

**Global
Nuclear
Power**

**Goldman Sachs
Ninth Annual Power and Utility Conference
19 May 2009**

**Edward Kee
+1 (202) 370 7713
edk@edwardkee.com**

Cover photo: Isar 1&2 near Essenbach, Bavaria; about 75 kilometers northeast of Munich

Disclaimer

These slides that follow do not provide a complete record of this presentation and discussion.

The views expressed in this presentation are mine; these views may not be the same as those held by my clients or my colleagues.

Global nuclear update

- **Important events in the last year**
- **Global nuclear development**
- **Global vendor race**
- **US projects and likely timing**

I am covering only 4 things today:

Important events – from my point of view - in the last year

Nuclear development outside the US, with a focus on China, Russia, and India

The race for market share among vendors

US Nuclear projects and related issues

Nuclear renaissance – overtaken by events?

- **High capital cost estimates pervasive**
 - Conservative, so less chance of cost overruns
 - But, nuclear economics now not so good
- **Economic depression/recession**
 - Difficult to finance large capital projects
 - Electricity demand lower, need for new capacity lower/later
 - Natural gas cheaper, may return to electricity generation
 - Power plant commodity prices down, may lower capital cost
- **Climate change**
 - Emphasis on renewable energy
 - Nuclear not in stimulus bill or energy bills
 - Carbon benefits for nuclear still unclear

Capital cost estimates – The trend toward high, conservative cost estimates will minimize the potential for cost overruns and lower the cost overrun risk for regulated utilities that will seek up-front prudence review. However, these high capital cost numbers make the relative economics of nuclear electricity look worse.

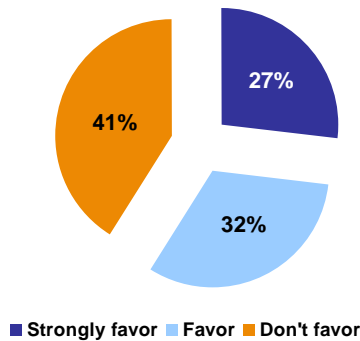
Economy – Finance/funding is difficult today; may be better by the time first-wave US projects start construction in about 2012. Electricity demand is down, so a delayed nuclear plant may be consistent with modified utility capital expansion plans. Natural gas prices are lower, may lead to increased use of existing (and even new) combined cycle units as baseload. The part of nuclear plant cost estimates that is based on projections of commodity prices may be lower today.

Climate change – Nuclear power offers significant reduction of carbon emissions, but the [financial] benefits for new nuclear plants from this carbon reduction are still uncertain. May take a few years before policy makers appreciate that wind and solar will not be enough to meet demand or to solve global warming – and that nuclear is needed

Strong nuclear support in March 09 surveys

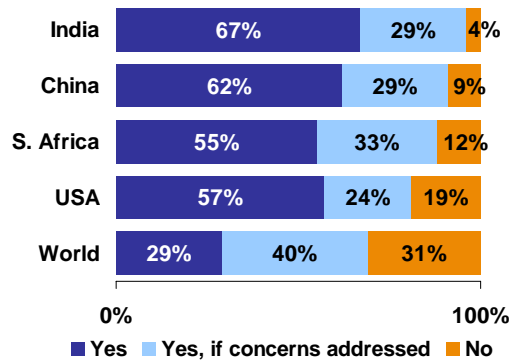
GALLUP POLL

"Do you favor the use of nuclear to produce electricity in the US?"



accenture

"Should your country start using or increase the use of nuclear power?"



Two large polls on nuclear energy done in early 2009

The Gallup poll, focused on US, had about 1,000 respondents; global Accenture poll had more than 10,000 respondents; Gallup shows that 59% of US favors nuclear



Accenture's poll has US favorable of 57%, consistent with the Gallup poll. Accenture includes another slice that shows that another 24% of Americans would support nuclear if their concerns were addressed (for a total of 81%).

These concerns are related to safety, used fuel disposition, protection from terrorism, and link between nuclear power and nuclear weapons proliferation. In my view, these are all policy/perception issues, not fundamental issues. Resolving these issues is a matter of policy positions and public relations, not a matter of re-designing nuclear power plants.

Energy density

to produce 1 GWh of electricity

Important events in the last year

	Uranium (5% enriched)	Coal
Fuel	3 kg (300 cubic cm)	400,000 kg (265 cubic meters)
Waste	3 kg (w/o reprocessing) .1 kg (with reprocessing)	1,090,000 kg of CO ₂ + NO _x , SO _x , particulates, arsenic, mercury, etc

6 | Ninth Annual Power and Utility Conference Edward Kee LLC

There is increased awareness that nuclear energy arises from a different paradigm than fossil fuels or diffuse renewables like wind and solar

Nuclear power is the conversion of mass into energy – this mass is lost when a large atom (uranium) undergoes fission into 2 or more smaller atoms; a small amount of mass conversion creates a large amount of energy, while:

- Fossil fuel combustion is lower density chemical reaction
- Wind and solar are real-time (and really renewable), but diffuse and low density

Compared to coal, nuclear produces a tiny amount of waste, waste that is highly regulated and controlled

Nuclear electricity provides reliable base-load electricity that is consistent with modern society's use of electricity to deliver high-energy-density power to multiple end-use applications across all aspects of the economy

Society has perhaps hundreds of years of coal + oil + renewables; but has thousands of years with nuclear + closed nuclear fuel cycle + breeder reactors

Nuclear energy = renewable?

- **Exelon Energy - Emission-Free Energy Certificate (EFEC)**
- **RWE - ProCLimate 2011 in Germany**
- **Atoomstroom.nl nuclear energy retailer in Netherlands**



Is nuclear energy renewable?

