A Case for Private - Public Investment in Advanced Nuclear
Addressing Critical Risks in Commercial Deployment

Presentation to US NIC
June 2017

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Clean, Urban Electricity, Reliable Baseload
Policy and Market Factors Shaping National Nuclear Strategies

"Nuclear Energy Remains Vital to Urban Energy Reliability, amid "Pivot to Asia" (2015) Expanding populations in Asia, high levels of economic growth, and increasing urbanization are combining to create demand for large amounts of reliable and affordable base-load electricity. Governments in Asia and some in the Middle East have recognized this need and have made nuclear power a major part of the energy mix. China alone is expected to have eight mega-cities and more than 200 cities with over one million residents by 2030. Affordable baseload electricity is crucial for these countries to sustain the high level of economic growth they have experienced during the last decade. Government enterprises are responsible for the building and operating nuclear power plants. IAEA sees total world capacity touching 600 GWe by 2030, from 370 GWe today, but capacity in Europe (160 GWe today) will decline by then.

www.climatechangebusiness.com/Policy_Market_Factors_Shaping_National_Nuclear_Strategies
Powering major cities. Losing lead to Urban Asia

- Reactor orders in N.America and EU are not sufficient to fuel a nuclear industry. Stagnant economies and low load growth jeopardize prospects and financing.

- Sovereignty for UNSC “P5” countries rides FIRST on nuclear technology.

- The nuclear resurgence is continuing in Asia, despite the Fukushima disaster. Asian mega-cities are big demand driver (14 of largest 20 cities are in Asia). Cities cannot function without reliable electricity, resistant to severe weather.

- Demand-side factors are dominating National Nuclear Energy Strategies. Curbing urban air pollution is vital. "Nuclear power enables clean urban living"

- The supply chain has been globalized; no nation is self sufficient. But, large reactor projects have experienced serious cost overruns (multiple vendors and countries)

- Industry success will be driven by global alliances; policies must be based on this new reality where “US leadership” means embracing strategic partnerships.

- It is crucial to ensure that responsible global trading partners maintain the security foundation upon which a commercial nuclear industry rests, but different allies wield different capacities and commitments going forward.

- Given chronic constraints on public sector budgets, new approaches and joint ventures are critical to financing nuclear energy in a political economy as a “Private-Public Investment Case”. Benefits of nuclear are NOT well monetized.
Nuclear is for large cities. Why pursue parity with Renewables?
Large Cities need reliable power 24/7, all seasons...

Where to put the wind turbines and solar panels?

Chongqing on the Yangzi

Tokyo, winter

BBC weather outlook: “Chance of sun”
Protest on UK Wind: “ISLE OF BLIGHT!”

ISLE OF BLIGHT! 650ft wind turbines could see UK lose its only natural world heritage site on Dorset Coast
Offshore 194-turbine wind farm proposed by French and Dutch power firms
656ft towers would dominate horizon towards Isle of Wight, report warns
www.dailymail.co.uk/news/article-3123852/Isle-Blight-650ft-wind-turbines-UK-lose-natural-world-heritage-site-Jurassic-Coast.html#ixzz4isZNnjZ

TOWERING THREAT TO PREHISTORIC COASTLINE

SHELVED

JURASSIC COAST
- 185 million years old
- 95 miles long, from Exmouth in East Devon to Studland in Dorset
- One of the few places in the world with exposed rock

from all three periods in which dinosaurs lived (Triassic, Jurassic and Cretaceous)
- £1bn a year in tourist spending
- 25,000 jobs supported by tourism

HOW THEY COMPARE

Gherkin, London
590ft
London Eye
443ft
Needles lighthouse
102ft
Airbus A380
239ft

DORSET
Bournemouth
Lymington
Weymouth
Swanage
Durlston Head
The Needles
Isle of Wight
Drivers for the Political Economy of Nuclear Energy

McKinsey: 600 Global Cities = 60% of World GDP

The Primary Driver for Nuclear Power is Urban Development, the need for Clean, Reliable Energy. Cities fuel more than 60% of world GDP. Growth shifted to Asia in 2000 as OECD crested.

Urban world: Mapping the Economic Power of Cities (March 2011)
The “DEVELOPING” WORLD is… Developing.

