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The Role of Nuclear Energy in Global Energy Markets

Nuclear Energy Development Summit 2013: Turkey, Black Sea & Middle East

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Insight in Economics™

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Two topics today

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Where are new nuclear projects being built?

What factors drive nuclear development?

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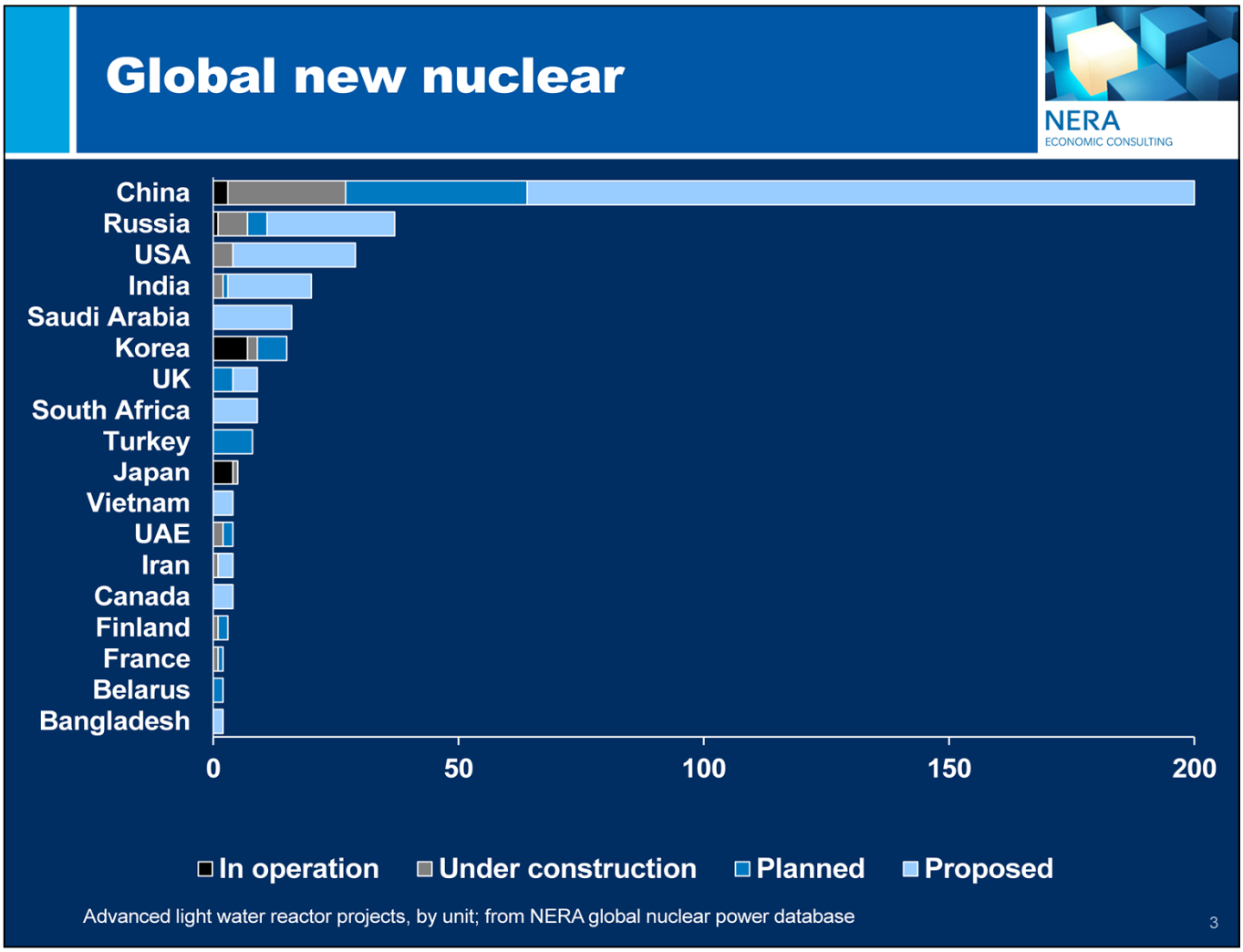
Examining nuclear power projects, including those that are built, under construction, planned and announced, can provide insight into the factors driving nuclear development.

Understanding these factors can help vendors, buyers of nuclear power (and nuclear power plants), and governments develop more effective strategies.



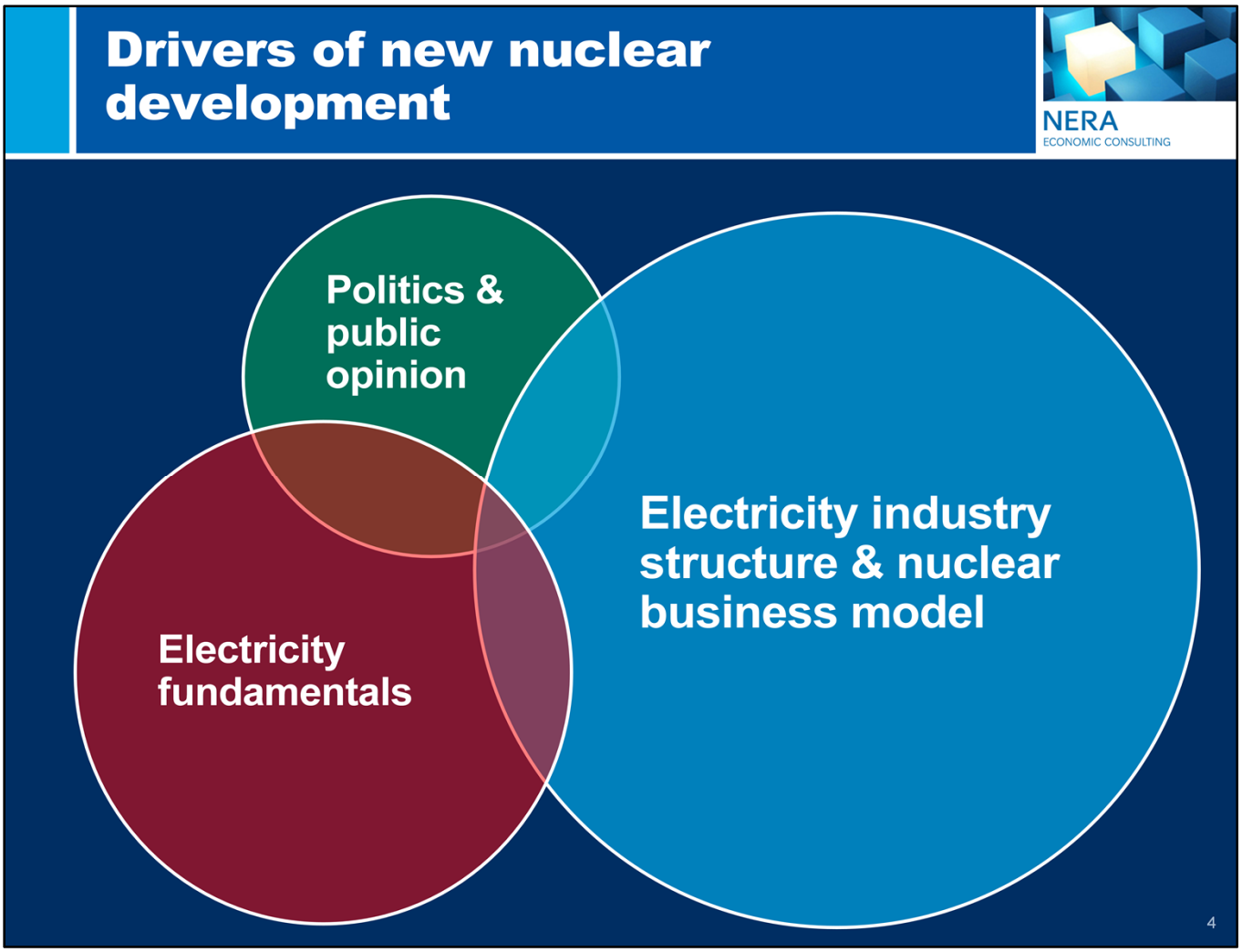
This comes from my global nuclear database