Formal definition of renewable energy is an energy source that is inexhaustible, such as biomass, waste, geothermal, wind, and solar; practical definition in policy debates links renewables to clean electricity (i.e., with little carbon emissions); yet some renewables emit carbon (e.g., biomass and waste)

Real definition is in laws, tax codes, and other places – lately, there is a move to add nuclear energy to the list of energy sources that can help reduce carbon emissions, even if this means classifying nuclear as renewable. Some in the nuclear industry point to the use of breeder reactors as a path that is virtually inexhaustible

Exelon Energy (retail marketing sub of Exelon Corp) announced “Emission-Free Energy Certificate (EFEC)” in early 2009; energy is from nuclear, wind and other carbon-free generation; customers can claim carbon-free energy use

RWE ProCLimate 2011 offers in Germany; offers carbon-free energy (mix of nuclear and hydro) that comes with a 3-year price freeze (result of stable generation costs)

Atoomstroom.nl “Nuclear Energy”); sells “Clean, CO2-free, subsidy-free” nuclear energy in Netherlands. Greenpeace challenged ads with Dutch regulator; “Clean” was not allowed (due to nuclear waste), but “CO2-free” and “subsidy-free” were allowed. Atoomstroom customers get a tiny “nuclear waste” container for their keychain – this is the estimated amount of nuclear waste produced in a year for a typical household

Important events in the last year

Yucca Mountain

- \$13.5 billion spent on the project
- NRC license application in 2008
- John McCain: “Close it down, stop charging for it, and return the \$22 billion collected to date.”



Opinion
March 13, 2009

There Is No Such Thing as Nuclear Waste

By WILLIAM TUCKER

'White House Buries Yucca,' read the headlines last week after Secretary of Energy Steven Chu said the proposed storage of nuclear waste in a Nevada mountain is "no longer an option."

8 | Ninth Annual Power and Utility Conference

Edward Kee LLC

The Obama Administration admits that Yucca Mountain is infeasible

The “fallback” for used nuclear fuel is the status quo – on-site storage at nuclear plants. This approach has been the approach in the US for the last 50 years, with no problems. NRC allows this for 100 years – might be extended to 125 years.

Given the potential for the re-use of nuclear fuel after initial use, may be better to keep used fuel assemblies in a state that allows easy retrieval for reprocessing if/when that is allowed in the US.

Spent/used nuclear fuel issues are policy issues, not technical or safety issues.

Rise of the i-nuke



- **Toshiba 4S (Super Safe, Small and Simple; 10 MWe)**
- **Hyperion (25 MWe)**
- **NuScale (40 MWe)**
- **Pebble Bed Modular Reactor (200 MWe)**

Interest in micro-nukes seems to be related to personal experience with consumer electronics; Moore's Law means more and more capability in ever smaller phones, PCs, etc. - why not get this in nuclear power plants?

Moore's law applies to information, specifically to the number of transistors that will fit onto silicon chips; Moore's law does not apply to power generation. Large amounts of power involve large power plants and large transmission wires; as the electricity industry developed, power plants achieved higher thermal efficiency and lower electricity cost through *increases* in size to benefit from scale economies

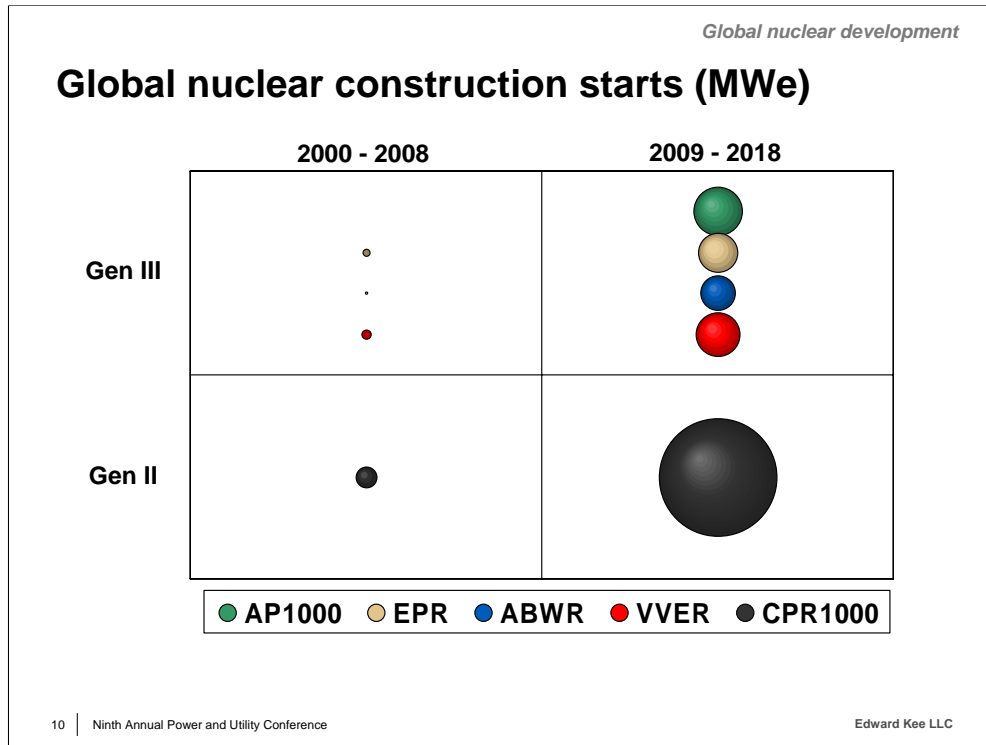
Economies of scale still apply and apply strongly to power plants and nuclear power plants:

- Costs of developing and building a new nuclear power plant are relatively fixed, regardless of the plant size (geophysical assessment, site acquisition, environmental assessment, NRC permitting process)
- Major nuclear plant components exhibit economies of scale (buildings, containment, piping systems, reactor pressure vessels)
- Non-fuel operating costs largely consist of fixed annual O&M costs (people, security, etc.) that are not tightly linked to plant size

These scale economies mean that a larger nuclear power plant will achieve lower costs per unit of electricity produced; new Generation III designs have pushed scale economies to lower costs.

