Nuclear Power: Global View

The Competitive *(or… not so much)*
Market Landscape

*US Nuclear Infrastructure Council (USNIC.org)*
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What was yesterday?

W.P.D.
What was yesterday?

7.5B
Nuclear Strategies: Upfront Messages

• The drivers that led to US Leadership in nuclear energy have shifted dramatically. Cities: “urban energy security” is now the key driver.
  ➢ The primacy of those drivers has changed, from Supply to Demand.
  ➢ Low N.gas prices will undercut new nuclear, if no policy interventions.

• Market drivers alone cannot sustain nuclear energy. Policy drivers (e.g., national security, air regulations, urban resilience) loom large.

• Other Governments do not have a problem “picking winners and losers”. For several, Nuclear is a winner. And, nuclear is uniquely regulated at federal level. Most reactor build is by National Enterprises.

• All of the “P5” countries are struggling to sustain their commitment to nuclear energy… but in different ways. [P5 = USA, UK, France, Russia, China]

• Without new construction, US leadership has withered. Global JVs, SMRs, Ars are become very important, and need resources + a fast track. US regulatory prowess and fuel security are not enough for “leadership”.

• Choices made NOW will lock-in a generation portfolio for 40+ years.
Powering major cities, Pivot 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, in part, on nuclear technology.
- The nuclear renaissance 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 now dominating National Nuclear Energy Strategy.
- Incentives for GHG savings could aid NP. Curbing urban air pollution is vital.
- The supply chain has been globalized – with Gov’ts playing a larger role.
- Industry success will be driven by global alliances; policies must be based on this new reality where “US leadership” means embracing strategic partnerships. For the USA, Toshiba owns Westinghouse, and GE-Hitachi is 80% Hitachi.
- New approaches and joint ventures are critical to financing nuclear energy in a political economy where “Leaving it to the market” = Leaving it to China and Russia.

NUCLEAR IS DIFFERENT.
CITIES NOW DRIVE THE NEW WORLD ORDER
“Urban Archipelagos” as Global Economic Hubs

Not “islands”, linked Archipelagos… Powered by which energy source?

“Urban Archipelagos” as Global Economic Hubs

URBAN ARCHIPELAGOS AS CENTERS OF GRAVITY
Mega-city clusters dominate the world economy. In many countries, the capital city or financial center often represents up to half or more of the national GDP. By 2030, we could have as many as 50 such urban hubs anchoring the global system.

http://www.paragkhanna.com/connectography/
Khanna: Seven New Mega-Regions in USA

Meet Your Seven New Mega-Regions

How a realigned lower 48 could benefit cities, tied together by better roads and new rail

Pacific Coast
Home to three thriving urban archipelagos: The California corridor, Silicon Valley and Greater Los Angeles. The California High Speed Rail Authority aims to partly link this spine, but more can be done to join the three areas' high-tech sectors.

Inland West
Boise has seen steady growth in agriculture and alternative energy, and even investment interest from China as an assembly and logistics hub for its exports. Stronger rail connections across the region would bring more technology to help diversify its economy.

Great Lakes
Great potential: Detroit and Ontario are linked by a congested tunnel and the crumbling 60-year-old Ambassador Bridge. Plans for a new crossing have languished despite obvious regional benefits.

Great NorthEast
Boston thrives but much of New England suffers. Better transportation and affordable housing will lift surrounding towns.

The Southeast Manufacturing Belt
It's America's second manufacturing hub but remains plagued by poor roads. Tennessee alone needs $40 billion in infrastructure by 2017. Rather than cooperate, states like Georgia and South Carolina compete for jobs and investment.

Gulf Coast
Louisiana is the region's linchpin, and yet budget cuts and the aftermath of Katrina have left it unable to keep up with Texas and Florida. Regional efforts to boost the state's roads and other infrastructure would help the entire Gulf Coast.

[ NOT IN KHANNA’S ANALYSIS – Khanna did not go to a football school (G’Town, then LSE) ]

Mega-Regions… also tied to Athletic Confcs

Meet Your Seven New Mega-Regions

Meet Your Seven New Mega-Regions

Nuclear Power – Where are we?
Investor Ready Cities
How cities can create and deliver infrastructure value
UN: Another 2 billion in cities - 2040 (6b total urban)

2 reactors serve a city of 500k-1m people, depending on consumption per household, plus level of urban development (office towers, mass transit, water needs, elec cars). One billion people require 400 to 1,000 Gwe of new e’s if served by nuclear energy.

Global urban population growth is propelled by the growth of cities of all sizes

US: 80 urban areas >500k

100 reactors: $600B investment

Key issue: “Urban Reliability”, What power source?