The USA bar is optimistic; two new plants (4 units) are under construction, but most other U.S. new nuclear projects have been significantly delayed and may not be built

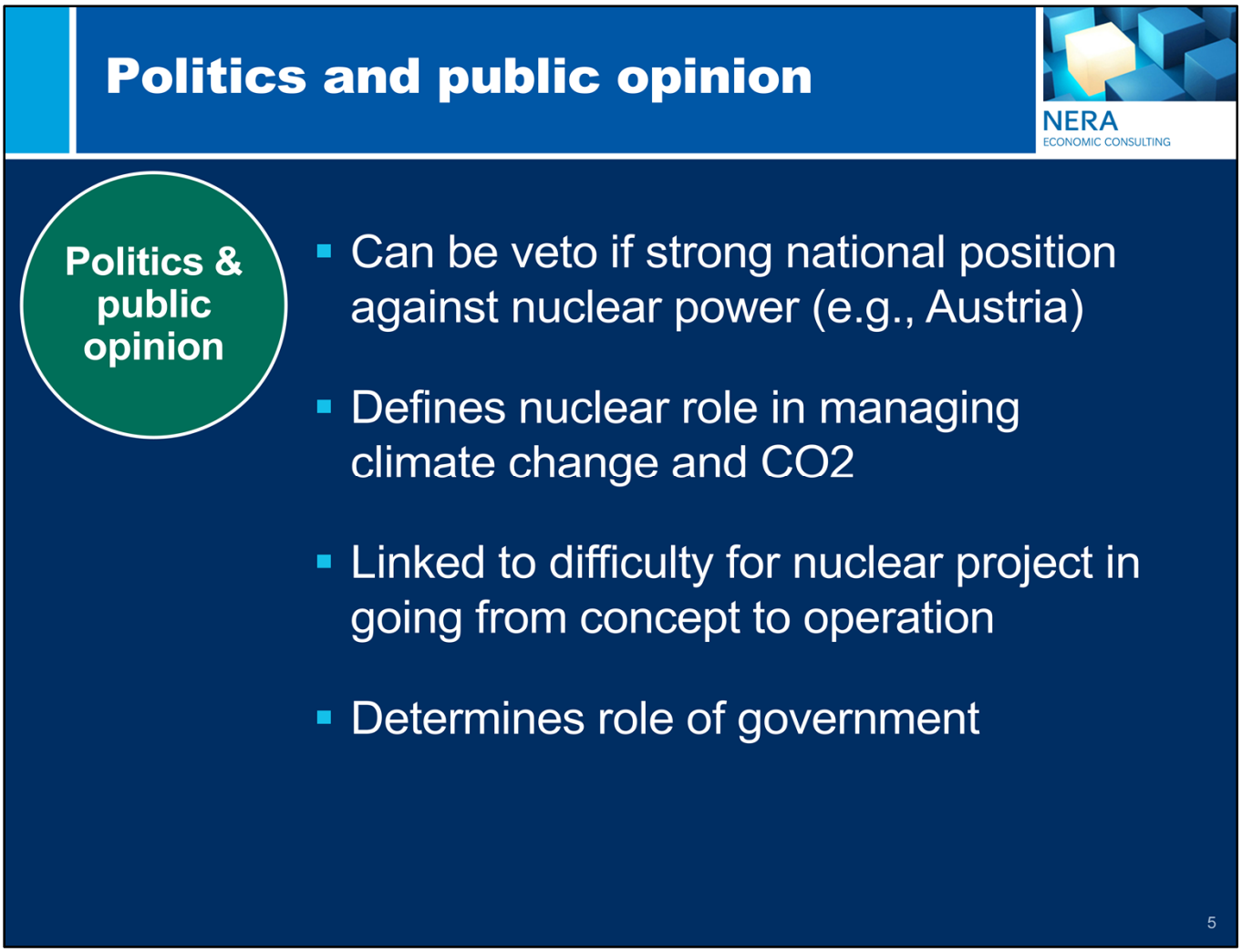
There is a lot of information for each country and each project on this simple bar chart.

Examining this information can help us understand the drivers of new nuclear in the world