If micro-nuke designs include breakthroughs that result in significantly lower fixed capital or fixed operating costs, these designs may produce electricity at lower costs than Generation III nuclear plants. If there are no significant fixed cost breakthroughs, these advanced reactors will remain as R&D projects.

In December 2008, the NRC stated (in a one-page letter) that NRC efforts are focused on applications for real power plants that use current generation reactor technology and that advanced reactors based on alternate technology will be considered on a much longer schedule



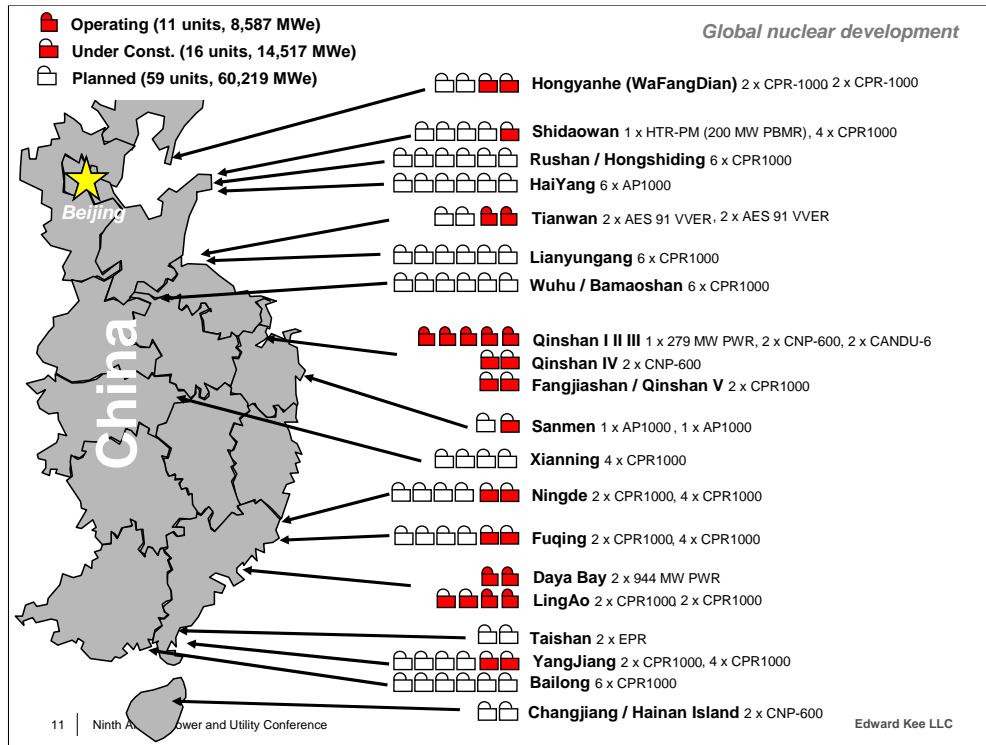
Size of the bubble is number of MWe – for example the CPR-1000 bubble in the “2009 - 2018” column is 47,000 MWe (about half of the current US nuclear capacity)

These units started (or are scheduled to start) construction in:

- 1/1/2000 to end of 2008 - recent projects that are now under construction (i.e., does not include some long-term stalled construction projects)
- 1/1/2009 to end of 2018 - assumes that ALL US COL applications result in first-wave construction starts (not likely to happen) and that Chinese and Russian plans proceed (likely to happen)

The US is focused on a small number of Generation III plants, only a few of which may proceed to construction start in the next decade.

The Chinese are now building a large number of Generation II units, while developing a Generation III design based on the AP1000.



China has 11 operating nuclear power units producing 8,687 MWe.