#1 Driver for Nuclear: Clean Energy for Urban Reliability with small footprint
URBAN Geo-politics of Energy consumption and Land use

US Suburbs... not same urban density as in Asia
S. Korea: Largest Auto Factory in the World (Ulsan)

Where can enough solar panels or wind turbines be placed to power this?

- Nuclear: 4,500 MW
- Solar: 30 MW, of Rooftop PV
- In Ulsan
Russia: Floating Reactor for Coastal cities, Remote Ops

Powering Mega-cities a Major Driver in 21\textsuperscript{st}C. (2030)

Massive growth in Asian mega-cities continues to drive demand for nuclear.

<table>
<thead>
<tr>
<th>2030 Rank</th>
<th>2010 Rank</th>
<th>Megacity</th>
<th>Country</th>
<th>Continent</th>
<th>Pop’n 2010</th>
<th>Pop’n 2030</th>
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<td>Paris</td>
<td>France</td>
<td>Europe</td>
<td>10.2</td>
<td>11.3</td>
<td>10.5%</td>
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</tbody>
</table>
18 February 2016 – Many countries are facing a perfect storm of financing constraints and water infrastructure shortfalls. Dramatic declines in oil and commodity prices, low water tariffs, groundwater overdrafts, and untreated wastewater discharge are prompting governments to tap the private sector through public-private partnership (PPP) schemes. According to a new report by Bluefield Research, the global market for Water PPP projects is set to nearly triple between 2016 and 2020,
Clean, Compact, Reliable Energy for Large Cities

SUMMARY OF DRIVERS

- **Safe, Reliable power for Cities**
  - Biomass; Geotherm

- **Without emissions** (HazAPs + GHGs)
  - Coal, [less so N.gas]

- **In any weather**
  - Wind, Solar, Hydro (drought, flood)

- **On a small footprint**
  - Wind, Utility Solar

- **For dense 24/7 end use**
  - Wind, Solar, Biomass
  - [Geotherm may not be near]

- **In Advanced Mfg economies**
  - Biomass, Storage$

- **Economic, w/ stable pricing, reliable supply**
  - Oil, N.gas, if imported (Asia, EU)

- **Often with Gov’t as customer**
  - Depends on policy
Financing Nuclear Power

Urban electricity, 21st Century
Global trade and development
Observations:

- Capital Supply
- Capital Behavior
- Uncertainty
- Negative IR’s
- Investors Options
- Equity – inc in risk
- Debt – where are the pension funds to go?

- Mostly good news for NE ....and Infrastructure
BRICS Bank now open financing member projects

India, Russia to accelerate civil nuclear energy cooperation

The nuclear cooperation includes building on negotiations to sign advance contract for the design of the third and fourth reactor units to come up at the Kudankulam site in Tamil Nadu.

A contract for the design (of the third and fourth power units) has been under negotiation.


Kundapur Vaman Kamath (India), former CEO of Industrial Credit and Investment Corporation of India, will head the Bank, capitalized at $100 billion ($10B from each, plus “$50B equity on call” as needed).

Each founding country 1 vote; no vetoes.

Finance ministers and governors of the central banks of BRICS countries convene New Development Bank Governing Council, 7 July 2015

HQ in Shanghai. Regional office in Johannesburg, SA.

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PLUS, the BRICS countries’ currency reserves pool is $100 billion. China will contribute $41 billion, while Brazil, India and Russia will provide $18 billion each and South Africa will put forward $5 billion – “an insurance instrument against financial risks and the risks related to the situation on the world financial markets”.

www.russia-direct.org/russian-media/brics-development-bank-begins-operation
Subsidies:

Currently in Law:
- Price-Anderson Nuclear Indemnification Act
- Government R&D
- NRC – Regulatory Delay insurance (EPAct 2005)
- Production Tax Credit (EPAct 2005)
- Accelerated Depreciation
- Loans / Loan Guarantee (@ Treasury interest rate)
- State level specific incentives

Other possible mechanisms:
- Line tariff / Feed-in tariff / Revenue support
- Dispatch Preference (e.g., via FERC or states)
- Carbon / GHG incentive (tax provision or rate adder)
- Other… (already risk isolated via Utility)
New construction of reactors is 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: N.Am, EU lag

Sovereign Nuclear Energy Landscape 2030, but...

