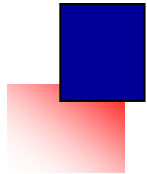


Political & Market Drivers for Nuclear Energy: The Global Landscape to 2030... and 2050

US Energy Association
July 2016

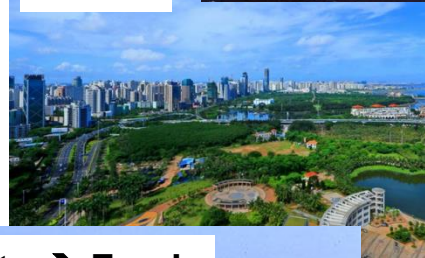
"Nuclear Energy enables Urban Living - Globally"



Andrew D. Paterson
EBI / Verdigris Capital
adpaterson@gmail.com
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www.environmentalbusiness.org

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**Clean
cities**



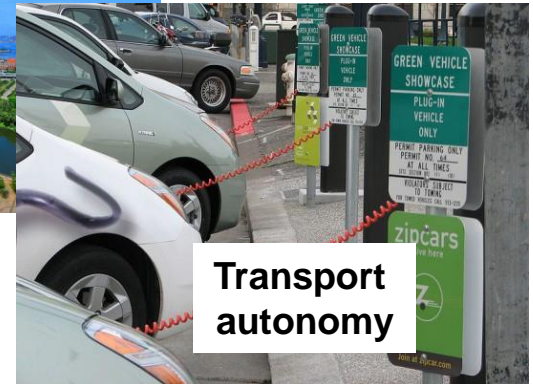
Water surety → Food



**National
Sovereignty**



**Transport
autonomy**





OUTLINE

Overview: Shifting Global Landscape

A) Nuclear Power enables Urban Living

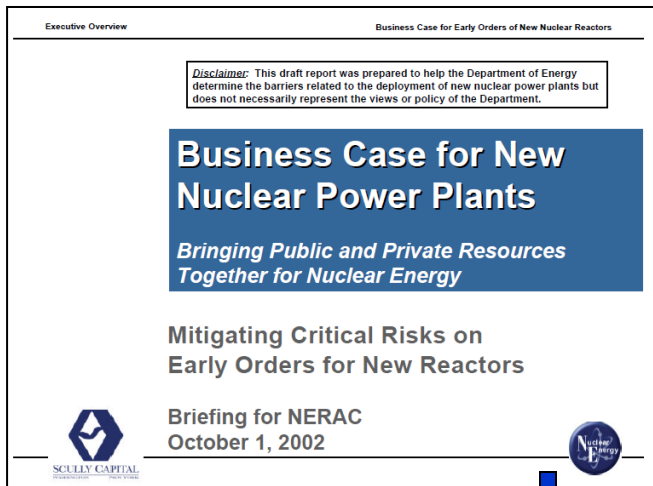
B) US Strategic Position Declining

C) Nuclear: Sovereign Marketing & Finance

D) National Strategies shaped by Supply/Demand Factors

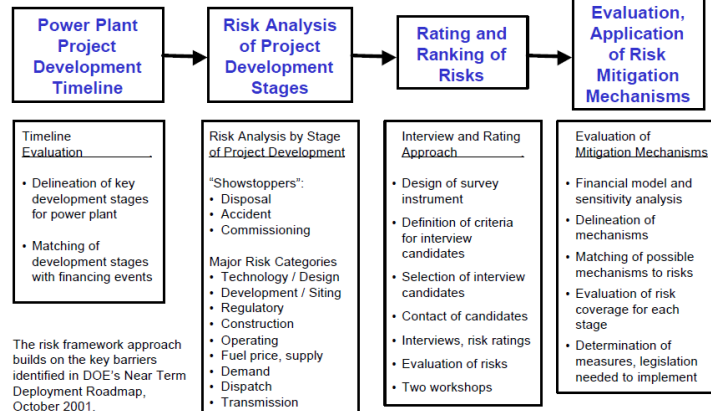
Elements of Strategy: EPAct 2005, Recovery Act 2009

Our analytical work fed the creation of DOE Loan Program in EPAct 2005, expanded in 2009.



Overview and Approach to the Risk Framework

This diagram depicts the study's logic flow and approach to the analysis.



Energy Policy Act of 2005



Title 17 DOE Loan Program: Innovative Tech

<http://www.ne.doe.gov/neac/neacPDFs/bergOct02NERAC.pdf>

Recovery Act of 2009; \$6B for Title 17

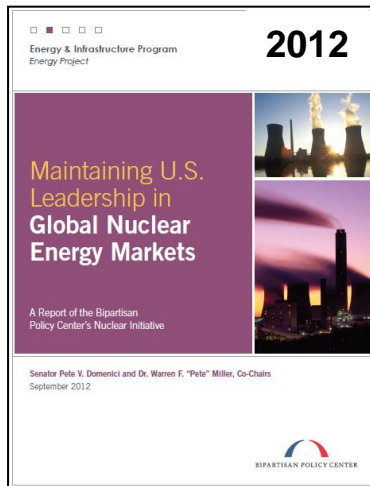


"The DOE Loan Program is an important tool to address market gaps and promote innovation."

Walter Howes
First DOE Loan Program Director (2006-2007)

Shifting Leadership in Nuclear Power...

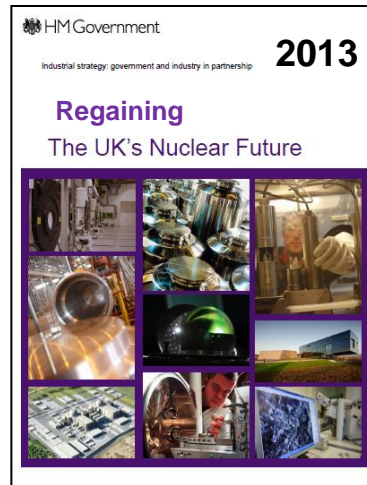
“Maintaining”...



CSIS: “Restoring”



UK DECC: “Regaining”...



The power of international alliances

Redefining Leadership



Redefining Leadership in the Global Nuclear Market

Andrew Paterson and Walter Howes

**Andrew Paterson
Walter S. Howes**

“No country is now self-sufficient in nuclear power.”

Nuclear Energy: CURRENT GLOBAL LANDSCAPE

- While the USA leads the world in Operating reactors (100 units).
USA no longer leads in construction. China is building.
- Most reactor build is *outside* NATO-- in Asia, MidEast.
*much of that market is open to US companies, allies?**
- **“Restoring US leadership” in nuclear power requires a strategy.**
USA lost capabilities to make major components.
Japan owns US vendors.
- US utilities are smaller, and not active globally.
- Financial markets will NOT lead on new financings –
reactor build requires a National strategy, Federal investment, Alliances, and Risk-sharing.
- *“Getting the government out of the way”* is not a viable national strategy in the nuclear sector. Well-negotiated financing can leverage federal funds, better than \$10 to \$1 (vs. just subsidies).

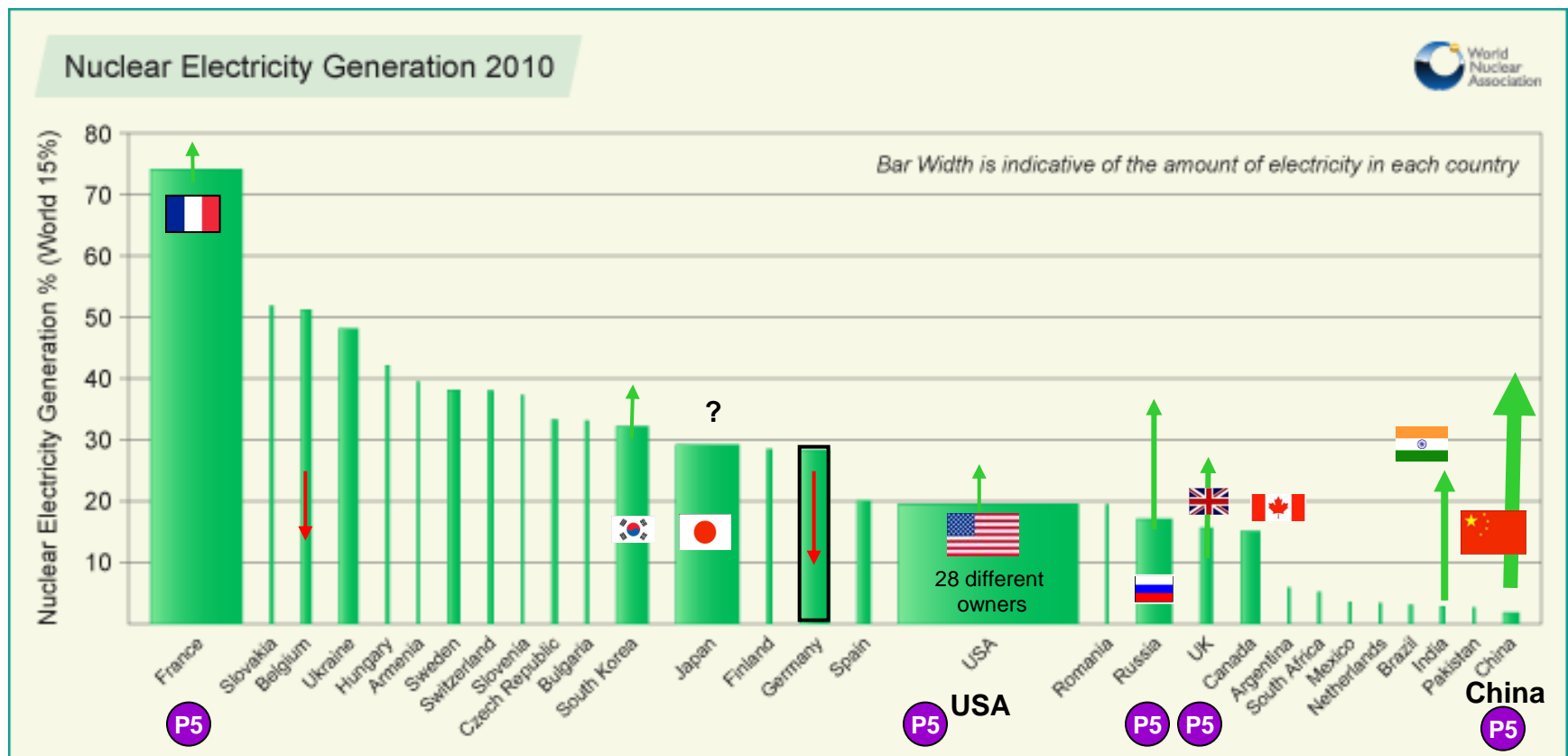


CHINA AND RUSSIA LAY
FOUNDATION FOR MASSIVE
ECONOMIC COOPERATION

P5 Elite UNSC “P5 Club”... still more than half all operating reactors

Nuclear Generation by Country - 2010

Portion of electricity from nuclear (vertical) by volume (width); **P5s still dominate.**
China + India are >50% of new reactor build, but still over-dependent on coal.



P5 = UN Security Council Permanent Voting Member: USA, UK, France, Russia, China – Nuclear powers

IFNEC: Nation-States Govern Nuclear Acceptance

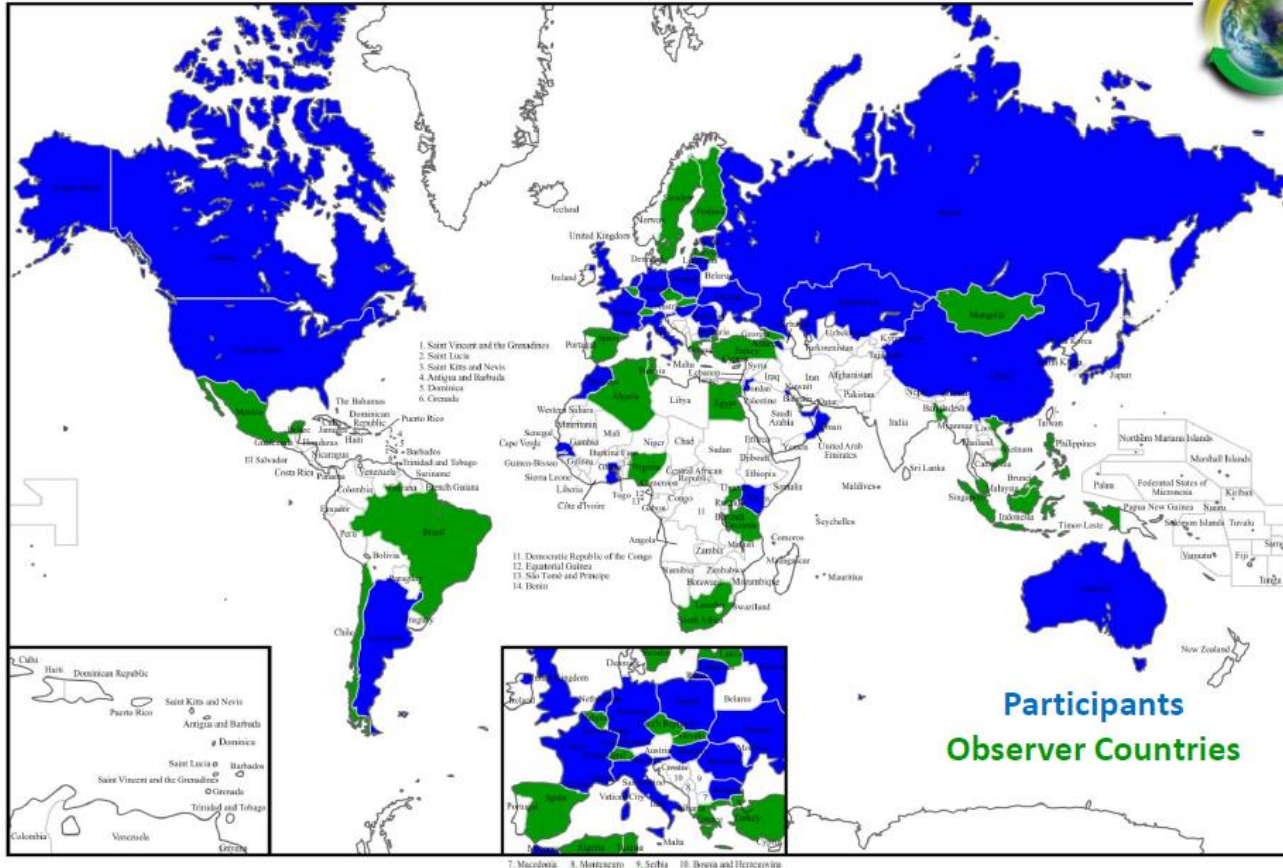
Despite Fukushima and higher costs, more countries are weighing nuclear... **why?**



U.S. DEPARTMENT OF
ENERGY

IFNEC Expanded to 61 Countries + 3 Int. Orgs
(31 Participants, 30 Observers)

Nuclear Energy



Why we still need Nuclear Power... (after Fukushima)

Why We Still Need Nuclear Power -- Making Clean Energy Safe and Affordable

"In the US, an already slow approach to new nuclear plants slowed even further in the face of an unanticipated abundance of natural gas. **It would be a mistake, however, to let Fukushima cause governments to abandon nuclear power** and its benefits. Electricity generation emits more carbon dioxide in the US than does transportation or industry, and nuclear power is the largest source of carbon-free electricity in the country."

Dr. Ernest Moniz, then director of MIT Energy Initiative; now US Secretary of Energy (2013+)

"Why We Still Need Nuclear Power", Foreign Affairs, **December 2011**



SCIENTIFIC
AMERICAN

How Nuclear Power Can Stop Global Warming (Dec. 2013)



Leading climate scientist **James Hansen of NASA**, now Columbia University:

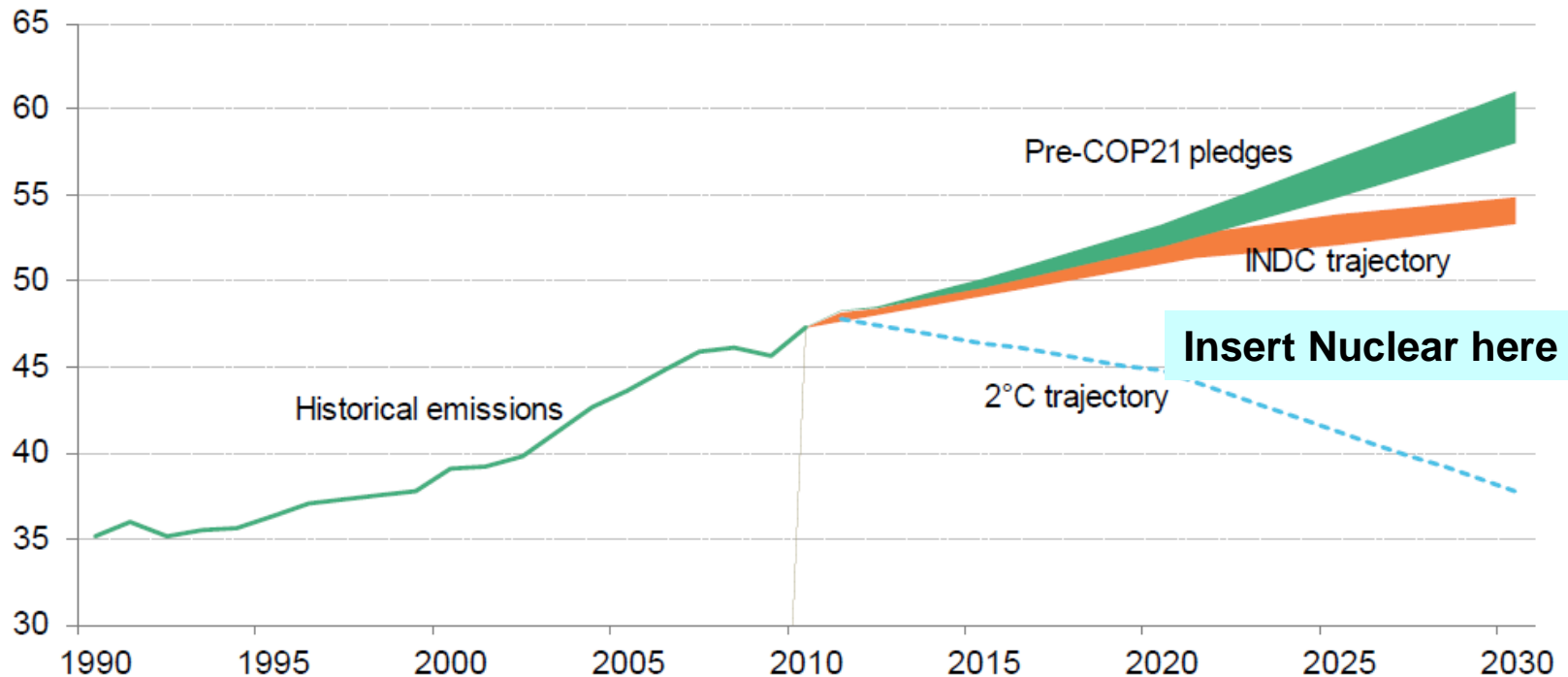
"Environmentalists need to recognize that attempts to force all-renewable policies on all the world will only assure that fossil fuels continue to reign for base-load electric power, making it unlikely that abundant affordable power will exist and implausible that fossil fuels will be phased out... A preferable approach, for the sake of both global climate and local pollution reduction, would be a combination of renewable energy and advanced (3rd and 4th) generation nuclear power plants."

www.scientificamerican.com/article/how-nuclear-power-can-stop-global-warming/

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

GLOBAL GREENHOUSE GAS EMISSIONS (GtCO₂)

Bloomberg
NEW ENERGY FINANCE



Source: UNFCCC, UNEP, Climate Action Tracker, Bloomberg New Energy Finance

Michael Liebreich

BNEF Summit, New York, 5 April 2016

@MLiebreich

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UN “Deep De-carbonization” Calls for Nuclear + RE

ENERGY, ENVIRONMENT, UNITED NATIONS

July 2014

UN Report Envisions 40% Renewable, 30% Nuclear US Energy Mix By 2050

To dramatically reduce carbon emissions by 2050, the U.S. must halt the construction of coal plants without carbon capturing systems.

UNITED NATIONS (TRNS) – In order to achieve necessary carbon emission cuts by 2050, the U.S. must scale up investment in the research and development of low-carbon technologies, as well as halt the construction of dirty coal plants, according to a new U.N.-affiliated report released today.

The 2014 “Pathways to Deep Decarbonization” report outlines sustainable carbon policies for 12 countries, each of which was assembled by national research teams.

Jeffrey Sachs, Director of the Earth Institute at Columbia University, described the U.S. report (developed by Energy+Environmental Economics) as “superb,” and the report’s U.S. chapter presents a portrait of the 2050 U.S. energy mix that differs substantially from the current emphasis on fossil fuels.

pathways to deep decarbonization

interim 2014 report



<http://unsdsn.org/what-we-do/deep-decarbonization-pathways/>

BASELOAD NEEDED FOR RELIABILITY

- Wind varies
- Hydro competes for water; vulnerable to drought
- Solar cannot power urban cores or mfg.
- Biomass faces drought, floods and scaling issues
- Geothermal not available broadly
- Baseload CCS faces cost challenges
- **Nuclear needed in urban areas to electrify transport**



A) Nuclear Power enables Urban Living

Why, after Fukushima, are countries pursuing Nuclear Power ?

Why is it being built at all ?

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.