What follows is my view of the most important drivers

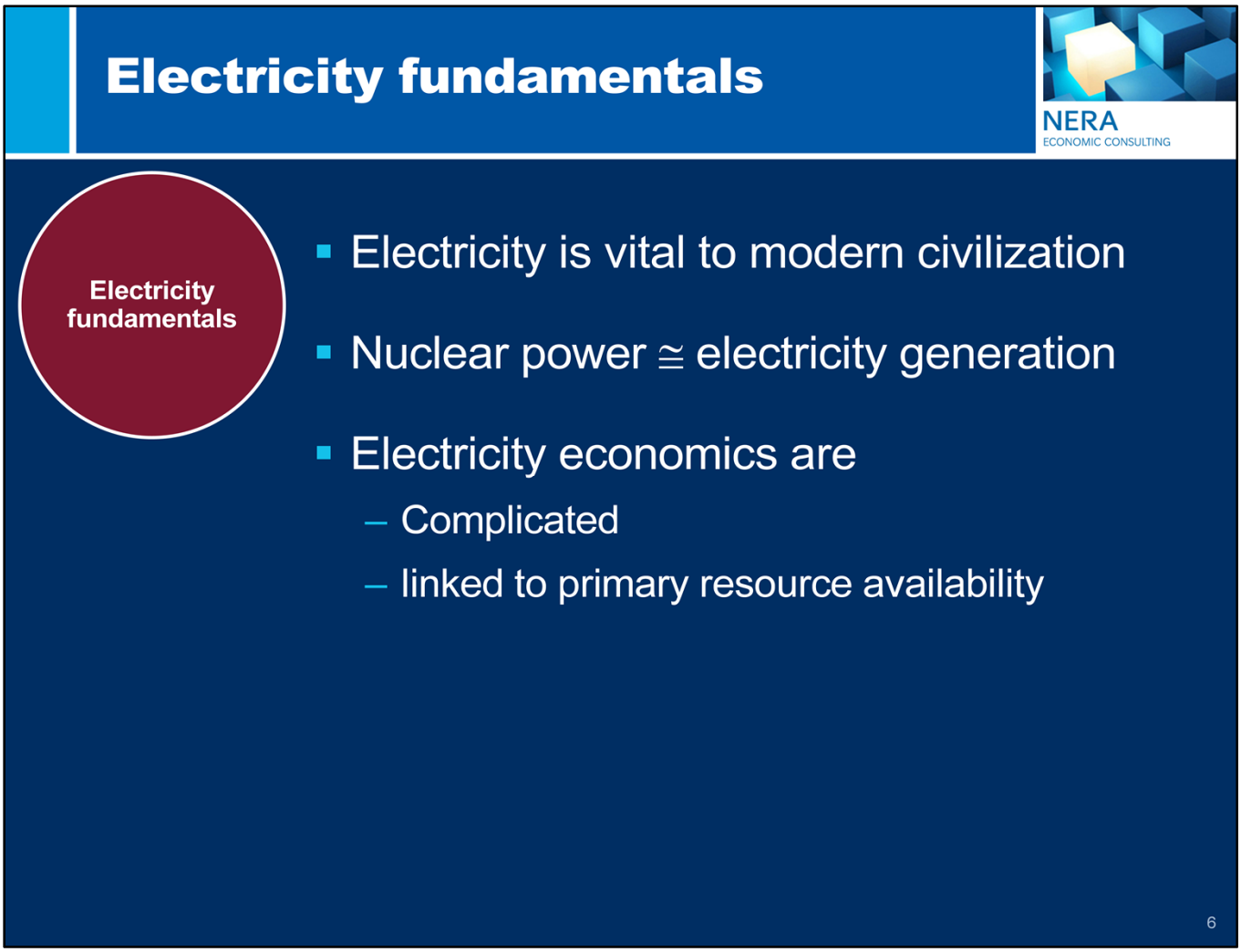


The size of the circles indicates my view of the importance of these three drivers



Politics and public opinion is an important factor, but not sufficient

- In addition to Austria, Germany and Italy are examples of political vetoes
- In many countries, political positions have led to subsidies for renewables, but little support for nuclear
- The EU blanket exemption for renewable subsidies compared to the State Aid challenges to nuclear assistance
- A nuclear project can take longer and cost more if there are demonstrations, legal challenges, and other opposition tactics by nuclear opposition groups
- Government positions cover a wide range:
    - Oppose nuclear power
    - Support or subsidize non-nuclear energy options, but not nuclear power
    - Do nothing
    - Support nuclear power
    - Develop and own nuclear power plants

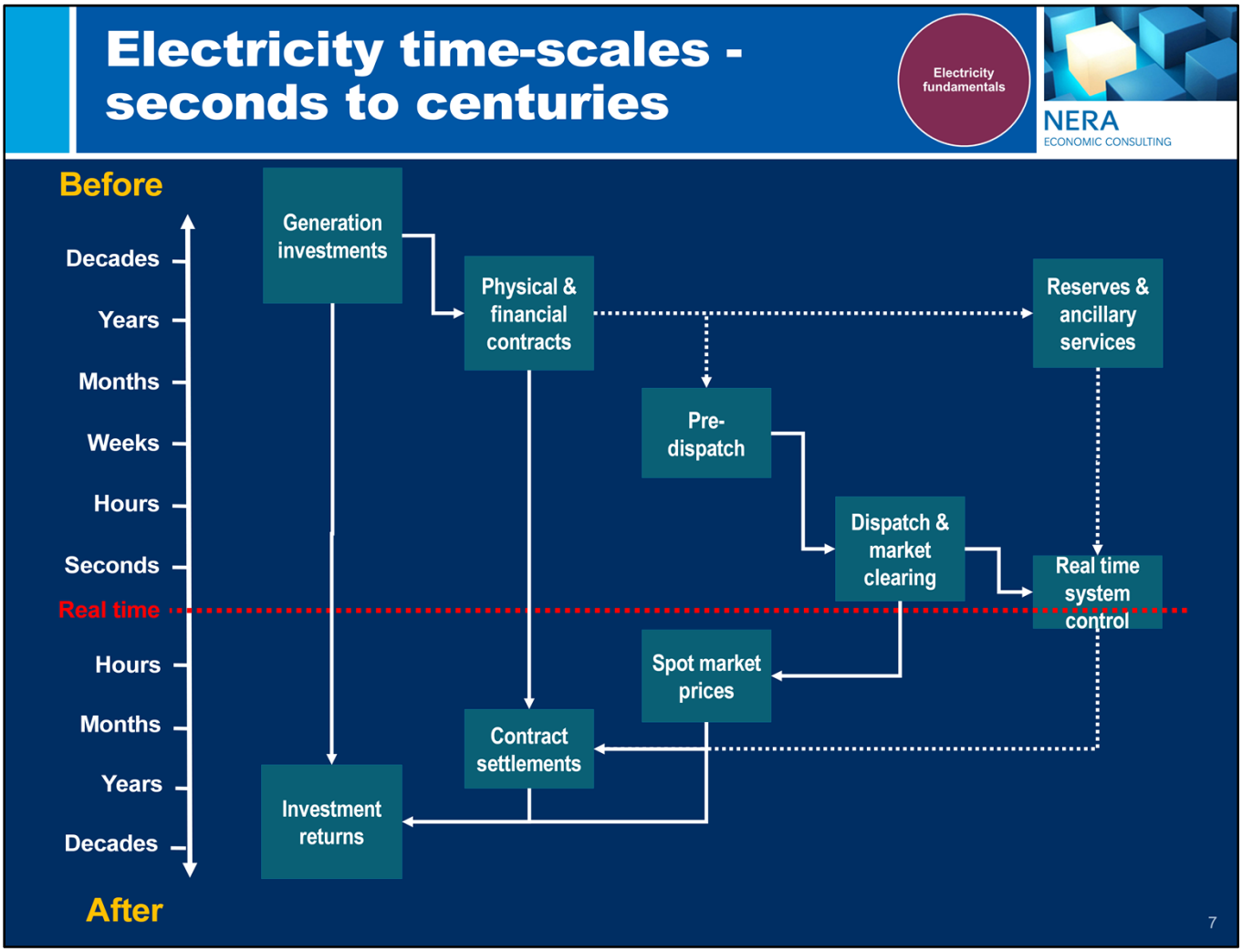


Cost-competiveness of nuclear based on electricity industry fundamentals

Electricity industry economics and economics of nuclear power plants are related

The cost of nuclear power is important, but the ***relative worth*** of nuclear electricity is more important

Relative worth of nuclear electricity depends on factors outside the nuclear power plant



The electricity system must work well in real time and work well over the long term

Before electricity markets, all this was done by utilities that managed both real-time dispatch and long-term resource planning – seeking to minimize costs

Electricity markets were developed to do the same thing - electricity market prices developed in the shortest term (i.e., spot prices) would lead to new investments.

