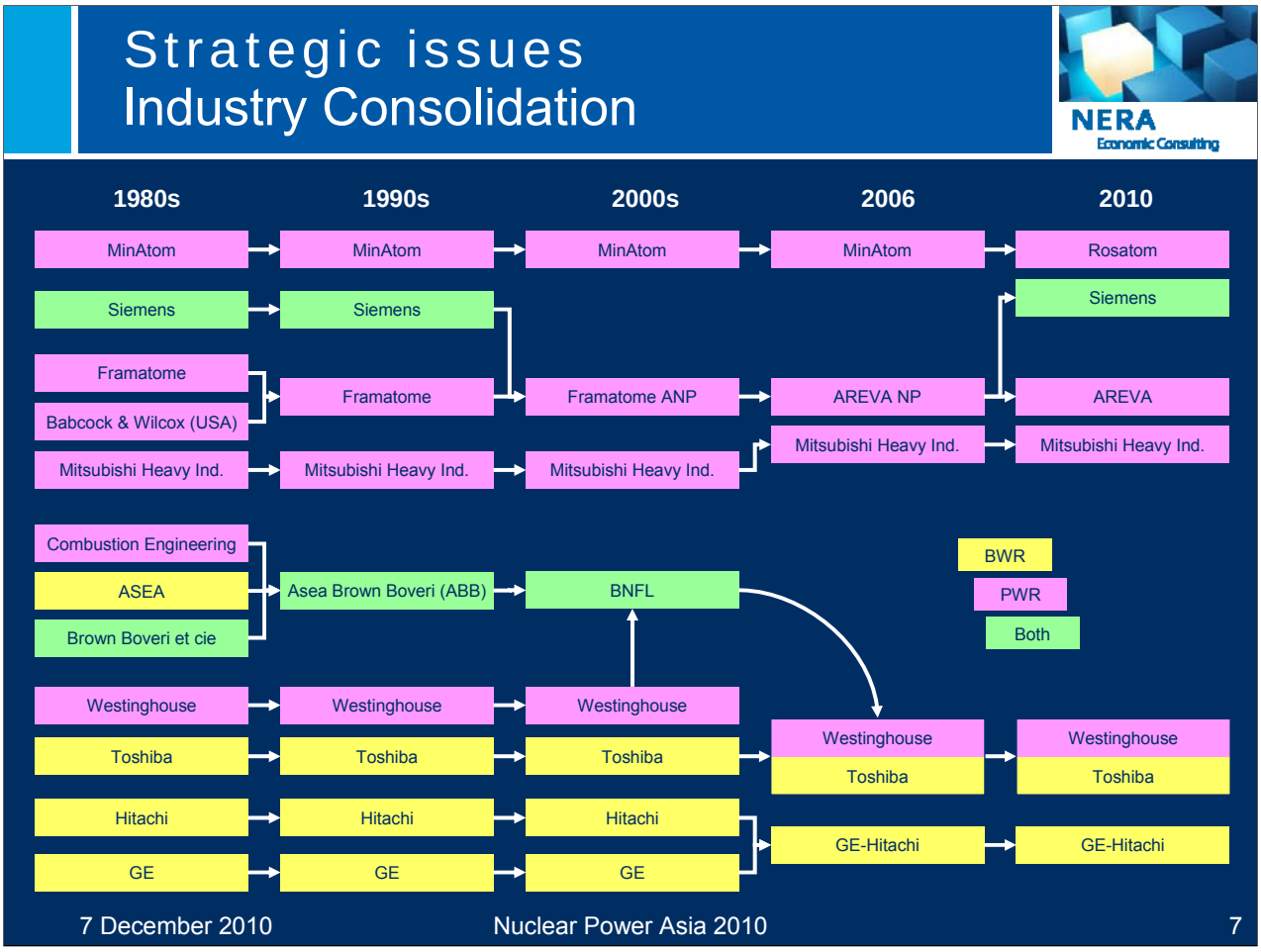
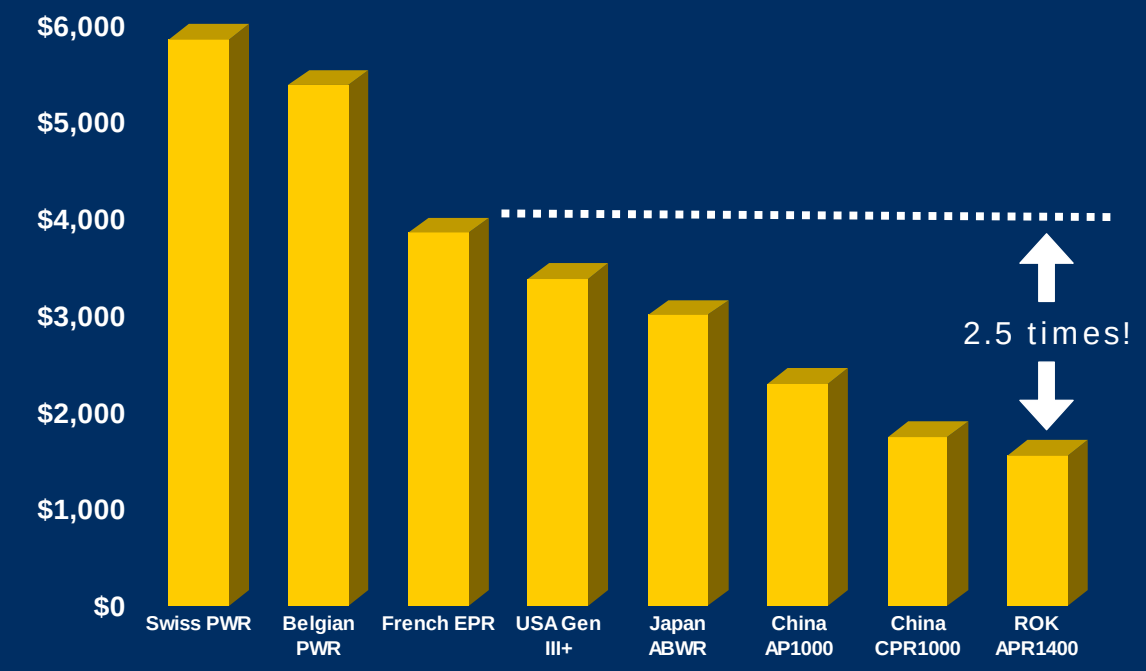


While the government-owned Areva and Rosatom are on this page, the new government vendors in China and South Korea are not.