Home

600
cities

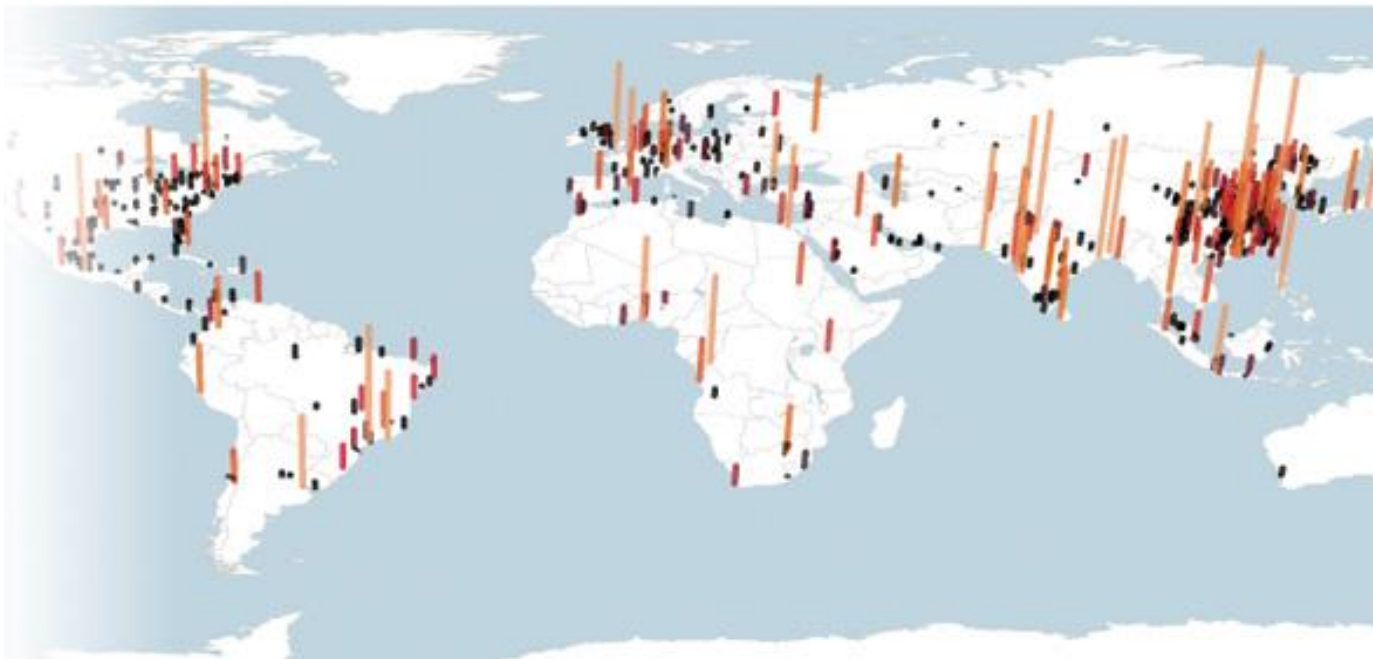
Emerging
markets

Hot
spots

Regions

Urban world: Mapping the Economic Power of Cities (March 2011)

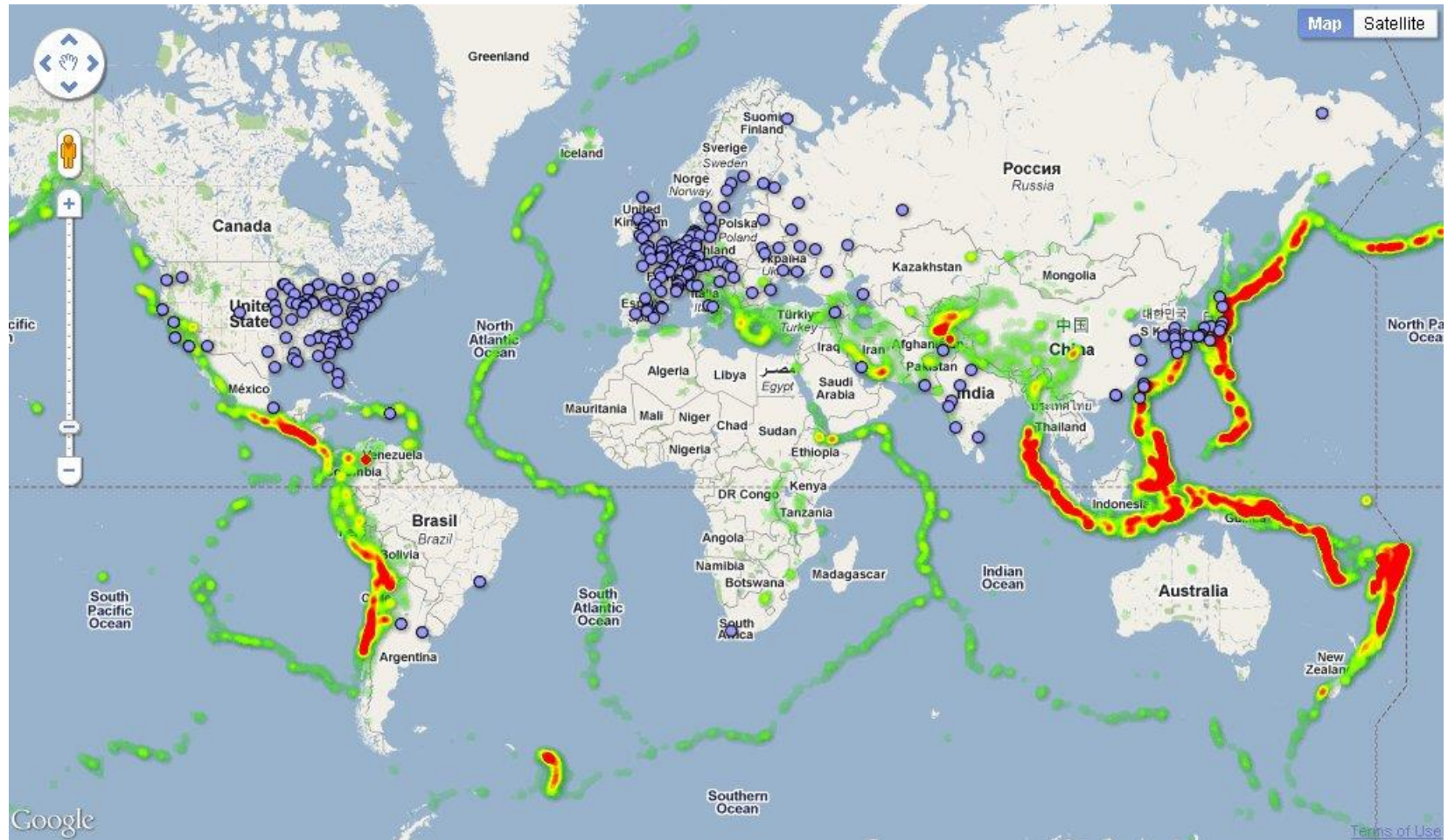
www.mckinsey.com/global-themes/urbanization/urban-world-mapping-the-economic-power-of-cities



Political Economy of Nuclear Energy: Plants power Major Cities

World: Nuclear Power Plants, Seismic Zones

Nuclear can be built in most regions, but not seismic, volcanic zones.



“DEVELOPING” WORLD is... Developing.

Pace of Growth: Then (1990) and Now (2010)

Migration to cities is largest trend shaping development in 21stC, 4-5m / month.

Shanghai, 1990



Shanghai, 2010



MUMBAI 1990



MUMBAI 2015

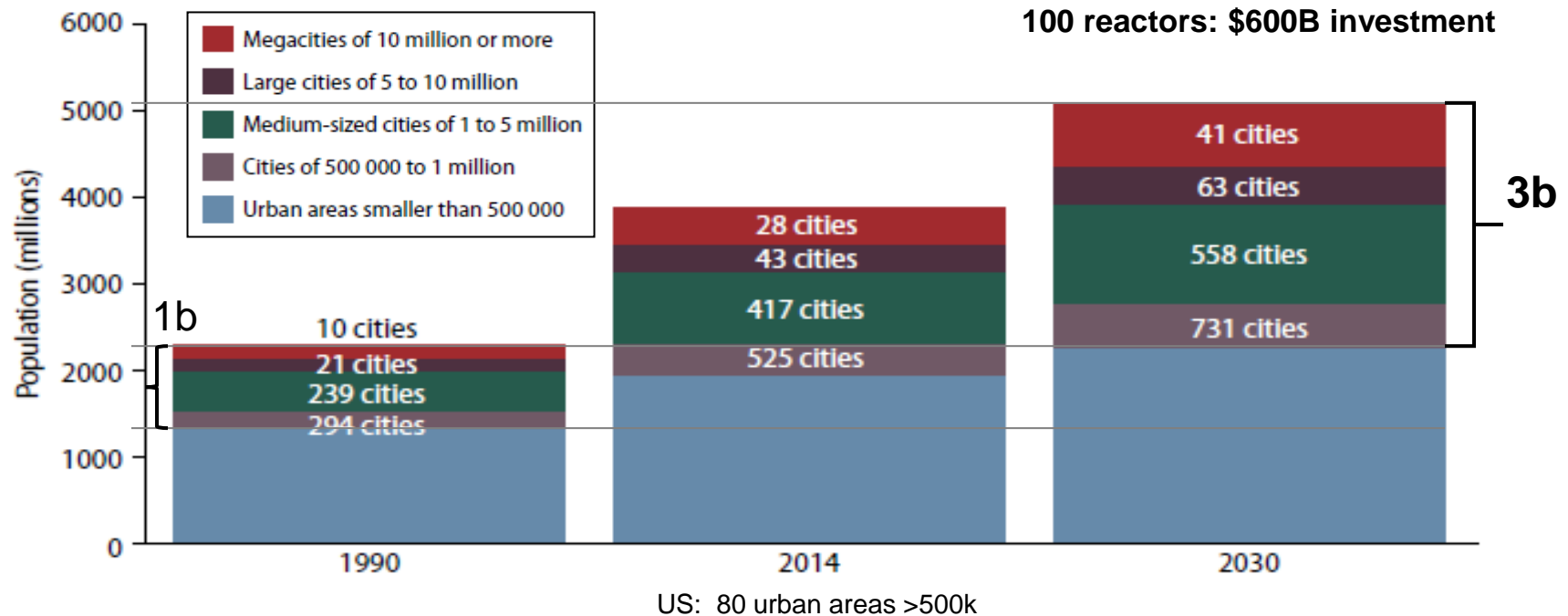


UN: Another 2 billion in cities by 2040 (6b total)

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 if served by nuclear energy.

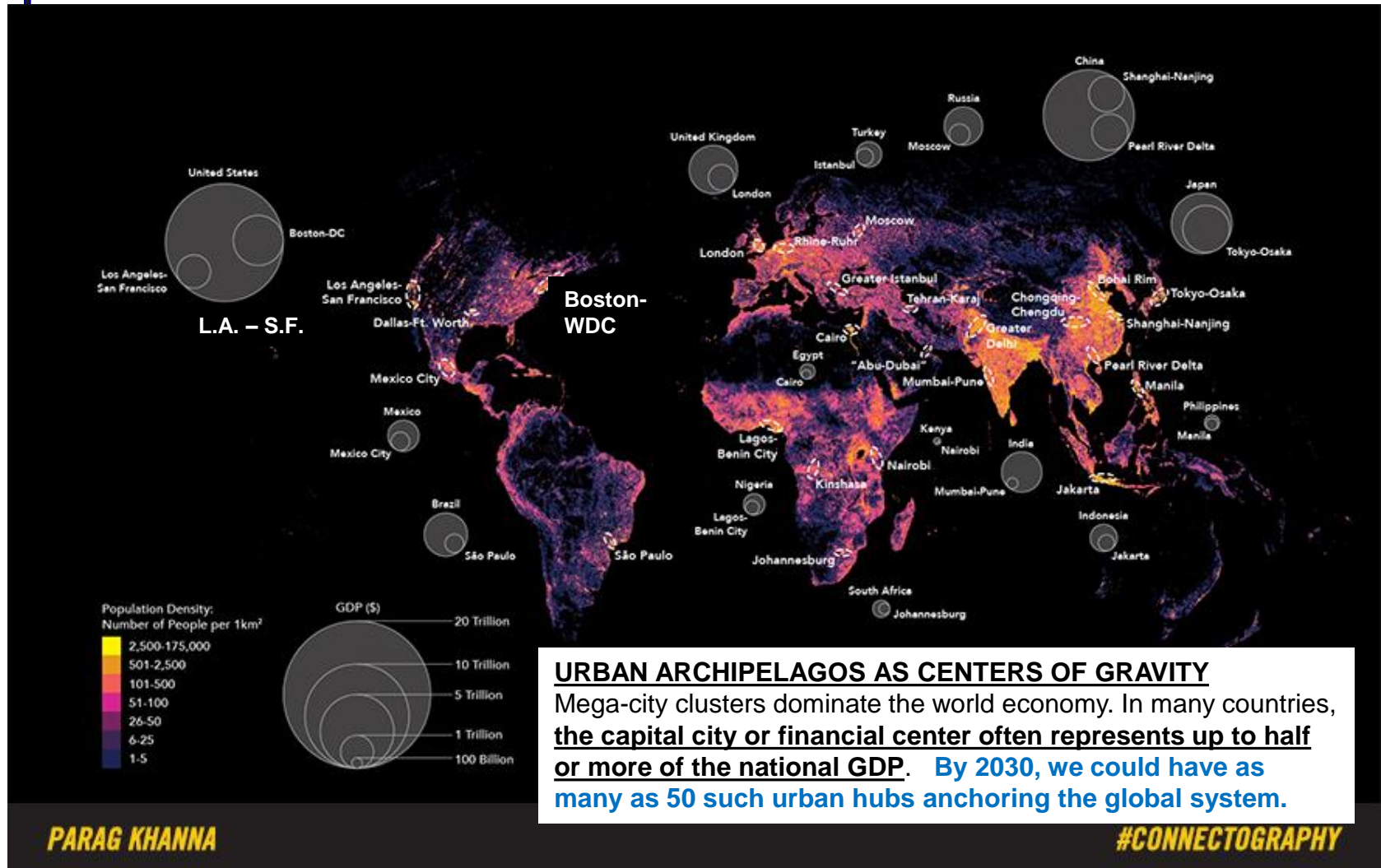
Figure 8.

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



Linked Archipelagos demand highly reliably clean energy

“Urban Archipelagos” as Global Economic Hubs

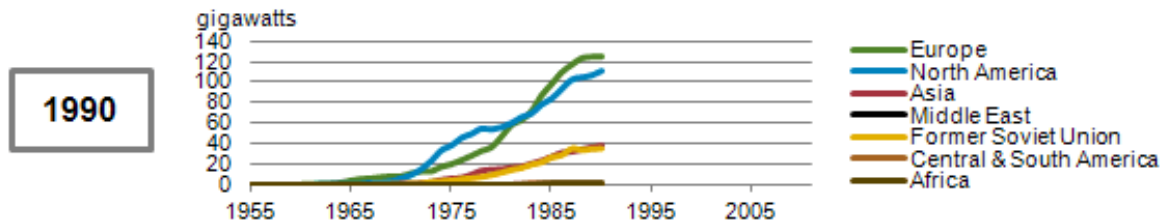
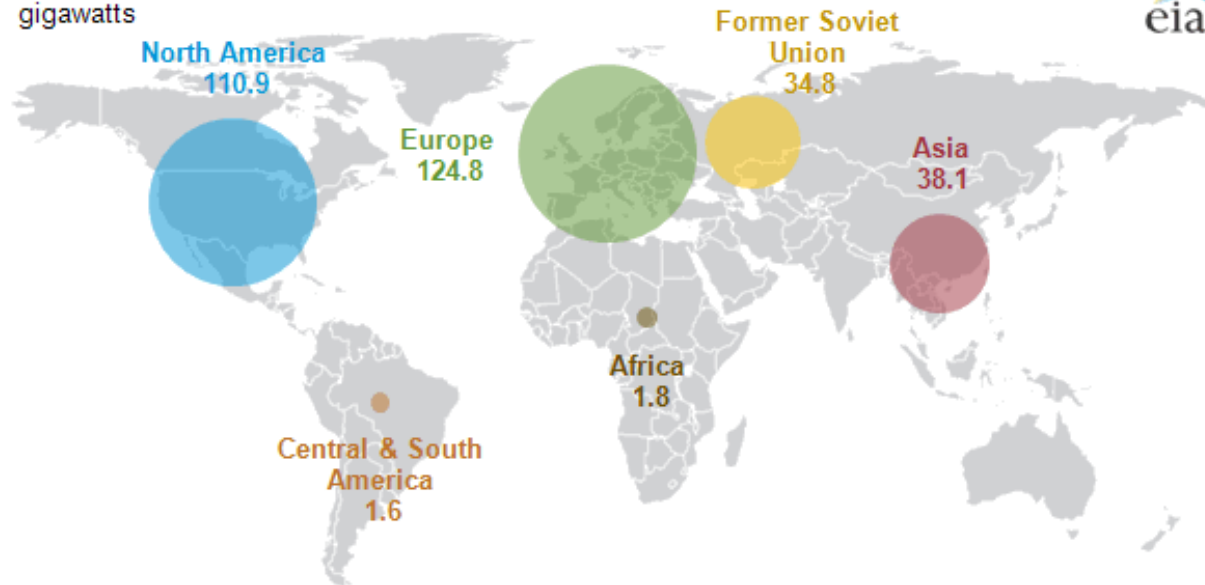


EIA: Nuclear Capacity by decade, 1990

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

Most regions double capacity in 80s

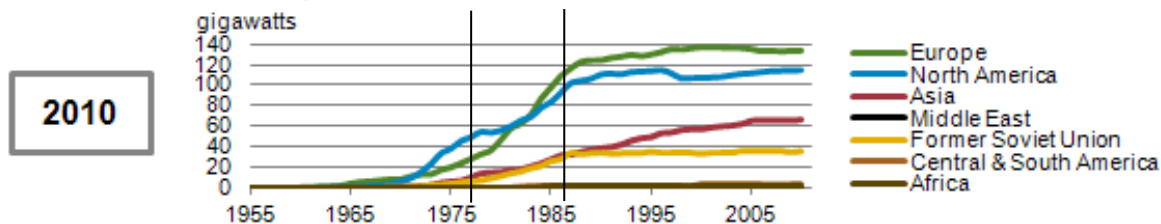
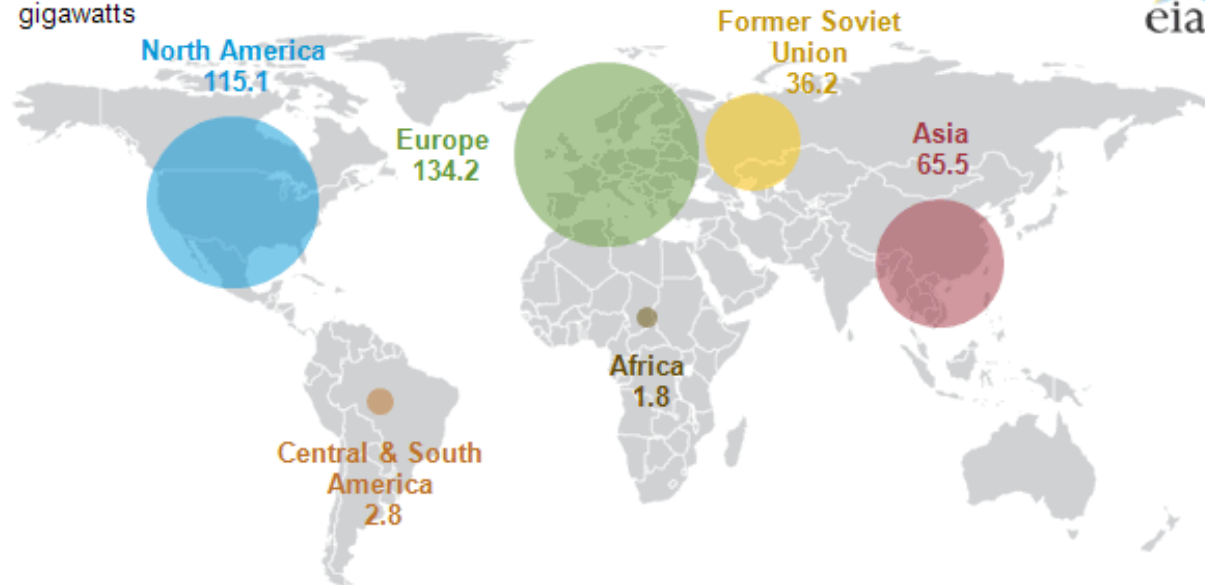
World nuclear electricity generating capacity by region, 1955-2011
gigawatts



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**

World nuclear electricity generating capacity by region, 1955-2011
gigawatts

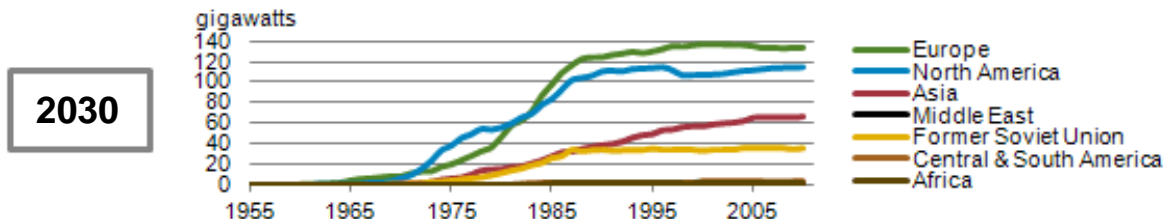
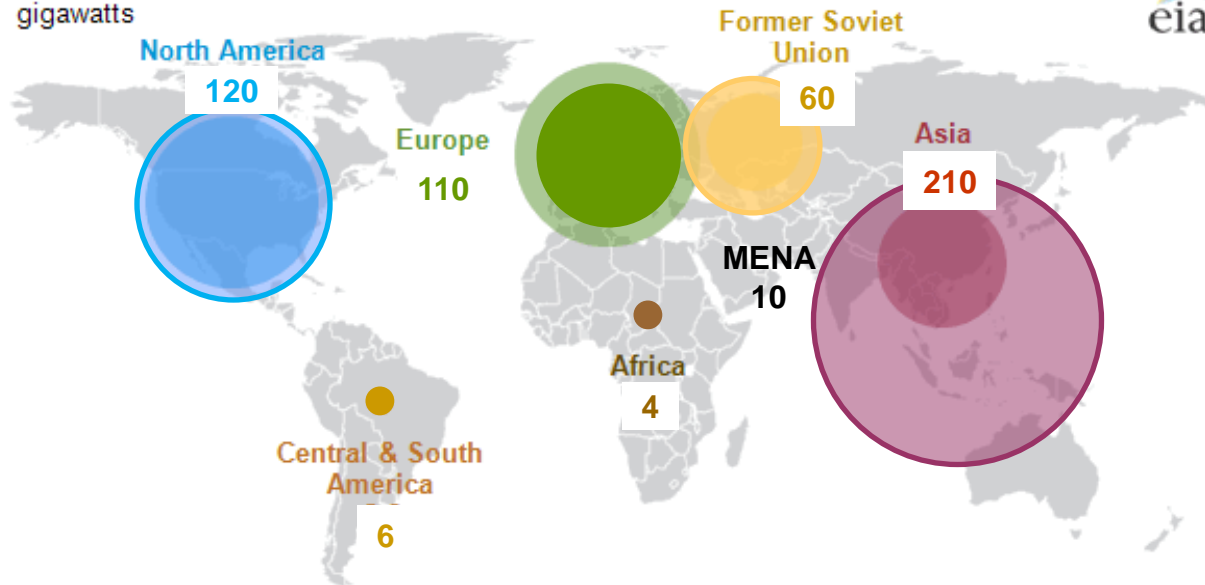


