Major Drivers and Key Risks for Nuclear Energy & Advanced Reactors in the Global Landscape

To VCU / ANS Richmond – October 26, 2017

"Nuclear Energy enables Urban Living - Globally"

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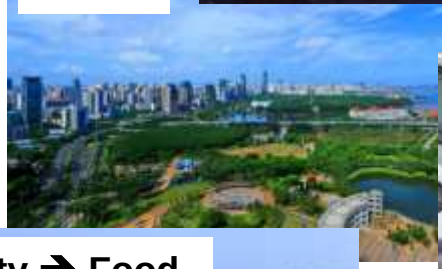
National Sovereignty

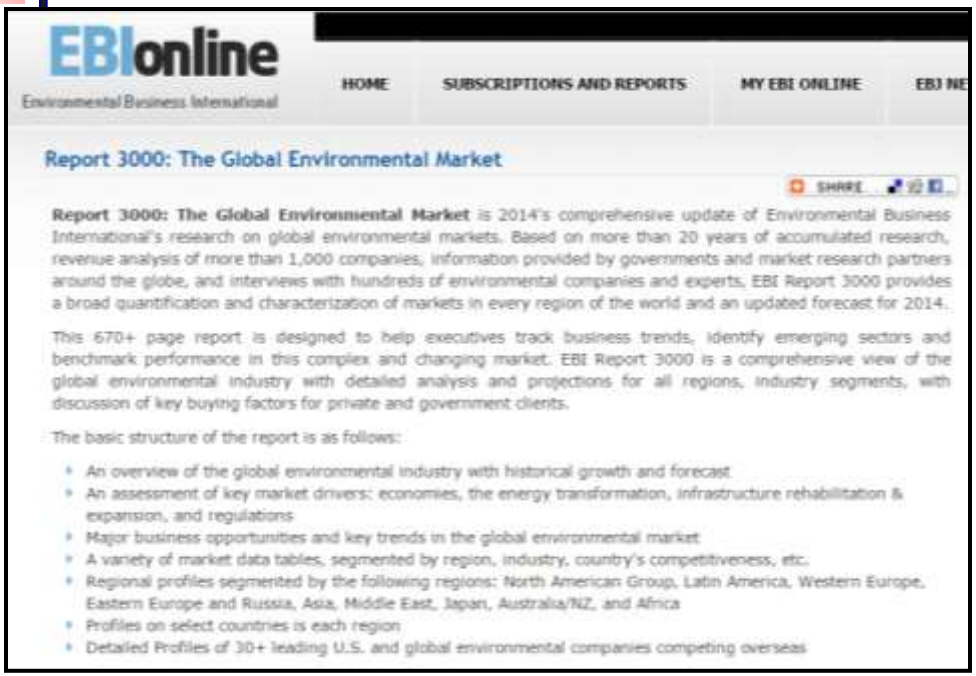
Clean cities



Transport autonomy

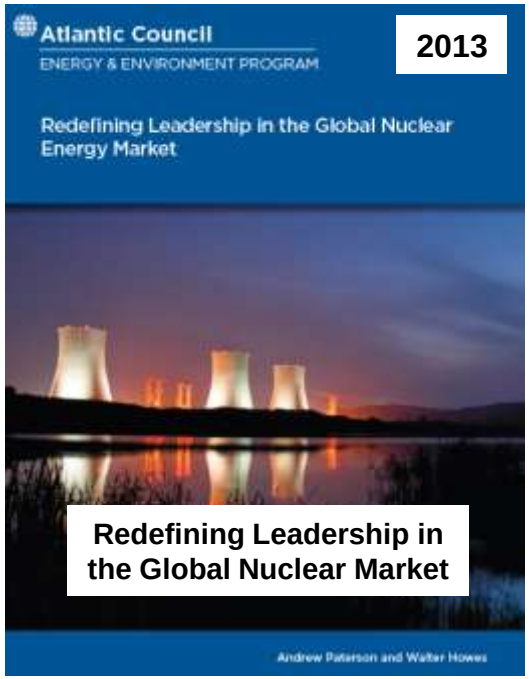
Water surety ➔ Food

EBI – *Verdigris Capital* Alliance on Strategic Intelligence & Finance



Presentation to U.S. Nuclear Infrastructure Council

United States NIC Nuclear Infrastructure Council



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

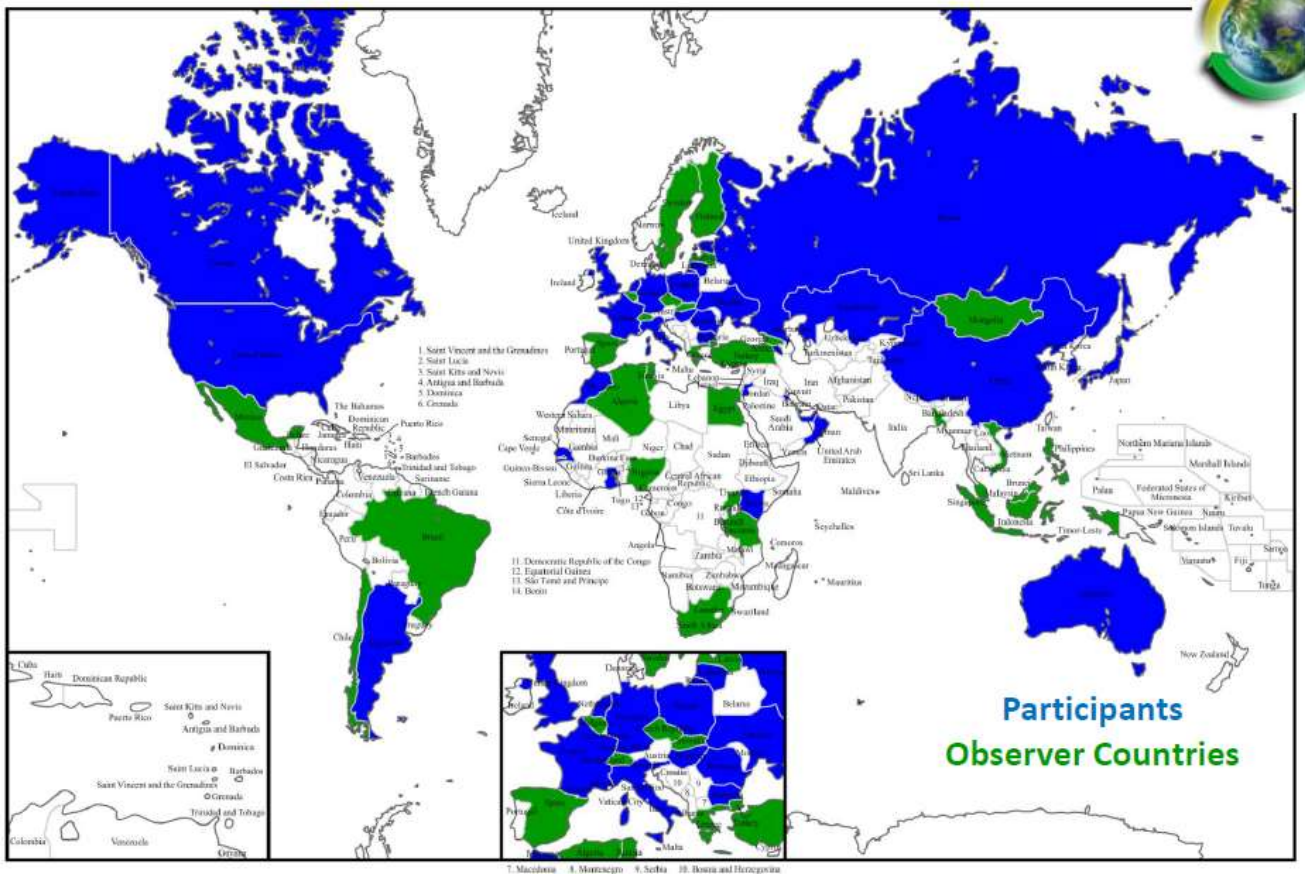
IFNEC: Nation-States Govern Nuclear Acceptance