Strategic issues
New industry competitors

- 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)

Strategic issues
Overnight capital costs



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

This is from the OECD 2010 generating cost report

Very large range of overnight capital costs

French EPR is 2.5 times as much as ROK APR1400

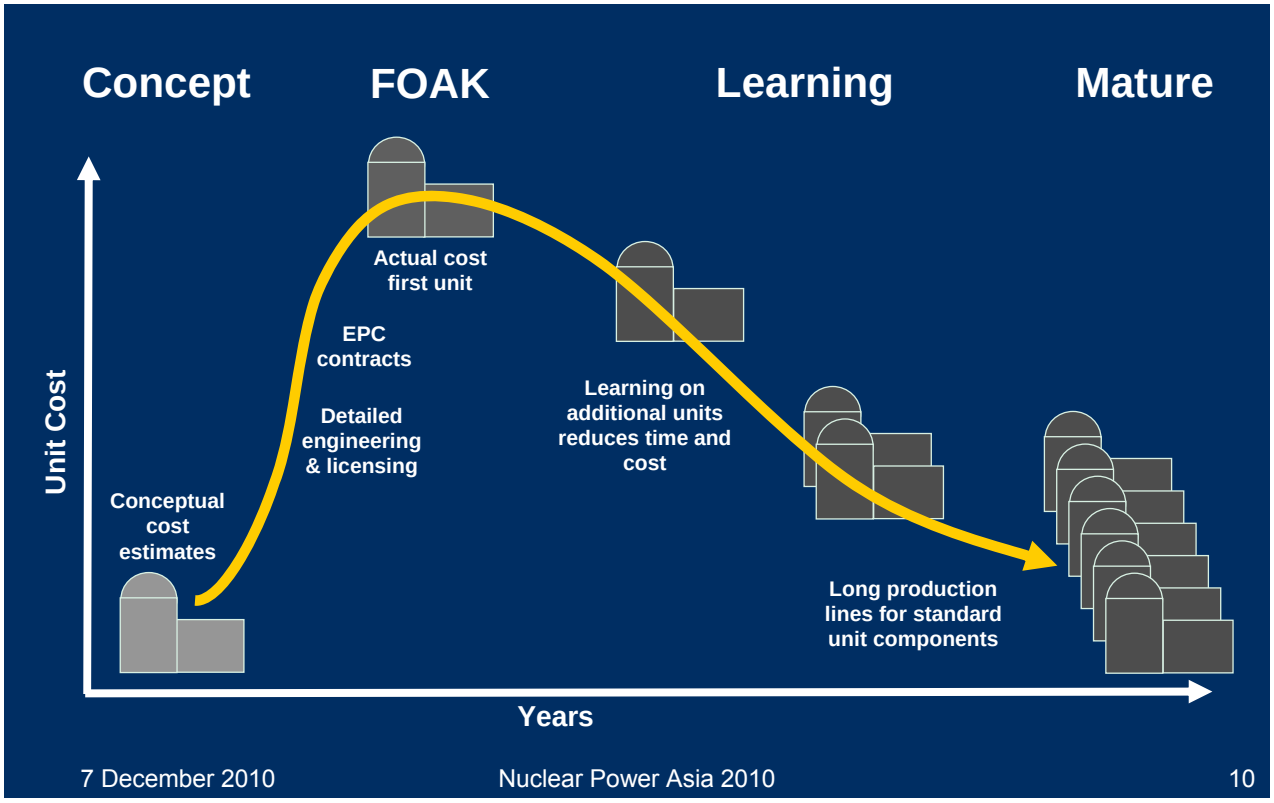
Many reasons for this difference

This differential cannot be sustained

If government vendors can build in the export market at comparable prices, and meet local safety regulations, traditional vendors will not be able to compete

Comment from UK: “Why can’t we get some of these low-cost Korean reactors in the UK?”

Strategic issues
Product development cycle



For some reactor designs, the industry is only now moving from high-level conceptual cost estimates to real contracts to build the first new units.