EIA: Nuclear Capacity by decade, 2030

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

Asia dominates to 2030 to feed cities

World nuclear electricity generating capacity by region, 1955-2011
gigawatts

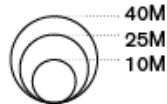


**520 GW
TOTAL**
(IAEA mid-range)

Largest cities by 2030 concentrated in Asia

Cities with a projected 2030 population of more than 10 million

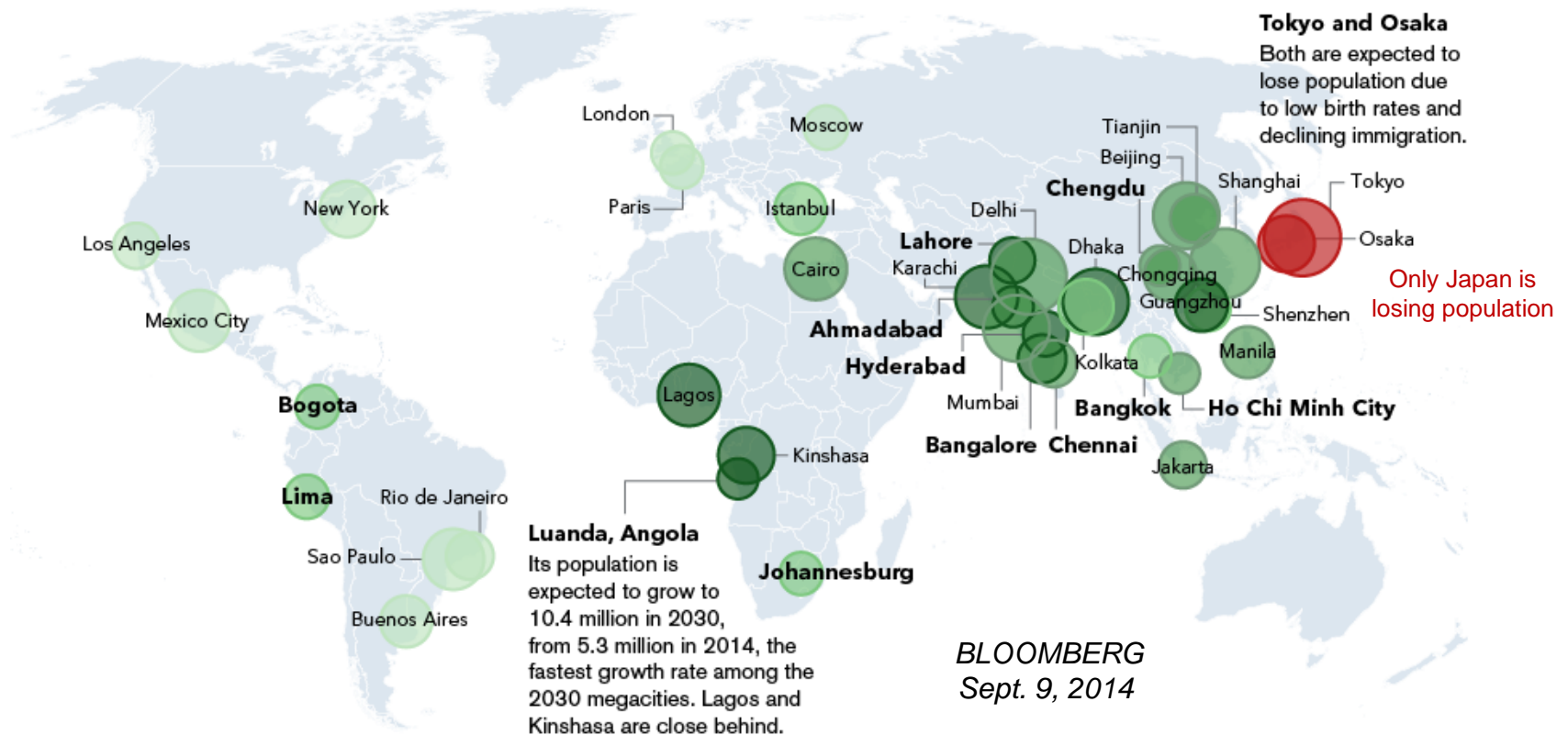
2030 population



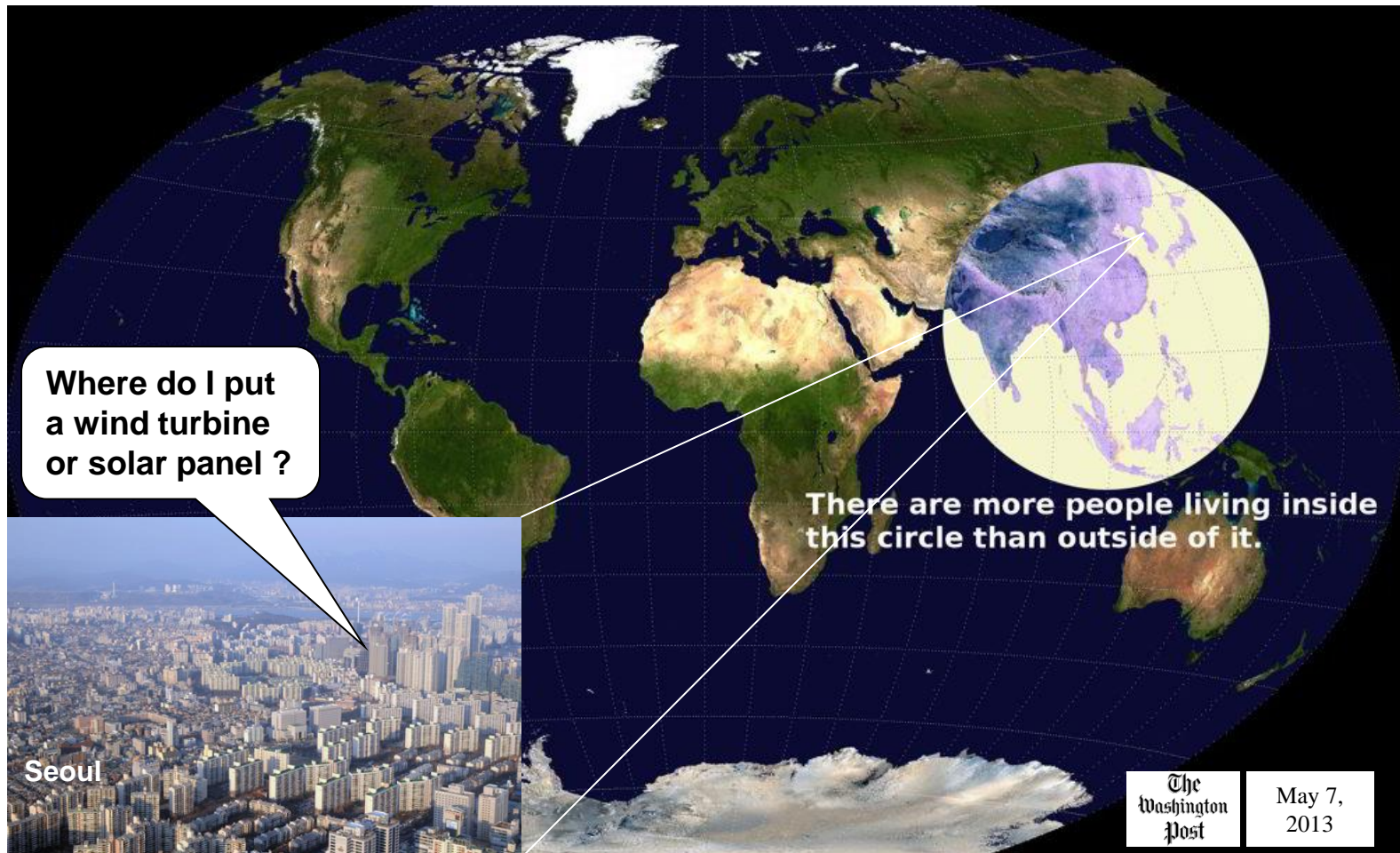
Change in population from 2014 to 2030



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



21st Century: Urbanization drives demand in Asia



UK, Asia: Wind, Solar use much more land

Wind and solar are (1) less dense energy forms; (2) only run 15%-30% of the time (<15% in UK); and (3) require storage and backup gas turbines for downtime.

$$E=mc^2$$

Hinkley Point C land area and energy output compared to other types of energy production sites

Hinkley Point C Reactor

430 acres

26TWh (terrawatt hours) per year

3.2 GWe

**10 SqKM
(with buffer)**

WIND FARM

Onshore wind farms =
250,000 acres*

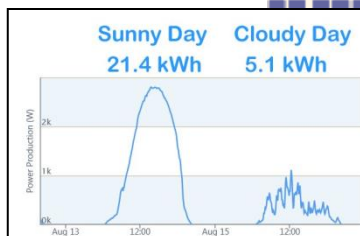
> 800 SqKM

Washington DC = 177 SqKM

400 - 500 SqKM

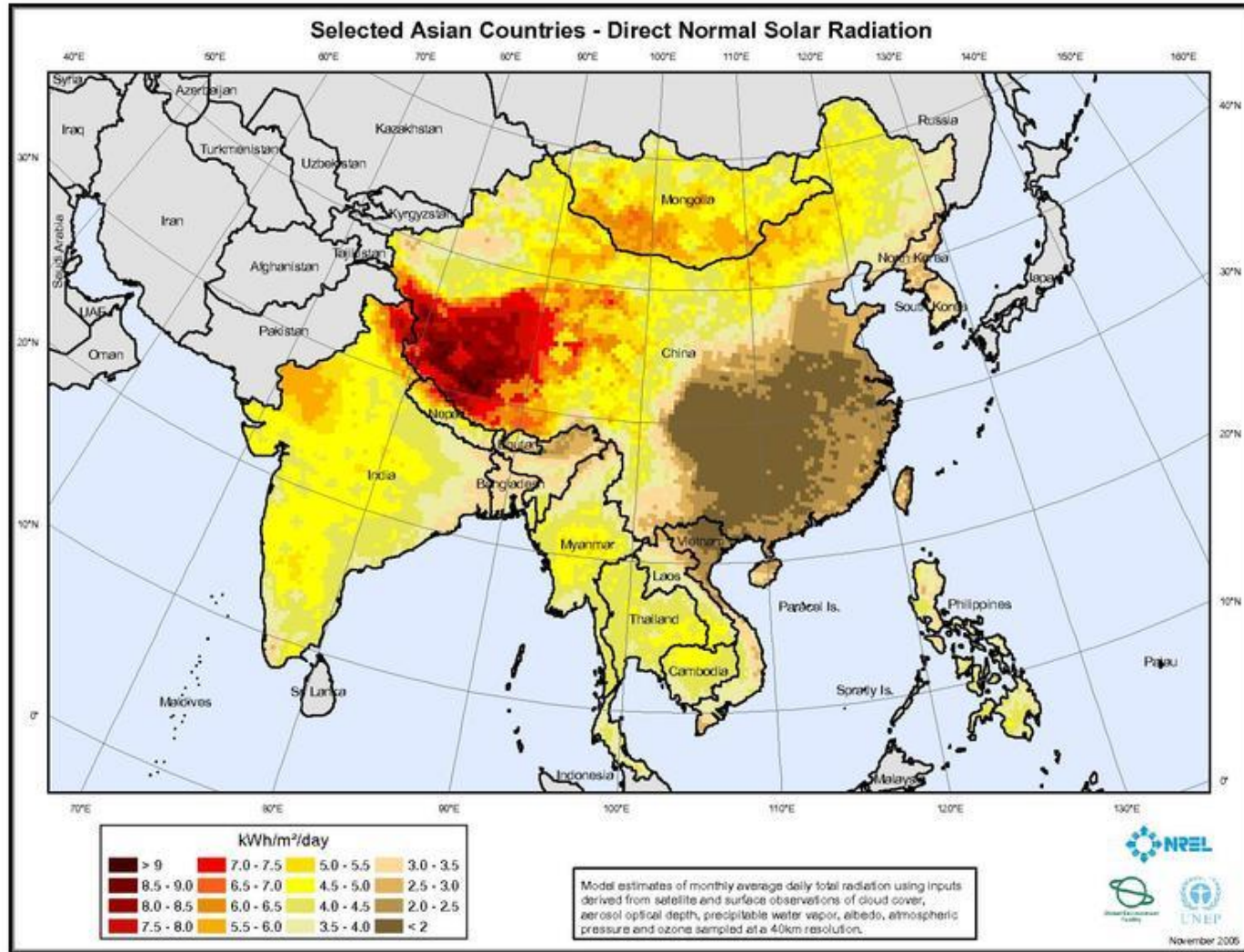
Solar farms =
130,000 acres

SOLAR

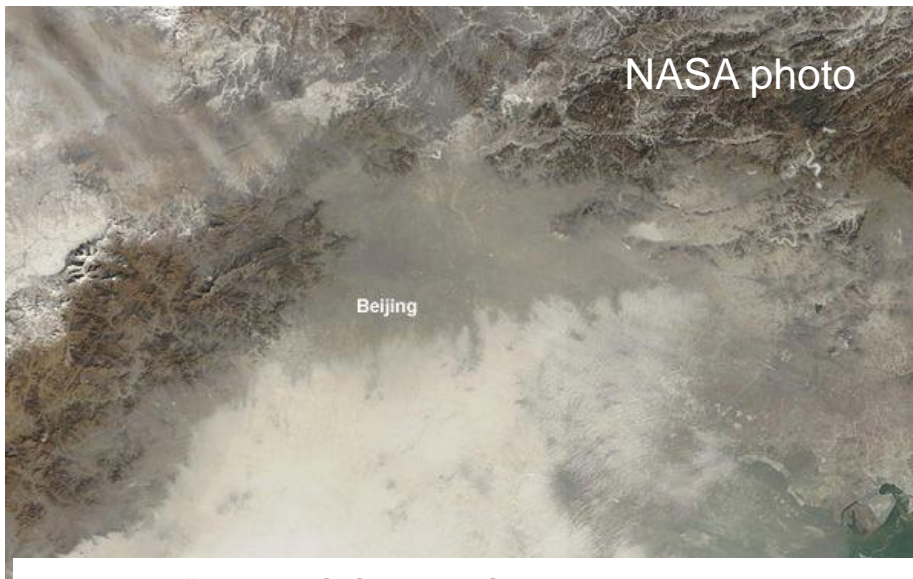


Solar Intensity in Asia – not near cities

No matter the cost for solar panels or efficiency, PV requires sunlight.



Another reason solar doesn't work well in Beijing...



Beijing "AIR-POCALYPSE", Jan. 2013: **750+**



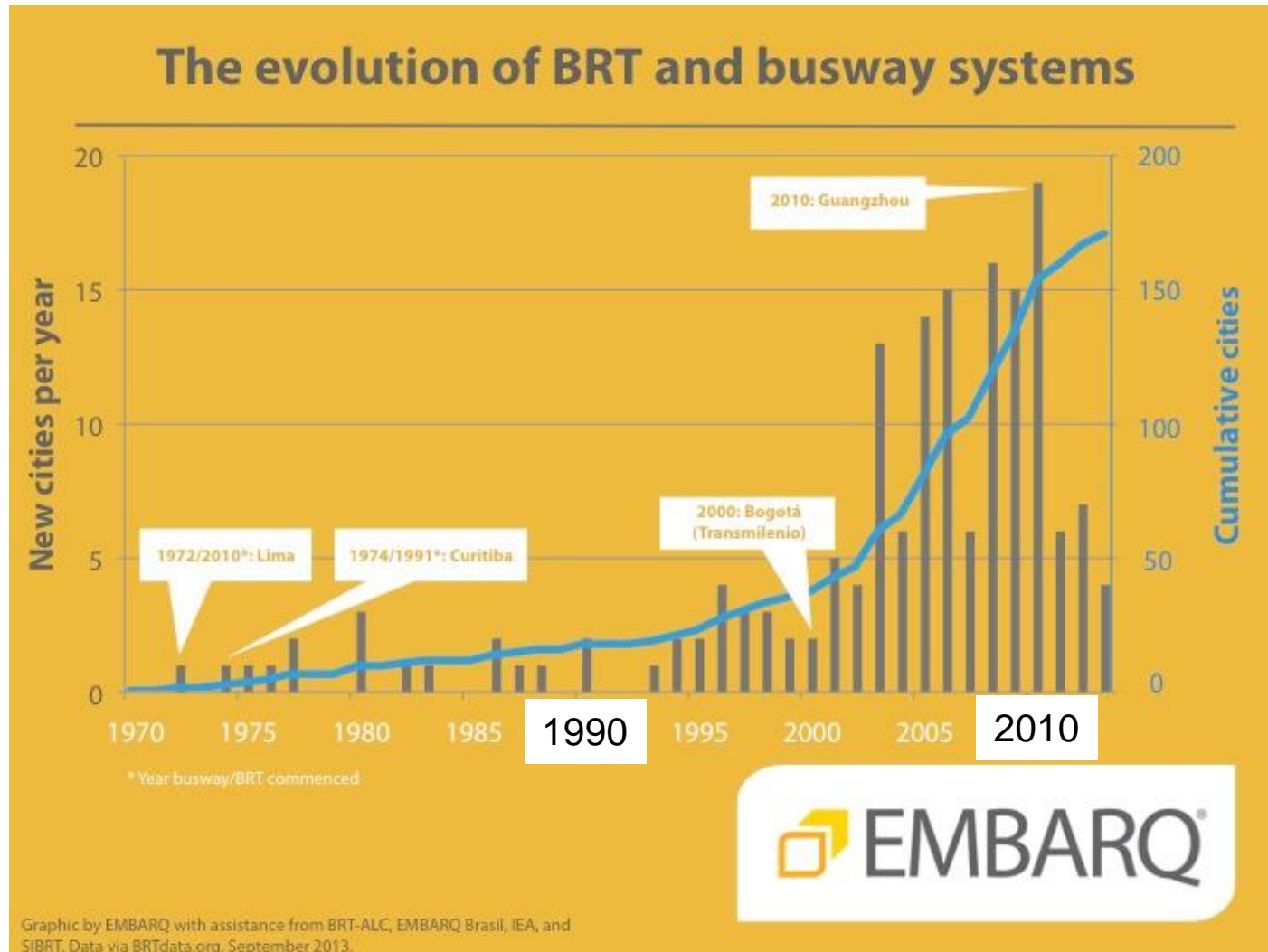
Measured at US Embassy, Beijing

Urban Transit: E-buses starting to roll

BOMBARDIER
the evolution of mobility



Sharp Growth in Urban Bus Systems since 2000

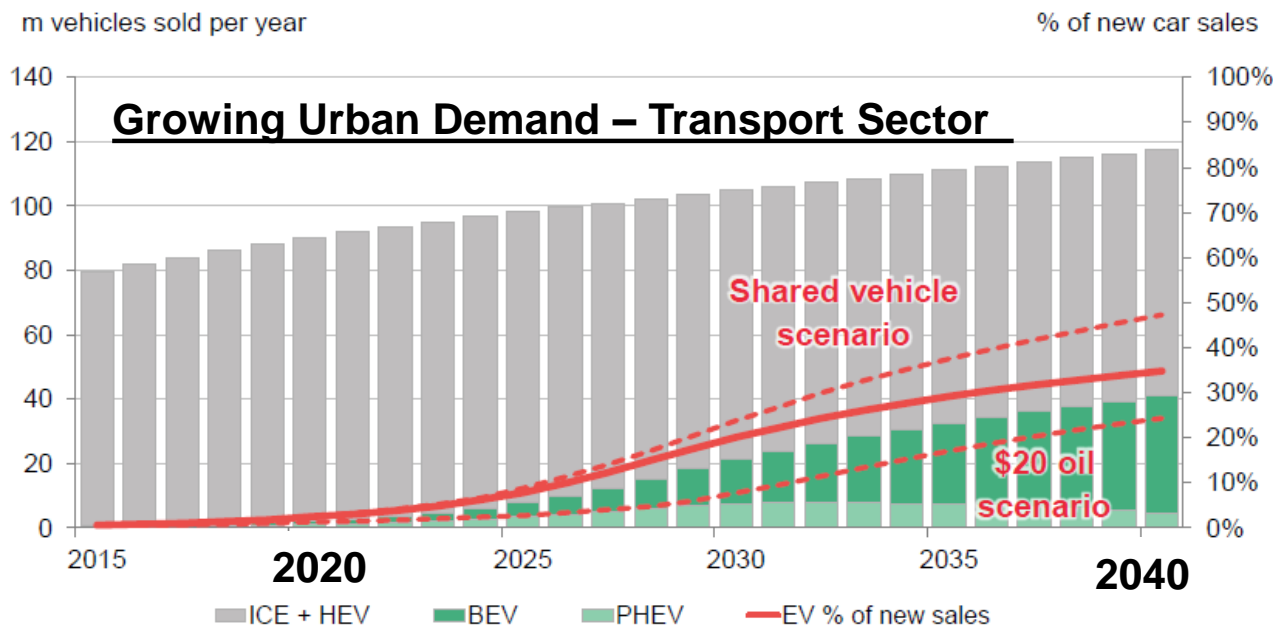


EVs/PHEVs: 20% of Global sales by 2030

Onset of Electric Vehicles after 2020 matches growth in Adv. Nuclear for big cities.