Size of bubble = Reactor GWs now under construction

Operating Capacity ➔

Total GWs Operating

Gov’t Owned

Private Owned

Ownership: % Public or National

Nuclear Entities 2030: Ownership, Operating GWs + Under Construction (bubble size)
### Nuclear Financing Models: Private vs Sovereign

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Countries</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A)</strong></td>
<td>Private Utility (Traditional IOU)</td>
<td>USA, Japan</td>
<td></td>
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<tr>
<td><strong>B)</strong></td>
<td>Customer Consortium Financing</td>
<td>Nordic, Canada</td>
<td></td>
</tr>
<tr>
<td><strong>C)</strong></td>
<td>Industrial Vendor Team, w ECA</td>
<td>USA, S.Korea, Japan</td>
<td></td>
</tr>
<tr>
<td><strong>D)</strong></td>
<td>Project Finance (SMRs/GenIV)</td>
<td>USA, UK? -- Emerging…</td>
<td></td>
</tr>
<tr>
<td><strong>E)</strong></td>
<td>Electro – Exeltium (industry users)</td>
<td>France, EU?</td>
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</tr>
<tr>
<td><strong>F1)</strong></td>
<td>Sovereign w/ Revenue Subsidies</td>
<td>EU, UK, Canada</td>
<td>for emissions savings</td>
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<tr>
<td><strong>F2)</strong></td>
<td>Sovereign Monopoly Owner</td>
<td>China, India, Middle East, Russia</td>
<td></td>
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<tr>
<td><strong>G)</strong></td>
<td>Sovereign Vendor Team</td>
<td>Russia, China</td>
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</tbody>
</table>

Based on Fiona Reilly, PWC
## Financing Nuclear Power

### Global Competitive Landscape

### LOW GROWTH, OECD Economies

- **Nat’l Govt Lead**
  - **F1)** Sovereign Financing for replacement reactors (OECD) -- incentives for GHG savings
  - **E)** French Exeltium model -- Industrial User Consortium -- Sovereign EPC / Vendor [EDF]

- **Private Industry Lead**
  - **A)** Corporate balance sheet [US, Japan utility model.]
  - **B)** Nordic Consortia model Customer consortium with off-take. Owners = Off-takers

### HIGH GROWTH, Developing Economies

- **Nat’l Govt Lead**
  - **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 -- BILATERAL Gov’t deal

- **Private Industry Lead**
  - **C)** Industry Team overseas with Export Credit Agencies (ECA)
  - **D)** Project financing with Gov’t support [Tax subsidies, Gov’t loans, Feed-in-tariffs]
<table>
<thead>
<tr>
<th>Ref#</th>
<th>Category</th>
<th>CRITICAL RISK AREA</th>
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<td>1</td>
<td>FIN</td>
<td>Equity funding risk</td>
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<tr>
<td>2</td>
<td>FIN</td>
<td>Project development</td>
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<td>3</td>
<td>POLICY</td>
<td>Community risk, local opposition</td>
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<td>4</td>
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<td>Market off-take risk for sales</td>
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<tr>
<td>5</td>
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<td>Construction completion risk</td>
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<tr>
<td>6</td>
<td>TECH</td>
<td>Design, technology performance</td>
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<td>7</td>
<td>TECH</td>
<td>Infrastructure, grid interface</td>
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<td>8</td>
<td>TECH</td>
<td>Nuclear fuel proliferation security</td>
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<td>9</td>
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<td>NRC Regulatory delay risk</td>
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<td>Operating cost and maintenance</td>
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<td>ECON</td>
<td>Fuel supply disruption</td>
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<td>ECON</td>
<td>Force Majeure (Insurable)</td>
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<td>15</td>
<td>TECH</td>
<td>Nuclear accident (Off-site damage)</td>
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Global Competitive Landscape

Financing Models in Global Nuclear Landscape

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<tr>
<th>Role</th>
<th>Focus of NIC Members</th>
<th>Focus of Private Utility</th>
<th>Focus of Regulated Utilities</th>
<th>Focus of Contractual Partnerships</th>
<th>Focus of EPC / Vendor</th>
<th>Focus of Sovereign Financing</th>
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<td>Tech Regulator</td>
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<td>Capital structure: Debt coverage</td>
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</tr>
</tbody>
</table>

| Major Competitive Factors | Installed cost, Construct Mgmt | Installed cost, Customer ties | Financing, Tech Quality | Modular Mfg, Smaller size | Installed cost, Consortia terms | Bilateral Agmt, Best value | Bilateral Agmt, Strategic goals | Sovereign Finance, Strategic allies |

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PRIVATE Financing Models in Global Nuclear Landscape: Structures