Pace of Growth: Then (1990) and Now (2015)

Migration to cities is the largest trend shaping development in the 21st Century.

Shanghai, 1990

Shanghai, 2015

http://www.hongkiat.com/blog/world-skylines-then-now/
Growth in Electricity Demand, 2015 - 2030

The OECD Advanced Economies account for just 10% of total growth in demand.

Two-thirds of electricity growth will be in Asia

Source: IAEA midpoint estimates

100 MWs = 50,000 - 100,000 people a year
EIA: Nuclear Capacity by decade, 2010

Global generation capacity for nuclear power has grown to over 370 gigawatts since 1955. Stasis from 2000-10; Asia emerging.
EIA: Nuclear Capacity by decade, 2030

Projected
520 GW
TOTAL
(IAEA mid-range)
400 to 600 GWs

National Targets
Large Gen III reactors
feed cities >1 million

Asia dominates to 2030 to feed cities

Global generation capacity for nuclear power has grown to over 370 gigawatts since 1955.
EIA: Nuclear Capacity by decade, 2050

Global generation capacity for nuclear power has grown to over 370 gigawatts since 1955.

Asia builds to 2050 to feed cities

FEEDING CITIES
SMRs / Gen IV reactors can feed many more cities sooner, at a scale they can finance.

Projected
670 GW
TOTAL
(IAEA mid-range)
400 to 900 GWs
Largest cities by 2030 concentrated in Asia

Cities with a projected 2030 population of more than 10 million

2030 population
- 40M
- 25M
- 10M

Change in population from 2014 to 2030
- Pop. decline
- + 0-15%
- 16-30%
- 31-45%
- 46% or more

Bolded cities: projected to surpass 10 million people between 2014 and 2030

Chicago
Toronto

BLOOMBERG
Sept. 9, 2014

Only Japan is losing population

Driver for Nuclear in Asia: Deadly PM 2.5 Pollution

Comparison of annual average PM$_{2.5}$ concentrations in 2015 with WHO Air Quality Guidelines.

Source sector contributions to deaths attributable to PM$_{2.5}$ in China in 2013.

- **Industrial coal**: 155 thousand deaths
- **Transportation**: 137 thousand deaths
- **Domestic biomass burning**: 136 thousand deaths
- **Noncoal industry**: 95 thousand deaths
- **Power plant coal**: 87 thousand deaths
- **Open burning**: 70 thousand deaths
- **Domestic coal burning**: 41 thousand deaths

Global Covenant of Cities not waiting for UNFCCC

7,100+ CITIES REPRESENTING 600 MILLION PEOPLE 8% OF TOTAL GLOBAL POPULATION

The Global Covenant of Mayors for Climate & Energy is an international alliance of cities and local governments with a shared long-term vision of promoting and supporting voluntary action to combat climate change and move to a low emission, resilient society.

Urban Emissions

Regional Networks

Shared Solutions

Local Resilience & Adaptation

Local Governments are Key Contributors: The Global Covenant of Mayors works to organize and mobilize cities and local governments to be active contributors to a global climate solution.

City Networks as Critical Partners: Local, regional and global city networks are core partners, serving as the primary support for participating cities and local governments.

A Robust Solution Agenda: Focusing on those sectors where cities have the greatest impact, the Global Covenant of Mayors supports ambitious, locally relevant solutions, captured through strategic action plans that are registered, implemented and monitored and publicly available.

Reducing Greenhouse Gas Emissions and Fostering Local Climate Resilience: The Global Covenant of Mayors emphasizes the importance of climate change mitigation and adaptation, as well as increased access to clean and affordable energy.

www.globalcovenantofmayors.org/about/
EV Growth matches timeline for Advanced Nuclear

**February 2016 forecast**

Almost all the EV electricity sales will be in urban areas.

Electricity sales volume for charging vehicles rises 4x from 2030 to 2040.

Forecasts have shifted further out over time but battery costs are coming down; EVs might enter an S-curve as SMRs / GenIV are slated for commercial deployment.

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Emerging Markets: Look at Urban Clusters

Urban clusters in Asia comprise larger economies than some EU countries, and will see much more growth.

By 2020 China will have 15 mega-cities (>10m) and 150 cities of 1m+.