GLOBAL LIGHT DUTY VEHICLE AND EV ANNUAL SALES, 2015–40 (M VEHICLES SOLD PER YEAR, %)

Bloomberg
NEW ENERGY FINANCE



By 2040
Up to 50%
of new cars
will be EVs

Note: forecast uses Gasoline and electricity prices from EIA's 2015 Annual Energy Outlook 'Low Oil Price' scenario (ranging from \$50 to \$65 per barrel between 2015 and 2025). High scenario assumes greater vehicle utilisation. Low scenario assumes \$20 per barrel oil price

Source: Bloomberg New Energy Finance

S.Korea: Largest Auto Factory in the World (Ulsan)

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

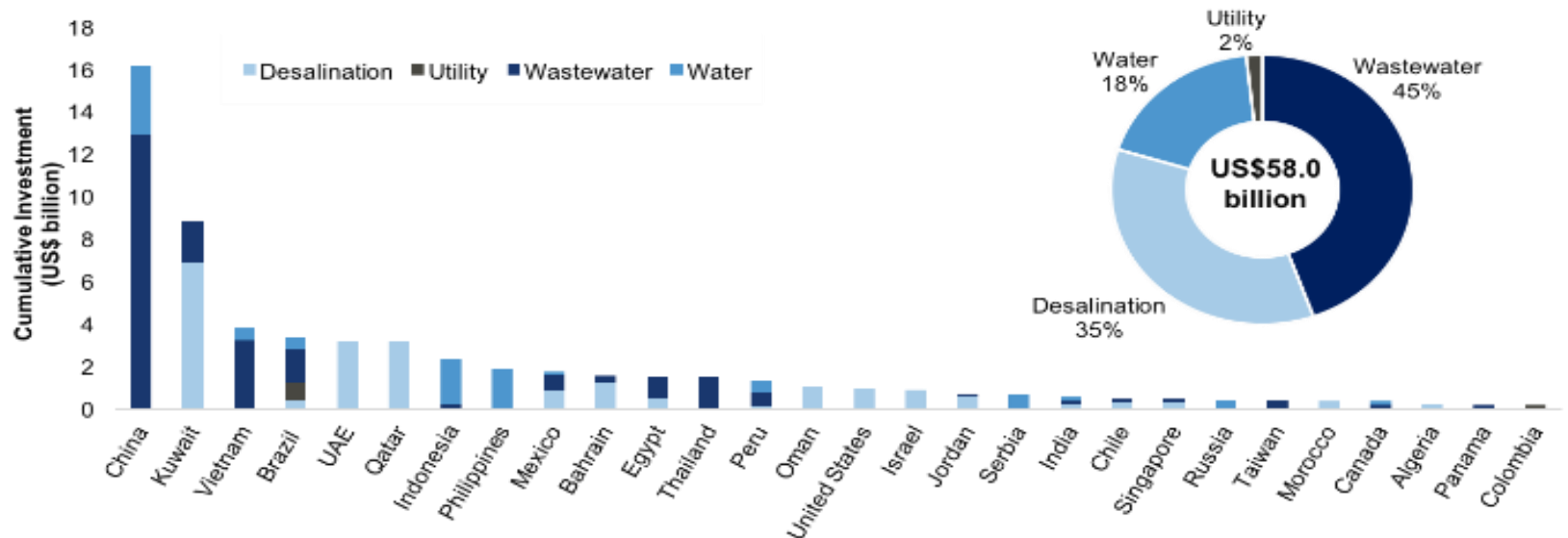


Nuclear
4,500 MW
Solar
30 MW, of
Rooftop PV
In Ulsan



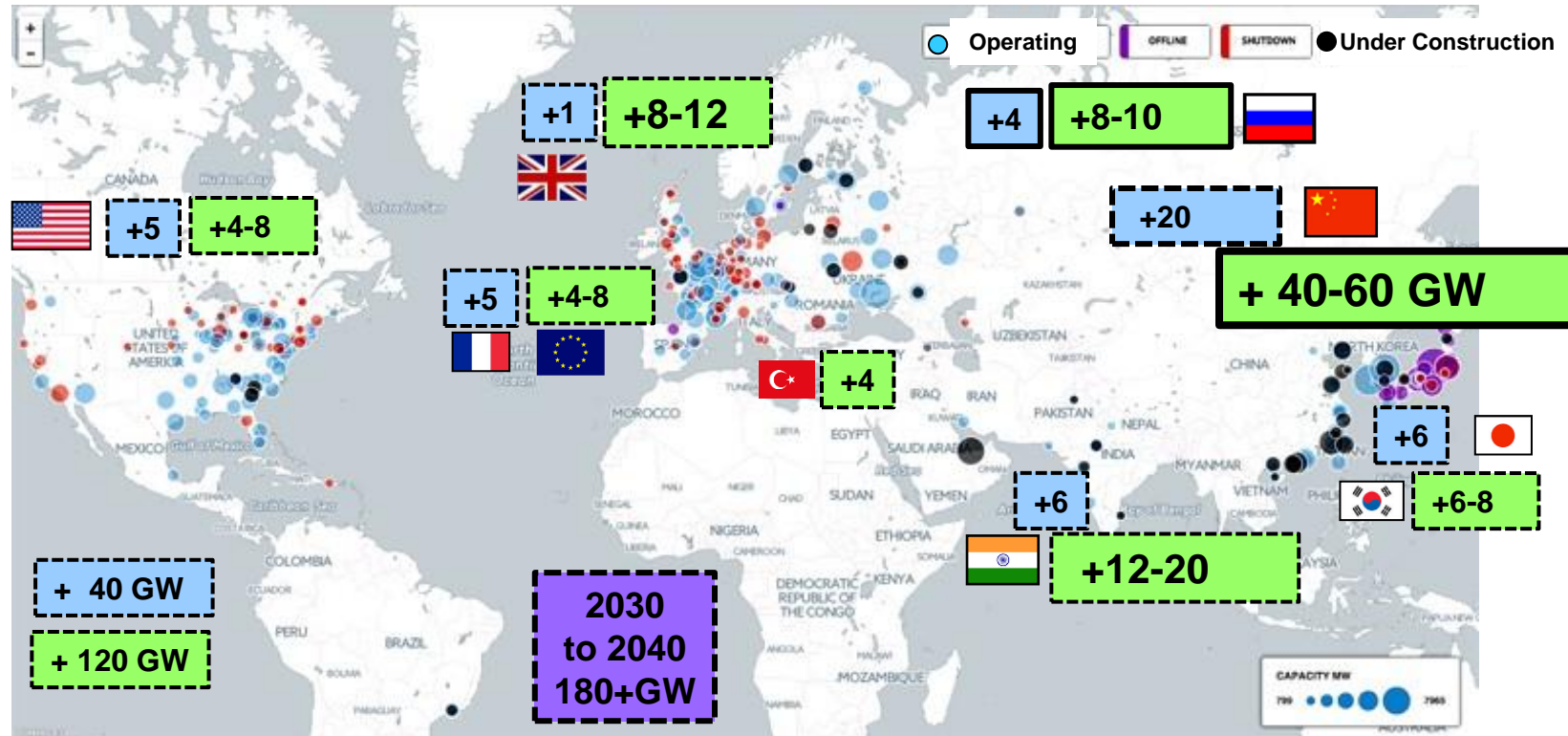
Water Project Market to Triple by 2020 from today

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,**



<http://bluefieldresearch.com/global-water-ppp-market-triple-2020/>

Reactors Under Construction + “Planned” (approved)



GW by 2020

GW by 2030

Some open bidding

More nationalized

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



Clean, Compact, Reliable Energy for Large Cities

SUMMARY OF DRIVERS

➤ **Safe, Reliable power for Cities**

➤ Without emissions (HazAPs + GHGs)

➤ In any weather

➤ On a small footprint

➤ For dense 24/7 end use

(Office towers, High-rise Apts, Elec transit)

➤ In Advanced Mfg economies

➤ Economic, w/ stable pricing, reliable supply

➤ Often with Gov't as customer

Weakest Alternatives

~~Biomass; Geotherm~~

~~Coal~~, [less so N.gas]

~~Wind, Solar, Hydro~~ (drought, flood)

~~Wind, Utility Solar~~

~~Wind, Solar, Biomass~~

[Geotherm may not be near]

~~Biomass~~

~~Oil, N.gas~~, if imported (Asia, EU)

Depends on policy



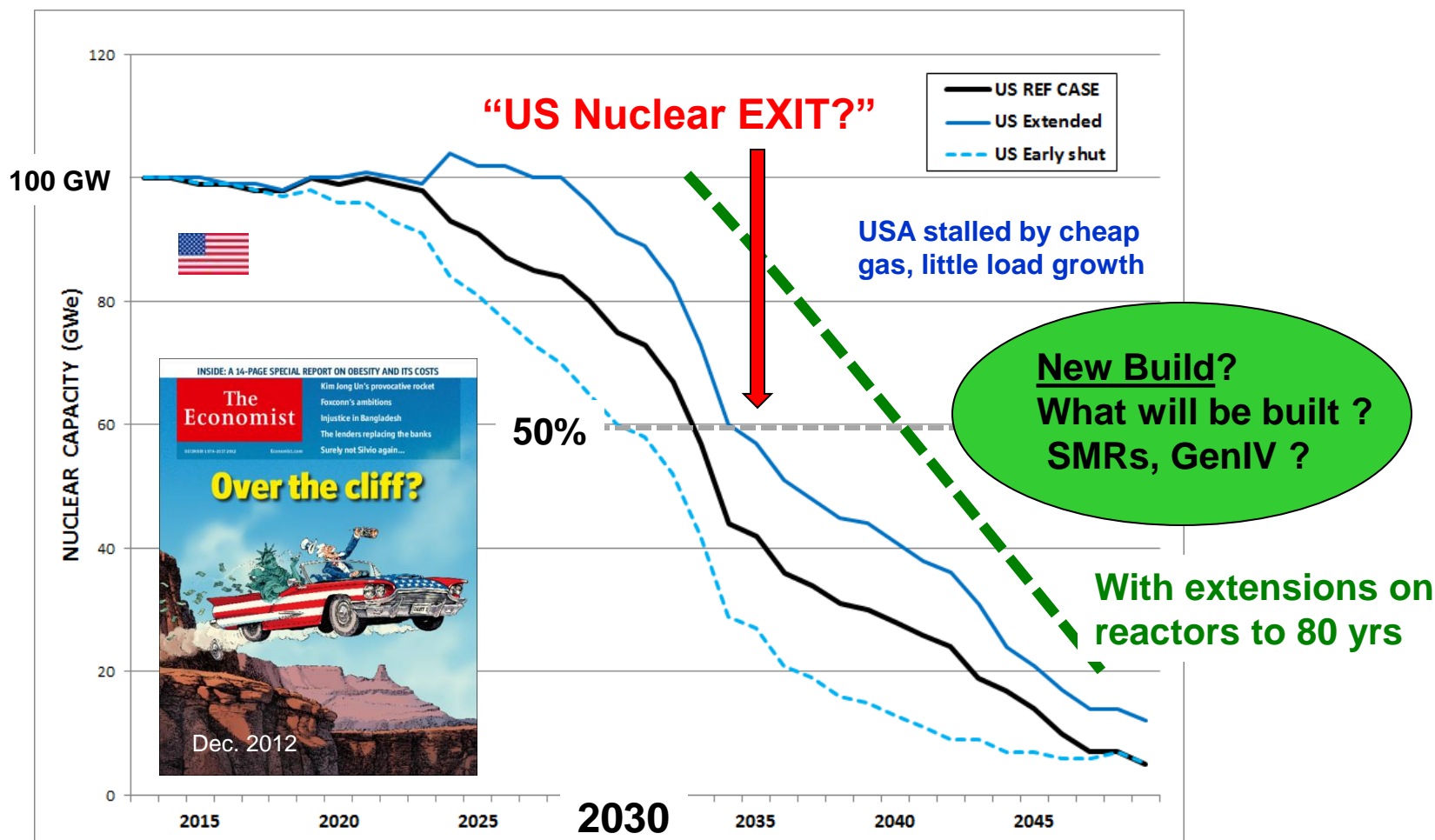
B) US Strategic Position Declining

**What is the US Position globally ?
Why is it declining? Do we care?**

Global Leadership eroding already...

USA facing NUXIT -- Half Nuclear Capacity in 30 yrs

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.

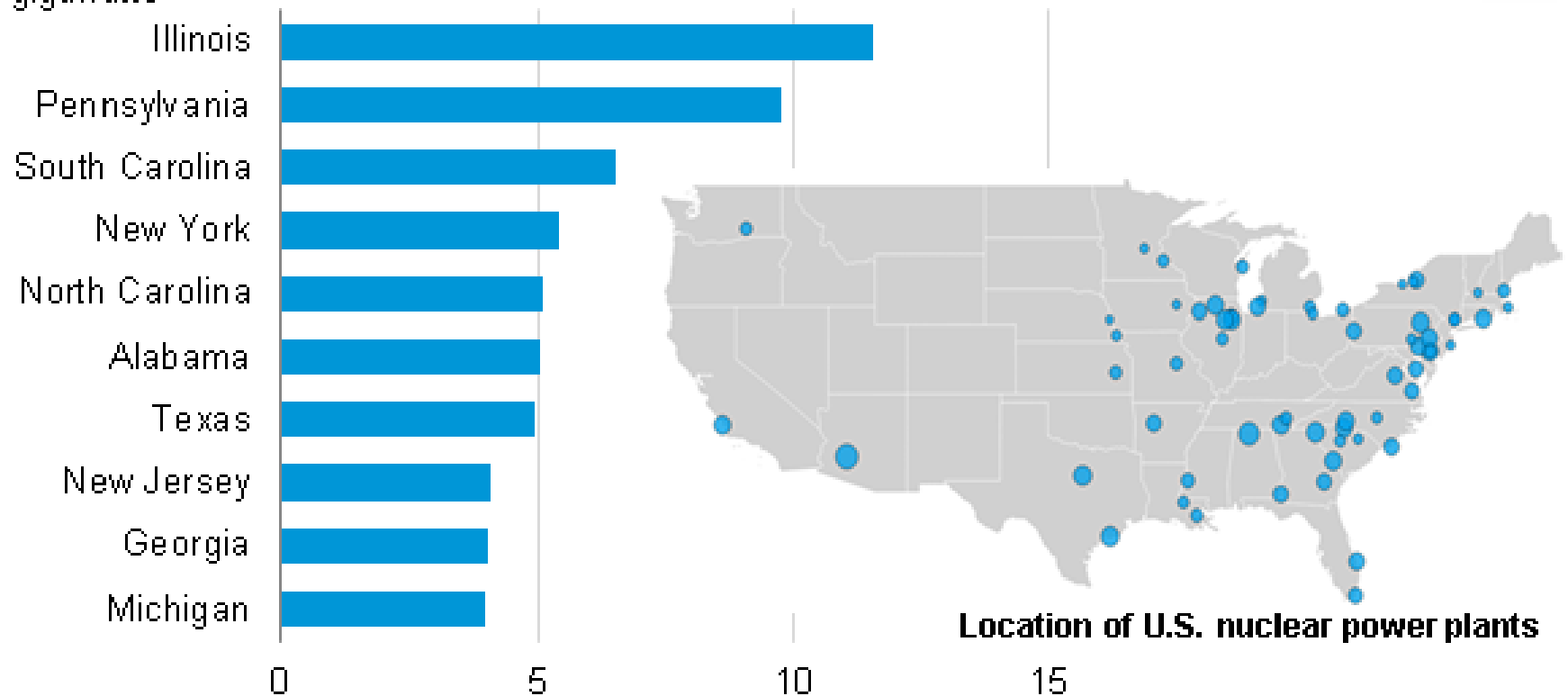


Sources: IAEA, WNA 2012

US Strategy...? Regional Differences pose challenge

Large regional disparity in impact of Nuclear Power hinders a National Strategy politically.

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



“Nuclear Matters”... How’s that going?

Exelon Shutting Two Nuclear Plants After Legislation Fails

by Jim Polson
jpolson9

June 2016 – 8:39 AM EDT *Updated on* June 2, 2016 – 10:23 AM EDT



- ▶ The reactors lost a combined \$800 million over seven years
- ▶ Low power prices, wind and solar energy pressuring reactors



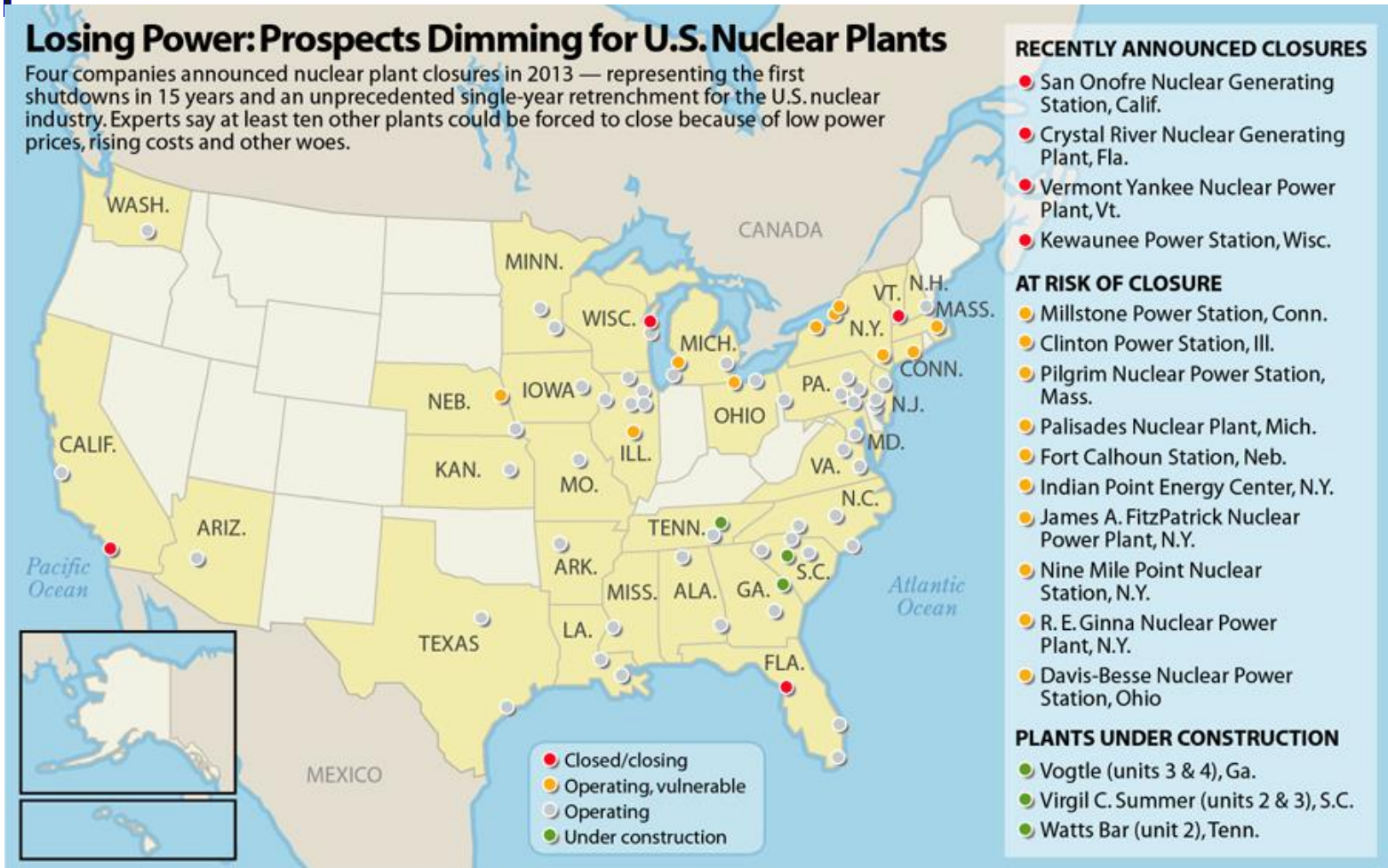
Exelon Corp., the largest U.S. generator of power from nuclear energy, said it will close two money-losing Illinois plants as competition from renewable energy and low-cost natural gas continues to pressure generators.

The Clinton Power Station will shut June 1, 2017 and the Quad Cities Generating Station will close June 1, 2018 after the state failed to pass legislation that would stem their

Nuclear Plants Vulnerable to Economic Shutdown

Losing Power: Prospects Dimming for U.S. Nuclear Plants

Four companies announced nuclear plant closures in 2013 — representing the first shutdowns in 15 years and an unprecedented single-year retrenchment for the U.S. nuclear industry. Experts say at least ten other plants could be forced to close because of low power prices, rising costs and other woes.



SOURCES: Nuclear Regulatory Commission; Mark Cooper, Vermont Law School; Google Maps; InsideClimate News research

PAUL HORN / InsideClimate News

Premature Nuclear Plant Shutdowns

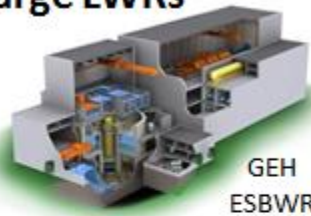
Plant	MWe	Reason	Closure Year	Latest Electricity Generated (billion kWh per year)	Latest CO2 Emissions Avoided (million tons/year)
Crystal River 3	860	Mechanical	2013	7.0	5.3
San Onofre 2 & 3	2,150	Mechanical	2013	18.1	8.8
Kewaunee	566	Market	2013	4.5	4.8
Vermont Yankee	620	Market	2014	5.1	2.7
FitzPatrick	852	Market	2017	7.4	3.9
Clinton	1,065	Market	2017	8.7	9.2
Quad Cities 1 & 2	1,819	Market	2018	15.6	13.2
Pilgrim	678	Market	2019	5.0	2.6
Oyster Creek	610	Policy	2019	5.3	4.4

- 9,220 MWe of baseload capacity
- 54.9 million short tons of CO₂ avoided
- 13.3% of Clean Power Plan's 2030 414-million-ton target
- Approximately 7,500 direct jobs

The Future of Nuclear Energy



Large LWRs



GEH
ESBWR

Advanced Reactors

- Hi-temp gas
- Liquid metal
- Molten salt



2015

2020

2025



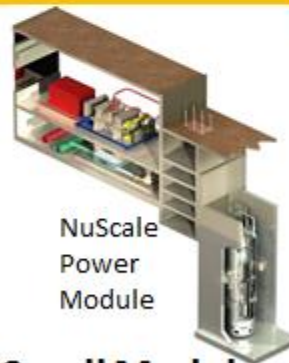
Watts Bar 2



Summer Units 1,2&3

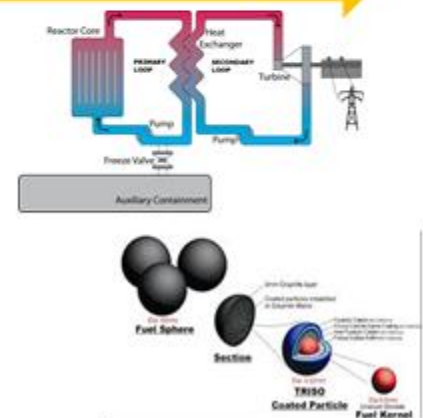


Vogtle Units 1,2,3&4



NuScale
Power
Module

Small Modular Reactors





The NEXT Chapter: Not Policy Parity... *Preference*

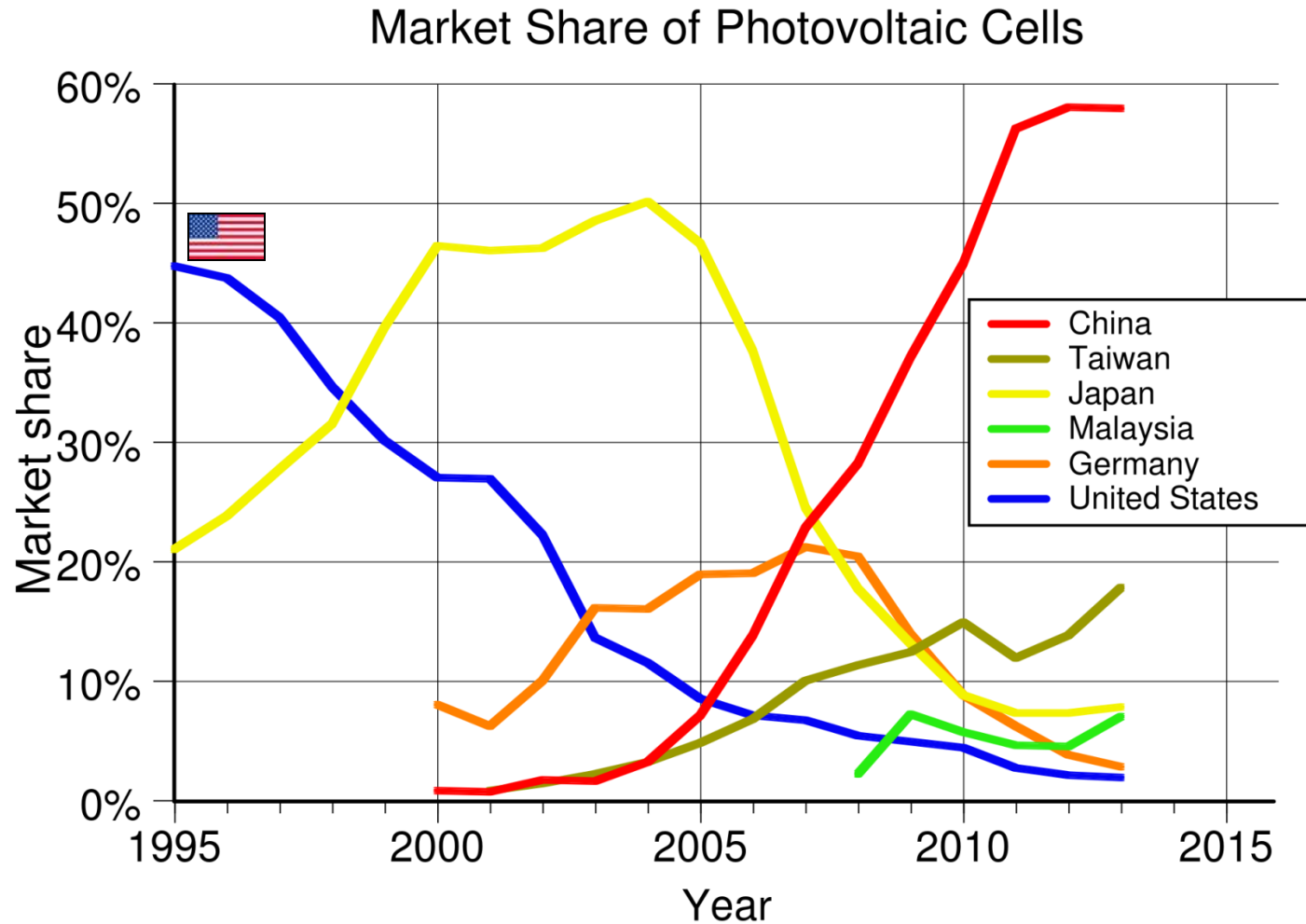
The Old Way... “Parity”