As a result of price caps, continued regulation of retail electricity, and other factors, spot prices may not fully reflect real-time value of electricity – so the link to investment is not working so well.

Electricity markets work well in the short term, but many of these markets have yet to demonstrate that market incentives alone can drive long-term resource development

Let's look at how these two things are different

Electricity economics

Electricity fundamentals

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- ***Real-time:*** System dispatch to meet electricity demand using existing generation plants within constraints (e.g., security & unit commitment) to: ***minimize system short-run marginal cost (e.g., fuel costs)***
- ***Long-term:*** Develop resource mix/plan; a complex multi-decade problem including existing and new generation plants; to: ***minimize system long-run marginal costs (e.g., total system costs, including capital costs, transmission system, etc.)***

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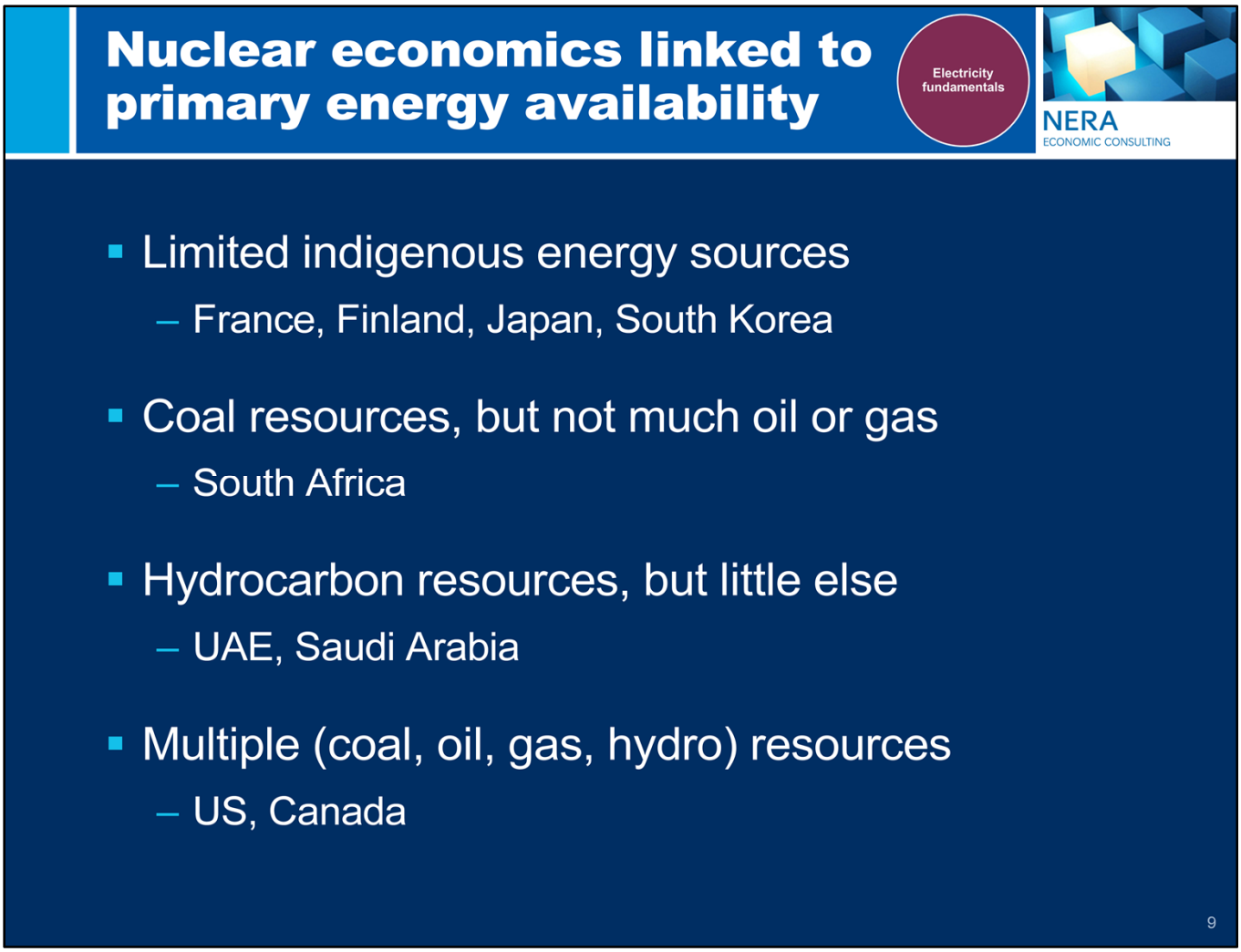
In real time, the system dispatcher (or market operator) uses existing power plants and transmission lines to meet demand.

In the long term, the system planner (or the market) aims to build out the total system in a way that minimizes LRMC, while meeting demand. Of course, the longer the period, the more uncertainty in fuel prices, demand, technology, and other things.

Electricity markets use prices to do both of these things,. But is it really feasible that electricity markets can simultaneously clear on timescales of seconds and centuries?

There is evidence that electricity markets work well in the short-term, but may not work so well in the long term.

Even where electricity markets have resulted in new investment, it is unclear how electricity markets would work to minimize system long-run marginal cost



The resources used in an electricity system depend on the options that are available *for that particular system.* This means that the value of nuclear electricity is different in different systems and in different situations.

The primary issue is the availability of primary electricity generation fuels.

- If there are few fuel resources available, nuclear has been a natural choice
- South Africa shows that there may also be differences in resource availability inside a country – Koeberg was built to serve Cape Town area far from the coal fields
- Gulf states see nuclear as a means to decrease internal use of hydrocarbon resources and make more hydrocarbon resources available for export
- Multiple primary energy options (i.e., the U.S.) all compete with nuclear

Economist article (1 June 2013 edition) "Fracking Off" – explains the issues faced by nuclear power in the U.S.