China will need hundreds of SMRs or Adv Reactors.

THE NUCLEAR GAMEBOARD

Leaders in Nuclear Infrastructure + MWs in 2030

SUPPLY-SIDE: “Excellence”

MWs of Nuclear Capacity in 2030 ➔

Likely Trend in 2030
Urban Population in 2020 vs MWs in 2030

MWs of Nuclear Capacity in 2030

DEMAND-SIDE: Urban Living

Expansion Market

Replacement Market

95% CI
Fitted values

UrbPop2020

Verdigris Capital
Several Observations:
1) **Given growing urban populations, China and India will dominate new construction.**
2) **Without stronger Federal / State policies, USA is on track to lose nuclear capacity.**
3) **France and Japan are not growing; new nuclear will depend on National imperatives.**
4) **To maintain MWs, a REPLACEMENT market will be the key driver in EU and N.Am.**
Capacity Under Construction + “Planned” (approved)

How much for SMRs / Advanced Reactors?

- Under Construction: Assured
- “Planned”: Likely (some approvals made)
- “Proposed”: Possible, based on need (after 2030)

GW by 2020
- Some open bidding
- More nationalized

GW by 2030

Compare
- IAEA 2015
  - Building 73GW
  - Planned 183GW

Globally: 2030 to 2040
- 150+GW

New construction of reactors is primarily a Sovereign decision, more than mere economics.

New Reactors: Where’s the Growth?... Asia, MidEast

Sovereigns dominate new orders. USA and Japan built their fleets of reactors in smaller regional utilities, rather than in national enterprises.
Asia, MidEast continue to dominate new construction.

Sovereign Nuclear Energy Landscape 2030

Size of bubble = Reactor GWs now under construction

Gov't Owned

Private Owned

Verdigris Capital
Financing Models Vary; Sovereigns Dominate

LOW GROWTH, OECD Economies

A) Corporate balance sheet [US, Japan utility model.]

B) Nordic Consortia model
Customer consortium with off-take. Owners = Off-takers

C) Industry Team bid overseas with Export Credit Agencies (ECA)

D) Project financing with Gov’t support [Tax subsidies, Gov’t loans, Feed-in-tariffs]

E) French Exeltium model
-- Industrial User Consortium
-- Sovereign EPC / Vendor [EDF]

F1) Sovereign Financing for replacement reactors (OECD)
-- incentives for GHG savings

F2) Sovereign Financing for high growth urbanization
[National Utility ownership]

G) Nat’l Vendor EQUITY for Export [Rosatom, China Nuclear, EDF]
-- with Export Credit Agencies
-- TRI-LATERAL Gov’t deal

HIGH GROWTH, Developing Economies

Britain: Near-term export market – who wins?

Which reactor technologies and Vendor Teams will prevail in the UK, given French stumbles?

UK: Go-ahead for 10 nuclear stations

May 2015

16 GW
Nuclear Sales and Finance… with Sovereigns

Nuclear power is uniquely MORE regulated by Gov’ts Increasingly…

- The reactor CUSTOMER will be a Sovereign Gov’t
- Projects will involve or be led by Sovereign Suppliers
- FINANCING will be arranged with Sovereign Sources
- FUEL will be managed with Sovereign Entities
- Electric RATES will be set by negotiation with Gov’t… and likewise transmission approvals and incentives

There will never be a “level playing field” with nuclear. Sovereign Govts do NOT just “leave nuclear to the market”.
Global Leadership eroding already…

USA facing NUXIT--Half of Nuclear Capacity by 2040

To maintain 20% share of US electricity; 30 GWs must be built by 2030; and >80 GWs by 2050! Building 30 GWs entails $180-220 billion over two decades, a mix of debt and equity finance.