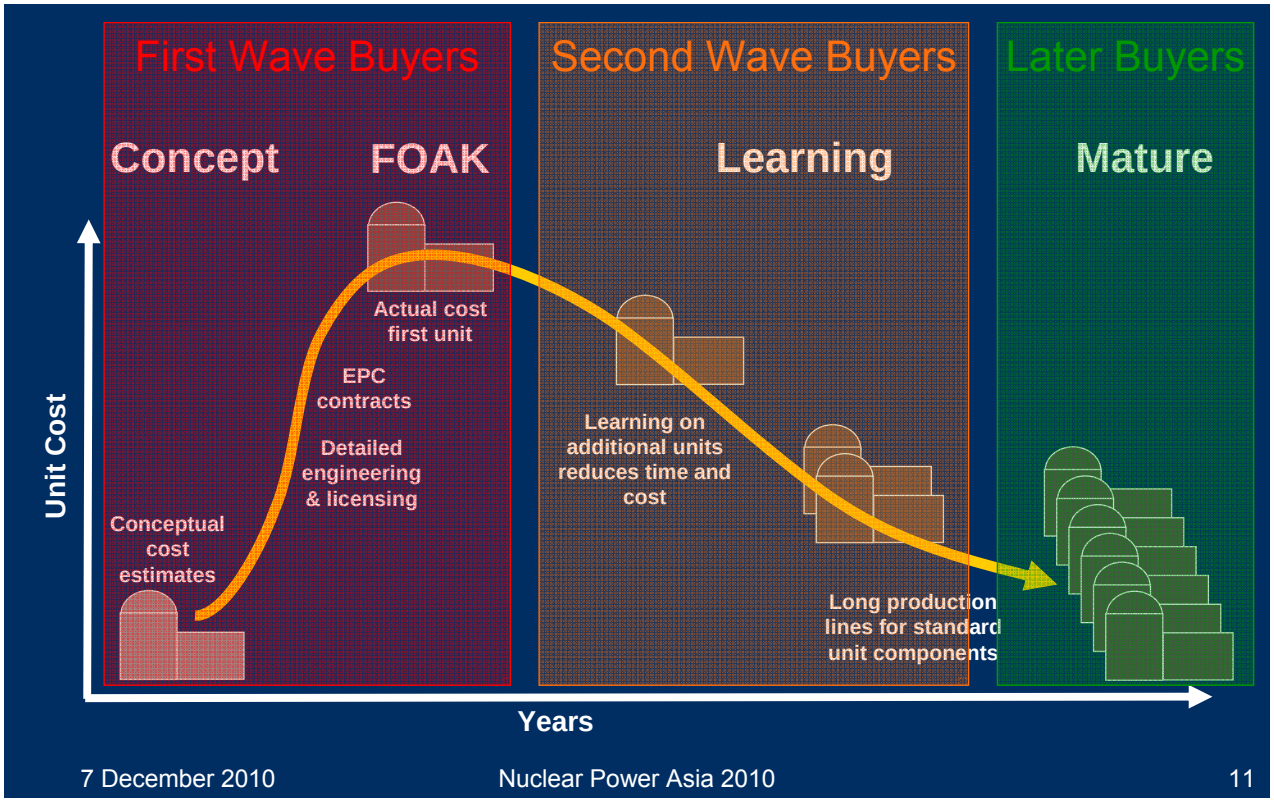
FOAK units are always more expensive and in the current environment, no vendor or builder will take a lot of cost risk (the total cost might make this exposure larger than the market value of some vendors).

As more units are built, the costs will be lower (some data show that the 5th or 6th unit of a kind are 40% less expensive than the first unit). As many units are built, the low costs become more certain and buyers will face lower project risk.

Problem is in how to get down the learning curve

- In the US market, may not be enough units built to do this
- In economies with growing demand and a strong commitment to nuclear (e.g., China, South Korea), real economies of scale and learning curves may be achieved.

Strategic issues
Commercial approach (e.g., USA)



When there is a commercial approach, there is a difficult issue of who gets the gains from learning curves and experience.

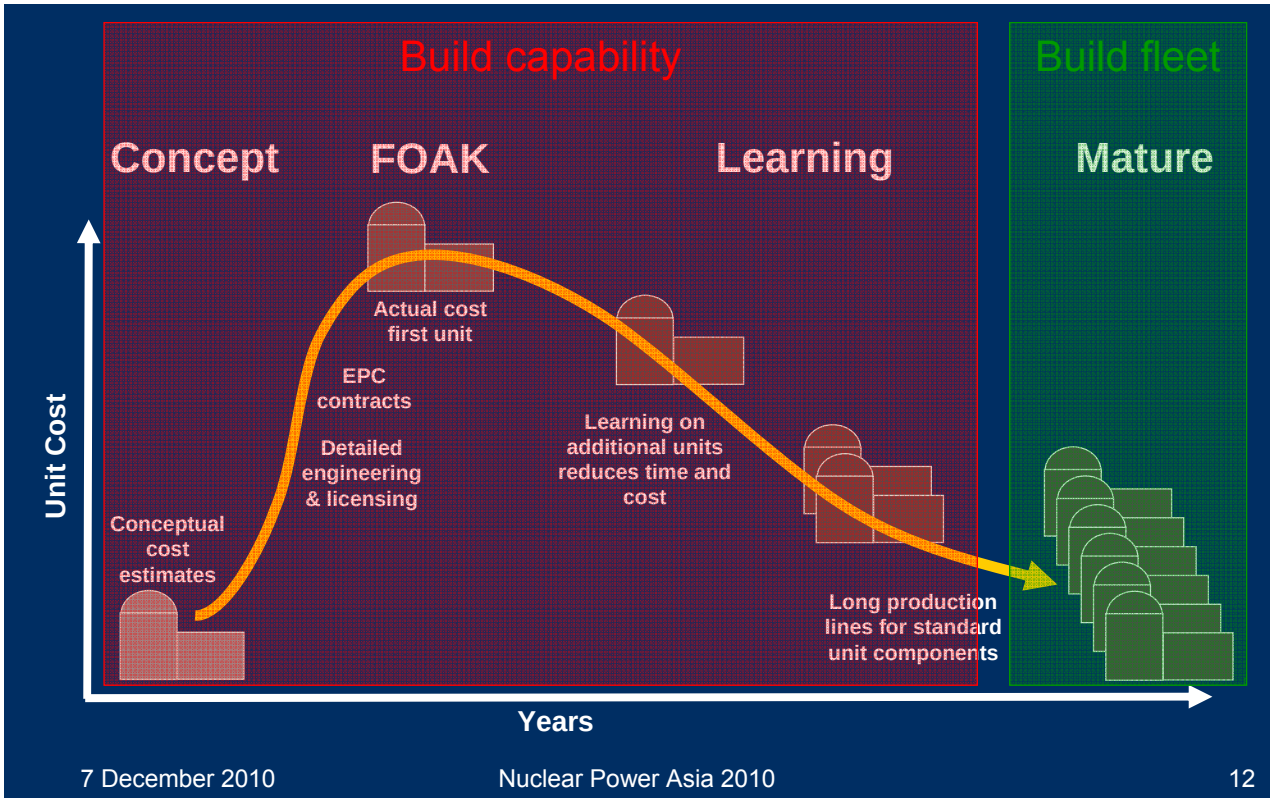
While there are some Intellectual Property issues here, many of the gains from learning may not be captured by the buyer who pays for them

When buyers share (or take) the risk of early unit costs and delays, shouldn't these buyers also share some of the upside in future units?