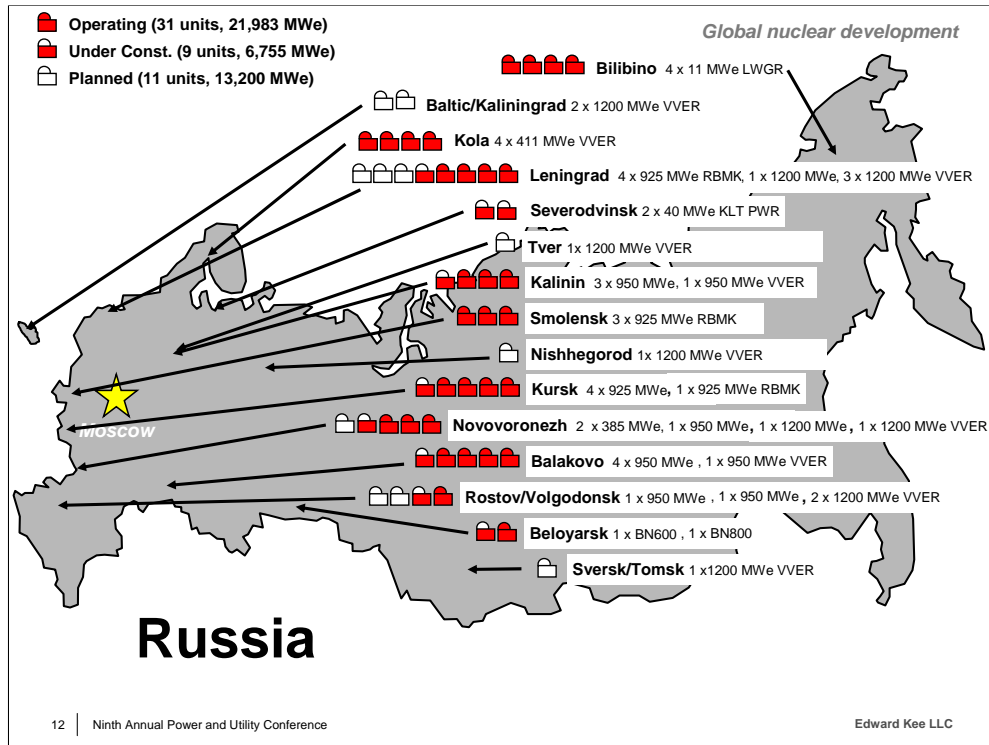
The operating units consist of

- 2 Daya Bay units that were built in the 1980s by the French
- 2 LingAo units based on Daya Bay units; now designated CPR-1000
- 5 Qinshan units including one 279 MW PWR unit designed in China, two larger Chinese Generation II PWR designs designated as CNP-600, and 2 AECL CANDU-6 units
- 2 Tianwan Russian Generation III VVER units

There are now 16 units under construction - 12 x CPR1000 units, 2 x CNP-600 units, 1 x 200 MWe PBMR unit, and 1 x Generation III AP1000 unit

An additional 59 units are formally planned, including 46 x CPR1000 units, 2 x EPR units, 2 x Russian VVERs, 7 x AP1000 units (of which several will be Chinese variants), and 2 x CNP-600 units

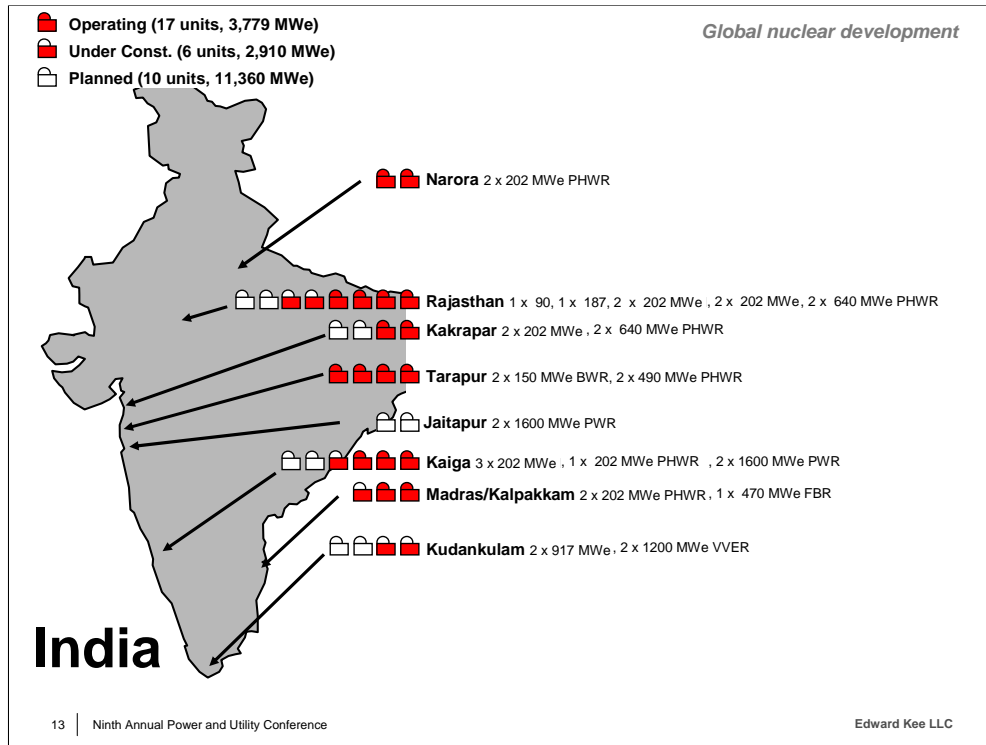
There are at least 20 more units (mostly CPR1000 units) that have been mentioned and that may appear in the “planned” category in the next year or so



In addition to these Russia units, there are another 22,000 MWe of new nuclear units that are proposed, but not planned; most of these are the new 1200 MWe AES2006 VVER design

Rosatom is the Russian government-owned company that controls the entire nuclear industry, including fuel, R&D, construction, major equipment, operating power plants, and other activities. Rosatom plans to build new nuclear plants inside Russia and to sell (through Atomstroyexport subsidiary) nuclear plants into the export market (e.g., China, Iran, Eastern Europe, etc.).

While US observers may not look favorably on Russian reactors, Rosatom and Atomstroyexport have designs that are comparable to western PWR designs that have a proven record of on-budget and on-time delivery; their reputation in Middle East and Asia is excellent.



This slide shows only the first glimmers of the large nuclear build in India that was predicted as a result of the India nuclear trade agreement

- In 2008, India emerged from the global embargo on nuclear power transactions
- Many thought that this would mean a lot of business for foreign vendors in building new nuclear plants in India
- Real result was very large nuclear fuel purchases (Areva sold 300 tons of uranium to India, 60 tonnes delivered so far)
- MoUs with France may result in more EPR units; additional agreement for more Russian reactors

Government-owned Nuclear Power Corporation of India, Limited (NPCIL) controls all existing and new nuclear plants in India. There have been efforts to open the nuclear power plant business to commercial entities. Concerns that the Indian electricity sector could support market-based nuclear power plant investments and even private nuclear plants with Indian or provincial government off-take agreements may be difficult to finance.

MENA and SA and Turkey

- **Iran - Bushehr VVER in testing now**
- **UAE - moving very fast**
- **Turkey - Russian nuclear IPP/BOO deal (maybe 4 units)**
- **Jordan and Egypt - looking to take next steps**
- **Saudi Arabia, Kuwait, GCC - interested**
- **South Africa - on hold**

The Bushehr VVER unit in Iran is in testing – expected to commence commercial operation in 2009. This is a power generation unit, particularly ill-suited to any use in a weapons programme.