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

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

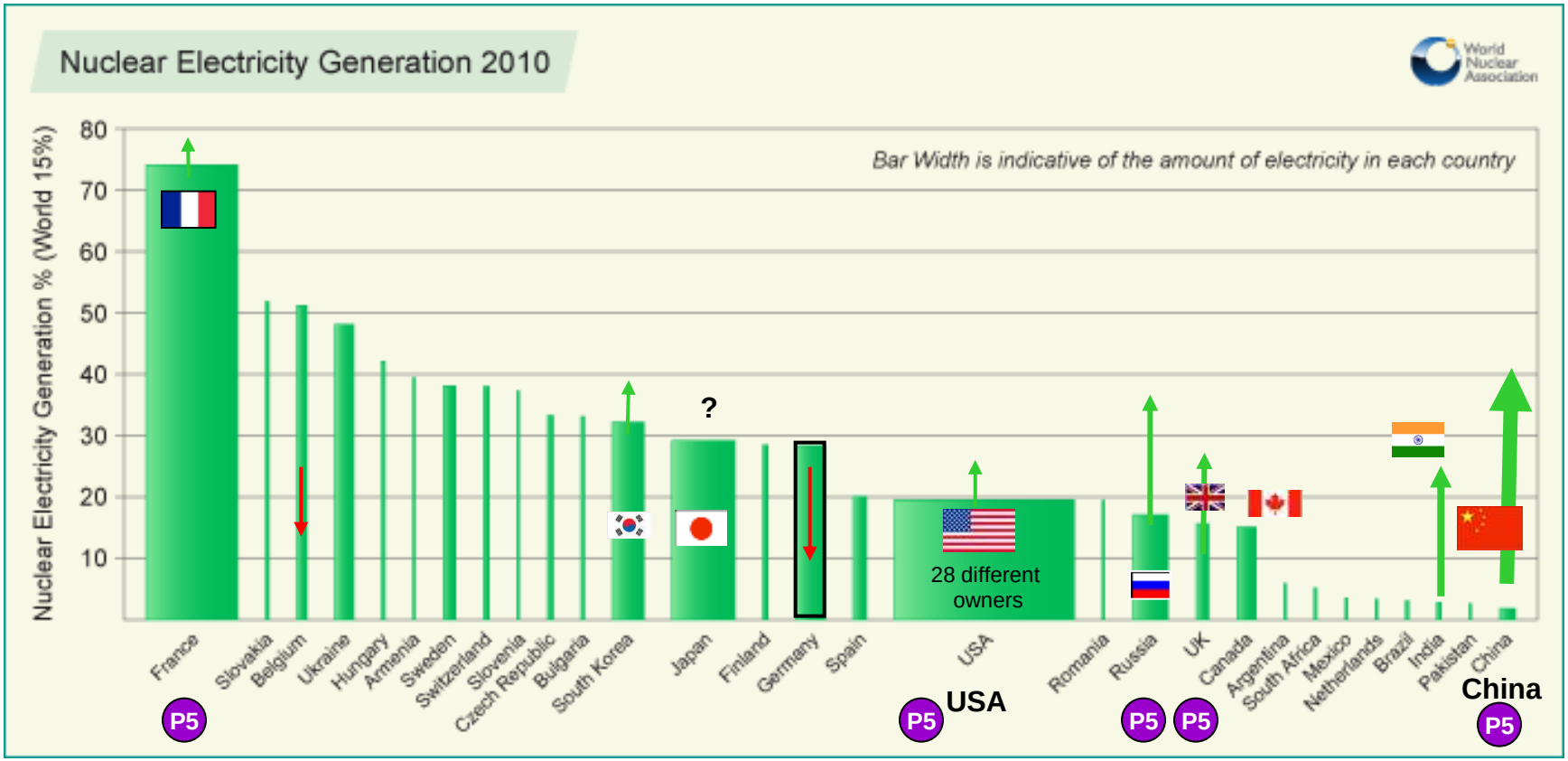
IFNEC Expanded to 61 Countries + 3 Int. Orgs
(31 Participants, 30 Observers)



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.