Sources: IAEA, WNA 2012
AEO 2017: US Nuclear Retirements… RED ALERT

[Graph showing U.S. nuclear electricity generating capacity and annual nuclear capacity changes (2015-50)]

www.eia.gov/todayinenergy/detail.php?id=31192
Losing the Fleet…

Recent announced retirements of U.S. nuclear reactors

<table>
<thead>
<tr>
<th>Reactor</th>
<th>Size (MW)</th>
<th>Region</th>
<th>State</th>
<th>Owner</th>
<th>Age (yrs)*</th>
<th>Retirement Date</th>
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<tr>
<td>Crystal River 3</td>
<td>860</td>
<td>Southeast</td>
<td>FL</td>
<td>Duke Energy</td>
<td>36</td>
<td>February 2013</td>
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<td>Kewaunee</td>
<td>556</td>
<td>MISO</td>
<td>WI</td>
<td>Dominion</td>
<td>39</td>
<td>May 2013</td>
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<td>San Onofre 2</td>
<td>1,070</td>
<td>California</td>
<td>CA</td>
<td>SCE &amp; SDG&amp;E</td>
<td>30</td>
<td>June 2013</td>
</tr>
<tr>
<td>San Onofre 3</td>
<td>1,080</td>
<td>California</td>
<td>CA</td>
<td>SCE &amp; SDG&amp;E</td>
<td>29</td>
<td>June 2013</td>
</tr>
<tr>
<td>Vermont Yankee</td>
<td>620</td>
<td>New England</td>
<td>VT</td>
<td>Entergy</td>
<td>42</td>
<td>December 2014</td>
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<td>Fort Calhoun</td>
<td>479</td>
<td>SPP</td>
<td>NE</td>
<td>Omaha PPD</td>
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<td>October 2016</td>
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<tr>
<td>Fitzpatrick**</td>
<td>847</td>
<td>New York</td>
<td>NY</td>
<td>Entergy</td>
<td>42</td>
<td>2017 (p)</td>
</tr>
<tr>
<td>Ginna**</td>
<td>582</td>
<td>New York</td>
<td>NY</td>
<td>Exelon</td>
<td>46</td>
<td>2017 (p)</td>
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<tr>
<td>Nine Mile Point 1**</td>
<td>637</td>
<td>New York</td>
<td>NY</td>
<td>Exelon</td>
<td>47</td>
<td>2017 (p)</td>
</tr>
<tr>
<td>Clinton†</td>
<td>1,065</td>
<td>MISO</td>
<td>IL</td>
<td>Exelon</td>
<td>29</td>
<td>June 2017 (p)</td>
</tr>
<tr>
<td>Quad Cities 1†</td>
<td>934</td>
<td>PJM</td>
<td>IL</td>
<td>Exelon</td>
<td>44</td>
<td>June 2018 (p)</td>
</tr>
<tr>
<td>Quad Cities 2†</td>
<td>937</td>
<td>PJM</td>
<td>IL</td>
<td>Exelon</td>
<td>44</td>
<td>June 2018 (p)</td>
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<tr>
<td>Oyster Creek</td>
<td>608</td>
<td>PJM</td>
<td>NJ</td>
<td>Exelon</td>
<td>47</td>
<td>2019 (p)</td>
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<td>Pilgrim</td>
<td>677</td>
<td>New England</td>
<td>MA</td>
<td>Entergy</td>
<td>44</td>
<td>June 2019 (p)</td>
</tr>
<tr>
<td>Diablo Canyon 1</td>
<td>1,118</td>
<td>California</td>
<td>CA</td>
<td>PG&amp;E</td>
<td>31</td>
<td>2024 (p)</td>
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<tr>
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<td>1,122</td>
<td>California</td>
<td>CA</td>
<td>PG&amp;E</td>
<td>30</td>
<td>2025 (p)</td>
</tr>
</tbody>
</table>

**SUMMARY**

|             | 4,665 MW closed | 8,527 MW planned | 13,192 MW total |

www.thirdway.org/report/preserving-americas-clean-energy-foundation
Illinois Sees The Light – Retains Nuclear Power
Dec. 4, 2016
The bi-partisan bill allows Exelon’s Clinton and Quad Cities nuclear power plants to remain open, saving 4,200 jobs and over 22 billion kWhs of carbon-free power each year, more than all of the state’s renewables combined.

These two plants were in jeopardy of closing because even at a low cost of five cents or so per kWh, they were losing a combined $100 million per year because they could not compete with cheap natural gas and wind energy that is subsidized at 2.3¢/kWh. Illinois taxpayers subsidize solar energy at 21¢/kWh. This bill provides these nuclear plants with just 1¢/kWh, and only until market conditions change.