<table>
<thead>
<tr>
<th>Sovereign Role</th>
<th>A) Traditional Private Utility</th>
<th>B) Customer Consortium</th>
<th>C) Industrial Vendor finance</th>
<th>D) Project Finance</th>
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</thead>
<tbody>
<tr>
<td>Focus of NIC Members</td>
<td>Regulated Utilities lead deals USA, Japan</td>
<td>Off-takers as Owners Nordic</td>
<td>Led by EPC/Vendor team USA / SK / JP</td>
<td>Private lenders Emerging model for SMRs/GenIV USA / UK?</td>
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<table>
<thead>
<tr>
<th>Where seen ==&gt;</th>
<th>Tech Regulator</th>
<th>May lead EPC</th>
<th>Export finance</th>
<th>Tech Regulator</th>
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<tr>
<td>Nat'l GOVT SELL Side</td>
<td>Rate Regulator</td>
<td>Developer</td>
<td>Customer</td>
<td>Regulator / Lender</td>
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<td>Industry SELL Side</td>
<td>EPC/Vendor</td>
<td>Vendor</td>
<td><strong>Lead EPC Team</strong></td>
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<td>Owner BUY Side</td>
<td>Private Utility</td>
<td>Consortium</td>
<td>Nation or Utility</td>
<td>Industry, Utility</td>
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<tr>
<td>Utility Role</td>
<td>OWNER / Ops</td>
<td>Operator</td>
<td>Operator</td>
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</tbody>
</table>

**CRITICAL RISK AREA**

- Private Utility (I O U)
- Customer Consortium
- Industrial Vendor Team
- Project Finance (SMRs/GenIV)
### SOVEREIGN Financing Models in Global Nuclear Landscape: Structures

<table>
<thead>
<tr>
<th>Sovereign Role</th>
<th>E) Exeltium</th>
<th>F1) Sovereign Financing</th>
<th>F2) Sovereign Monopoly</th>
<th>G) Nat‘l Vendor Equity</th>
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<tr>
<td>Where seen ==&gt;</td>
<td>France / EU?</td>
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<table>
<thead>
<tr>
<th>ROLES [Lead actor in BOLD]</th>
<th>Nat’l GOVT SELL Side</th>
<th>Nat’l GOVT BUY Side</th>
<th>Industry SELL Side</th>
<th>Owner BUY Side</th>
<th>Utility Role</th>
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<tr>
<td>Regulator / Vendor</td>
<td>Tech Regulator</td>
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<td>Equity / Finance</td>
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<td>Operator / Owner</td>
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<td>Subcontractor</td>
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<td>Industry User Consortia</td>
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<td>Sovereign GOVT</td>
<td>Sovereign Supplier</td>
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<p>| CRITICAL RISK AREA | Electro - Exeltium | Sovereign w/ Revenue Subsidies | Sovereign Monopoly Owner | Sovereign Vendor Team |</p>
<table>
<thead>
<tr>
<th>#</th>
<th>Category</th>
<th>Critical Risk Area</th>
<th>Private Utility (IOU)</th>
<th>Customer Consortium</th>
<th>Industrial Vendor Team</th>
<th>Project Finance (SMRs/GenIV)</th>
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<td>Private Institutional Investors</td>
<td>Customers</td>
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<td>Utility, Private Equity</td>
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<td>Community, local opposition</td>
<td>Nat'l / State GOVT</td>
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<td>Market off-take risk for sales</td>
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<td>Construction completion risk</td>
<td>EPC / Vendor</td>
<td>Consortium / EPC</td>
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<td>EPC Team</td>
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<td>TECH</td>
<td>Design, tech performance</td>
<td>Vendor</td>
<td>Vendors</td>
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<td>7</td>
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<td>Infrastructure, grid interface</td>
<td>Utility / GOVT</td>
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<td>Nuclear fuel proliferation</td>
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<td>NRC Regulatory delay risk</td>
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<td>POLICY</td>
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<td>12</td>
<td>FIN</td>
<td>Debt coverage; Structure</td>
<td>Utility / Lenders</td>
<td>Consortium</td>
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<td>13</td>
<td>ECON</td>
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<td>ECON</td>
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<td>Insurers / Fed GOVT</td>
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<td>Bilateral Agreement</td>
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</tbody>
</table>
Global Nuclear Financing Models: Major Competitive Factors

|-------------------------------|---------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------|-----------------------------|---------------------------------|-----------------------------|

**Major Competitive Factors**

- Installed Cost (A, B, C)
- Construction Mgmt. (A)
- Customer ties (B)
- Financing (C)
- Technology Performance (C, D)
- Modular Manufacturing (D)
- Small deal size - SMRs / GenIV (D)