Hard to do this in a commercial arrangement

The difficulty is also convincing a buyer to be a first mover, taking high costs and risks for early units, when the learning from these early units may well benefit other buyers who move later (or perhaps vendors who keep prices higher)

Strategic issues
National approach



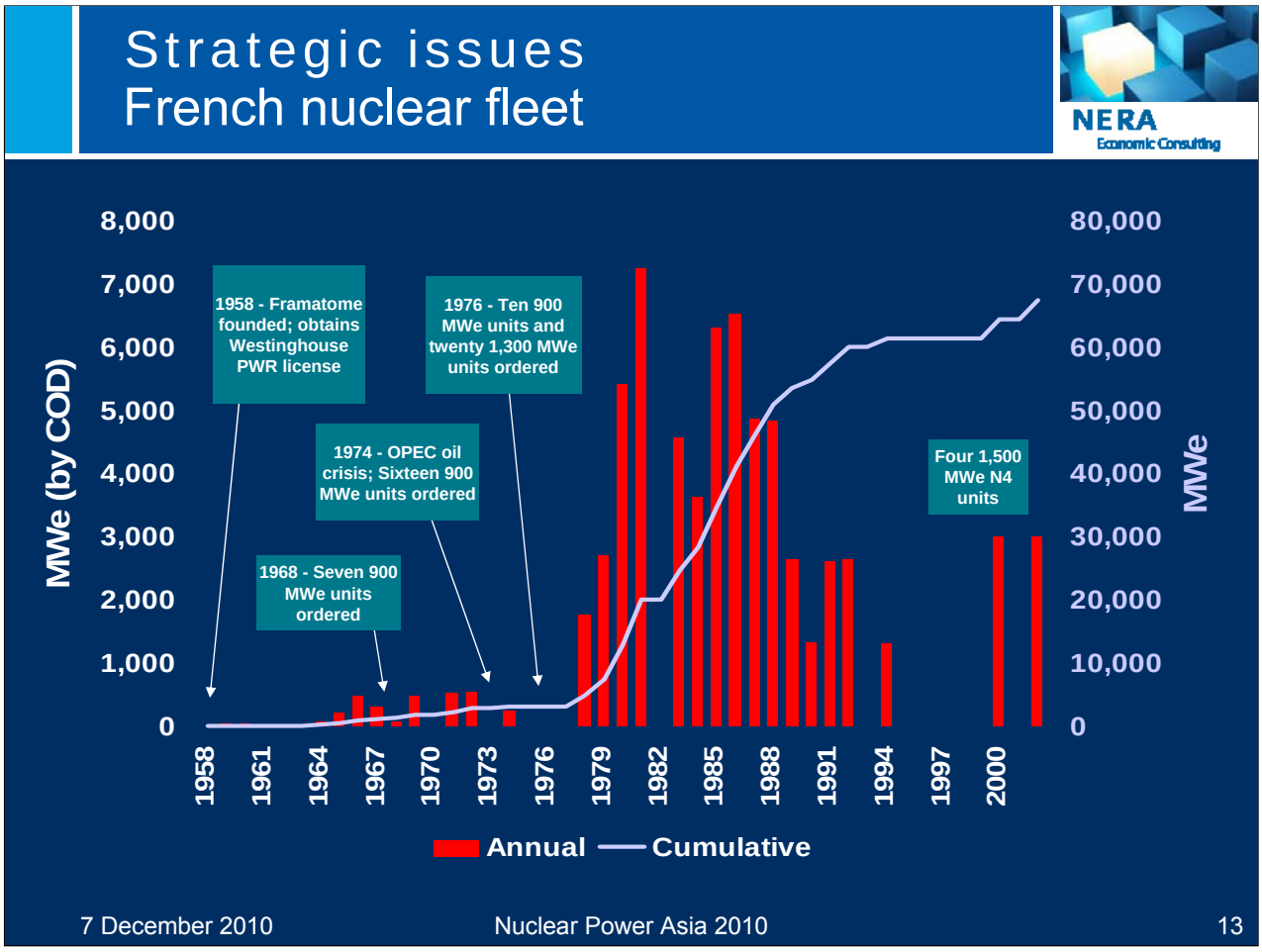
However, when the units are all in one government build programme, the learning curve benefits and capability building may be more fully captured.

Investing in FOAK units provides benefits in lower costs for the fleet build.

These benefits may be captured even more completely if the vendors, builders, and suppliers are part of the overall government nuclear effort.

Later, if the national supplier decides to sell to the export market, this may be profitable for both outside buyers and for the supplier

Areva seems to have a strategy that turns this approach upside down – using export sales to get down the learning curve for the EPR, with an eventual plan to use the mature costs and risks of the EPR in future French nuclear fleet replacement.



The earlier French nuclear build programme is a model for the current government nuclear build strategy.

This is the capacity (in MWe) of new LWR nuclear plants that were placed into commercial operation in France from 1958 to 2002.

The French linked the nuclear power plant build programme to an internal nuclear industrial development strategy.

More recent French strategy seemed to depend on sales of EPR in export market to support eventual French nuclear fleet replacement

Strategic issues
New nuclear countries

- High growth rate in developing world, but
  - Multiple smaller countries = multiple reactor sales
  - Physical and administrative infrastructure lacking
  - 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

Developing countries have a high and growing need for power – this might seem to make them ideal candidates for nuclear power.

However, there are some hurdles.