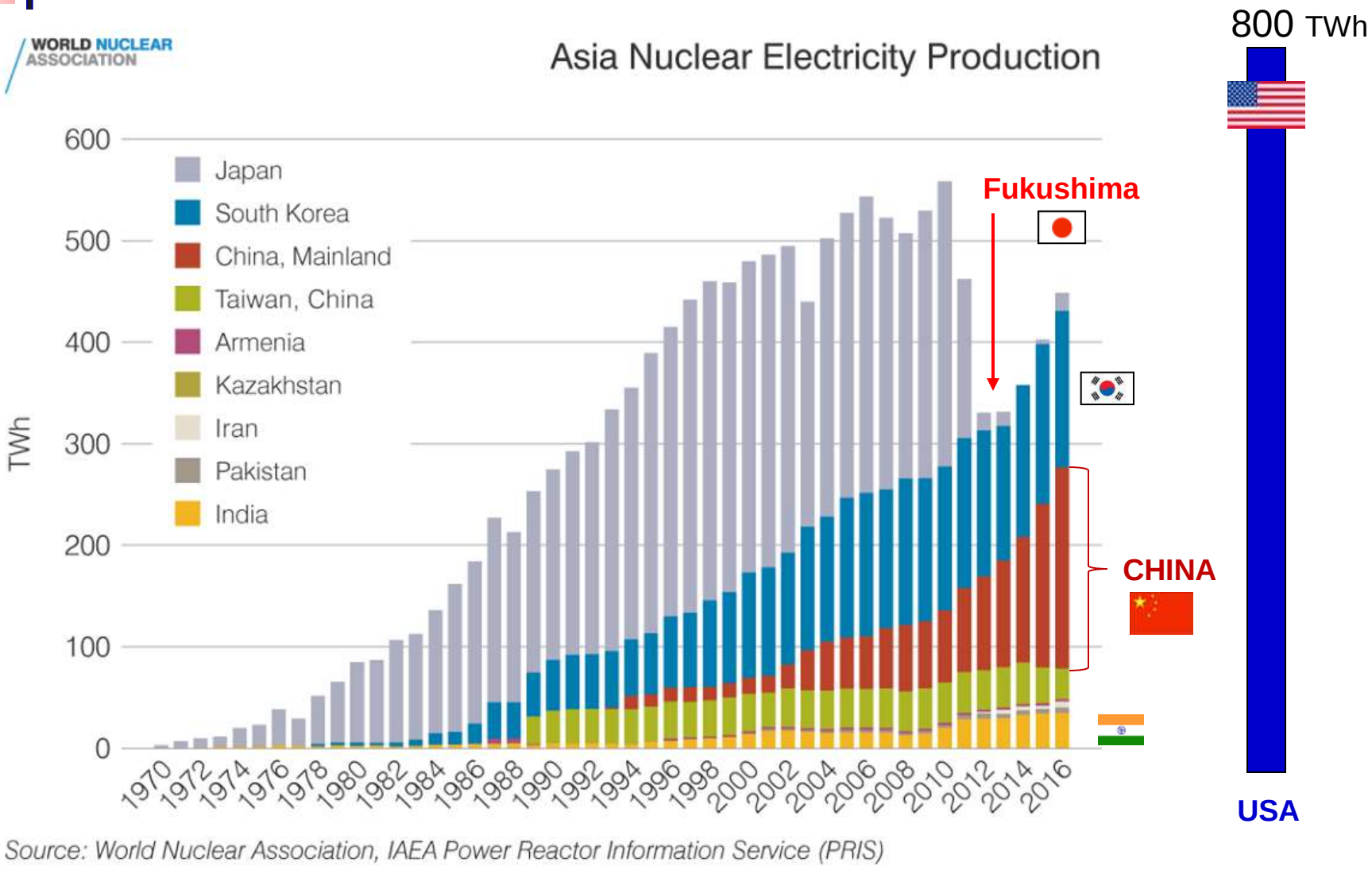


P5 = UN Security Council Permanent Voting Member: USA, UK, France, Russia, China – Nuclear powers

Powering major cities. Urban Asia surges ahead

- 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.

Latest Nuclear Generation in Asia, 1970-2016



Source: World Nuclear Association, IAEA Power Reactor Information Service (PRIS)

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

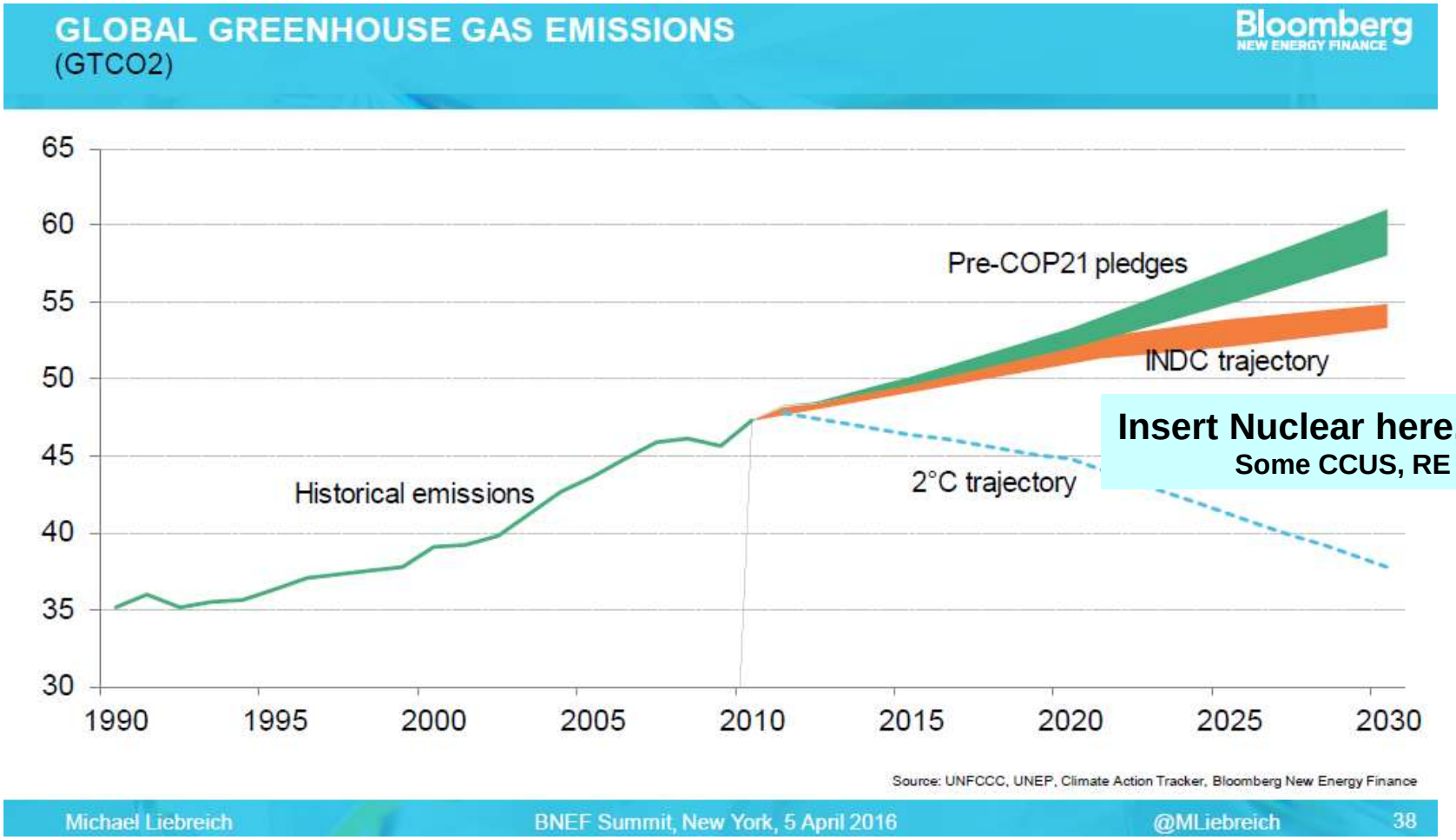
How Nuclear Power Can Stop Global Warming (Dec. 2013)

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/

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.



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?