New York State Aiding Nuclear Plants With Millions in Subsidies
By PATRICK McGEEHAN, AUG. 1, 2016
Utility customers in New York State will pay nearly $500 million a year in subsidies aimed at keeping some upstate nuclear power plants operating. The policy, championed by Gov. Andrew M. Cuomo, calls for half of the state’s electricity to come from renewable sources, such as solar or wind, by 2030. A long slump in the price of natural gas, a fuel for other generators, has hurt the profits of many nuclear plants, prompting plans to shut down some in New York.

State Options to Keep Nuclear in the Energy Mix
National Conference of State Legislatures | JAN 2017

Figure 3. States with Restrictions on New Nuclear Construction

Source: NCCL 2016
Assumes N.gas prices stay below $6 through 2040. RE tax credits expire in 2017-22. Includes CPP, State RE stds. License extension for some reactors.
Construction Spending: Jan 2013 – Jan 2018

 Infrastructure Spending is **NOT** keeping pace with other Construction sectors.

https://edzarenski.com/category/forecast/
Large Reactors: Multi-$billion cost overruns…

TVO steps up legal battle over Olkiluoto 3 reactor delays

28.9.2016 UUTISET -- Legal wrangling between French majority-state owned nuclear constructor AREVA and the Finnish power company TVO is escalating, with a new lawsuit filed in a French court. The start-up date for the third unit at the Olkiluoto plant near Pori – already nearly a decade late – remains in doubt.

Bigger… is no longer better?

Time to shift to GenIV

Feb. 2017
Vision and Strategy for Development and Deployment of Advanced Reactors

Double US Nuclear Capacity

Non-LWR designs require RD&D, first units, Licensing.

If fleet licensed to 60 years

Global Nexus Initiative calls for Private-Public Funding

PRIVATE – PUBLIC FINANCING

“It is unlikely that either governments or the private sector individually will have the resources to fully fund multi-billion dollar advanced reactor efforts through design, licensing and construction of a FOAK. Private-public partnerships are required to develop and deploy these technologies.

A private-public deployment driven strategy for next generation reactors would send a signal that the reactor class is important, allow for robust modeling, testing, and demonstration and winnow the number of technologies to a handful that the market deems valuable and that also can meet international safety, security and nonproliferation objectives. This approach, if seized on by the U.S. or other nations, also could elevate that country into the top tier of nuclear innovating nations and reinforce its status as an international standard setter in nuclear safety, security, safeguards and regulation.


GNI forums: Chris Mowery, Feb. 2015
Debt Financing drives the Framework, not Equity or Venture Capital

Risk-based Framework for “Private - Public Investment Case”

Energy Project Development Timeline

Risk Analysis of Project Development Stages

Rating and Ranking of Risks by Stages

Evaluation, Application of Risk Mitigation Mechanisms

Regulatory and policy risks

Advanced Nuclear Projects cannot complete financing without a comprehensive commercial risk analysis by creditors with debt financing.

Deployment = debt financing. [credit risk framework]

Technology and operating risks

Market and Financial risks

Design & Development
Engineering & Construction
Operations & Maintenance

Permitting

Close Financing

$ possible downtime

$ Revenues and profit

$
Critical Risks Ratings Summary – Advanced Reactors
(preliminary; 20 Interviews and Ratings completed)

NON-LWR Advanced Reactors
Respondents were asked to limit ratings to Advanced Reactors only, not conventional LWR reactors.
Respondents drawn from NIC, and Advanced Reactors Conferences.

Risks were grouped in three broad categories, based on Business Case for New Nuclear Reactors done for DOE in 2001-2002:
1. Technology & Operations
2. Regulatory & Policy
3. Market & Finance

Ratings of Likelihood and Impact of each risk rated High = 5, Low = 1.
The overall rating came out as 2.8 for Likelihood and 3.5 on Impact.
The Upper Right triangle shows the most critical risks to be addressed.
Risk Matrix: Likelihood vs Impact

Likelihood of a risk event occurring vs Impact on success of project.