UAE is moving briskly and with resolve; expected to announce a shortlist of vendors soon; may start construction as early as 2010

Russians have offered at least 1 (maybe 4) new nuclear power plants to Turkey under an IPP/BOO approach that only requires Turkey to take and buy power – Rosatom will build, own, and operate the plant; this is the Rosatom preferred approach to nuclear development in countries without a nuclear programme

Jordan and Egypt are moving forward; both have an interest in the IPP/BOO approach taken in Turkey – may be difficult for a vendor consortium group other than Rosatom to offer such a deal

GCC and Saudi Arabia interested; likely to be overtaken by UAE programme – they may be buying UAE nuclear electricity before they can build their own units

Eskom, in South Africa, was really close to starting on new units in 2008; this project was an early victim of the global financial crisis and the uncertainty of the early 2009 South African election – Eskom may still build these units, but later

Europe

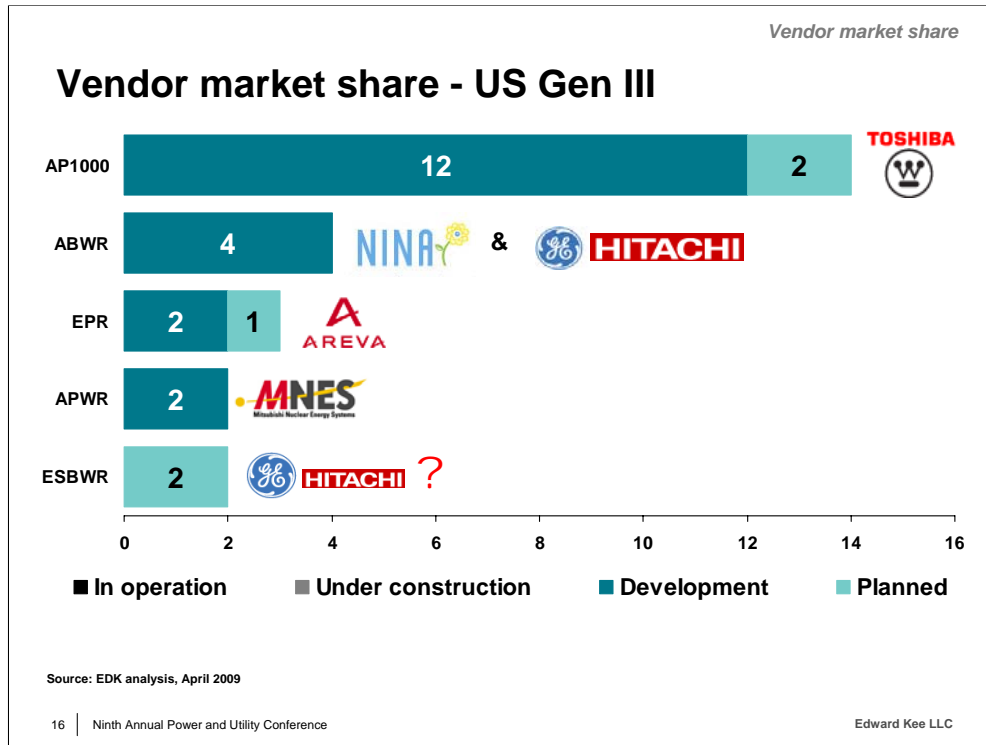
- **UK - EdF acquires BE; nuclear site auctions**
- **Sweden - overturns nuclear phase out**
- **Germany - rethinking of nuclear phase-out**
- **France - may build more new units**
- **Italy - now looking at nuclear**
- **Finland - windfall profits tax, another new unit**
- **Eastern Europe/Baltic - projects moving ahead**

A lot of nuclear power plant news in UK, with the EdF/BE merger and nuclear site auctions. UK Government commitment to carbon reductions may only be met with significant nuclear build. But new nuclear build commitment has yet to come, despite numerous press releases. Any new nuclear plant in the UK, even if EdF is the owner, will need some revenue certainty – this must come from some form of Government subsidies, even though the UK Government has taken a position that nuclear will get no subsidies.

Finnish windfall profits tax – intent is to remove windfall profits from nuclear and hydro projects that were operational prior to 1997 Kyoto Protocol ratification – may be harbinger for other countries

Nuclear phase-outs now look to be overturned – Sweden, Italy, Germany

There is really not much real nuclear plant development in Europe right now.



Operation = the unit has been placed into commercial operation

Under construction = nuclear safety-related construction has started

Development = firm plans and activity commenced; e.g., COL filed, regulatory activity, EPC contract, etc.