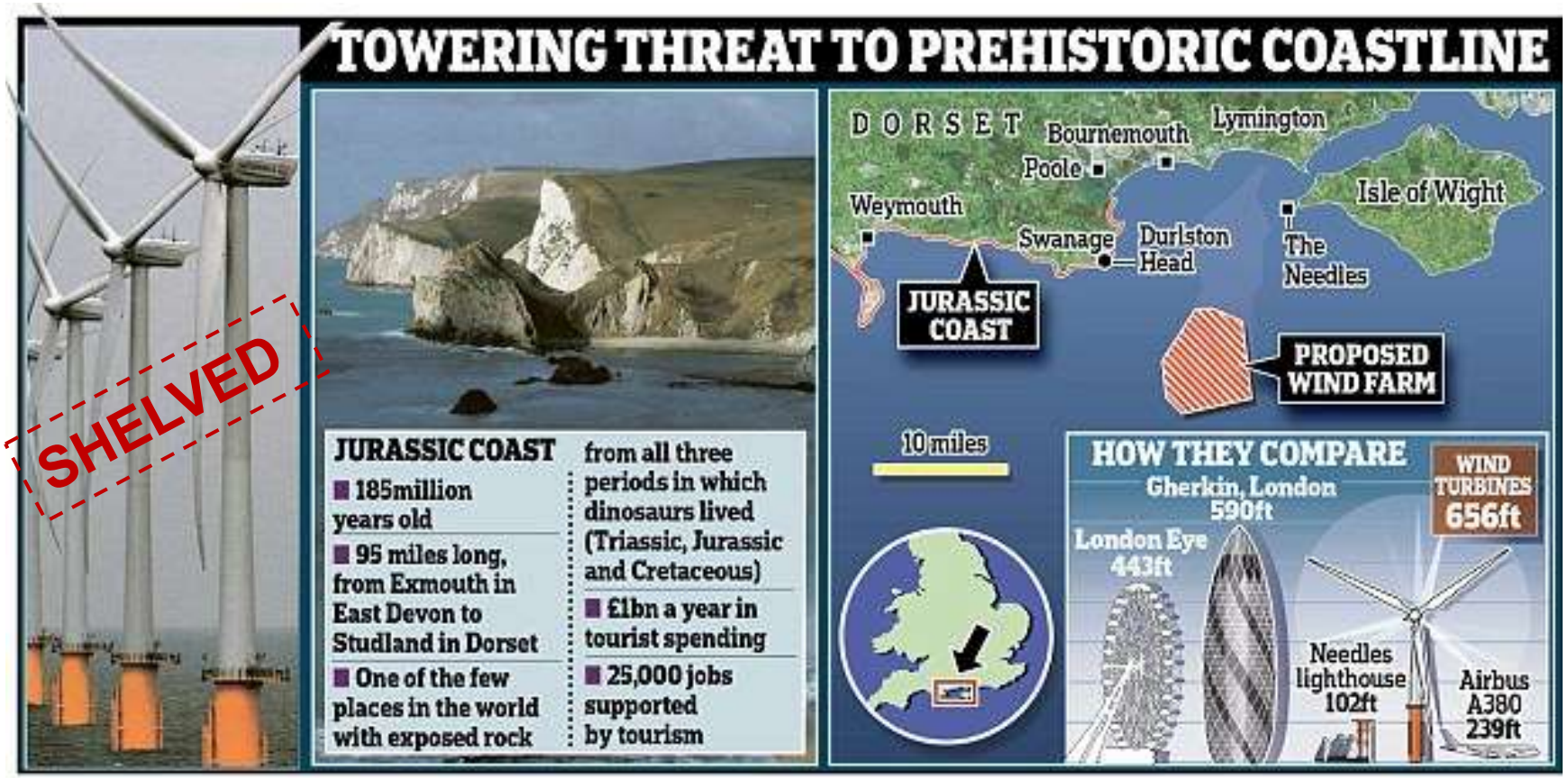
Protest on UK Wind: "*ISLE OF BLIGHT !*"

***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

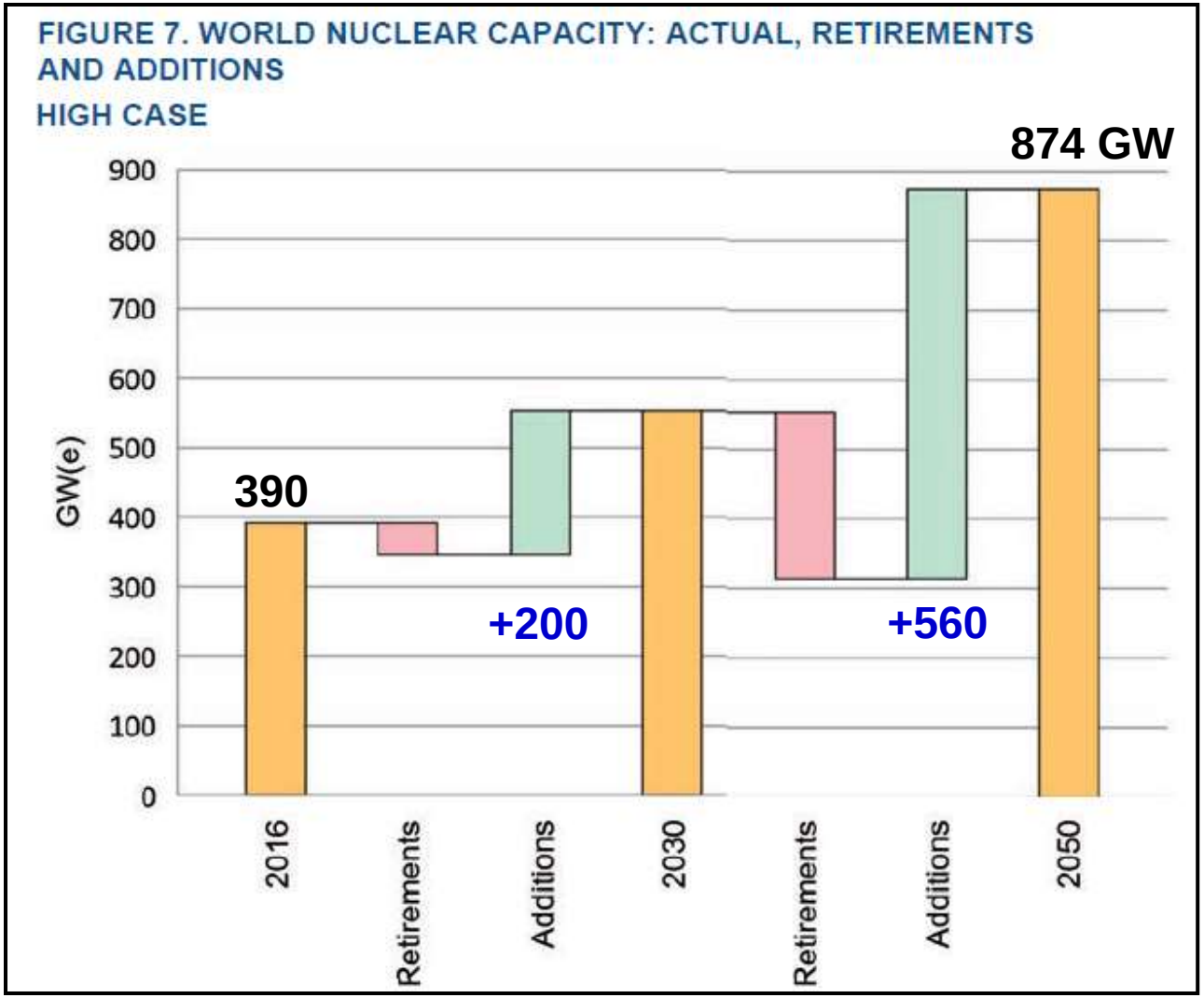
656ft towers would dominate horizon towards Isle of Wight, report warns

www.dailymail.co.uk/news/article-3123852/Isle-Blight-650ft-wind-turbines-UK-lose-natural-world-heritage-site-Jurassic-Coast.html#ixzz4isZNnjlZ



IAEA (Sept 2017) – HIGH Estimate: Projected Nuclear Capacity in 2030, 2040, 2050

In IAEA **HIGH** Case, **>750 GWe** must be built by 2050 to replace and for growth.