Electricity industry structure & and nuclear business model

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Electricity industry structure & nuclear business model

- 3 basic models
  - Government nuclear in government-owned electricity industry
  - Regulated nuclear in regulated electricity industry
  - Merchant nuclear in reformed / restructured / deregulated electricity industry

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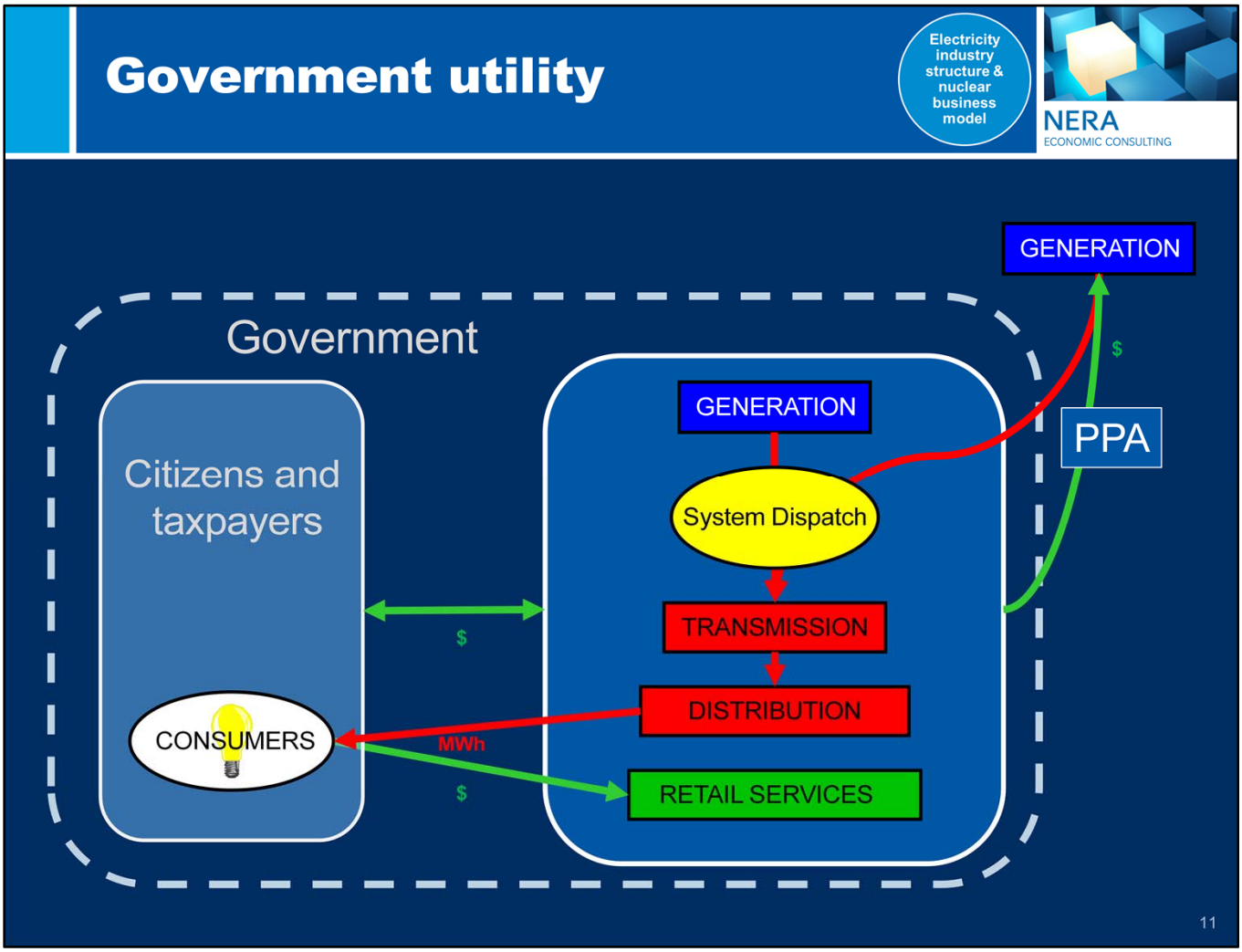
This is the most important factor

Even if politics and public opinion are favorable, and electricity industry fundamentals are good, the electricity industry structure issues can make nuclear difficult.

The next few slides cover the government and regulated model – important because all operational nuclear plants and most of the nuclear plants under construction are built under these models.

The more interesting model is reformed electricity industries. In these countries, nuclear power is having difficulty

Electricity markets offer big challenges to nuclear power, but also offer some new opportunities.



This was the dominant industry structure outside the US – remains in many countries.

Some points:

- Government investment decision-making is likely to be result in different outcomes than market investments – social benefits are a factor
- The prices charged for power may not be equal to costs – the government can subsidize rates or can use rates as a means of increasing government revenue. The green line in the middle shows this
- Some government utilities have used PPAs to "buy" power from IPPs – these IPPs usually depend on the credit of the government utility to support financing for the IPP project – depending on the details, an IPP based on a PPA with a government utility may be an effort by the government utility to engage in "off balance sheet" financing

Government nuclear plants

Electricity industry structure & nuclear business model

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- Government assumes project and market risk
- May mean faster decision-making
- Big purchases by creditworthy buyer may mean strong bargaining position with vendors
- But governments also want non-power outcomes
  - Develop local jobs and skills
  - Develop industrial capability / join global supply chain
  - Implement energy and/or climate change policy

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A government utility can make long-term resource planning decisions and commitments

Government utilities capable of undertaking infrastructure-like investments such as nuclear power

Increasingly, government buyers of nuclear power also want other things – localization is a typical objective.

Government nuclear

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- China, Russia, France, India, etc.
- UK - CEGB (now dismantled) - existing UK nuclear
- US - US federal power agencies (e.g., TVA), municipal utilities and cooperative power utilities