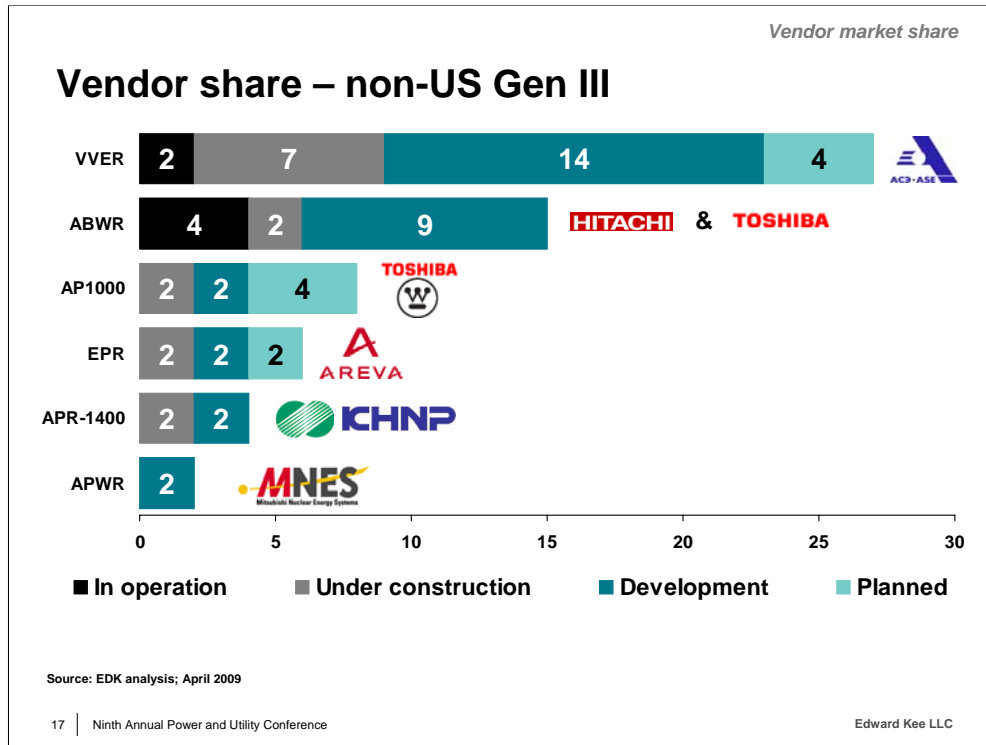
Planned = for US units, no COL filed yet

AP1000 is way ahead on this measure; ESBWR may be on verge of dropping off the list

All these projects are options; many will not be built in the first wave (i.e., start construction in 2012); some will be built in a second wave, and some will never be built.

In next year, we may see a lot of these units move to the second wave, as the DOE loan guarantee program moves toward closure with only enough money to fund a few new units.

Real news in US for vendors is about which units will be built in first wave – we will discuss this later



VVER units are a combination of the AES-91/92 1000 MWe units and the newer ASE-2006 1200 MWe units. All are Generation III

ABWR units include the operating units in Japan, the units under construction at Lungmen, and the units planned in Japan

In the next year, there will be some developments that will change this chart:

- Bushehr VVER commences operation

- VVER units moving from planned to development, including in Turkey, China, India

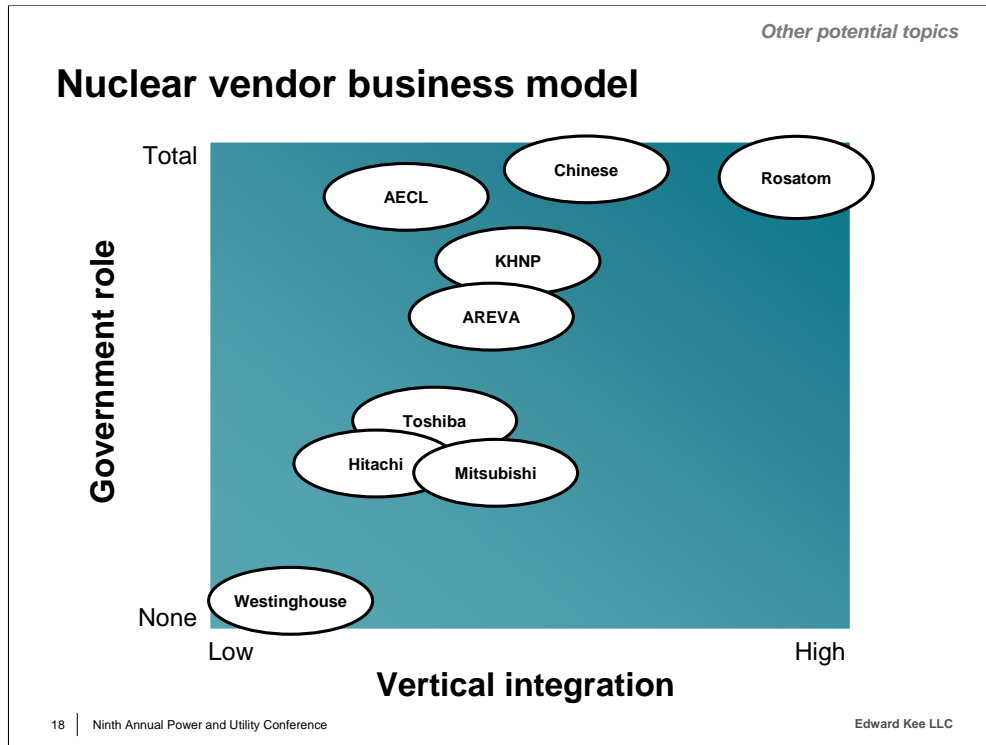
- UAE design/vendor selection

- Ontario design/vendor selection

- UK resolves subsidy and planning issues; moves to next phase that may include design selection

- Some Eastern Europe and Baltic projects may move ahead

- Second new nuclear plant in France



The only reactor vendor with operating power plants and operators is Rosatom; AtomStroyExport is now offering full IPP/BOO deals in the export market (e.g., Turkey), with Inter RAO (Rosatom subsidiary) acting as plant operator.