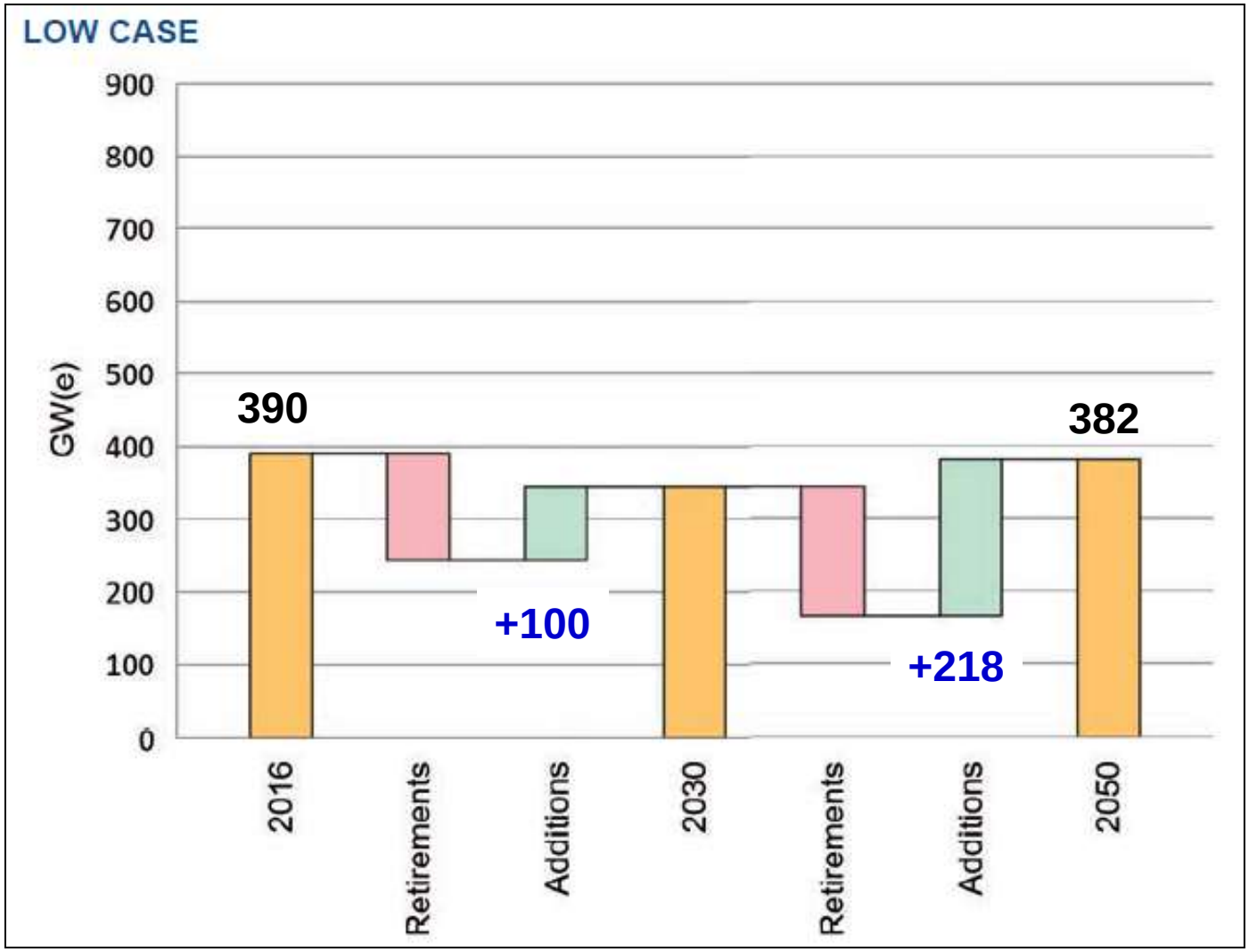
IAEA: Reactor Retirements and Additions (p. 20)

- In the high case only 44 GW(e) of nuclear electrical generating capacity will be retired by 2030, with an additional 241 GW(e) retired by 2050. In this case, the new reactors will add 206 GW(e) of nuclear electrical generating capacity by 2030 and about 561 GW(e) of capacity by 2050.

http://www-pub.iaea.org/MTCD/publications/PDF/17-28911_RDS-1%202017_web.pdf

IAEA (Sept 2017) – LOW Estimates: Projected Nuclear Capacity in 2030, 2040, 2050

Even in IAEA **LOW** Case, **>300 GWe** must be built by 2050 due to retirements.



IAEA: Reactor Retirements and Additions (p. 20)

● In the low case, about 147 GW(e) of nuclear electrical generating capacity will be retired and new reactors will add 101 GW(e) of capacity by 2030. Between 2030 and 2050, an additional 181 GW(e) will be retired and 218 GW(e) of new capacity will be added.

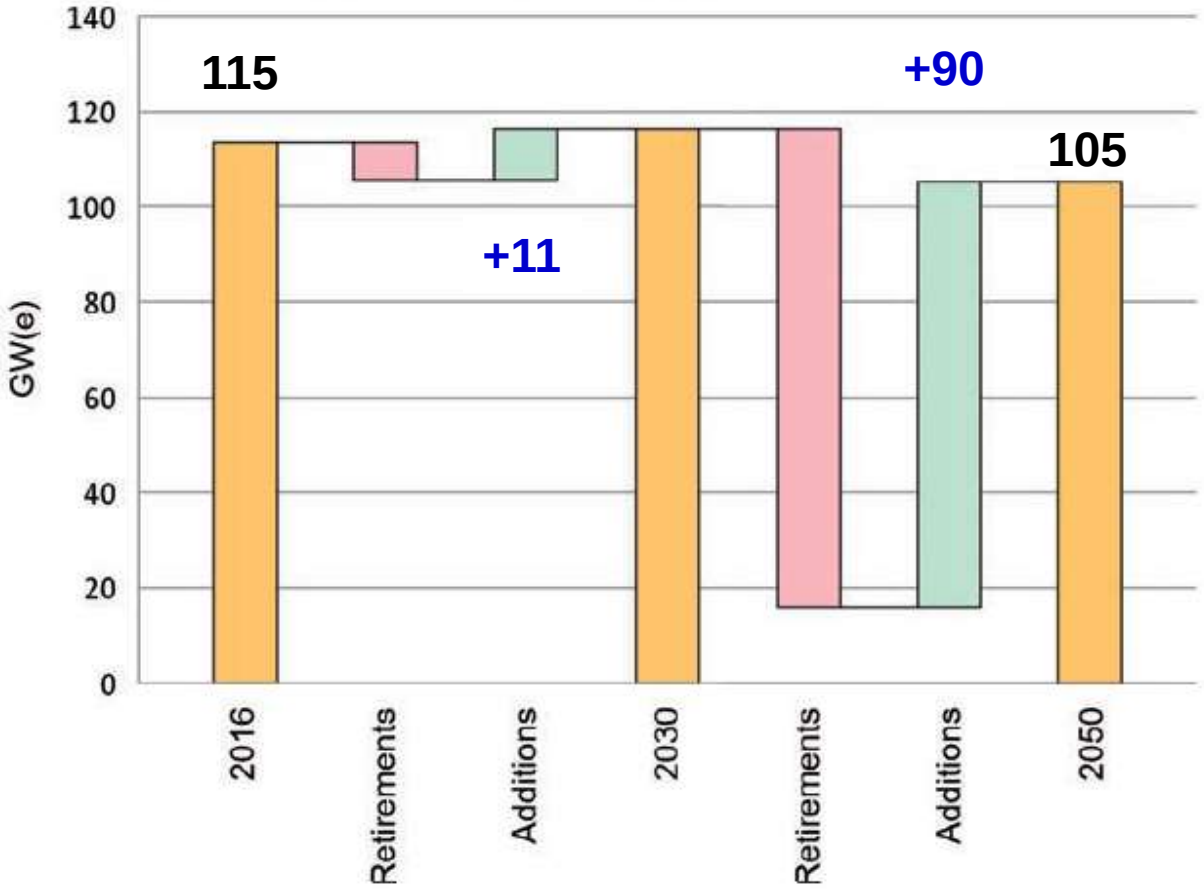
http://www-pub.iaea.org/MTCD/publications/PDF/17-28911_RDS-1%202017_web.pdf