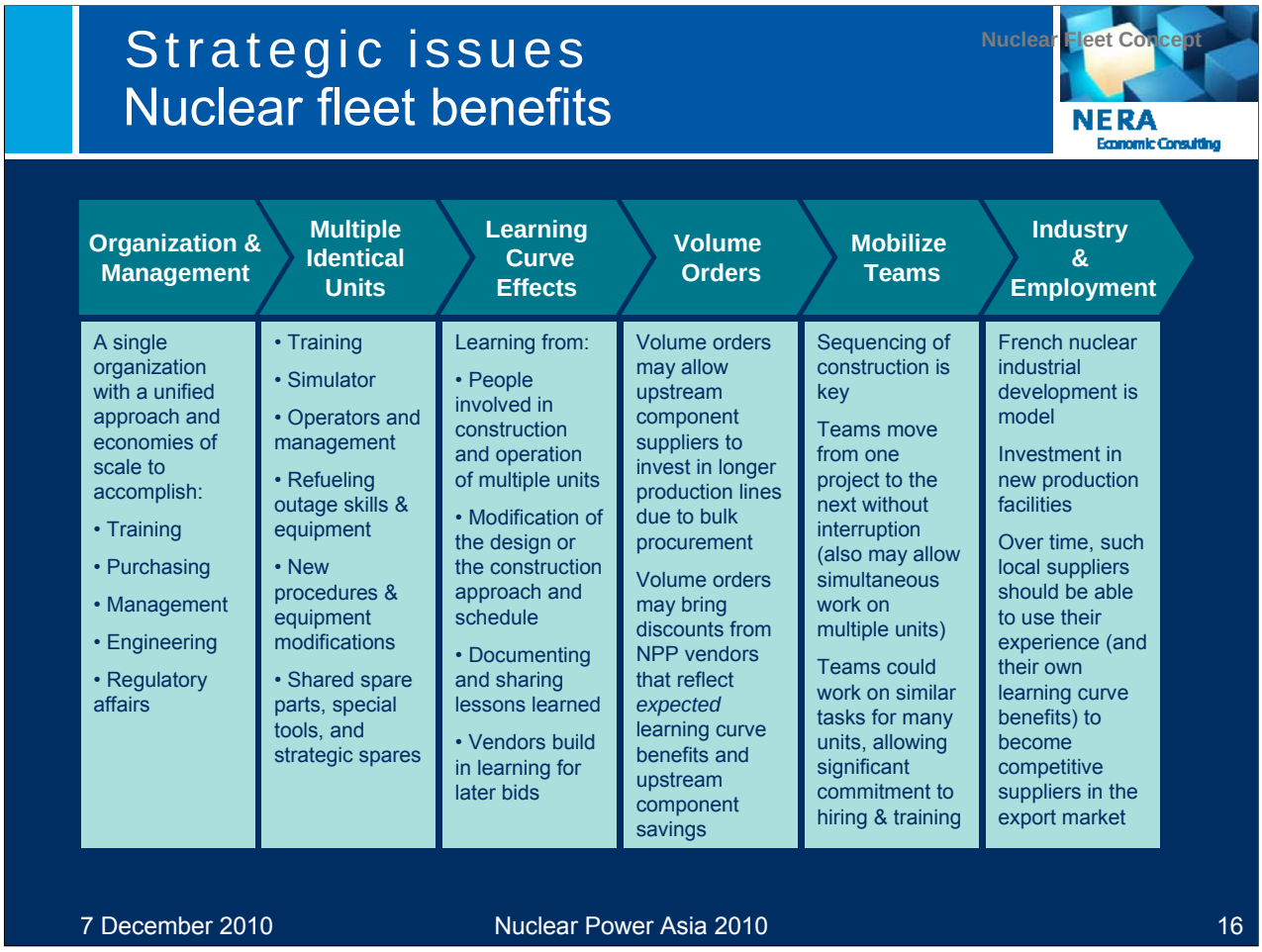
One nuclear power vendor strategy is to help overcome these hurdles to accelerate nuclear industry in developing countries as a means of facilitating reactor sales.

Strategic issues
Size of nuclear build programmes

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

If low and more certain costs are linked to a large and active build programme – then some countries will have a natural advantage.

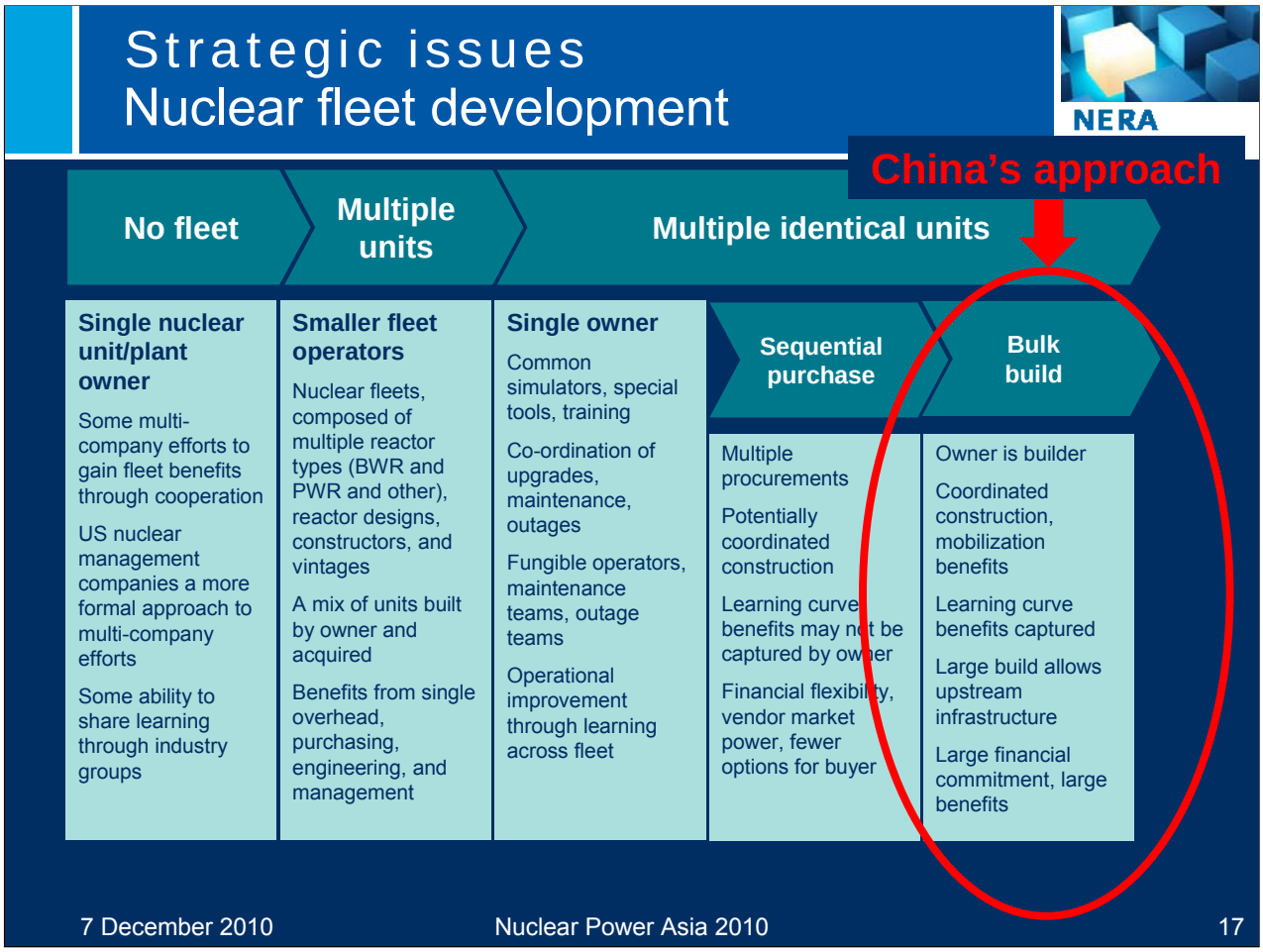
Other countries will have trouble getting nuclear to work