<table>
<thead>
<tr>
<th>Impact of Risk (Consequence)</th>
<th>Major</th>
<th>Medium</th>
<th>High</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>Medium</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Minor</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
</tbody>
</table>

Probability of Risk (Likelihood)

- Unlikely (0-33%)
- Moderately Likely (33%-66%)
- Highly Likely (66%-100%)

Seriousness of Risk = Probability x Impact

www.theprojectmanagementblueprint.com/?p=277
Accelerating a move to **Advanced Reactors**

Plot of Risks Based on their Attributes (Likelihood, Severity of Impact)

- Lower Likelihood
  - Higher Impact
  - Accidents
    - (Plant fires, or spikes in feedstock costs or a gas price slump with loss of competitiveness)

- High Likelihood
  - Higher Impact
  - “Show-Stoppers”
    - (e.g., high capital costs on large plants or lack of clarity about carbon regs)

- Lower Likelihood
  - Low Impact
  - Marketing and Operations
    - (Workforce issues, fuel transport, transmission congestion, etc.)

- Higher Likelihood
  - Lower Impact
  - Externalities
    - (e.g., pollution)
    - Or lax enforcement, lack of standards

Negotiating space for public and private investment

**DOE: Business Case for New Nuclear Power Plants, 2002 to NERAC**
Capital costs are too high for first-of-a-kind GenIV Advanced Reactors

Most Technical risks could likely be dealt with, once first units are built, fuel qualified.

Private - Public Investment

Industry can manage
Risk ratings conducted Feb.-May 2017

REGULATORY & POLICY Risks

NRC Regulatory process is unproven (risky); No clear value for emissions savings

USA lacks a clear National Strategy for Nuclear Power and its global position in it. Cheap fossil prices (coal, N.gas) with the Clean Power Plan rolled back mean that investors are not rewarded in clean energy.

Industry can manage
Risk ratings conducted Feb.- May 2017

MARKET & FINANCE Risks

N.Gas prices remain low, depressing electric prices; Wind is subsidized.

Private financing remains very difficult (more equity required, no commercial debt) with no rewards for importance of Nuclear Power. Low demand growth plagues the sector. Regulated rates (some states) offer some certainty.
“Leaving Advanced Nuclear to the market = no nuclear”

Combined HIGHEST RISKS

Mere subsidies are not enough to mobilize investment. Regulatory reform needed.

Private financing remains very difficult. Regulated rates (some states) offers certainty on revenues; rewards clean, reliable power. Regulatory reform at NRC with co-funding, and financing tools, like federal loans or off-take support are necessary, and can be negotiated for efficiency (vs subsidies).

Multiple risks means multiple tools.

Industry can manage
REMEDIES are driven by nature of underlying risks

**POTENTIAL REMEDIES**

**Probability of Event**

*Low Likelihood*
*Low Impact*

- Training
- Manufacturing upgrades
- Fuel, feedstock stockpiles

(Workforce issues, fuel transport, transmission congestion, etc.)

*Higher Likelihood*
*Higher Impact*

- Insurance; Price-Anderson
- Community outreach

(Plant fires, or spikes in feedstock costs or a gas price slump with loss of competitiveness)

**Impact if Event Occurs**

*High Likelihood*
*High Impact*

- Fed cost-share; R&D
- Federal credit support, Loans
- Subsidies for public goods
- Electricity rate regulation

(e.g., high capital costs on large plants or lack of clarity about carbon regs)

*Low Likelihood*
*Lower Impact*

- Clarification of regulations
- Industry Standards
- Modular manufacturing

Lack of standards, or lax enforcement
Enjoys Bipartisan Support in Congress

DOE Loan Solicitation for Nuclear: $12.6 Billion

Borrower Pays the “Credit Subsidy Cost” of the loan

Department of Energy Issues Draft Loan Guarantee Solicitation for Advanced Nuclear Energy Projects

September 30, 2014 - 8:30am

Washington D.C. — The Department of Energy has issued a draft solicitation that would provide up to $12.6 billion in loan guarantees for Advanced Nuclear Energy Projects, supporting the Administration’s all-of-the-above energy strategy and bringing the nation closer to its low-carbon future. Once finalized, these loan guarantees will provide critical financing to help commercialize advanced nuclear energy technologies, supporting projects that are often unable to secure full commercial financing due to their scale and use of innovative technology. This draft solicitation represents another step in the Department’s commitment to help overcome the financial barriers to the deployment of next generation technologies that will diversify America’s clean energy portfolio.