IAEA (Sept 2017) – HIGH Estimate N.AMERICA: Projected Nuclear Capacity in 2030, 2050

In **HIGH** Case for **N.AM**, **~100 GWe** must replaced by 2050 due to retirements.

FIGURE 13. NUCLEAR CAPACITY IN THE NORTHERN AMERICA REGION: ACTUAL, RETIREMENTS AND ADDITIONS

HIGH CASE



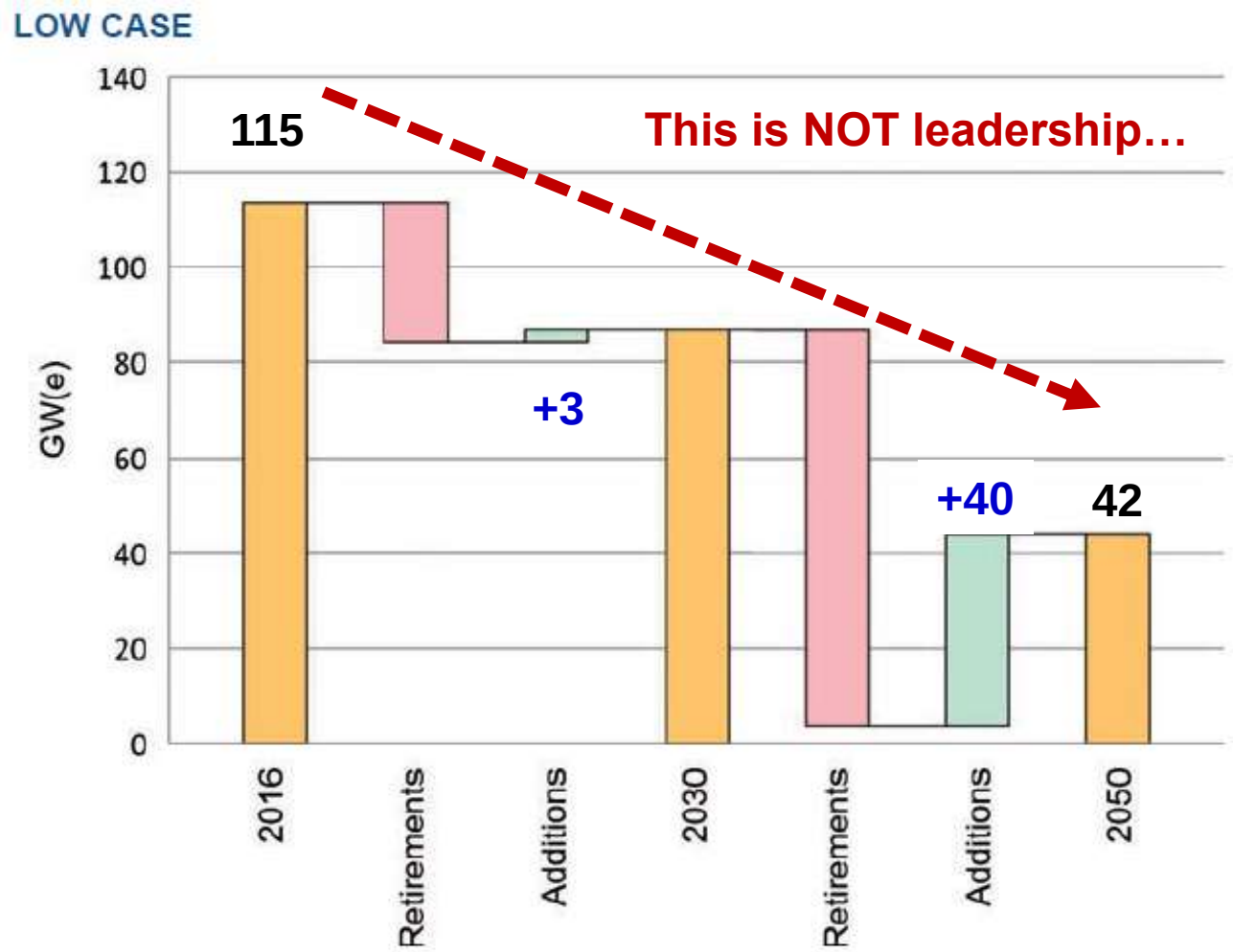
IAEA: Reactor Retirements and Additions (p. 34)

● some nuclear power reactor retirements will be delayed by plant life extensions; however, these plants will also be retired by the middle of the century. The additions of nuclear electrical generating capacity in this case are projected to be 11 GW(e) by 2030 and some 90 GW(e) by 2050.

http://www-pub.iaea.org/MTCD/publications/PDF/17-28911_RDS-1%202017_web.pdf

IAEA (Sept 2017) – LOW Estimate N.AMERICA: Projected Nuclear Capacity in 2030, 2050

In **LOW** Case for **N.AM**, **only HALF** are replaced by 2050 after retirements.



IAEA: Reactor Retirements and Additions (p. 34)

● In the low case, about 29 GW(e) of nuclear electrical generating capacity will be retired by 2030. An additional 83 GW(e) of capacity will be retired between 2030 and 2050. The projected additions of nuclear electrical generating capacity in this case are only 3 GW(e) by 2030 and 40 GW(e) by 2050.