This chart shows some of the benefits of a nuclear fleet.

Many of these nuclear fleet benefits are available without the full French national fleet approach.

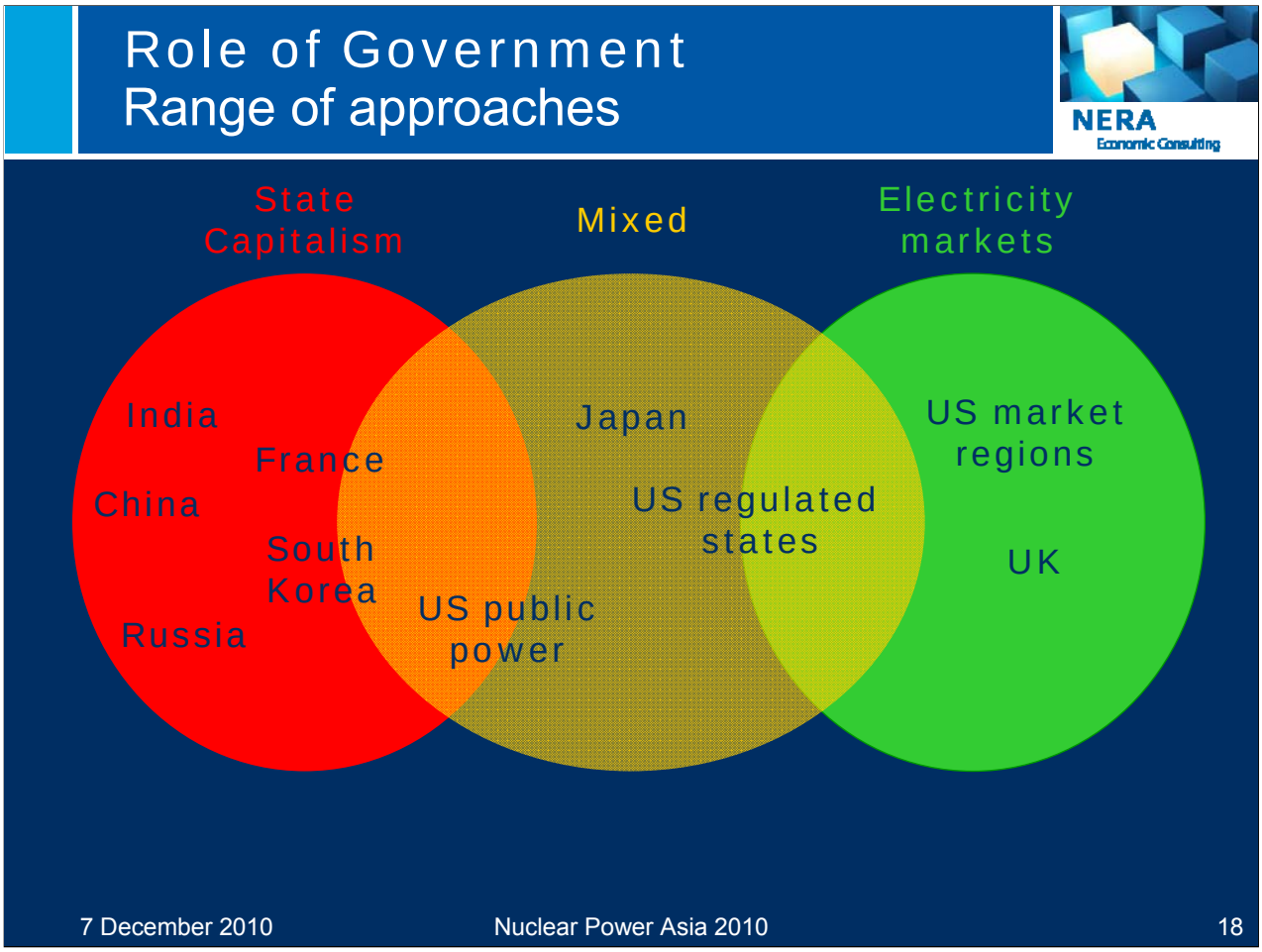
One example are the US nuclear fleet operators. These companies have built or acquired nuclear fleets with units of differing designs and vintages, yet have achieved many nuclear fleet benefits by adopting effective Organization and Management approaches.