Sept. 2014
Political Strategy / Tactical Options

- Place Energy projects within Infrastructure Bill

- Energy Modernization Bill with nuclear… 2017
  - Upgrade NRC Licensing; Financing, Preferences for Nuclear
  - A “Level Playing Field” in energy is a *fantasy*.
  - *P5 Power*: *Nuclear is different*. \( E = mc^2 \)

- Tax Reform with Energy provisions
  - RE got tax credits in 2015 Budget Bill --- What for Nuclear?

- Energy Appropriations for FY2018
  - Expand DOE Loan Program for Clean Energy, GenIV Nuclear
  - Expansion of EX-IM Bank? Roles for CNTAC to boost exports?

- Monitor **State** Clean Power Measures (NY, IL... PA, NJ?)
  - Lack of Nat’l Consensus; States weigh subsidies for nuclear

- FERC Preferences for Clean, Reliable Sources (?)
SUMMARY: Global Competitive Landscape

- Most of the next wave of NEW build is overseas
- Several Nuclear Financing Models vie for primacy
- **Sovereign** Finance Models dominate outside USA
- USA Private Utility model is the *exception*
- Cost is a major factor, but Key Risks are critical
- Strategic **Sovereign** interests play a large role
- Emissions savings are a BIG factor in Europe, Asia
- **Sovereign** Vendor financing will take market share
- USA must *accelerate* GenIV to remain competitive, *mindful of addressing critical risks in financing*
Curbing emissions is a big priority for Global Mayors

Nuclear Energy enables Clean Urban Living

www.globalcovenantofmayors.org/
Market for SMRs / Advanced Reactors is Urban: for Power, Clean Water, Transport

Mega-Cities need Millions of Clean Reliable MWHrs

TOKYO

SEOUL

MEGACITIES

LONDON

NEW YORK CITY

http://topxbestlist.com/largest-cities/
21st Century: Urbanization drives demand in Asia

ASIAN SOVEREIGNS don’t have a problem picking winners. Nuclear is a WINNER.

Where do I put a wind turbine or solar panel?

There are more people living inside this circle than outside of it.

Seoul
“Redefining Leadership in the Global Nuclear Energy Market”

Report: National Nuclear Energy Strategies

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Nuclear Energy Remains Vital to Urban Energy Reliability, amid “Pivot to Asia”


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Expanding populations in Asia, high levels of economic growth, and increasing urbanization are combining to create demand for large amounts of reliable and affordable base-load electricity. Governments in Asia and some in the Middle East have recognized this need and have made nuclear power a major part of the energy mix they are developing to meet this demand. China alone is expected to have eight mega-cities (population over ten million) and more than 200 cities with over one million residents by 2030. Affordable baseload electricity is crucial for these countries to sustain the high level of economic growth they have experienced during the last decade.

Government support, via regulations and financing, has been pivotal to the accelerated growth of nuclear energy. In China and India, as well as most of Asia and Europe, government enterprises are responsible for the construction and operation of nuclear power plants. More than 70 GWe of nuclear construction is underway globally, 70% of it in Asia. More than 200 GWe is in various planning stages, half of that in China or India. IAEA sees total world capacity touching 600 GWe by 2030, from 370 GWe today, but capacity in Europe (160 GWe today) will decline by then.

Initially, nuclear power was the sole province of the five post-WWII nuclear powers – USA, UK, France, Russia and China. Each still uniquely holds a coveted permanent seat on the UN Security Council, the "PS". Back then nuclear energy and Eisenhower's "Atoms for Peace" initiative supported a drive for broadening the impact of nuclear power from national security to domestic energy autonomy. The value of nuclear energy in curbing emissions was seen much later, in the 1990s, as national strategies emerged to deal with local pollution and carbon load in the atmosphere. Eighty percent of new reactor construction worldwide is proceeding under the aegis of Sovereign Enterprises, rather than investor-owned utilities. In its most recent "Redrawing the Energy Climate Map" report (June 2013), IEA states that nuclear energy remains a vital underpinning technology in the IEA's so-called 450ppm scenario, which seeks to limit global temperature increases to 2°C, especially vital to inhibit runaway glacier melting. This scenario sees nuclear generation increasing by almost 1800 TWh in 2035 (or by about 40%) over the level achieved in the "4 policy measures - for - 2°C" [4-for-2] scenario. But, energy demand in North America and Europe has largely crested, and can no longer sustain a nuclear industrial infrastructure based on domestic demand alone. Three national strategies have emerged: Renaissance, Restructuring and Rollback.