- Go along to get along
 - Party for parity with RE
 - But, not all RE groups support tax policy parity for nuclear
- Cheap gas undermines market position
- Capital intensive sources require stable prices, not merchant
- Commercial nuclear avoids link to Nuclear for National Security
- Nuclear utilities see less importance in exports

An UPRATE... “Preference”

- **“Nuclear is Different”**
 - Offers large scale GHG savings
 - INDCs cannot be met w/o Nuclear
 - Unique value for urban reliability where open space is scarce
- Grid reliability is crucial
- P5 Status tied to Nuclear
 - China, Russia lead in nuclear?
National Security consequences?
 - Other countries prefer US Lead
 - **SMRs and Adv Reactors can allow US to regain exports and enhance controls on proliferation**

“Policy Parity” did not work for US Solar PV Mfrs



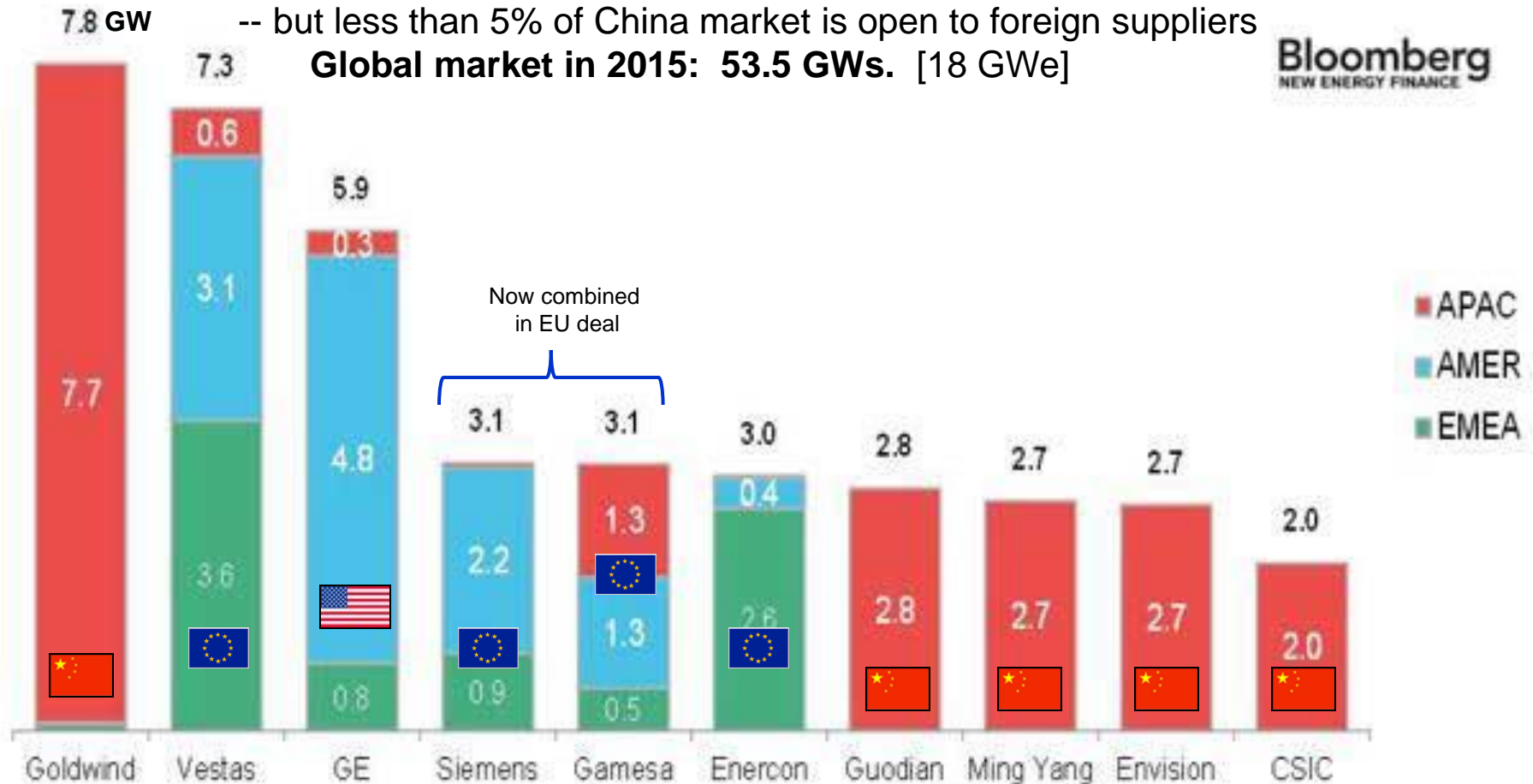
Policy Parity did not work for US Wind Mfrs either

For 2015, Vestas (DEN) lost its first place position to Goldwind (CHN).
China benefits from largest domestic market in the world.

-- but less than 5% of China market is open to foreign suppliers

Global market in 2015: 53.5 GWs. [18 GWe]

Bloomberg
NEW ENERGY FINANCE



RE Tax Subsidies, 2016-19

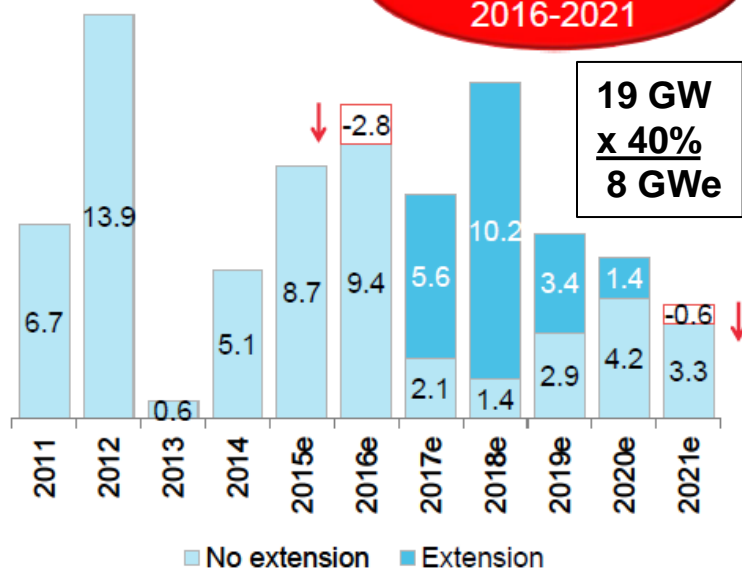
Renewables got their tax subsidies extended in 2015, plus CPP... Nuclear ?

IMPACT OF PTC & ITC EXTENSION

Bloomberg
NEW ENERGY FINANCE

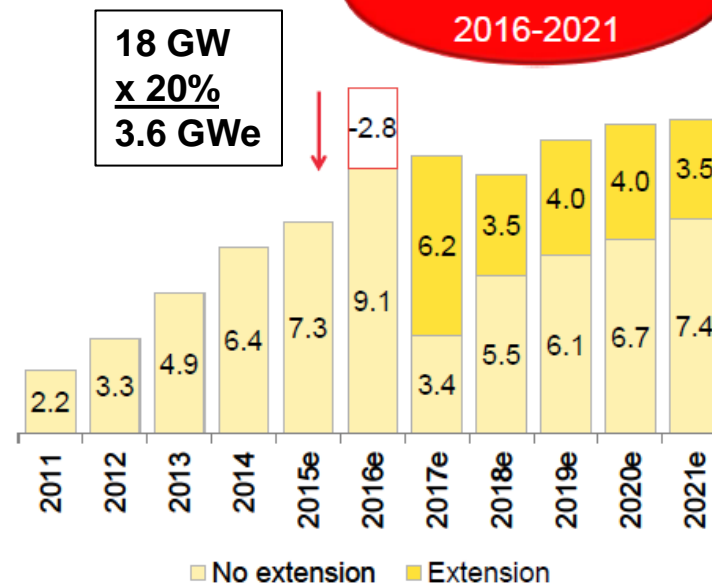
WIND INSTALLATION

Additional 19GW
of wind
2016-2021



SOLAR INSTALLATION

Additional 18GW
of solar
2016-2021



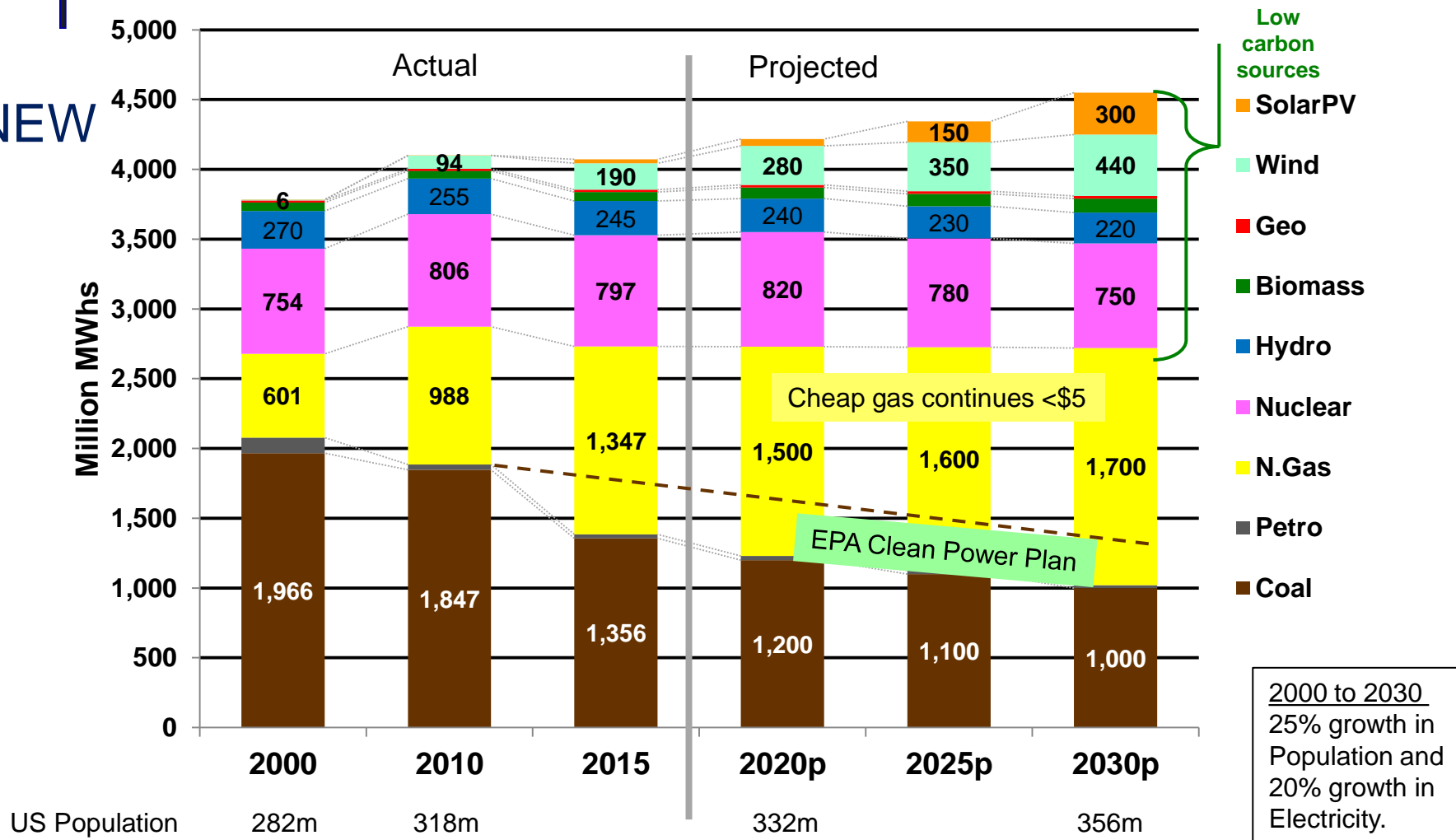
Note: PTC extension case assumes 5-year phase-out. 2015 onwards is forecast. PTC is production tax credit. ITC is investment tax credit

Source: Bloomberg New Energy Finance

From 2000 to 2030: US Population will grow by 74m people, up 26%

EIA: US Electricity Generation by Fuel, 2000 - 2030

NEW



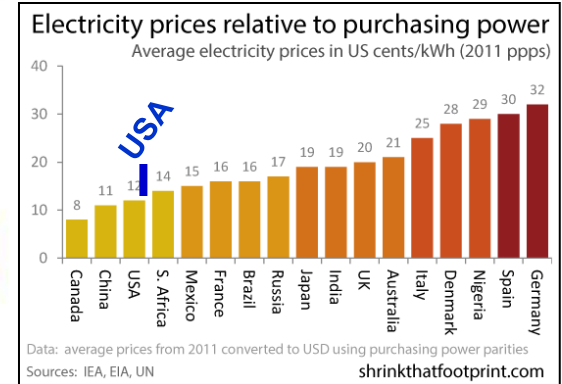
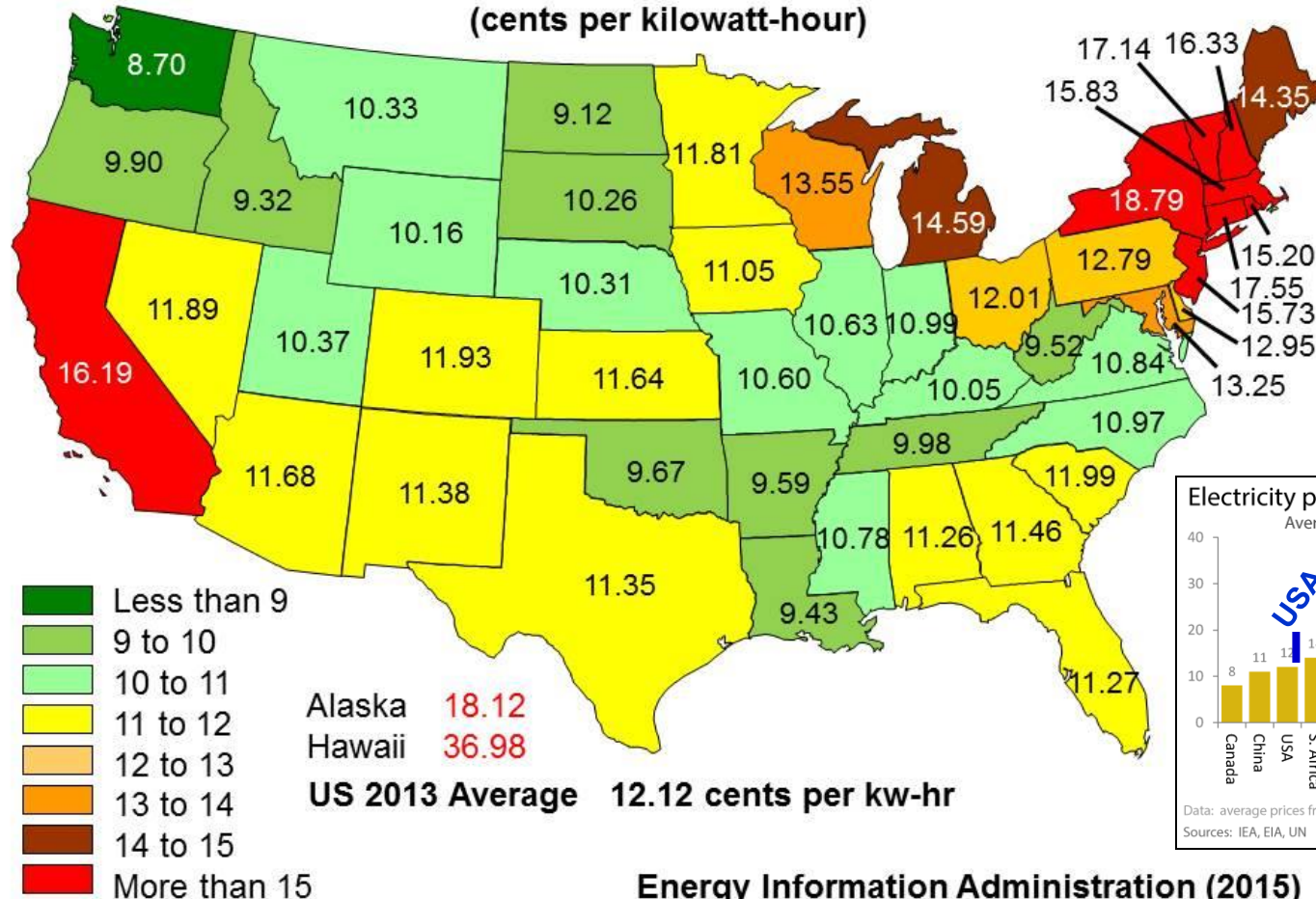
Cheap N.gas is replacing coal. Hydro, Bio, Geo remain stable. Renewables expand if subsidies continue.

[AEO 2015; Projection for 2030 modified, less Coal; higher for N.Gas and Renewables. Some Nuclear retired.] 43

Electricity rates vary markedly by State

State Average Residential Electricity Rates 2013

(cents per kilowatt-hour)



Energy Information Administration (2015)

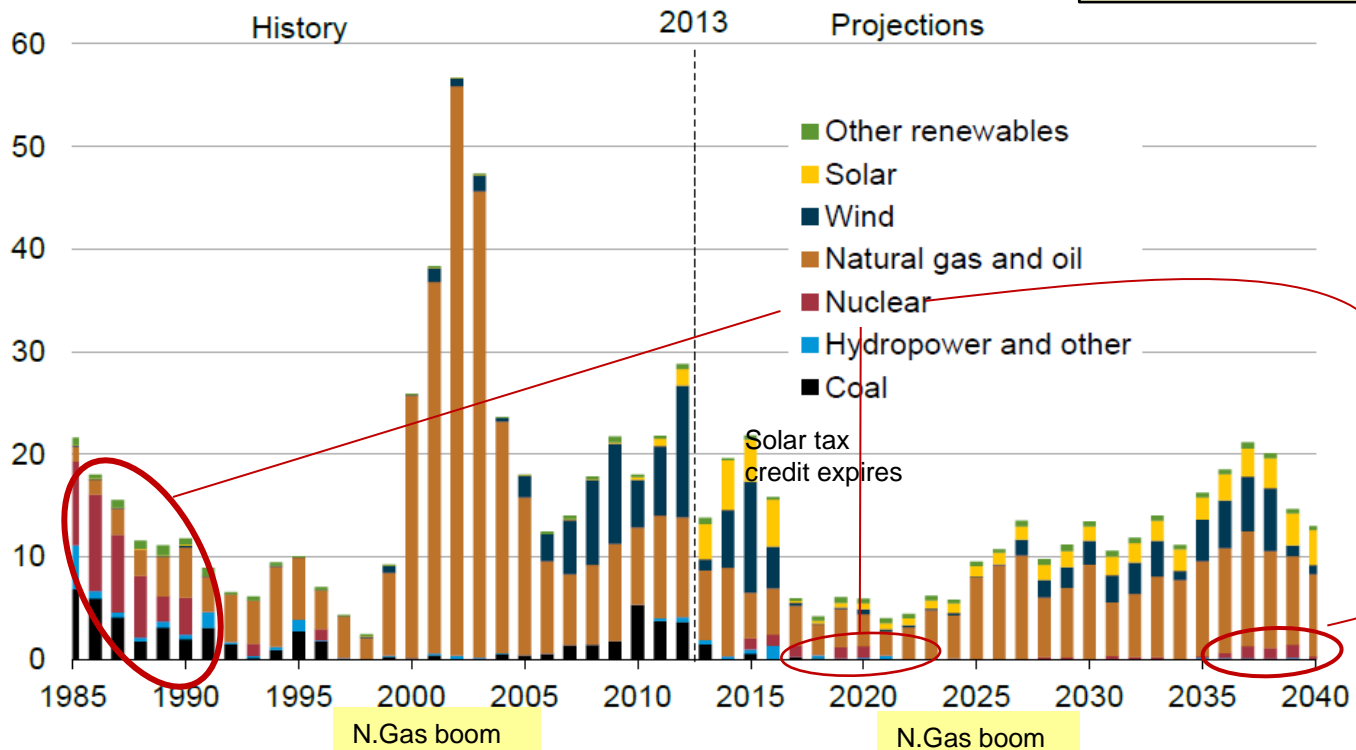
EIA AEO 2015: Projected Capacity Additions to 2040

Episodic construction of nuclear plants does not sustain a US industry.