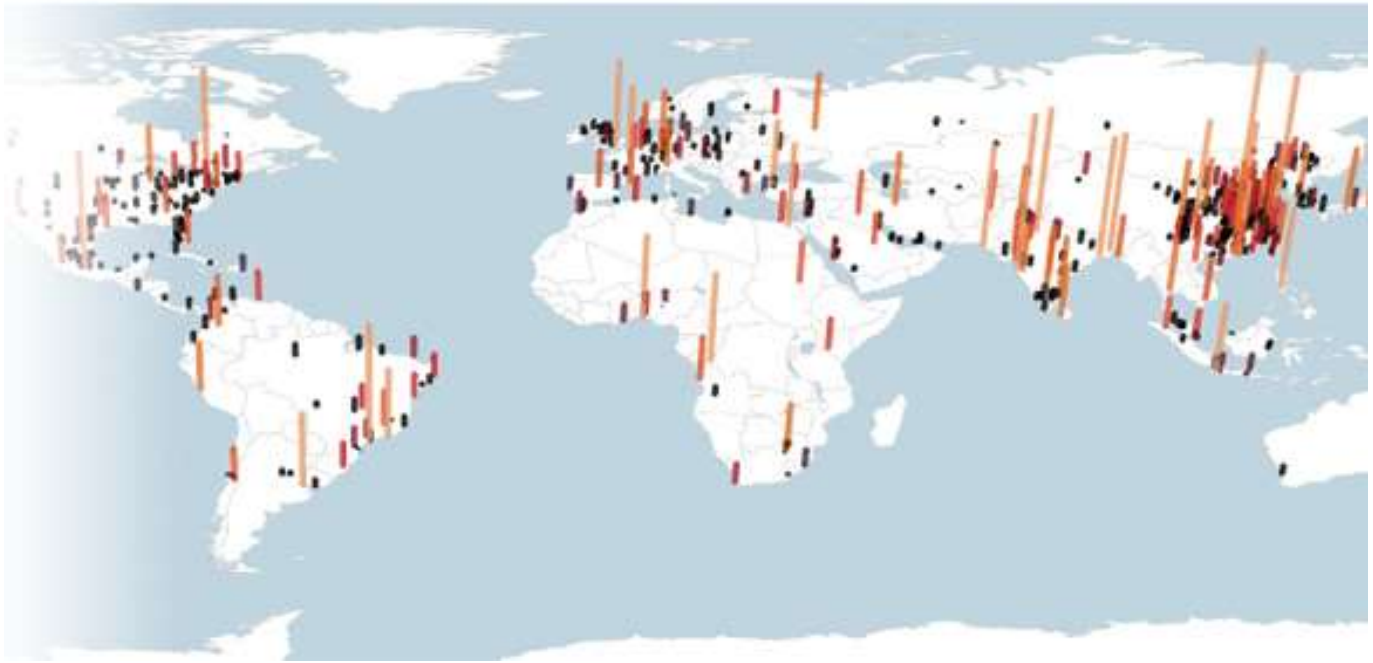
http://www-pub.iaea.org/MTCD/publications/PDF/17-28911_RDS-1%202017_web.pdf

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



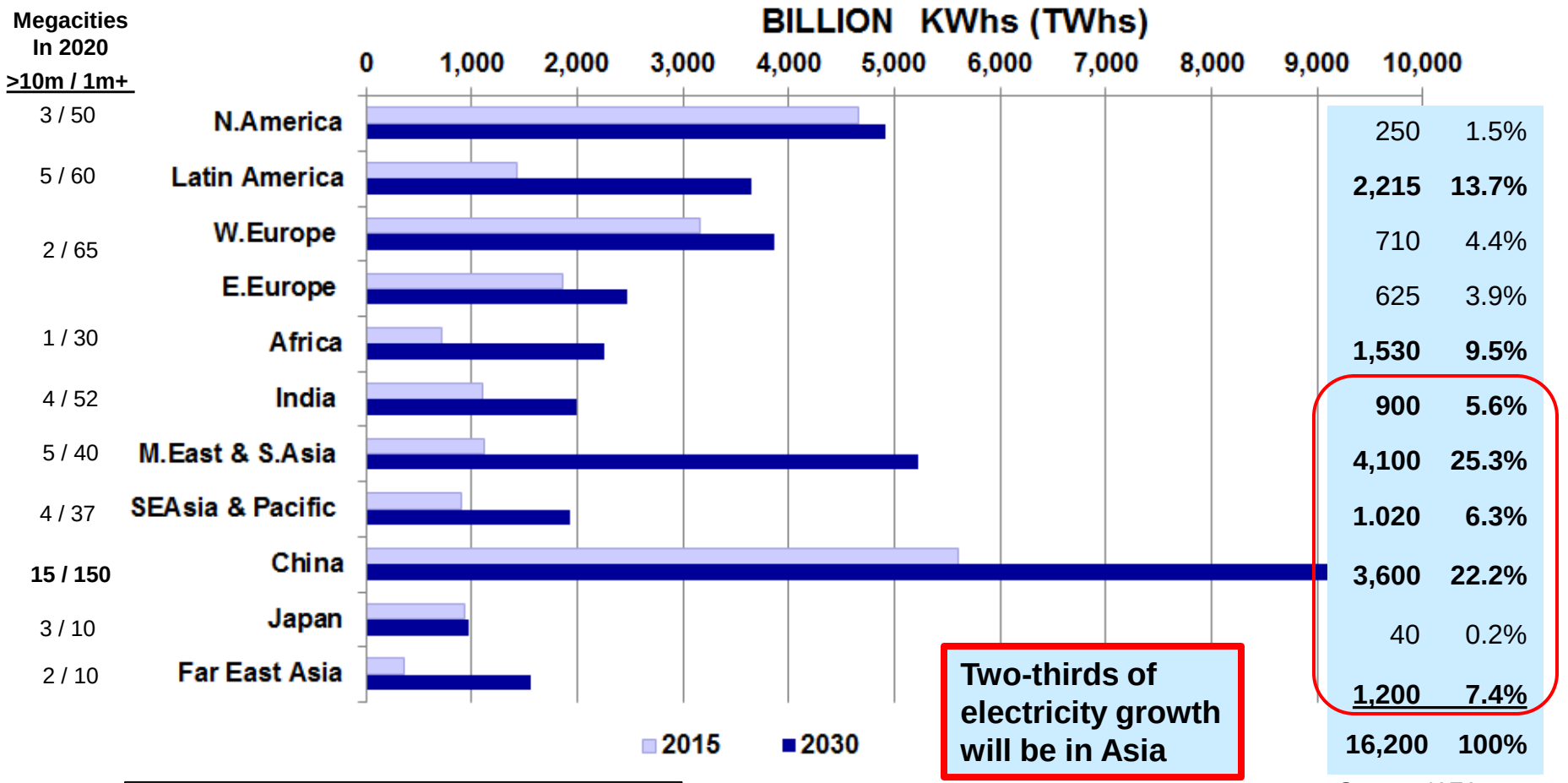
Pace of Growth: Then (1990) and Now (2015)