www.climatechangebusiness.com/Policy_Market_Factors_Shaping_National_Nuclear_Strategies
Treasury Grants (S1603): $25B, mostly Wind, Solar

Cumulative grants awarded, **2009 to July 2016**: $24.9B for 33.3 GWs gross (10.2 GWe Net)

$25B in Tax subsidies
$90B in Total Project Value

33 GW gross
10 GWe Effective

Wind $13B
Solar $9B

Total investment: $90.2B
($24.9B from 1603 grants)
For 10.2 GWe (net),
Or $8,900 per KWe.

Source: U.S. Treasury

http://www.treasury.gov/initiatives/recovery/Documents/STATUS%20OVERVIEW.pdf
Large regional disparity in impact of Nuclear Power hinders a National Strategy politically.

**OBSERVATION:** Wind is in the West... Nuclear is in the East, near major urban areas

**US Strategy…? Regional Differences are Severe**

### Nuclear capacity for top ten U.S. states, 2015

<table>
<thead>
<tr>
<th>State</th>
<th>Gigawatts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>9.7</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>6.4</td>
</tr>
<tr>
<td>South Carolina</td>
<td>5.6</td>
</tr>
<tr>
<td>New York</td>
<td>3.8</td>
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<tr>
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<td>Texas</td>
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<tr>
<td>New Jersey</td>
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</tr>
<tr>
<td>Georgia</td>
<td>1.6</td>
</tr>
<tr>
<td>Michigan</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Competition for nuclear from wind focused in Upper MidWest**

**Location of U.S. nuclear power plants**
How much New Nuclear Capacity with $25B?

- For $25B in subsidies, USA got 21.6GW of Wind, 8.3GW of Solar With an effective capacity of 10 GWe. ($90 Billion total investment) --- does not include cost of storage or transmission.

- 10 GWe of Nuclear capacity would take 11 GW of gross capacity.
- At $6B per GW, $90B would build about 15 GW of nuclear capacity. $25B in subsidies would amount to $1.67B per GW. [$25B / 15 GW]
- Nuclear offers the same emissions savings per MWh, but provides grid stability for cities on a small footprint, unlike intermittent RE.
- **How much nuclear capacity could be built with $1.67B of subsidy per GW?** [$600M total project cost per 100 MWe]

### Advanced Reactors

- **200 MWe**
  - $800M debt
  - $400M equity
  - Conventional financing (NOT available for Advanced Reactors)

- **200 MWe**
  - $670M debt
  - $200M equity
  - Tax Reform & Nuclear Infrastructure
  - $330M ITC
  - Use DOE Loan

**How many GW of Advanced Reactors could be built with this incentive structure? Would bidding for ITC stretch the dollars?**
OBSERVATION: When EXPORTING, Emissions still matter

COP21 (Paris) won’t be enough; Nuclear needed

Exports could be a mix of Gen III+ and GenIV reactors, but only GenIV can be made in N.America.
Treasury Grants for Energy, a $25B Experiment

- From 2009-2015, we conducted a $25B experiment and got 10 GWe of mostly wind and solar, concentrated West of the Mississippi.
  -- $90B in total project costs for 33.3 GWs gross, 10.2 GWe.

- Obs #1: ASK How much nuclear can be built for $25B in Subsidies?
- Obs #2: Most of the Wind capacity (75GW) is WEST of Chicago.
  -- Wind only competes with Nuclear in the Upper Midwest.
- Obs #3: Solar power will triple from 1% to 3% of US Total, and in SW.
- Obs #4: Plenty of reactor capacity needs to be replaced at current sites – Siting is not really the problem. (Cheap gas is).
- Obs #5: When targeting Exports, Emissions savings still matter.

- For $90B, >15GW of nuclear can be built (@$6B per GW).
  ➔ $25B in Subsidies like T.Grants would be $1.67B per GW.
  ➔ Why not target HALF of that as Advanced Reactors? [National Policy]