AEO2015 projected annual generating capacity additions are moderate relative to historical levels

We are still living on a huge overbuild of gas turbines, 1998-2003

Additions to electricity generating capacity, 1985-2040
gigawatts



2016 Politics? BOTH supportive of Nuclear Power

World | Sun Dec 2, 2012

Clinton in Prague to lobby for Westinghouse nuclear bid

[Progress on Carbon Emissions; American exports]



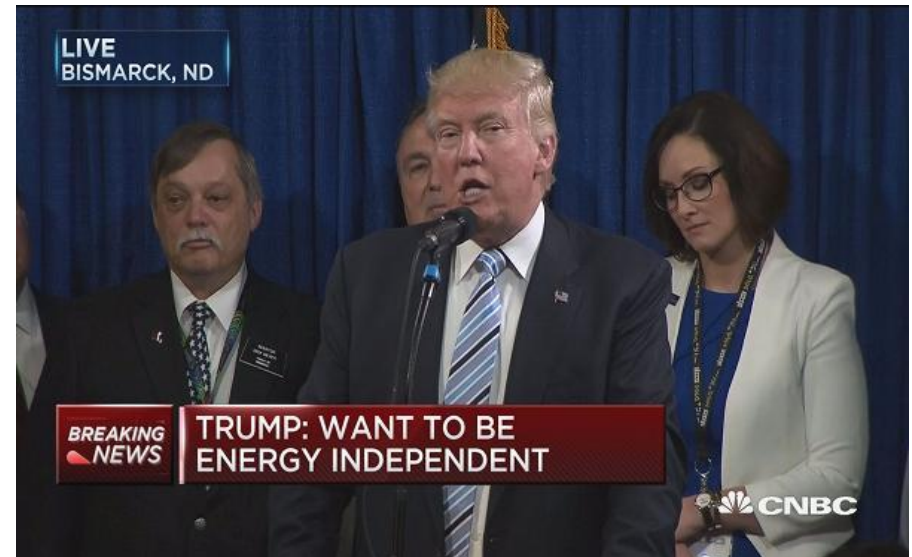
U.S. Secretary of State Hillary Clinton shakes hands with Czech Prime Minister Petr Necas in Prague

www.reuters.com/article/us-czech-energy-clinton-idUSBRE8B20G320121203

Bismarck, ND – 26 May 2016

Energy plan for independence needs to include nuclear power

[American competitiveness and Sovereignty]



Donald Trump makes “America First” energy speech

www.donaldjtrump.com/press-releases/an-america-first-energy-plan

White House & Congress United on Nuclear

The White House
Office of the Press Secretary

For Immediate Release



Nov. 2015

November 06, 2015

FACT SHEET: Obama “GAIN” Administration Announces Actions to Ensure that Nuclear Energy Remains a Vibrant Component of the United States’ Clean Energy Strategy [In advance of COP 21]

As detailed in the Climate Action Plan, President Obama is committed to using every appropriate tool to combat climate change. Nuclear power, which in 2014 generated about 60 percent of carbon-free electricity in the United States, continues to play a major role in efforts to reduce carbon emissions from the power sector. As America leads the global transition to a low-carbon economy, the continued development of new and advanced nuclear technologies along with support for currently operating nuclear power plants is an important component of our clean energy strategy. Investing in the safe and secure development of nuclear power also helps advance other vital policy objectives in the national interest, such as maintaining economic competitiveness and job creation, as well as enhancing nuclear nonproliferation efforts, nuclear safety and security, and energy security.

Senate Vote 87-4 (Feb. 2016)

Senate Joins House in Supporting Innovation in Advanced Reactors

- Bill encourages public-private partnerships on advanced nuclear R&D
- Opens national laboratory sites to private nuclear projects
- Legislation added as amendment to comprehensive energy bill

Feb. 4, 2016—The U.S. Senate’s significant support for nuclear energy was evident last week, with the near-unanimous passage of legislation that encourages public-private collaboration on advanced nuclear research projects at national laboratory sites.

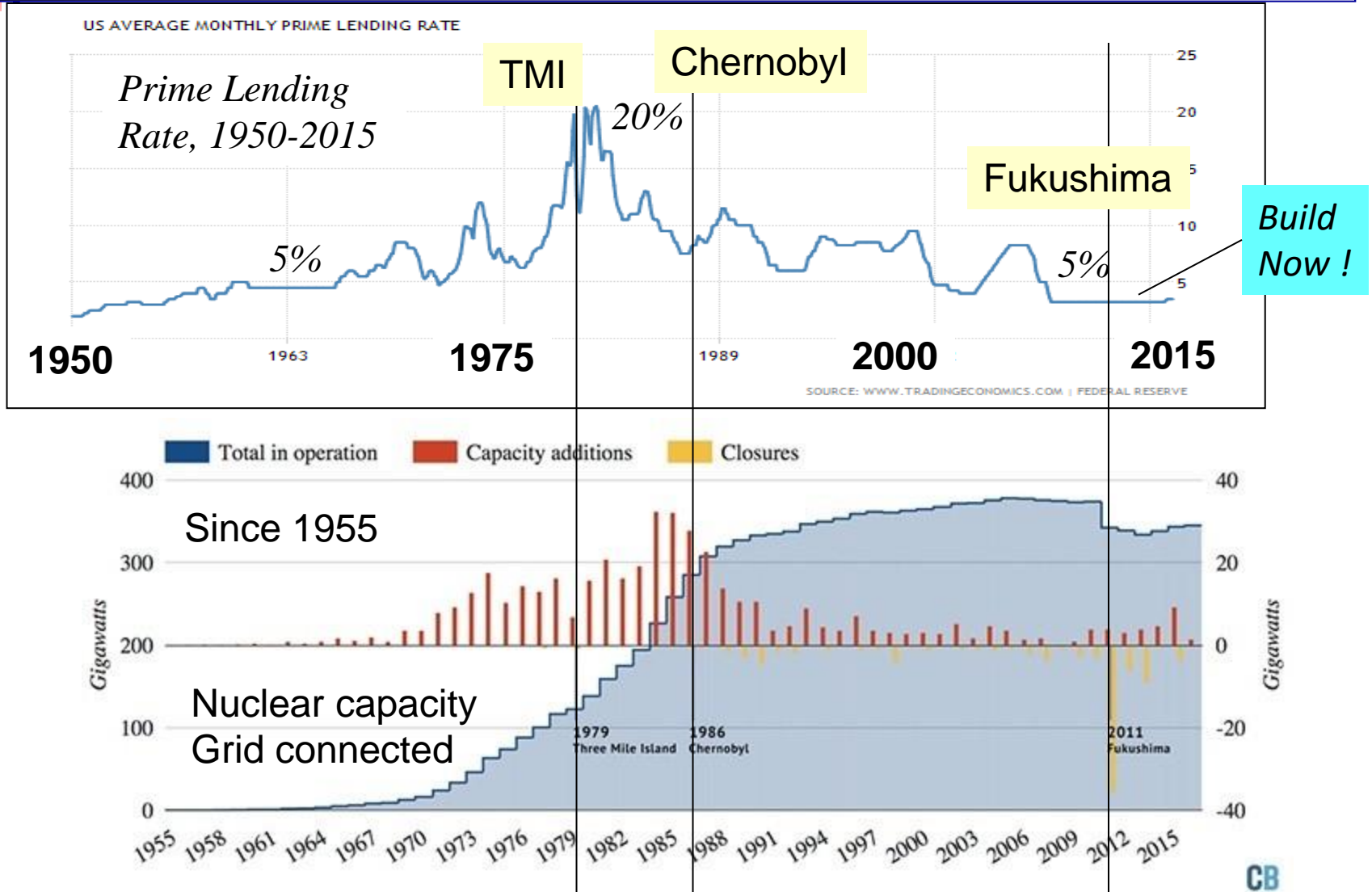
The Nuclear Energy Innovation Capabilities Act ([S 2461](#)), approved 87-4, is now an amendment to the larger Energy Policy Modernization Act of 2016 ([S 2012](#)), which is expected to be voted on by the Senate next week.

S 2461 directs the U.S. Department of Energy to prioritize partnering with private innovators on developing and prototyping new reactor technologies and to use DOE sites such as Idaho National Laboratory (INL) to build, test and demonstrate privately funded prototype reactors.

The bill requires the U.S. Nuclear Regulatory Commission to report to Congress any foreseeable problems in licensing reactors within four years of receiving an application, whether introduced through a DOE partnership or privately developed. DOE also is required to develop a 10-year plan for prioritizing nuclear research and development programs that support new reactor technology.

[Amendment to Energy Modernization bill]

Interest Rates and Nuclear Construction



Risk-based Financing, not just subsidies -- **Budget scoring only entails \$120M to \$500M**

New DOE Loan Solicitation for Nuclear: \$12Billion

Borrower Pays the “Credit Subsidy Cost” of the loan [Probability of default]

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[Home](#) » [Department of Energy Issues Draft Loan Guarantee Solicitation for Advanced Nuclear Energy Projects](#)

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

Sept. 2014

September 30, 2014 - 8:30am

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NEWS MEDIA CONTACT

- 202-586-4940

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

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.

RELATED ARTICLES



Fostering the Next Generation of Nuclear Energy Technology

Department of Energy Issues Draft Renewable Energy and Efficient Energy Projects Solicitation to Foster Clean Energy Innovation

COP21 and Mission Innovation includes Nuclear

FORBES: Paris COP21 And The Urgent Need For More Nuclear Energy

James Conca, Dec. 15, 2015



“Drs. Hansen, Wigley, Caldeira and Emanuel declared that the anti-nuclear position of environmental leaders is causing unnecessary and severe harm to the environment and to our planet’s future. To ignore the leading climate scientists at the leading climate conference is foolish. And stupid. And risky.”

www.forbes.com/sites/jamesconca/2015/12/15/paris-cop21-and-the-urgent-need-for-more-nuclear-energy/#4aa561194952



Political Strategy / Tactical Options

- **Energy Modernization Bill... 2017?**
 - Upgrade NRC Licensing; Financing, preference for Nuclear
- **Tax Reform in 2017 with Energy provisions (?)**
 - RE got tax credits in 2015 Budget Bill --- What for Nuclear?
- **Energy Appropriations in Omnibus**
 - Expand DOE Loan Program for Clean Energy, GenIV Nuclear
 - Renewal of EX-IM Bank (done)
- **Monitor State Clean Power Plans (+Court Cases)**
 - Lack of Nat'l Consensus = States are more Important
- **EPA CPP at SCOTUS: A redo to favor Nuclear?**
- **FERC Dispatch Preference for Clean Sources (?)**

Nuclear Power Enables Urban Living... Globally



Nasa. 2000



SUMMARY: Nuclear Power Enables Urban Living

- **Urban development is the major trend driving demand for clean, reliable energy for cities. Top 600 cities comprise 60% of World GDP**
- **Most urban growth lies outside OECD economies, in Asia, MidEast**
- **“Policy Parity” did not work well for Renewables; Most Mfg now overseas**
- **Wind and Solar require large empty tracts of land; Not for dense cities**
- **“Nuclear is different”; US P5 Status rides on Nuclear, not others**
- **Cost is a major factor for Nuclear, but not ONLY factor**
- **Strategic National interests, financing drive new construction + GenIV**
- **“Policy Preference” is deserved for security benefits, emissions avoided**
- **Emissions savings are a bigger factor in Europe than USA or elsewhere**
- **To be competitive, USA must accelerate deployment of GenIV Reactors**



C) Nuclear: Sovereign Marketing & Finance

C) How are Nuclear Projects being financed ?

Why are Sovereigns so heavily involved ?
-- as Customers *and* Suppliers

D) Which Key Supply and Demand factors are driving these transactions?

US Nuclear Plant Owners; Top Ten = 72% of fleet

Ten Utilities account for >70% of US operating reactors. Several foreign entities are larger.

<u>OWNER / UTILITY</u>	<u>MWe</u>	<u>% Total</u>	<u>STATES most active in</u>
Exelon Corp	20,791	21.0%	IL, NY, PA, NJ, MD, TX
Entergy Corp	9,405	9.5%	AR, MS, LA, TX
Duke Energy Corp	8,712	8.8%	OH, IN, NC, SC, FL
Tennessee Valley Authority	7,861	7.9%	TN, MS, AL
NextEra Energy Inc (FPL)	6,031	6.1%	FL
Dominion Resources Inc	5,369	5.4%	VA
FirstEnergy Corp	3,940	4.0%	OH, PA, WV
Southern Co	3,667	3.7%	GA, MS, AL
Public Service Enterprise Group	3,635	3.7%	PA, NJ
AEP	2,069	2.1%	OH
TOP TEN	71,480	72.1%	Majority East of Miss River
Others (single plants)	27,657	27.9%	
Total MWe	99,137	100.0%	

Source: www.NEI.org

GLOBAL: Major Nuclear Owners, Sovereigns

	2015	
MAJOR NUCLEAR OWNERS, 2015	MWe	%World
P5 EDF (France)	63,000	16.3%
Japan (8 regional owners)	40,300	10.4%
P5 China (CNNC, CGN)	29,000	7.5%
P5 Rosatom (Russia)	25,242	6.5%
KEPCO (Korea)	23,000	6.0%
Canada (OPG; Bruce Power)	13,524	3.5%
National Nuclear Energoatom (UKR)	13,100	3.4%
Germany (RWE, E.ON) -- closing	10,800	2.8%
Sweden (Vattenfall)	9,650	2.5%
P5 UK (EDF Energy/France)	8,900	2.3%
Spain - ANAV (Endesa+Iberdrola)	7,120	1.8%
NPCIL (India)	5,300	1.4%
Subtotal -- Foreign "Majors"	248,936	64.5%
P5 USA (25 to 30 owners)	99,137	25.7%
Others	37,927	9.8%
World Capacity (MWe)	386,000	100.0%

UNSC "P5" Countries account for nearly 60% of all operating MWs.

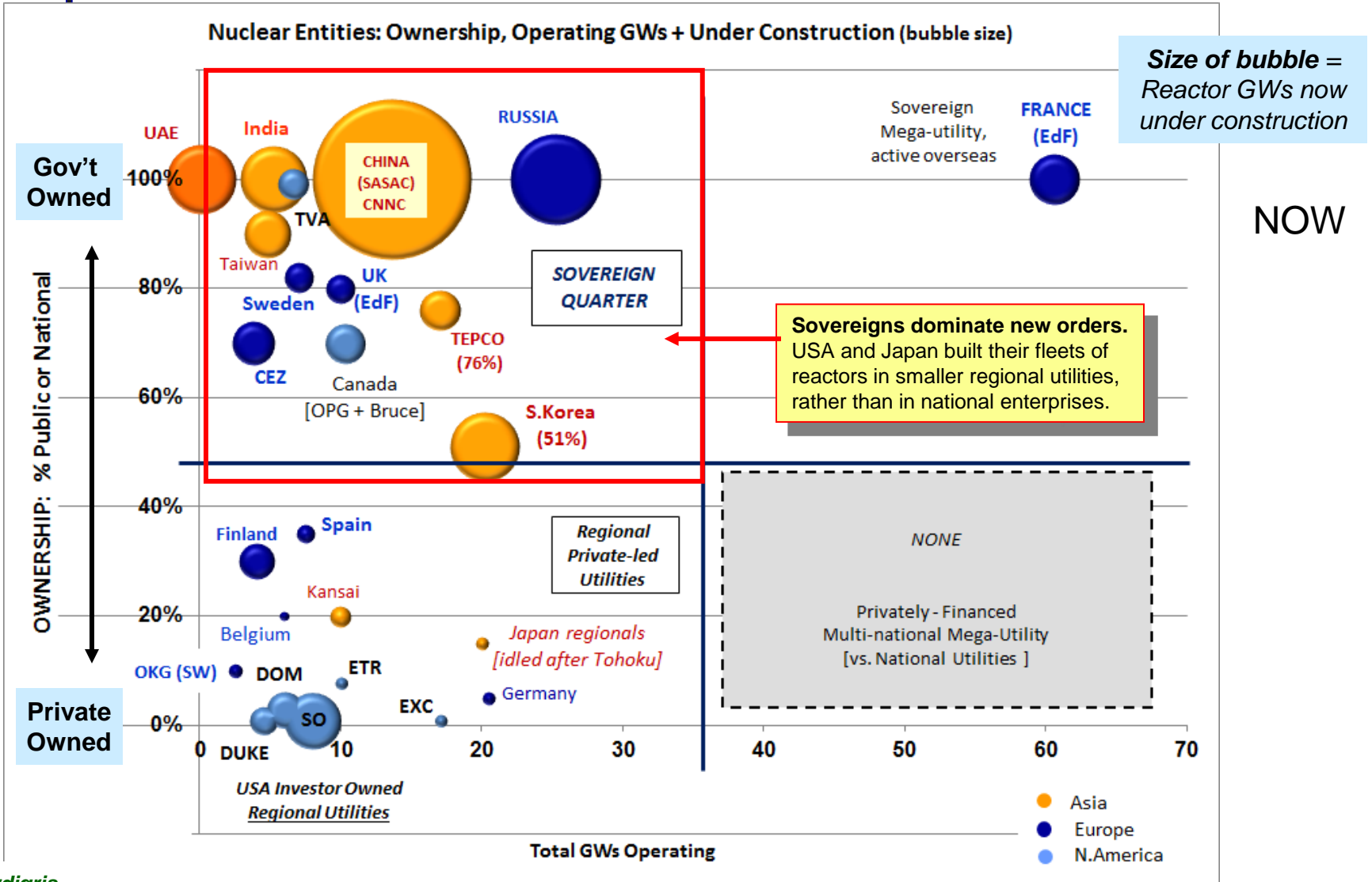
"Sovereign Energy Co's" (state-owned entities) own and operate almost 50% of all reactors, but nearly 80% of new construction.

Several are Hybrid Co's (partial State / Muni / Co-op ownership).

USA and Japan use a private investor-owned utility model.

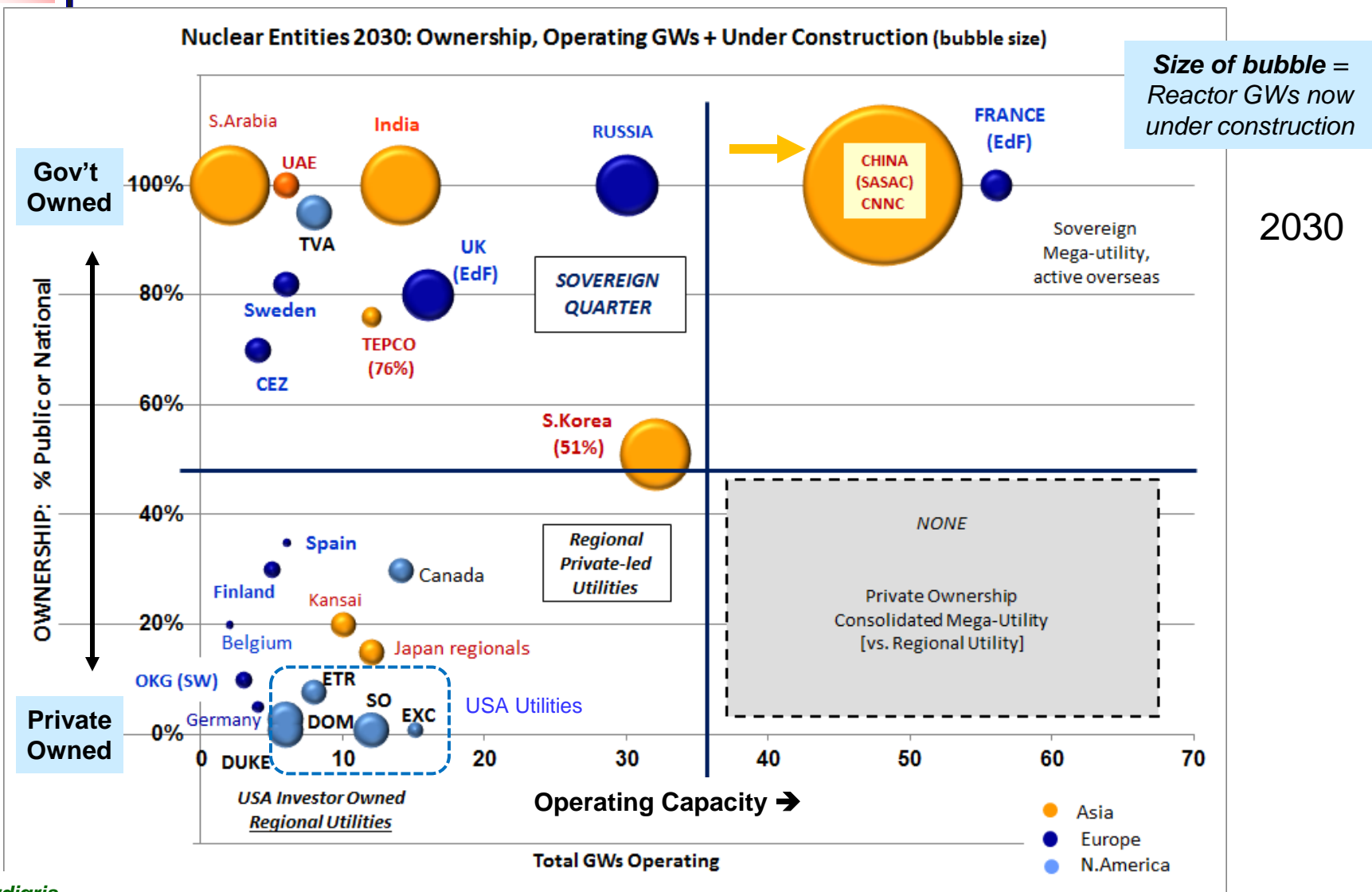
New construction of reactors is a Sovereign decision, more than mere economics.

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



Asia, MidEast continue to dominate new construction: N.Am, EU lag

Sovereign Nuclear Energy Landscape 2030



Britain: Nuclear restart...under France with China

Declining North Sea production, climate goals, energy security, and “P5” status drive UK reactor restart (10-16GW).

Politics & Policy

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Last updated: October 17, 2013 9:36 am

Osborne hails UK nuclear deal with China as ‘new dawn’

October 2013

By Elizabeth Rigby



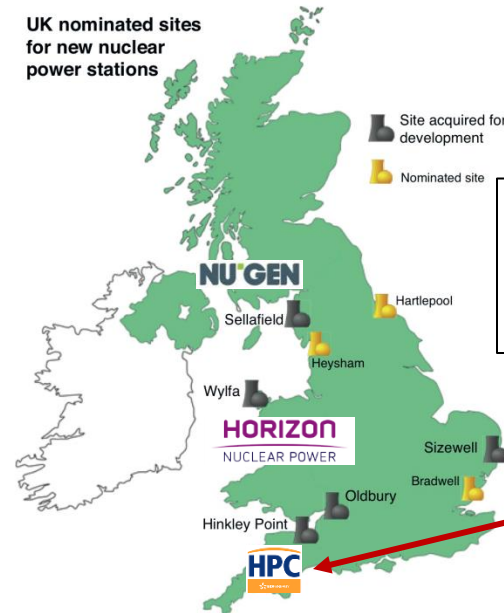
George Osborne visits the nuclear power plant being built at Taishan in southern China's Pearl River delta

George Osborne on Thursday hailed a new dawn for Britain's civil nuclear programme as he announced a deal between Chinese investors and EDF Energy to build the first nuclear power station in the UK in a generation.

The Chinese General Nuclear Power Group and the French energy company are expected to sign a letter of intent as the two sides finally agree a deal for a planned new plant at Hinkley Point in Somerset.

The main commercial details of the agreement will be announced on Monday by Ed Davey, energy secretary.

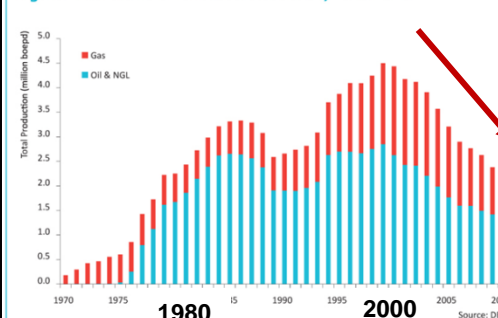
UK nominated sites for new nuclear power stations



Does UK have room for Advanced Reactors in next wave (16 GWe) ?