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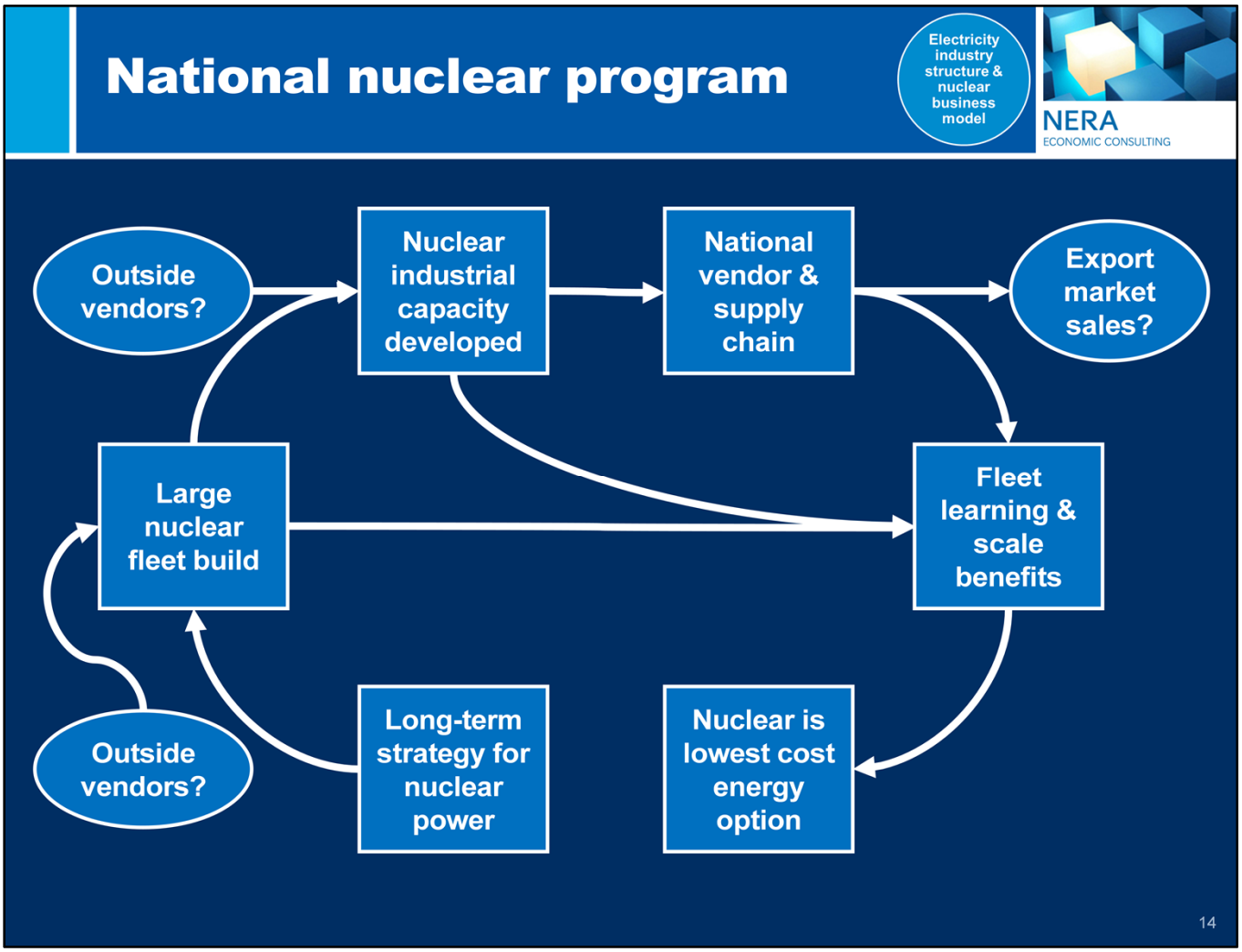
Some examples of government nuclear power programmes

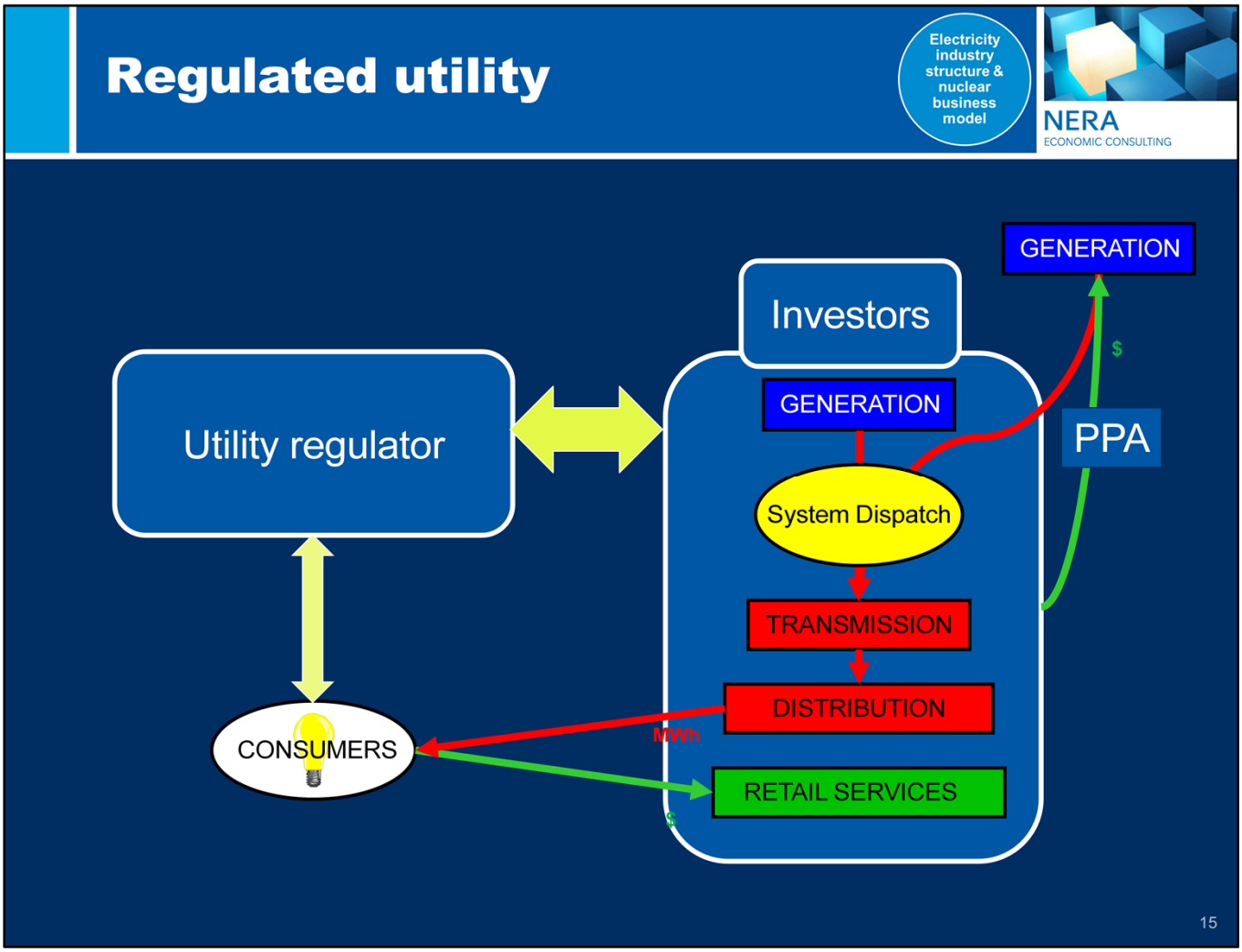


Some government nuclear programmes are about more than electricity industry economics.

- France and Russia established a national nuclear industry that serves nuclear industry markets outside the country
- South Korea has built a nuclear industry that is now active in the world market
- Now China is doing the same

Some of these national nuclear companies are also positioned to use national financial capability (e.g., government-to-government loans) to support merchant nuclear projects built by the country's national nuclear vendor – more on this later

A private shareholder-owned nuclear power plant vendor may find it hard to compete with these national nuclear programmes.



This was the dominant approach in the USA

The regulated utility approach remains in US regions that did not undertake reforms (e.g., the Southeastern U.S. states)

Like a government utility PPA-based IPP, regulated utilities may buy power using PPAs that are supported by the credit of the utility (and its ability to recover costs from customers).