This picture provides a simplified version of the framework for examining different approaches to nuclear fleets.

A key insight is that there are significant nuclear fleet benefits that do not directly depend on the procurement approach.

China has embarked on a strategy to build large fleets of identical units. Adding to the benefits of a fleet, there are the benefits of building the nuclear industrial capacity that comes from a large nuclear build programme.

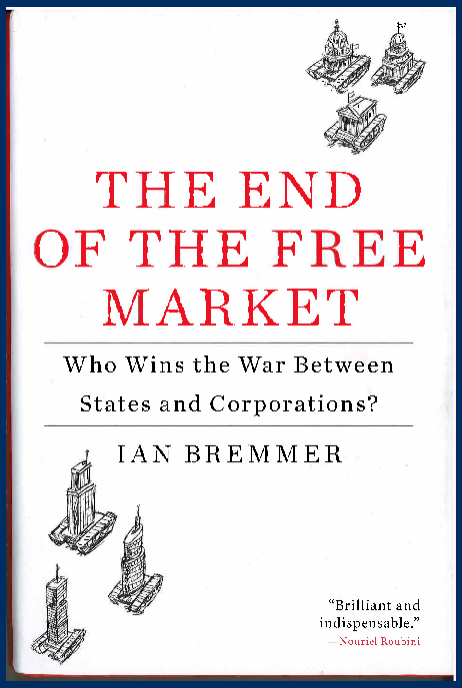


Electricity Markets – merchant nuclear plants – the limited experience with true merchant nuclear plants in the US and UK suggest that this will be difficult and may require some level of government support.

Mixed – while the utility purchaser or owner of a nuclear power plant may be government or publicly supported (ie, a regulated utility), the industry that builds that nuclear power plant is private and the procurement is a commercial contract. Depending on the industry model, the utility buyer may be a publicly-traded corporation.

State Capitalism – in the purest form of state capitalism, the owner, buyer, seller, financer, builder, supplier, etc are all government owned.

Role of Government
State Capitalism

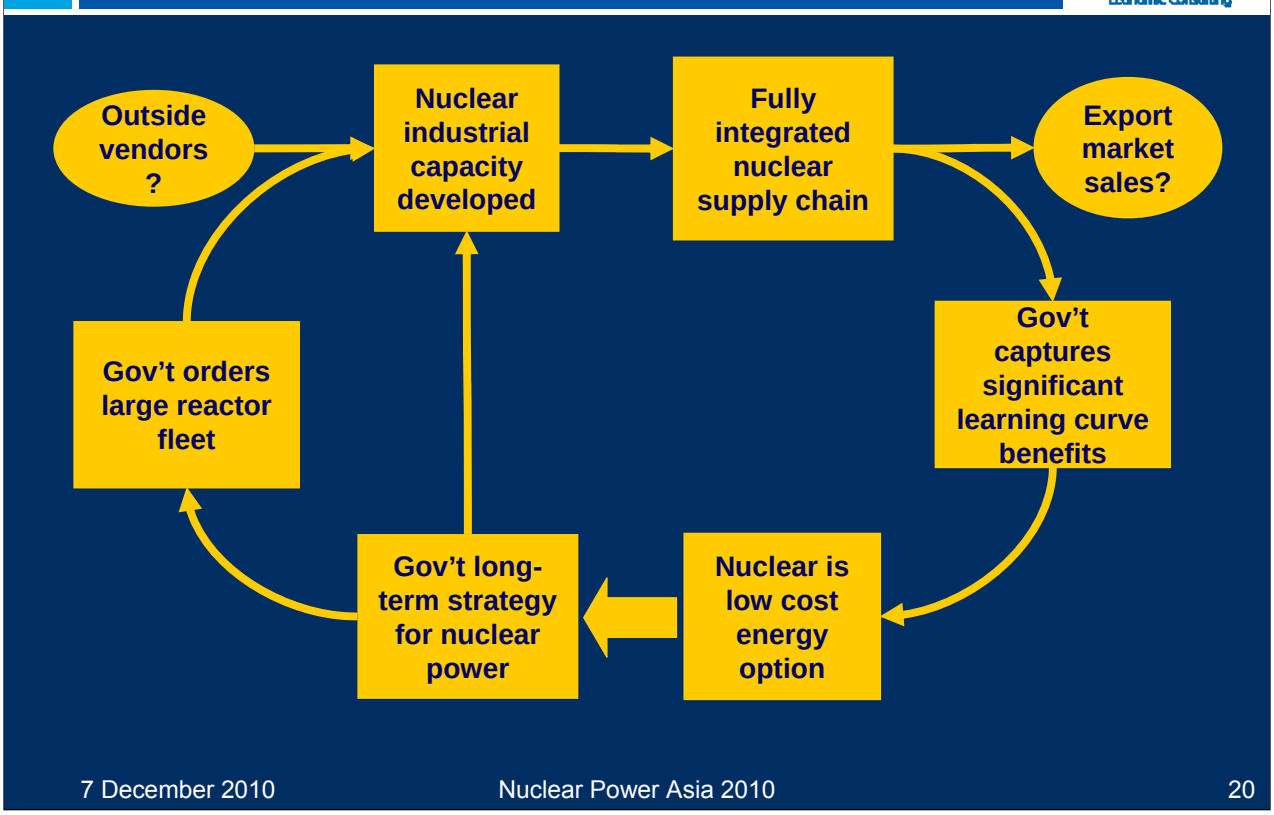


- Strategic and long-term state domination of markets
- National Corporations & State-Owned Enterprises
- Strategic goals above profits
- Inside & outside host country
- China and Russia leading examples

Published in 2010

Bremmer's book does not mention nuclear power, but he could have used nuclear power as an example of state capitalism.