Will EPR cost overruns trigger shift at HP-C ?

Figure 14: the UK's Oil and Gas Production, 1970-2010



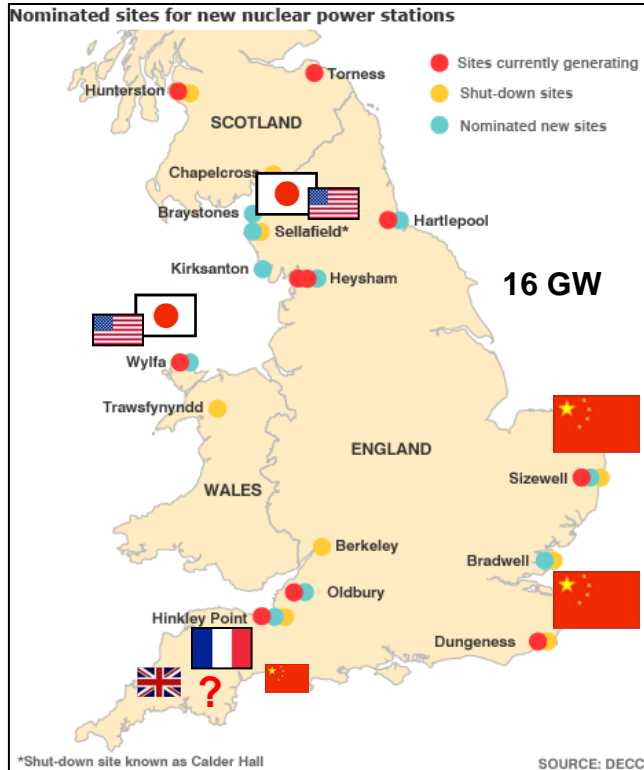
Declining North Sea oil and gas production since 2000

Britain: Near-term export market – who wins?

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

BBC

UK: Go-ahead for 10 nuclear stations



world nuclear news

Energy & Environment New Nuclear Regulation & Safety Nuclear Policies Corporate Uranium

China starts building first Hualong One unit

May 2015

Construction has officially started on unit 5 of the Fuqing nuclear power plant in China's Fujian province, China National Nuclear Corporation (CNNC) announced today. The unit will be a demonstration Hualong One reactor, a design the company aims to export.

Related Stories

- Construction cleared for China's first Hualong One units
- Hualong One selected for Argentina
- Hualong One deployment at Fuqing 5

WNA Links

- Fuqing 5

Related Links

- China General Nuclear Power Group (CGNPC)
- China National Nuclear Company



Construction gets under way at Fuqing 5 (Image: CNNC)

MEANWHILE... back on the Global Gameboard

Russia – India Mega-deal on Reactors, 2014

Russia - India: Putin agrees to build 10 nuclear reactors



Russia will help India build at least 10 more nuclear reactors, Indian Prime Minister Narendra Modi has said following a visit by Russian President Vladimir Putin.

<http://www.bbc.com/news/world-asia-india-30408274#>

US\$100 billion New Development Bank (NDB)

Putin markets Rosatom in Turkey, 2014

Dec. 2014



Russia-China deal on Small Floating Reactors

Floating Nuclear Power Plants Might Be the Future of Energy

By Kayla Ruble; August 1, 2014

Following a \$400 billion gas supply DEAL signed by the countries in May, the export sector of Russia's state nuclear reactor company Rosatom penned a memorandum of understanding with China on Tuesday to develop waterborne nuclear power plants (NPPs) starting in 2019.

Rosatom previously announced that in 2018 it would implement the first floating NPP in the world, just offshore in the country's eastern region of Chukotka.
<https://news.vice.com/article/floating-nuclear-power-plants-might-be-the-future-of-energy>

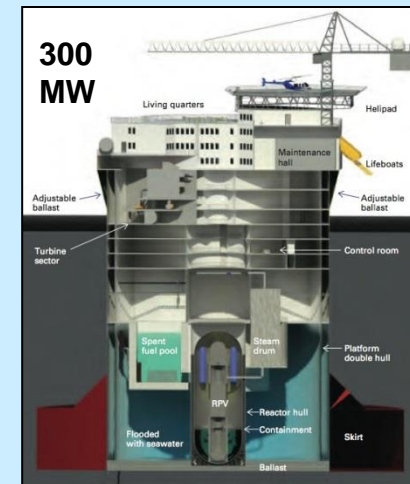


Russian floating nuclear powerplant "Academic Lomonosov" under construction (RIA Novosti / Alexei Danichev); 2 x 35MWe

MIT Thinking Outside of the Box with Floating Nuclear Plant

MIT researchers are now working on a nuclear power plant design that for off-shore floating nuclear power plants, which would be built in shipyards and moored out to sea, about eight to ten miles off shore. This would keep them in territorial waters, but allow them to be placed in water deep enough so that tsunami events would never hit them. Tsunami events, a potential disaster for coastal nuclear power plants, do not take place in deep water, said MIT in a recent release. They only build up to dangerous levels in shallow water environments.

A floating nuclear reactor, built on an oil-rig type of platform, would have the reactor components underwater for balance and to keep potential overheating events from ever occurring, given the seawater could passively cool the reactor. In general, during normal operations, cool water from lower ocean layers would be pumped up to cool the reactor and the warmer water would be released near the surface, where the water is already warmer – making for a zero-impact reactor regarding its affect on the thermal conditions of the ocean. *Nuclear Street News*, June 25, 2015



"PICKING WINNERS": Russia and China understand the STRATEGIC value of nuclear...

Rosatom: "A market leader in Asia, outside China"

Rosatom has the second largest and the most geographically diversified NPP new build portfolio in Asia

P5
Vendors

P5

P5

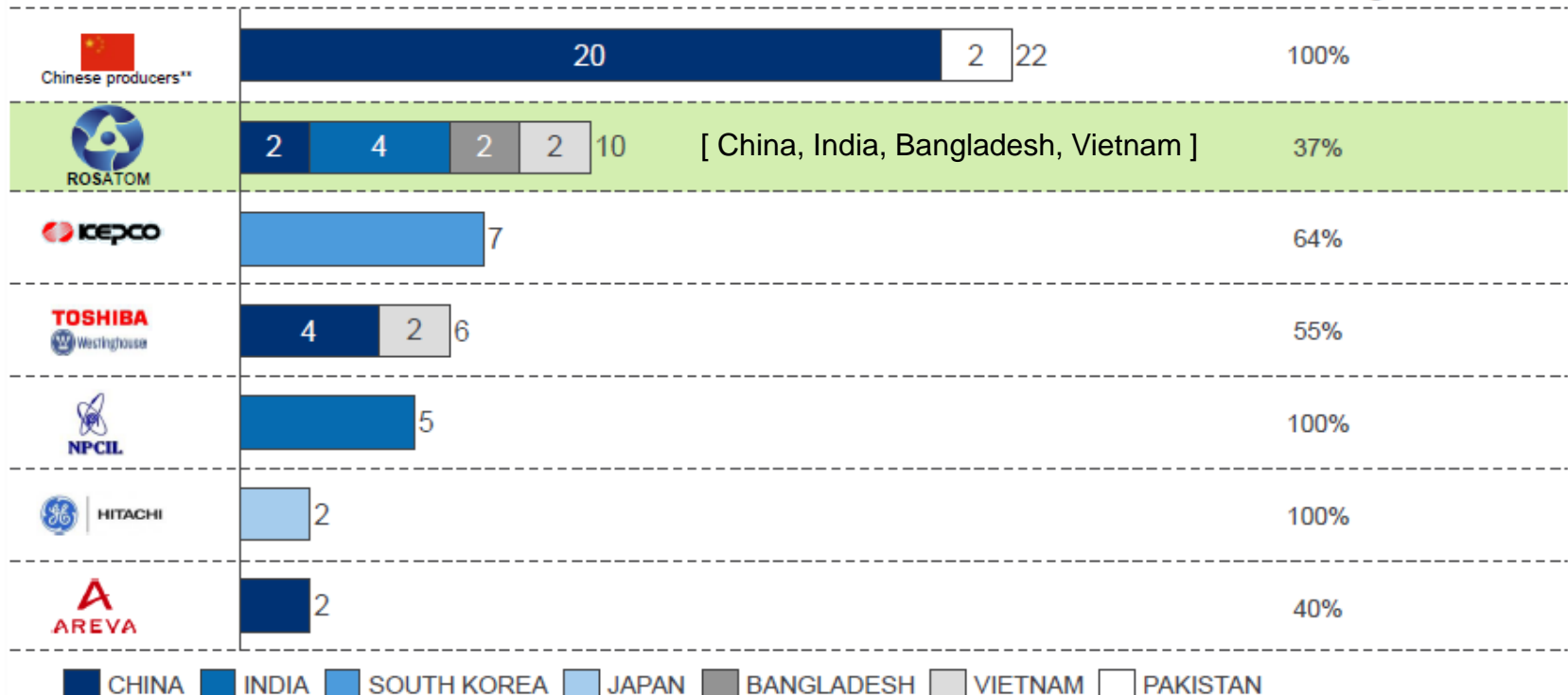
P5

P5

P5

Amount of confirmed projects* in Asia, reactors

Share of Asian NPP projects
in backlog



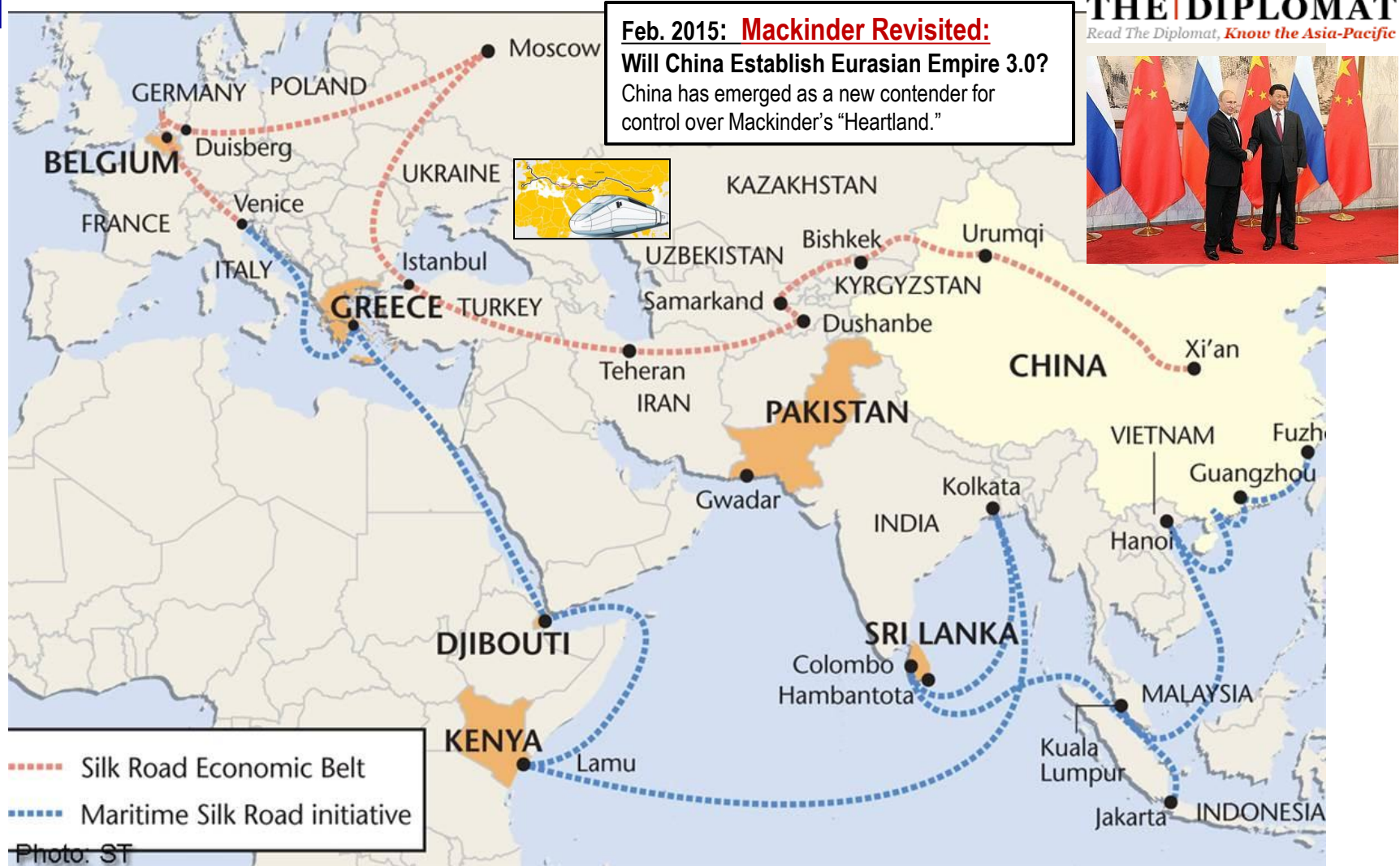
* - Projects under construction or with signed agreements

** - CGNPC, CNNC, SNPTC

ROSATOM: Igor Karavaev, Chief Strategy and Investments Officer

Backed by SCO and BRICS Bank; Russia to provide Security role

China's New Silk Road "Economic Belt"; 2 Routes

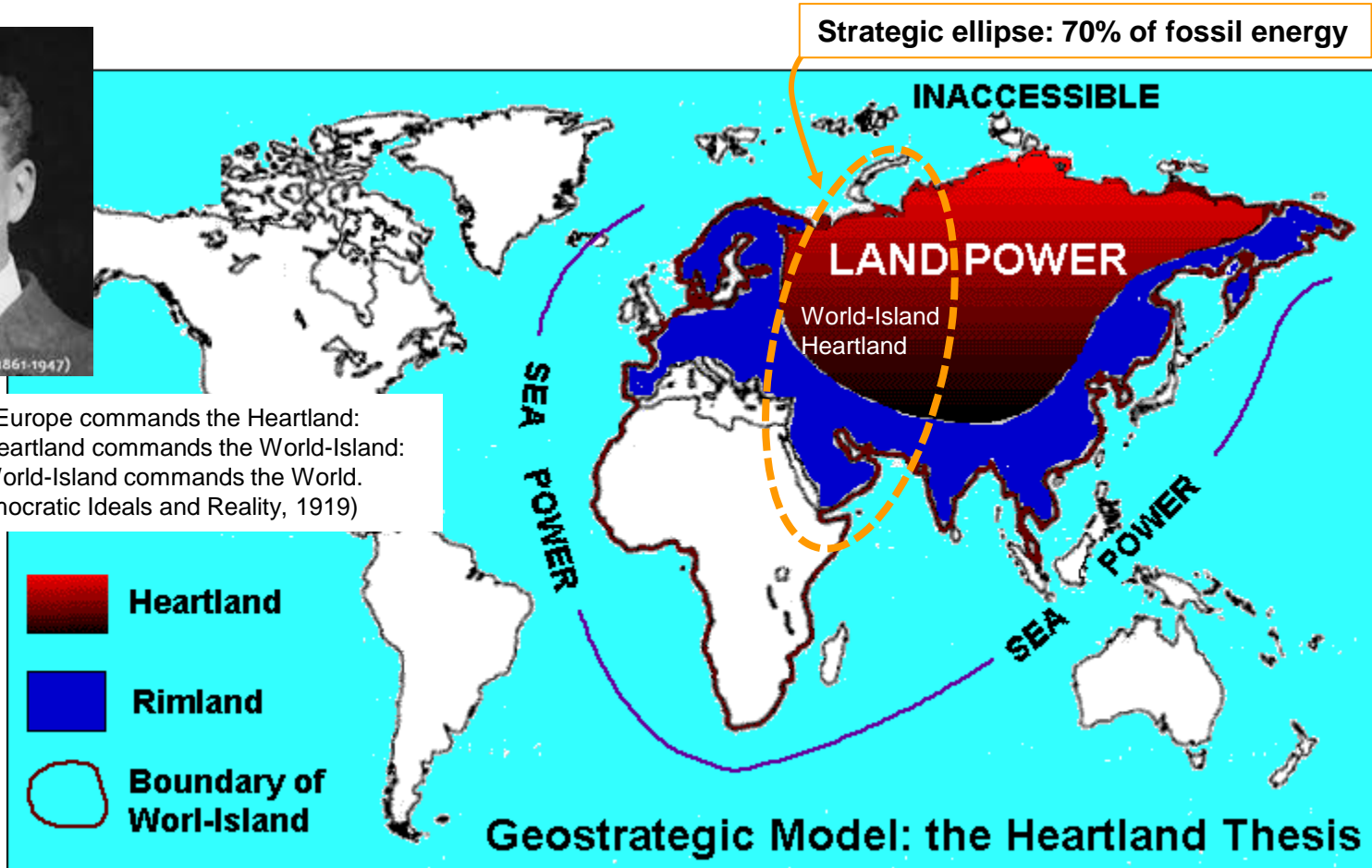


<http://thediplomat.com/2015/06/eurasian-silk-road-union-towards-a-russia-china-consensus/>

Mackinder (1904, LSE): Land Power > Sea Power



Who rules East Europe commands the Heartland:
Who rules the Heartland commands the World-Island:
Who rules the World-Island commands the World.
Mackinder: (Democratic Ideals and Reality, 1919)

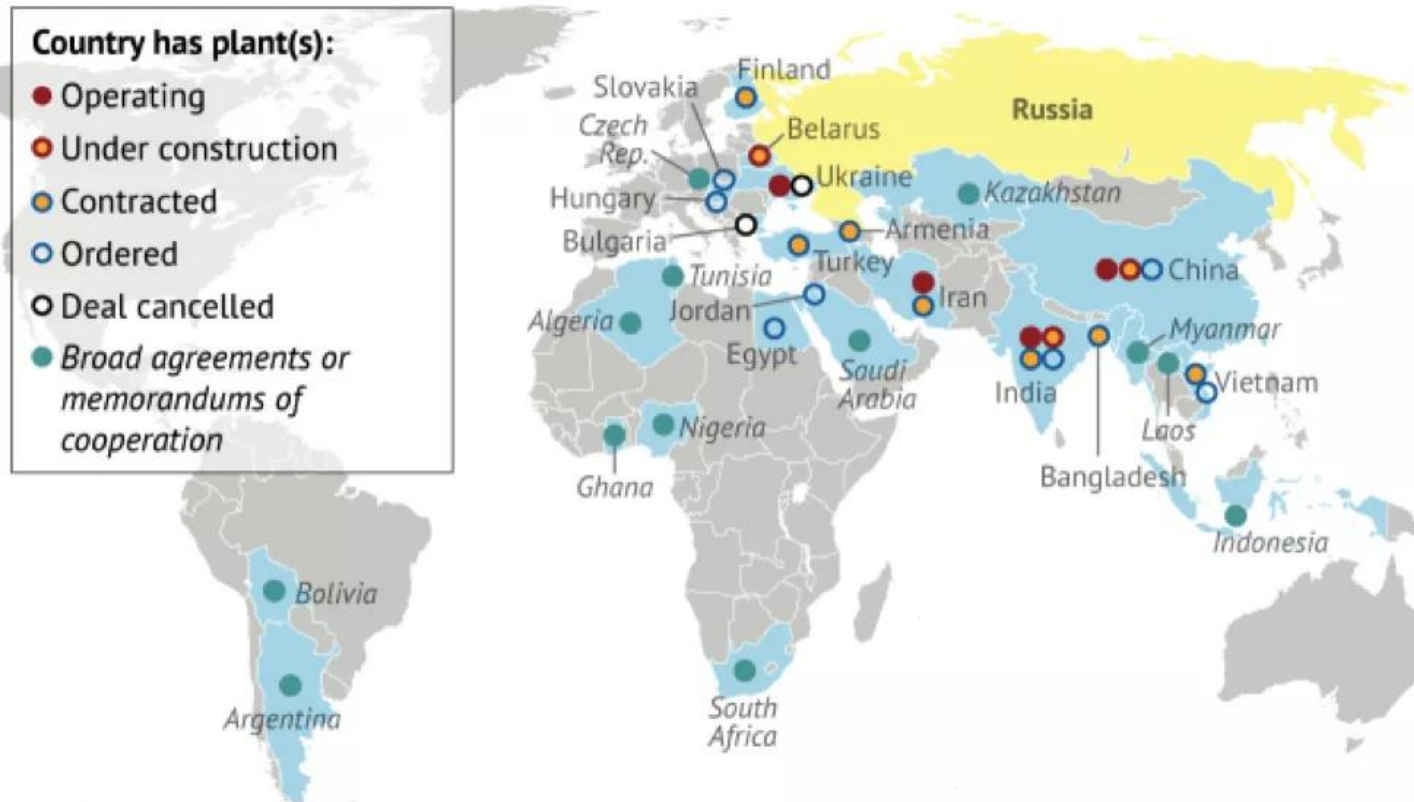


In 1904 Mackinder gave a paper on *"The Geographical Pivot of History"* at the Royal Geographical Society, in which he formulated the Heartland Theory. This is often considered as a, if not the, founding moment of geopolitics as a field of study. In 1895, he was one of the founders of the London School of Economics.