**Major Competitive Factors**

- Installed Cost (E, G)
- Consortia terms (E)
- Bilateral Agreement (F1, F2, G)
- Best value (E, F1)
- National Strategic goals (F2)
- Sovereign Finance (F1, F2)
- Strategic alliances (F1, F2, G)
SUMMARY: Global Competitive Landscape

- Several Nuclear Financing Models vie for primacy
- USA Private Utility model is the exception
- Most of the next wave of NEW build is overseas
- SOVEREIGN Models have taken lead outside USA
- Cost is a major factor, but not the ONLY factor
- Strategic National interests & financing play a role
- Emissions savings are a factor in Europe & Asia
- Sovereign Vendor financing poses a large threat
- SMR’s and Advanced Reactors are impacting now
The Nuclear Sales map for the 21st Century?

Major Urban Areas: 1950(red) vs 2010(blue)
Xi Hosts 56 Nations at Founding of Asian Infrastructure Bank – June 29, 2015
Questions?

Nuclear Power: Global View
The Competitive (or... not so much)
Market Landscape

Walter S. Howes
Verdigris Capital
WSHowes@gmail.com
202-342-5323

Andrew D. Paterson
Verdigris Capital
ADPaterson@gmail.com
571-308-5845
US vs Global Market

**US Market**
- Little load growth
- Replacement reactors after 2030
- Inadequate GHG policy driver and Uncertainty about Clean Power Plan
- Very cheap natural gas prices past 2025
- Seeking technical leadership in Advanced Reactors
- Need National / Regional action

**Global Market**
- OECD: little load growth
- OECD: Replacement reactors after 2020
- OECD: Carbon emissions savings

ELSEWHERE:
- Massive urban growth
- National ownership and financing
- Unique positioning of nuclear
- Opportunities for deeper electrification in transport sector
BRICS take the lead in Nuclear after 2025

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.

China building most
India also planning more than 40GWe
Russia building at home, avidly selling abroad with finance
UK rebuild to 16 GWe
E. Eur wants to build
S. Korea building at home and abroad.
USA stalled by cheap gas, no load growth
Japan in slow recovery from Fukushima, but building overseas.
France in limbo…?
Germany shuttering (as is some of EU)

Sources: IAEA, WNA
Critical Project Elements – UAE / KEPCo deal

U.S. Ex-Im Bank backs $2 billion loan for UAE nuclear plant (Sept. 2012)
Critical Project Elements – Hinkley Point C Reactor

- **Equity Finance (Sovereigns)**: $40B
- **Private Lenders** (debt capital): Credit rating
- **Gov’t Credit Support (as Contract for Diffs)**: $20B
- **Credit markets (interest rates, credit supply), Insurance**: Market competition, price volatility (fuels, power)

### Critical Project Elements

- **Fuel Feedstock (uranium)**: URENCO
- **Feedstock transport and security**
- **Coastal water supply**
- **Other basic services**

### Nuclear Power Plant

- **2 x EPR (3.2GW)**

### Critical system suppliers

- Piping, frames, turbines
- Reactor vessels
- Welding, cement

### Financials

- **$2B Engineering Contract (EPC)**: AREVA / EDF
- **$40B**
- **$20B**

### Other

- **Project Site Selection**
- **$40B Off-takers for spent fuel; LLW**
- **$2B**

### Links

- [http://www.world-nuclear-news.org/NN_Strike_price_deal_for_Hinkley_Point_C_2110131.html](http://www.world-nuclear-news.org/NN_Strike_price_deal_for_Hinkley_Point_C_2110131.html)
Critical Project Elements – VOGTLE

**Equity Finance**
- Southern Co
- Oglethorpe
- Muni GA

**Private Lenders** (debt capital)
- Credit rating
- Gov’t Credit Support
  - DOE Loan
  - + commissioning delay support

**Power Off-takers**
- Southern
- Oglethorpe
- Muni GA
- Off-takers for spent fuel; LLW

**Engineering Contract (EPC)**
- CB&I / Shaw

**Fuel Feedstock** (uranium)
- Urenco
- ConverDyn

**Feedstock transport and security**
- River water supply
- Other basic services

**Nuclear Power Plant Project**

**Critical system suppliers**
- Piping, frames, turbines
- Reactor vessels
- Welding, cement

**State Commission** on regulated rates

**Credit markets** (interest rates, credit supply)

**Insurance**

**Market competition, price volatility (fuels, power)**

**Regulated rate set**

**Project Site Selection**

**External Equity sources**
- (Institutions, hedge funds, insurance funds)

**External Equity sources**

**$16B**

**$8.3B**

**$15B**

**Federal Production Tax Credits ($1.2B)**

**Project Site Selection**