Vendor news

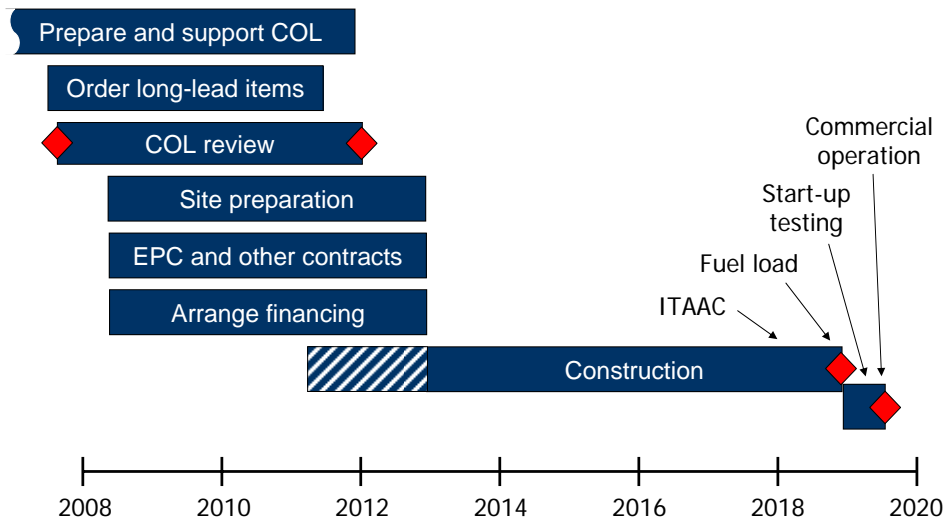
- Siemens abandoned JV with Areva; joined into new JV with Rosatom
- GE - Hitachi JV strained as ESBWR withdrawn from several international markets (UK, Ontario) and ESBWR orders dropped in US
- KHNP looking to build first APR1400 PWR outside South Korea
- Chinese bought AP1000 design details and are developing local version of AP1000 for domestic build programme; will almost certainly look to sell this design in export market in future

GE Nuclear seems to be in the process of exiting the new nuclear plant business; only hope is the ABWR design, but they face stiff competition from Toshiba/NINA

Nuclear industry M&A

- EdF buys BE and half of CEG – both deals seem to be mostly about Areva market share in new reactor business; French government has a nuclear business model that is similar to Rosatom, but may not work as well
- Exelon acquiring NRG may really be about nuclear power projects (STP) in Texas

The first wave of nuclear in the US



Likely first wave projects include:

- Vogtle (ranked to get Loan Guarantee, state PSC favorable)
- Summer (first in US AP1000 queue, favorable state PUC action, etc.)
- STP (ABWR lowers commercial risk, CPS public power partner, Exelon merger)
- Calvert Cliffs (EdF investment; strong desire for Areva to enter US market)

A typical first-wave strategy is aimed at being first in the queue, in order to get multiple benefits:

- EPC of 2005, with benefits limited to few new nuclear power plants on a first-come-first-served basis
- NRC COL process dedicated resources as COL applications were received – first in should mean earlier COL approval
- Early commitment of potentially scarce resources (important if first wave is large; may mean less if it is small)
- Reactor vendors and EPC contractors offered more attractive terms to buyers first in the overall build sequence
- Capacity would meet near-term baseload capacity need

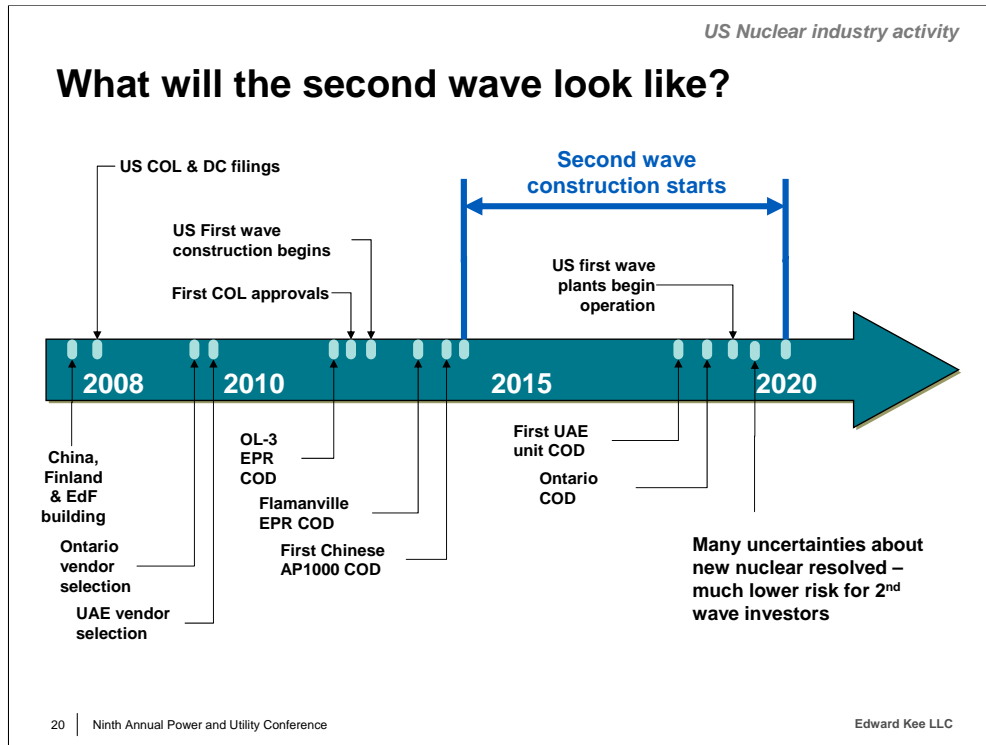
But a first-wave project faces risks and higher costs:

- Higher risks and costs, including potentially scarce nuclear industry resources
- Uncertainties about carbon control and electricity demand
- Potential target for organized anti-nuclear efforts
- Some first-of-a-kind (FOAK) risks and higher costs
- Need to establish nuclear financing and funding arrangements that have few recent precedents.