Russia's Strategy: Imperial reach with Nuclear

“Russia is creating a global nuclear power empire”

RUSSIAN NUCLEAR POWER PLANT EXPORTS



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AIIB: \$100B+ for Euro-Asian Growth



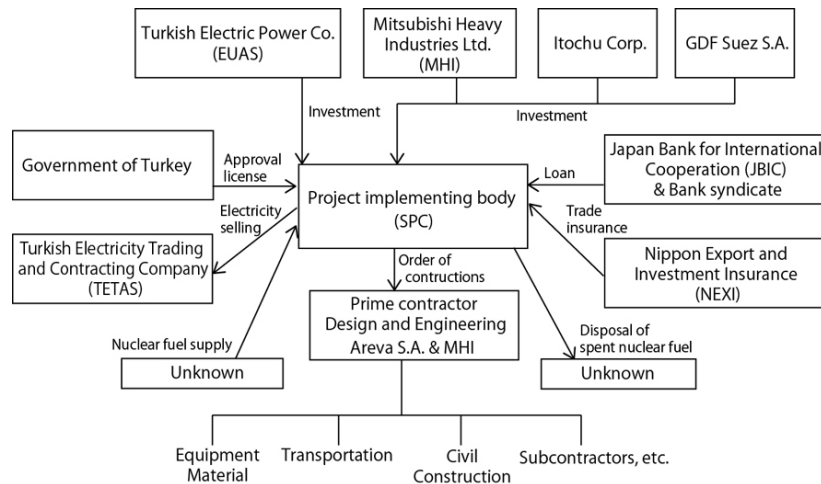
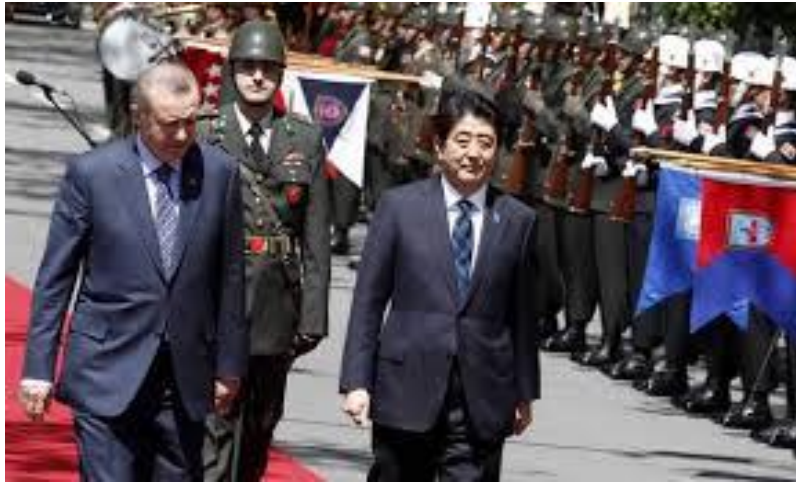
Asian Infrastructure Investment Bank (AIIB)

Founding members
57

USA not a member



Japan sells in Turkey (Sinop site; MHI-Itochu), 2013

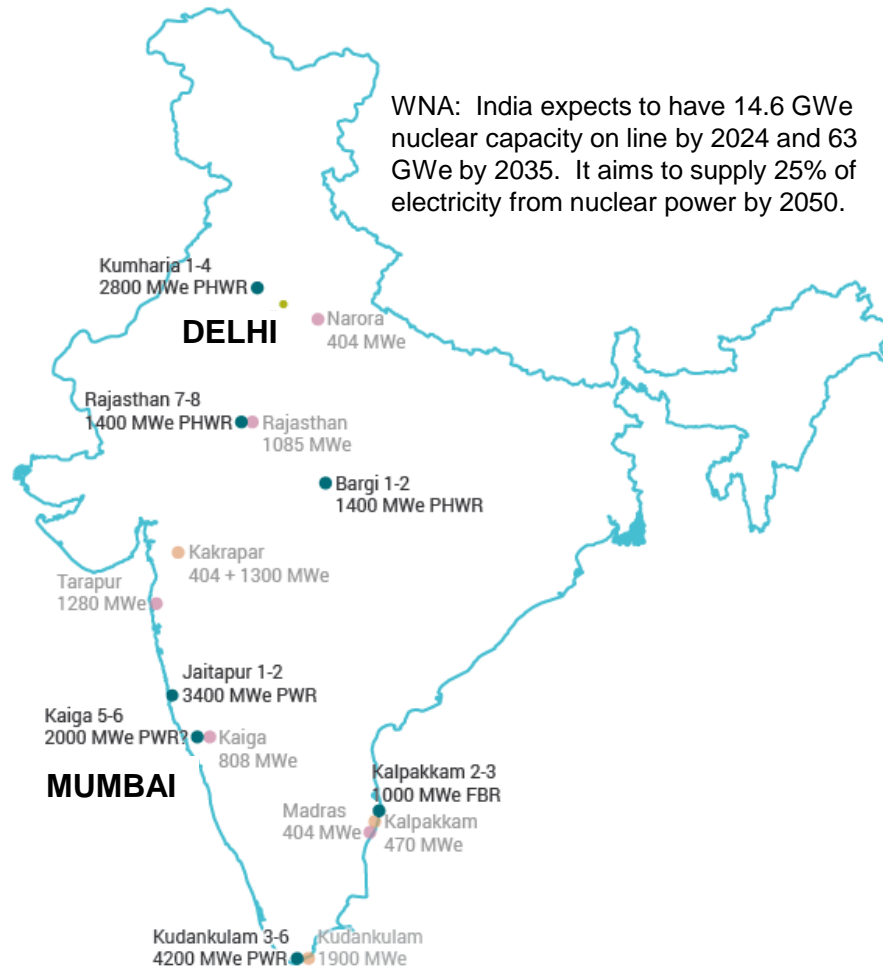


Sinop (Black Sea), \$22B for 4.4 GW

India plans 60+ GW by 2035; USA winning 6 now.

Planned Nuclear Power Plants in India

Amishi
Kumar,
USEA



Source: World Nuclear Association

NBC HOME U.S. ▼ NEWS MARKETS INVESTING TECH MAKE IT VIDEO

Obama, Modi welcome preparatory work for India reactor project

Tuesday, 7 Jun 2016 | 8:48 PM ET

JUNE 2016

REUTERS

Westinghouse, 6 x AP1000s

Dennis Brack-Pool | Getty Images

President Barack Obama meets with Prime Minister Narendra Modi of India in the Oval Office at the White House on June 7, 2016 in Washington, DC.

U.S. President **Barack Obama** and Indian Prime Minister **Narendra Modi** on Tuesday welcomed the start of preparatory work for six nuclear reactors in India, a key step in closing the first deal stemming from a US-India civil nuclear accord struck more than a decade ago.

Not just a Company, a Nation-State stands behind the performance of the project

South Korea Signs for Barakah in UAE, May 2014



ROK President Park Geun-Hye

<http://www.korea.net/NewsFocus/Policies/view?articleId=119513>



متصور بن زايد ورئيسة كوريا الجنوبية يشهدان وصول حاوية المفاعل لأول محطات الطاقة النووية السلمية
مؤسسة الإمارات للطاقة النووية ووزارة التجارة والصناعة والطاقة في كوريا الجنوبية

<http://www.wam.ae/en/news/emirates/1395250425368.html>

National Nuclear Strategies: Summary Points

- **The drivers that led to US Leadership in nuclear energy have shifted dramatically. Cities: “urban energy reliability” 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.
 - Extended Fiscal crisis forces Governments to explore new means, JVs.
- **Market drivers alone cannot sustain nuclear energy. Policy drivers (e.g., national security, air pollution, urban resilience) loom large.**
The mythical “level playing field” does not recognize nuclear benefits.
- **Other Governments do not have a problem “picking winners and losers”. For many, 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 will wither. Global JVs and SMRs 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 30+ years.**

National Strategies shaped by Supply/Demand Factors

SUPPLY (20th Century)...



“Technology Push”

...DEMAND (21st Century)

“Market Pull”



Report: National Nuclear Energy Strategies


EBIonline
Environmental Business International

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

SHARE

News Release -- San Diego, Calif. -- Policy and Market Factors Shaping National Nuclear Strategies: Part II of “Redefining Leadership in Global Nuclear Energy Markets”.

 [Click here to view free report](#)

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 “P5”. 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.

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Principal,
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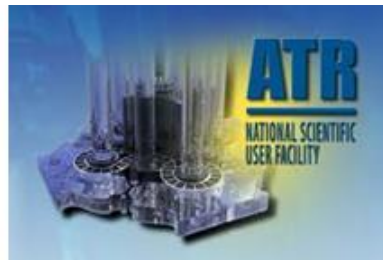
Historical Factors for Nuclear Leadership: SUPPLY

Factors for competitiveness and leadership in nuclear energy can be looked at from both the Supply side for reactors, and the Demand side in terms urban and population growth.

Early on, Supply-side Policy, Operational excellence drove nuclear energy:

SUPPLY SIDE FACTORS – “TECHNOLOGY PUSH”

-  S1 R&D Reactors, Univ. programs, Nat'l Labs; Tech innovation
-  S2 Military industrial base for nuclear navy
-  S3 High quality nuclear regulatory practices
-  S4 Nuclear fuel infrastructure and ore supply; spent fuel
-  S5 Nuclear engineering talent (university programs, firms)
-  S6 Access to low cost debt financing, capital (public or private)
-  S7 Current reactor operating base (privately operated in US)
-  S8 Engineering firms with recent construction experience



Future Factors for Nuclear Leadership: DEMAND

Factors for competitiveness and leadership in nuclear energy can be looked at from both the Supply side for reactors, and the Demand side in terms urban and population growth.

Market-driven, Demand-side factors are now fueling new construction:

DEMAND SIDE FACTORS – “MARKET PULL”



D1 Growing population overall (demographics)



D2 Current dense, urban electric loads (large cities)



D3 Advanced industrial and manufacturing base



D4 Rising per capita energy use (vs. OECD average)



D5 Higher natural gas prices (nuclear competitiveness) vs portfolio



D6 Significant air pollution (need for clean energy options)



D7 Future growth in urban load (urbanization rate)



D8 Policies and regulations favoring reduced emissions



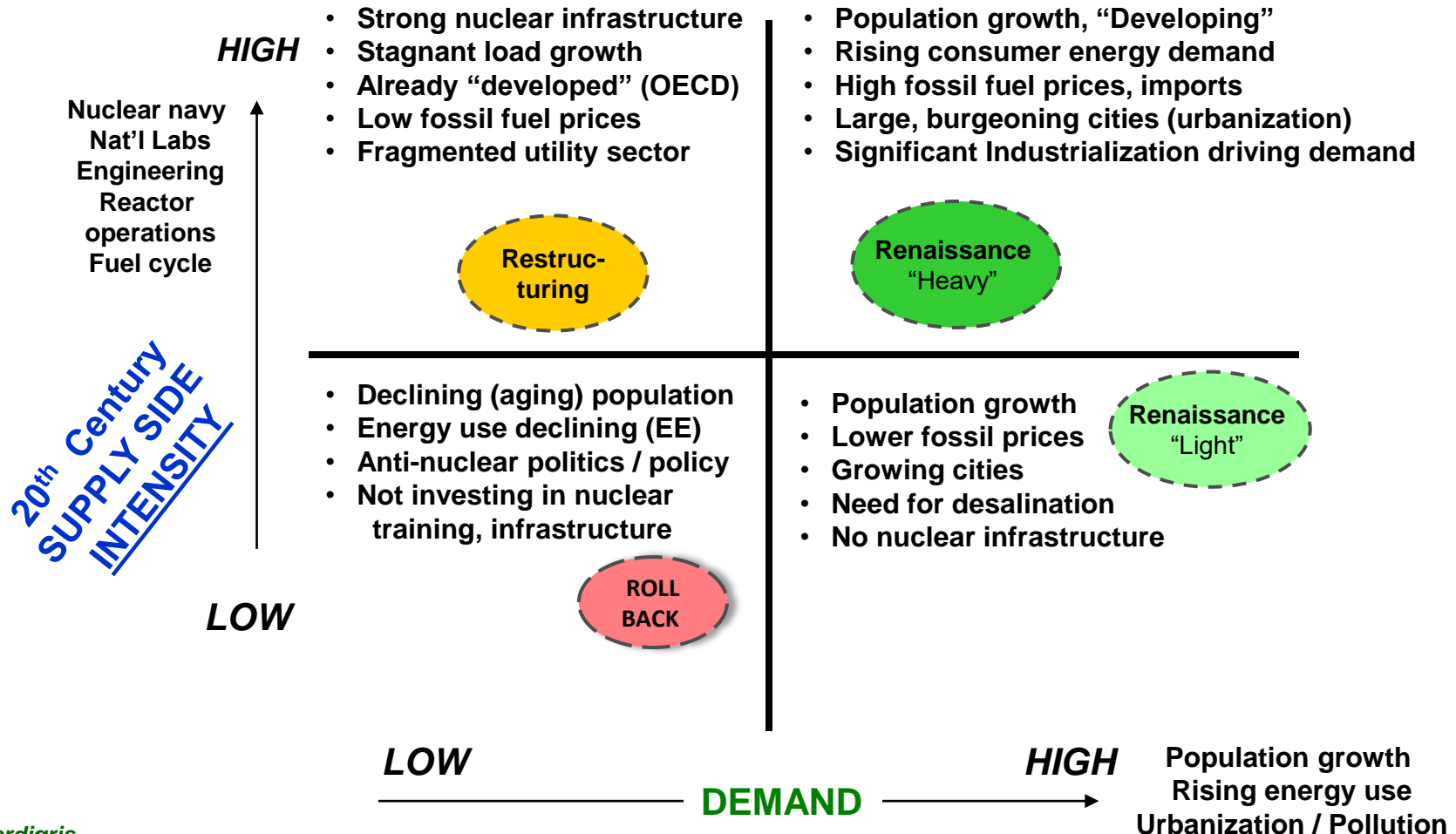


Insights from Supply vs. Demand Factors

- Demand side factors highlight benefits of nuclear power: reliable, no emissions, smaller footprint (land use constraints), economic gains
- Satisfying urban demand requires attention to public engagement (typically public is not just “for” or “against”; can be both; regional)
- Build reactors in regions where public favors benefits of nuclear, as is happening in US, UK, Canada, EU. Asian urban public wants reliability.
 - Expanding or new nuclear users are importing supply-side expertise.
- Supply-side “excellence” cannot easily be rebuilt; must be maintained.
UK let their capacity atrophy: A grand challenge for EU, USA to 2030.
 - BNFL was broken up (2006); EdF acquired British Energy (2008)
 - Toshiba now owns Westinghouse (2006); GE with Hitachi (2007)
- **SMRs with discipline of quality manufacturing could enable quality control in construction and operation to highest quality specs**
- **Adv. Reactors could become important where cooling water is limited**
- Other Governments do not have a problem “picking winners and losers”. For many, Nuclear is a winner: reliability, no emissions

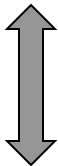
Supply / Demand Factors and National Strategies

21st Century, Post Cold War DEMAND-SIDE INTENSITY →

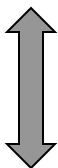




Nuclear Strategy: “Renaissance”, “Rollback”, “Restructuring”



“Renaissance”: Countries building reactors, relicensing the ones they operate, and are addressing spent fuel issues with storage or reprocessing or recycling are fully engaged in the “nuclear renaissance” after a global hiatus. Some are pursuing next generation “small modular reactors” (SMRs; under 300 MWs each in capacity). Their societies value the reliable, low emission electricity from reactors, particularly for large urban loads, and have active safety programs in place.

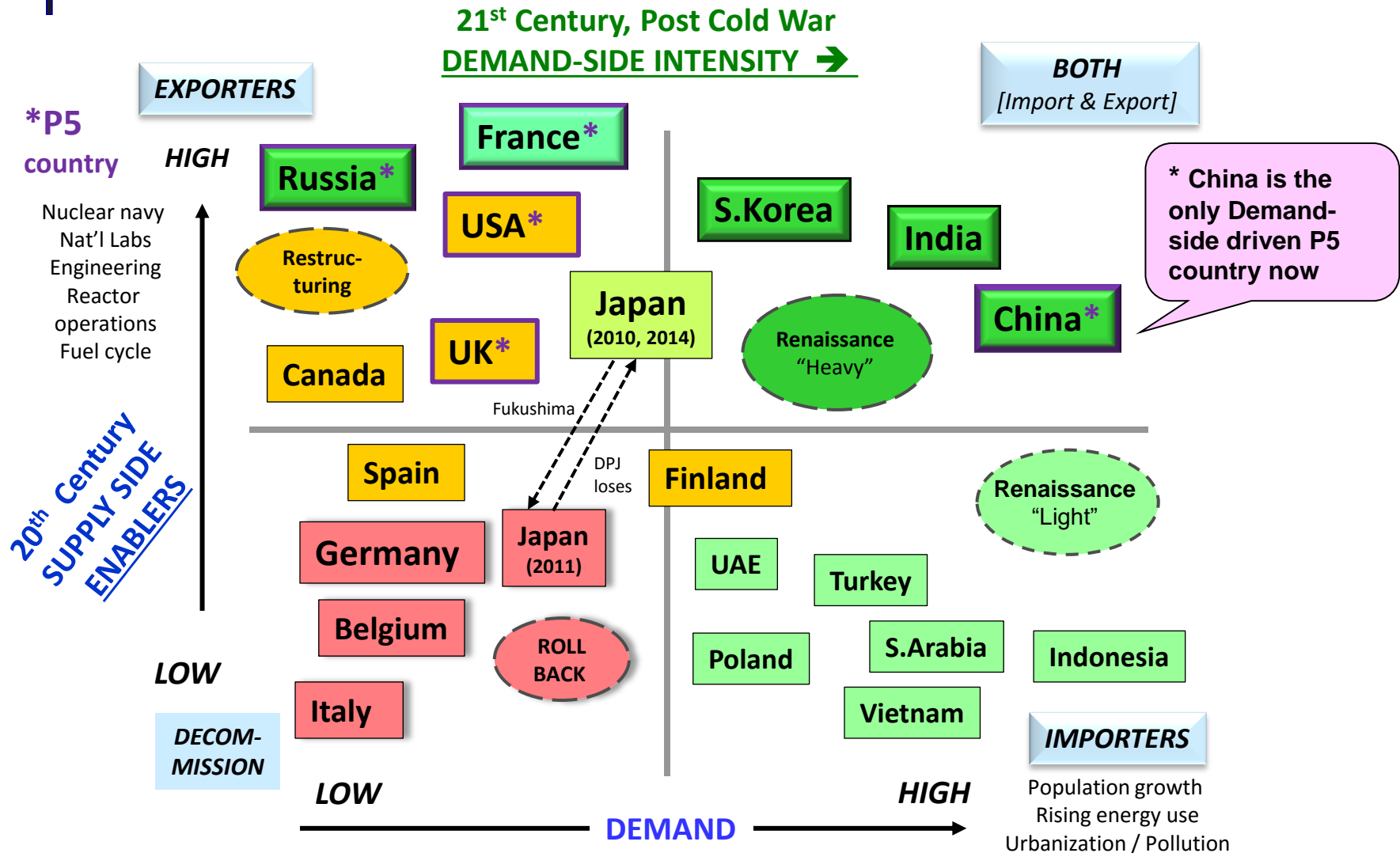


“Restructuring”: In some leading nuclear countries, including USA, some construction is underway, but not at a robust pace as seen in Asia. Liberal democracies (particularly those manifested as Entrepreneurial Market States) are more pluralistic, allowing more openings for interveners (e.g., anti-nuclear stakeholder groups). Spent fuel disposal is not resolved either. Financial incentives may be in flux, depending on political changes. Some merger or restructuring activity in the electric sector may be needed to bolster utility balance sheets.

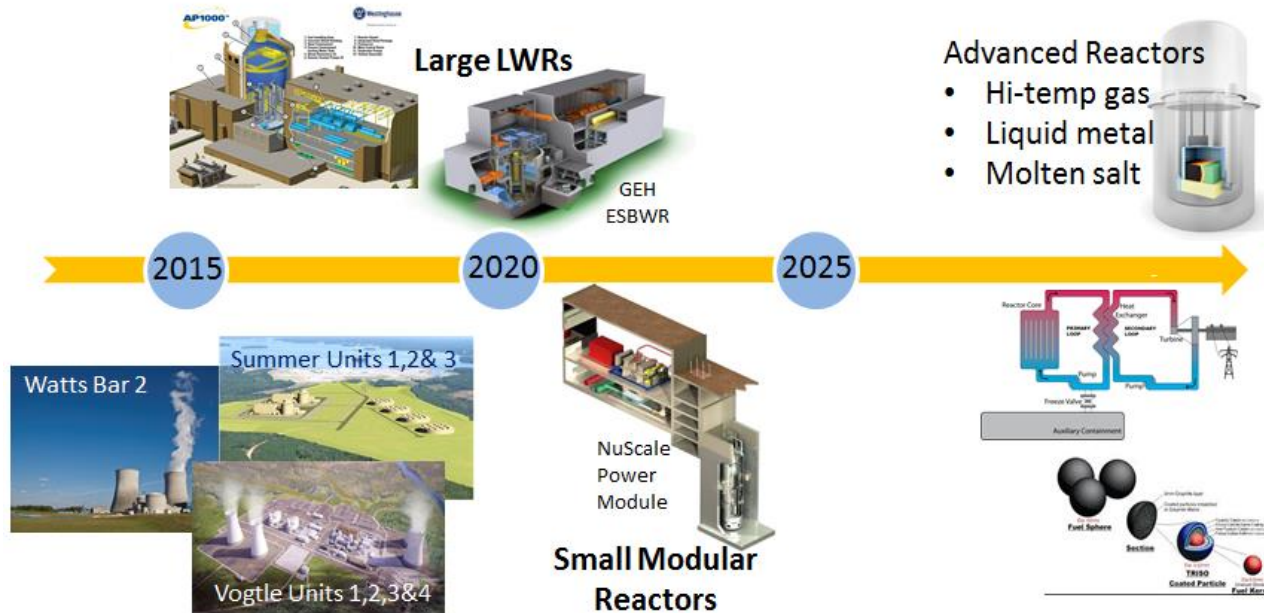
“Rollback”: Some EU countries currently operating reactors are not relicensing them, or some are shutting down reactors early. With 185 reactors (162 GWe), just five countries account for 75% of EU capacity (France, Russia, Ukraine, Germany, UK). Nor are they pursuing alternative reactor technologies, such as SMRs, and are not reprocessing spent nuclear fuel, except UK and France, both P5 countries.

Part II: “Redefining Leadership in Nuclear Energy Markets”

Supply vs Demand Factors and National Strategies



END -- DISCUSSION / QUESTIONS



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The Emerging Global Landscape driving Nuclear Power

www.climatechangebusiness.com/Policy_Market_Factors_Shaping_National_Nuclear_Strategies

IAEA Projection of Global Capacity (Sept 2012)

IAEA projection shows 25%-30% growth each decade in global total; little of it in N.America

TABLE 3. ESTIMATES OF TOTAL AND NUCLEAR ELECTRICAL GENERATING CAPACITY

Country Group	2011			2020 (a)			2030 (a)			
	Total Elect. GW(e)	Nuclear		Total Elect. GW(e)	Nuclear		Total Elect. GW(e)	Nuclear		
		GW(e)	%		GW(e)	%		GW(e)	%	
North America	1180	114.1	9.7	1278 1312	121 123	9.4 9.4	1351 1528	111 148	8.2 9.7	
Latin America	330	4.1	1.2	463 581	4.8 6.1	1.0 1.1	997 1389	7 14	0.7 1.0	
Western Europe	873	114.5	13.1	1025 1071	93 117	9.1 10.9	1152 1406	70 126	6.1 9.0	
Eastern Europe	460	48.5	10.5	631 631	65 76	10.3 12.1	690 872	80 107	11.5 12.3	
Africa	134	1.8	1.4	354 386	1.8 1.8	0.5 0.5	722 1001	5 13	0.7 1.3	
Middle East and South Asia	441	6.0	1.4	553 926	13 22	2.3 2.3	1454 1830	30 52	2.1 2.8	
South East Asia and the Pacific	190			304 322			491 542	0.0 6	0.0 1.1	
Far East	1604	79.8	5.0	2200 2364	123 162	5.6 6.9	2789 3321	153 274	5.5 8.2	
World Total	Low Estimate	5210	368.8	7.1	6808	421	6.2	9645	456	4.7
	High Estimate				7593	508	6.7	11889	740	6.2
N.America as % of total		30%			26%			22%		