Regulated nuclear in USA

Electricity industry structure & nuclear business model

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- Regulator (state-based in US) with long-term view approves decisions and sets rates
- Consumers (i.e., ratepayers) take most project and market risks
- 1980s prudence reviews shifted nuclear costs to shareholders and shaped regulatory approaches
  - Integrated Resource Planning (IRP) processes
  - Regulator has project oversight
  - Lower risk of nuclear disallowance for utility

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U.S. approach to regulated utilities based on decades of experience and legal challenges

U.S. nuclear power plant build activity in the 1980s led to problems as project costs increased significantly and expected demand growth did not happen.

Some of these U.S. nuclear projects were found to have costs that were not “prudently” incurred and that were disallowed (i.e., not passed to ratepayers)

This was a major disturbance in the regulatory approach:
- Utilities were reluctant to invest
- Regulators were reluctant to allow major projects

The result was a set of new regulatory approaches that balance the need for major investment with regulatory oversight

Regulated nuclear

Electricity industry structure & nuclear business model

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- Vogtle 3 & 4 – Georgia
- Summer 2 & 3 – South Carolina
- Levy County – Florida (under review)
- South Africa – NERSA (uncertain path)

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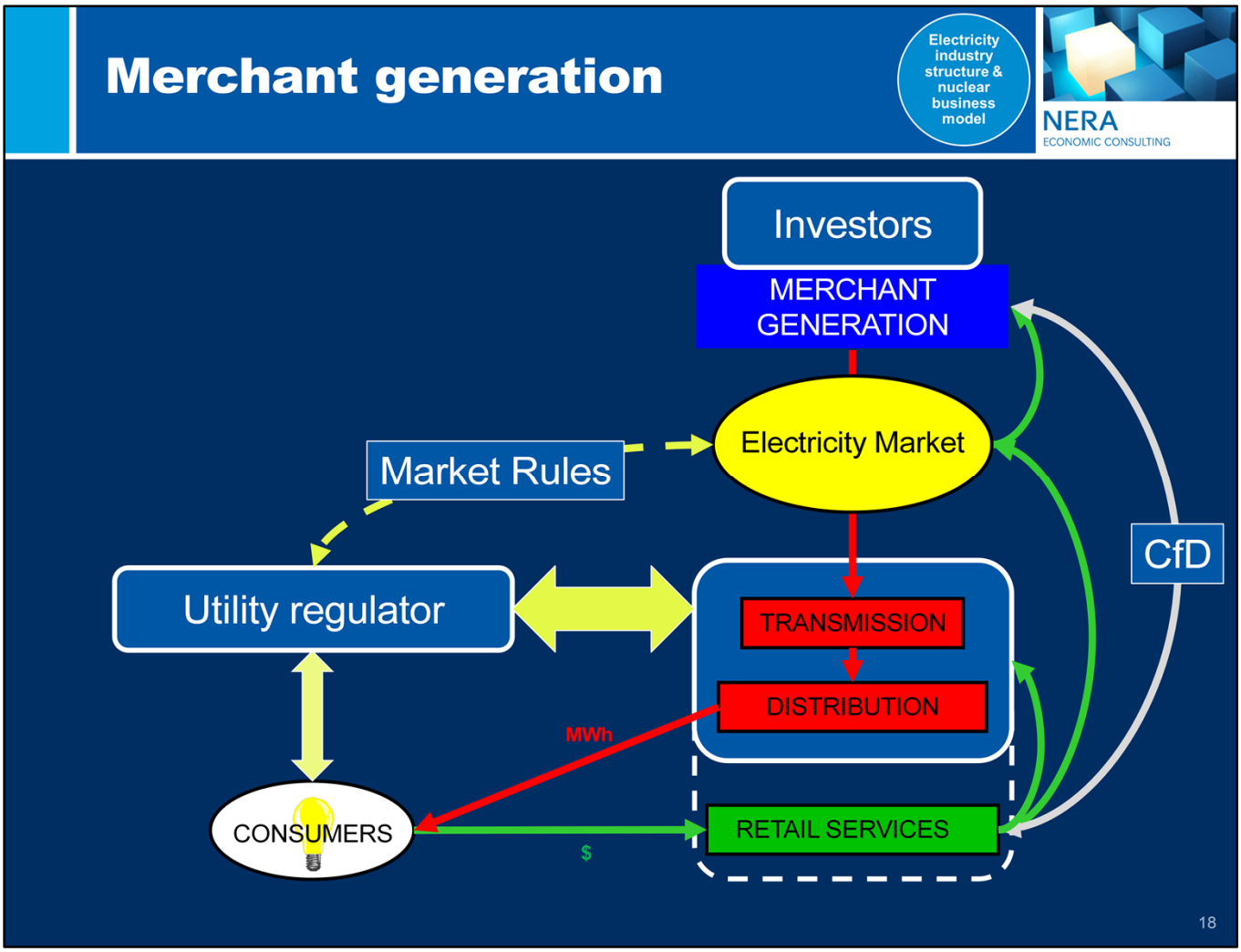
The new nuclear project under construction in the US are regulated

South Africa has a state-owned utility (Eskom) and an economic regulator (NERSA) – but the regulatory process in South Africa is not settled - a recent Eskom rate case suggests that new nuclear may be difficult as an Eskom regulated project



This is a more complicated picture!

Some parts of the electricity industry (e.g., transmission and distribution) usually remain regulated . Retail electricity service may be unregulated, but may remain regulated

The regulator may have oversight of market rules (and changes to those rules)

Consumers pay for power, with payments to regulated T&D and to the market for energy

Market payments are made to generators for energy generated

There may also be contracts for difference (or other hedging arrangements) in place between end users (or load serving entities) and generators – if retail customers or load-serving entities are exposed to spot market prices, this helps hedge the spot market price risk.

Some markets also have separate capacity markets, reliability requirements, or other features to provide incentives for generation ownership and investment.

Merchant nuclear is hard

Electricity industry structure & nuclear business model

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- Project and market risk assumed by owner
  - Cost & completion risk - before COD
  - Market price and unit availability - after COD
- Project finance approach strained by
  - High capital intensity and large project size
  - Long development and construction period
  - Lack of revenue certainty
  - NPV / IRR / payback period for investors/lenders
- No merchant nuclear plants built . . . so far

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A merchant power plant gets revenues from the market – this is different from the a PPA-based IPP (as discussed earlier) that may have secure long-term revenue source

Merchant power plants using other fuels and technologies than nuclear have been built

Natural gas fired combined cycle gas turbine power plants are the most common merchant power plants

Uncertain revenue in electricity market

Electricity industry structure & nuclear business model

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- Predicting future revenues is complex
  - Detailed market simulation model with short-term and long-term assumptions
  - Scenarios to reflect uncertainties and to identify key revenue risks and opportunities
- Nuclear project time-line adds difficulty
  - Revenue starts at COD (~10 years after project start)
  - Project operates for 60 years (or more)
- PPA or CfD may be required for revenue support