First-wave nuclear build strategy includes committing significant resources to establish a viable strategy to build as soon as COL is approved, but without making a firm commitment to invest

While the primary decision point for a first-wave project is at the time of COL approval, most first-wave strategies include intermediate decision points and “off-ramps” that will allow the project sponsor an opportunity to delay or cancel the project prior to COL approval

While there may be significant opportunities to lower cost and risk by taking an earlier “off-ramp” and moving to a second-wave strategy well prior to COL approval, only a few companies seem to have taken these early off-ramps so far.



Second-wave strategy benefits come from additional information that is available as a result of additional time passage; this information largely comes from the experience with first-wave projects.

First-wave projects will not be completed and placed into in commercial operation until 2018 or later, even though a few may start construction in 2012

Second wave projects may not have a lot of additional information by 2014, but will have a lot more information by 2020.

Most important information is on the success of designs/vendors. Second-wave projects that wait until 2018 to select a design/vendor might choose the most attractive (successful) of several approved standard reactor designs.

An approved COL might be banked, but incorporates a design and vendor. If a second-wave project with an approved COL decides to switch designs, these projects will likely have to undertake a new COL process. This might mean that it is better to go for an ESP rather than a COL, to facilitate switching designs/vendors later.

As fewer projects seem unlikely to move forward in the first wave, moving to a second-wave strategy now may look attractive – lower costs, slowing the burn rate and expanding the options rather than driving forward to the COL approval date. Waiting until the COL is approved in 2012 to decide to delay to the second wave might be an expensive strategy

Some regulated utility projects are allowed to recover the cost of developing and maintaining a first-wave strategy option in current rates – this may skew the decision to move to the second wave

Nuclear-related developments

- DOE Loan Guarantees
- Litigation cases
- No nuclear in stimulus bill
- NRC process
- State regulatory actions

DOE Loan Guarantee program has produced four finalists, but the \$18.5 billion is only enough for a few units and the terms and costs of DOE loan guarantees remain unclear. Even the 4 finalists may not find the loan guarantees attractive.

The Supreme Court ruling on the Riverkeeper vs. Indian Point case – allowing EPA to consider costs of a retrofit from direct-cooling to cooling tower in cost-benefit analyses – suggests that nuclear may get favorable rulings if COL process is challenged

US stimulus bill has nothing for nuclear, despite attempts to put something in. The Obama administration has little in its agenda for nuclear. The US climate change approach is still unsettled and there is a good chance that any cap and trade program may mean little for new nuclear

NRC process is sound, but is moving more slowly than some would like. New NRC chair (Jazcko) raised issues about a hearing at the end of the ITAAC process – this might mean higher risks of delayed projects and remove a primary benefit of the new two-part NRC licensing process. The NRC has worked out its earlier resource constraints, as it deals with multiple Design Certification reviews and COL applications, as well as the aircraft crash rule, digital I&C safety, and other issues.

State regulatory actions show some favorable outcomes for nuclear, or at least a reasonably rational debate. Some states have allowed CWIP recovery in current rates (e.g., GA PSC approved Vogtle with CWIP). Some states (e.g., FL) are moving to include nuclear in the definition of renewable (or as energy that will meet state requirements for clean energy). Several state bans on new nuclear plants were re-considered.

FERC repeals laws of physics and economics

- **22 April 2009 (Earth Day) – FERC Chairman Jon Wellinghoff decides that *baseload power is no longer needed*.**
- **“People talk about, 'Oh, we need baseload.' It's like people saying we need more computing power, we need mainframes. We don't need mainframes, we have distributed computing.”**
- **“I think baseload capacity is going to become an anachronism,” he said. “Baseload capacity really used to only mean in an economic dispatch, which you dispatch first, what would be the cheapest thing to do. Well, ultimately wind's going to be the cheapest thing to do, so you'll dispatch that first.”**

A lot of discussion about this statement from electricity and nuclear industry.

Wellinghoff has backed down a bit, but for a FERC Chair to say something like this in public is a worry.

Just as the public link between consumer electronics and Moore's law cannot be applied to nuclear, it is not possible to power our electricity-intensive society with solar and wind.

While this is an appealing and simple story (“let's just build a lot of wind and solar and get rid of those big dirty power plants”), it is just not consistent with reality.

The reasons that this story is untrue are complicated and require detailed analyses and an understanding of the electricity industry – not something for which the public has much patience. A knowledge of the electricity industry based on being a retail consumer is not enough.

The US might need to experience electricity system failures (i.e., blackouts) as a result of policy decisions (rather than a unique disaster) before this view is seen as flawed.

Nuclear industry thinking is that it will take 3 to 4 years for the administration and the public to come around to nuclear – longer if electricity demand and natural gas prices remain low.

Look for nuclear to be a really big issue in the 2012 presidential elections.



Edward Kee
+1 (202) 370 7713
edk@edwardkee.com

23 | Ninth Annual Power and Utility Conference

Edward Kee LLC

This is a photo of the Sanmen 1 AP1000 site in China. The project is ready for safety-related concrete pour (the industry measure of the start of construction) and there is a ceremony to mark the occasion.

SHANGHAI, 19 April 2009 - Westinghouse and The Shaw Group Celebrate First Concrete Pour at Sanmen

Nuclear Site in China

- Significant milestone in China's ambitious nuclear energy program
- AP1000(TM) nuclear power plant set to come on line in 2013

Westinghouse Electric Company, its consortium partner The Shaw Group Inc., China's State Nuclear Power Technology Corporation (SNPTC) and Sanmen Nuclear Power Company of China National Nuclear Corporation today announced the successful completion, on schedule, of the first pour of basemat structural concrete for the nuclear island at Sanmen, the site of the first of four Westinghouse AP1000(TM) nuclear power plants to be built under a contract signed in 2007.

The pour encompassed 5,200 cubic meters of concrete, 950 tons of reinforcing steel and 1000 anchor bolts. The concrete will serve as the foundation for all of the nuclear island buildings, including the containment vessel and the shield building.