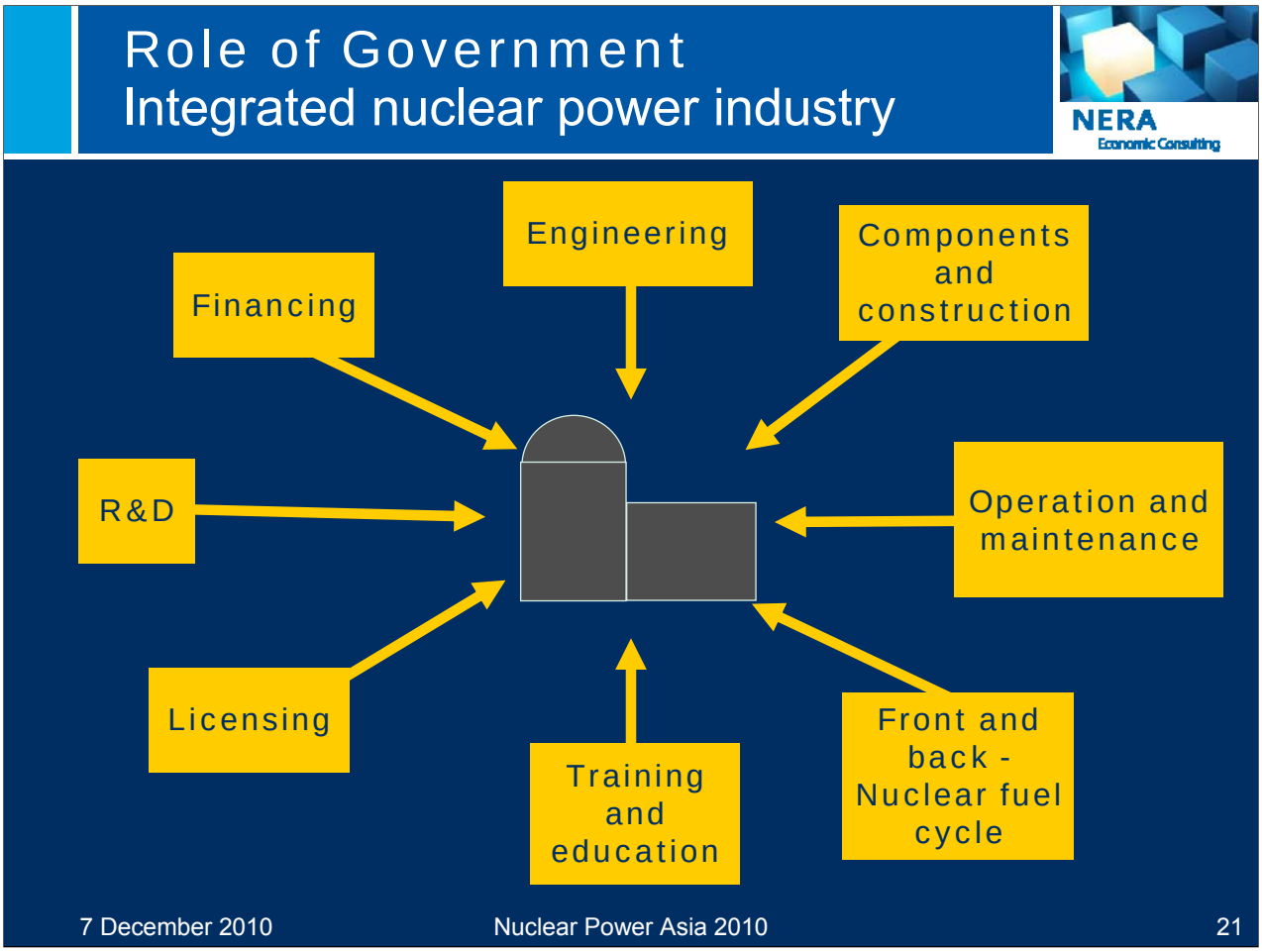
Role of Government
State capitalism - nuclear power



This is an animated slide – starts at the bottom left box ("Gov't long-term strategy"), then goes around the circle

Government plans for nuclear → large nuclear fleet purchase → may involve outside vendors, but drives industrial development → results in integrated supply chain → may involve export sales → allows the government to capture the benefit of learning curves and experience → result is low cost for nuclear option → Government nuclear strategy is confirmed and supported

Query – is nuclear too expensive to work outside this model (ie, in the commercial model)?



When a government is able to build its own integrated nuclear supply industry around a government-ordered large nuclear fleet build, it is possible to achieve significant cost reductions. Also possible are reductions in risk and in schedule, as the integrated supply chain is managed as a single economic entity.

The normal commercial approach involves subcontracts and other agreements to bring a team of unrelated commercial entities together.

If financing and operation is a part of the package, financial entities and utilities with nuclear operations expertise must be included in the team. Just getting a winning team in place is a major challenge. This portfolio of project agreements adds cost (to meet risk premiums and profit margins of subcontractors), risk (as responsibility is shared between multiple commercial entities), complexity (project management is more difficult due to multiple entities with multiple interests and contractual rights), and the need for effective project management.

Summary

- Pivotal time for nuclear power industry, with high capital costs and project risk
- Large nuclear fleet build by governments
  - Capture learning curve benefits of large orders
  - Build confidence through completed projects
  - Build integrated national nuclear infrastructure
- Will commercial vendors be able to compete with state nuclear suppliers?

We may be seeing a shift from the large nuclear vendor/constructor model (where a single company or a group of companies dominated the industry because they held the learning – from building multiple units for multiple buyers) to the State Capitalism vendor model.

Now governments can be both suppliers and buyers and build their own capability through their own purchases – a very different model of the industry. When these government reactor vendors enter the export market, they will be (are!) strong competitors.

Motivations for export market vary

•Political influence (e.g., China in Pakistan, Russia in Turkey)

-Build experience (Areva in Finland and China)

-Drive industrial activity in home market (South Korea)

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