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Predicting future revenue of a merchant power project is not easy. Doing this for a nuclear project is really difficult, given the long operating life of a nuclear power plant

A merchant nuclear project will need some long-term revenue certainty

- CfD under negotiation between EDF and the UK government is one approach for the project investor (EDF and any partners) to get more revenue certainty
- OL3 project in Finland, is another approach – nuclear plant ownership by energy-using companies is an implicit life-of-plant hedge against Nordpool electricity prices

U.S. merchant nuclear projects (now dormant) had a business model based on:
- projections of natural gas prices that were higher than today
- a possibility of carbon tax (or some equivalent) revenues
- U.S. government loan guarantees at low rates

Vendor financing and ownership

Electricity industry structure & nuclear business model

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- Merchant nuclear with vendor investment
  - to gain market share
  - to achieve other objectives
- Government nuclear vendor (e.g., Akkuyu)
- Non-government nuclear vendor
  - May make FOAK unit more manageable
  - Alternative to LSTK (buyer control and losses)
  - Merchant model has vendor control and upside
  - Sinop project in Turkey may be example

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There are some interesting developments in nuclear project business models

As the nuclear industry tries to develop projects in electricity markets, vendor financing seems to be a topic in many projects

The Rosatom approach in Turkey combines a limited PPA with the Turkish government and market sales with ownership and financing by the vendor (i.e., Rosatom)

Bidding for and negotiating a traditional EPC contract is a long and expensive process.

If nuclear vendor is also the buyer/owner of a nuclear plant – especially for FOAK units - these transaction costs can be reduced

A vendor may face lower risk by owning a FOAK merchant nuclear power project as compared to selling that FOAK project with a traditional lump-sum , turn-key (LSTK) contract

Some interesting new challenges as commercial nuclear vendors arrange financing in these projects.

Merchant nuclear

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- Existing units (divested or privatized)
  - US – existing nuclear units divested and operate as merchants in electricity market regions
  - UK – all existing units sold to EDF
- New units
  - US – Calvert Cliffs 3, South Texas Project 3 & 4, and others
  - UK – EDF, Horizon, NuGen

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There are a number of merchant nuclear projects that were based on nuclear units built under earlier government or regulated approaches

U.S. merchant nuclear projects were very profitable when electricity market prices were high; with lower electricity markets prices this may not be the case.

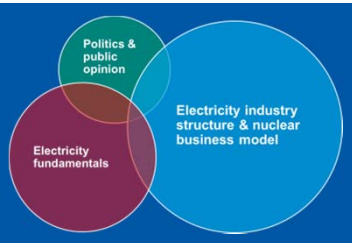
Kewaunee merchant nuclear plant (in the U.S. MISO market) was recently closed to stop operating losses:

- Low natural gas prices depress on-peak electricity market prices, and
- Wind out-of-market subsidies lead to negative bidding and negative market prices off-peak

New U.S. merchant nuclear projects are mostly on hold – NRC licensing process only

UK negotiations about the Hinkley Point CfD continue

SUMMARY



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- 3 main drivers of new nuclear - electricity industry structure is most important
- Regulated and government approach remains a proven approach for new nuclear projects
- Merchant nuclear approach not yet settled, but likely to be some role for government
- Nuclear vendor business model changing to reflect changing electricity industry

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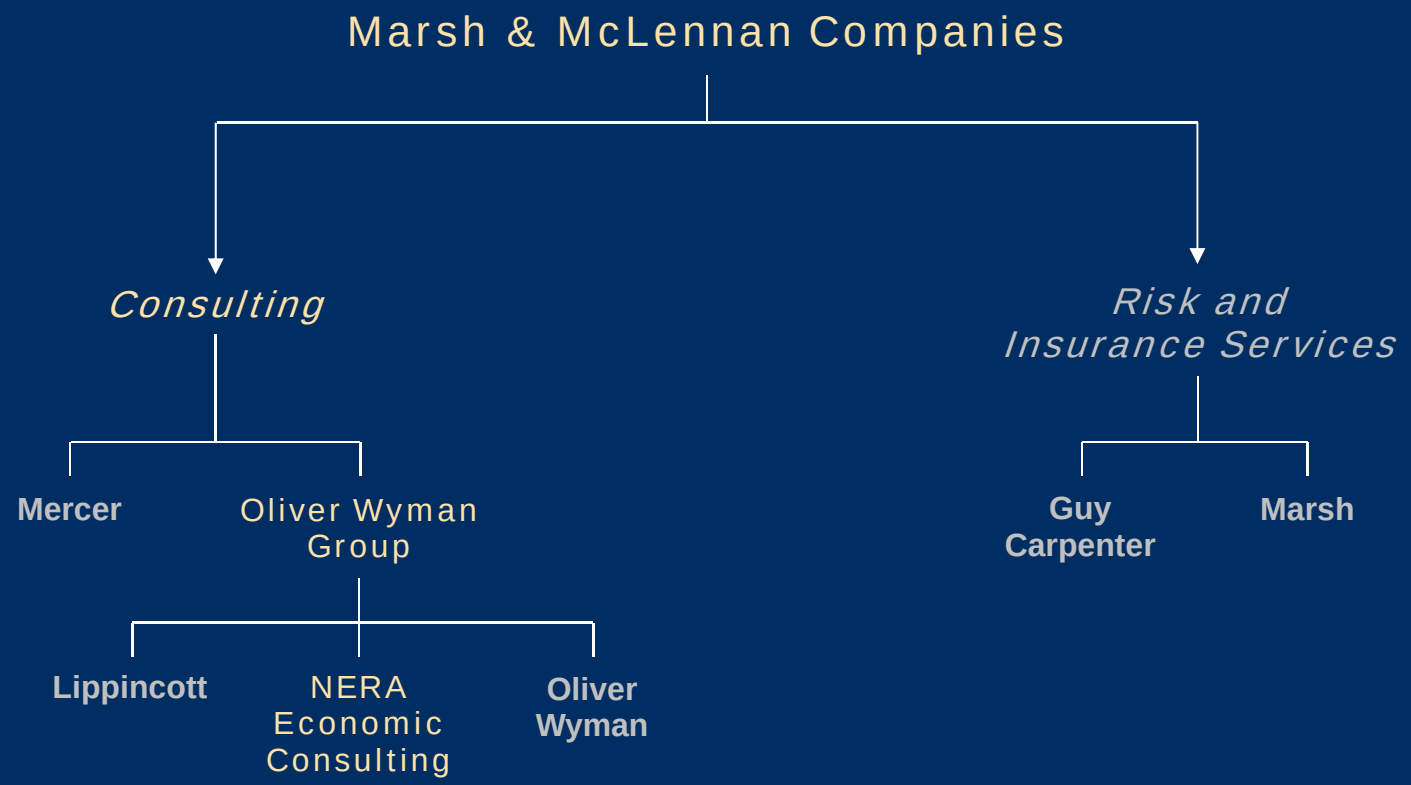

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