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

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

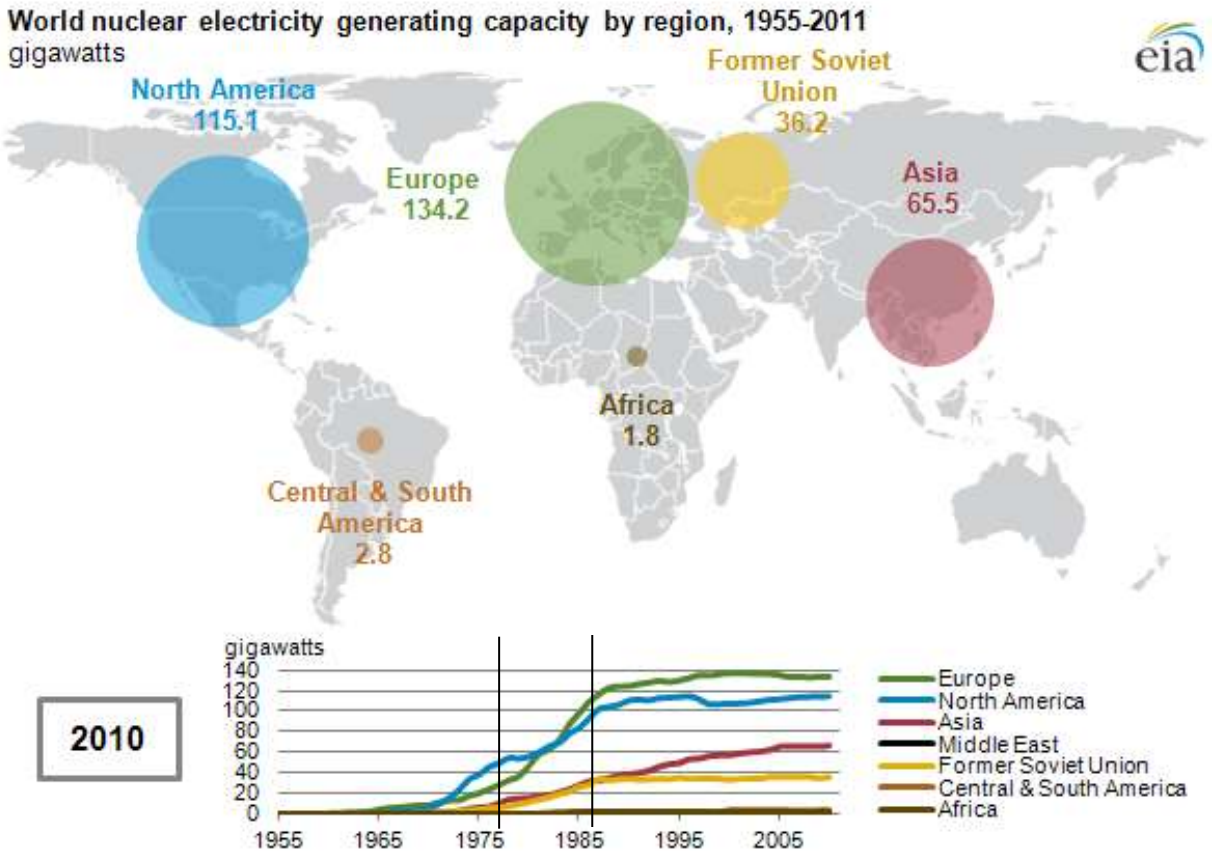
100 MWs = 50,000 - 100,000 people a year

Source: IAEA midpoint estimates

EIA: Nuclear Capacity by decade, 2010

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

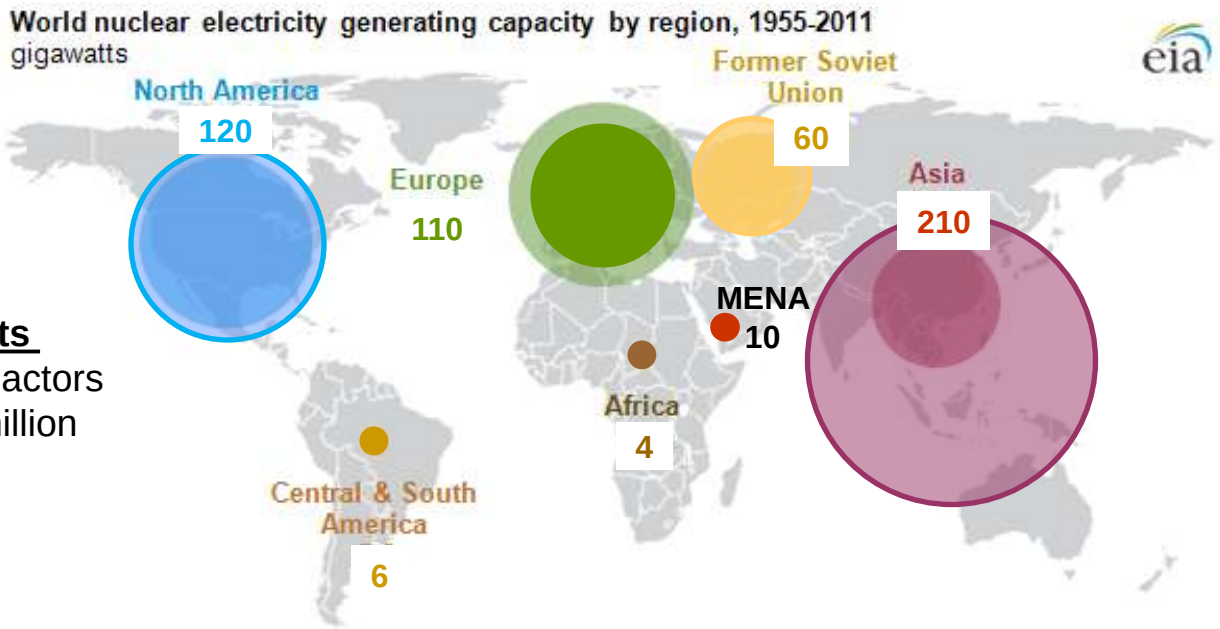
Stasis from 2000-10; Asia emerging



EIA: Nuclear Capacity by decade, 2030

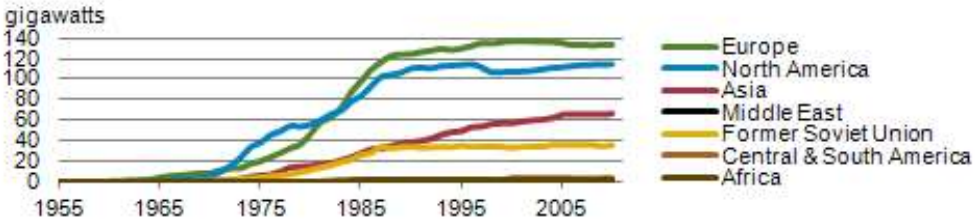
Global generation capacity for nuclear power has grown to over 370 gigawatts since 1955

Asia dominates to 2030 to feed cities



National Targets
Large Gen III reactors feed cities >1 million

2030



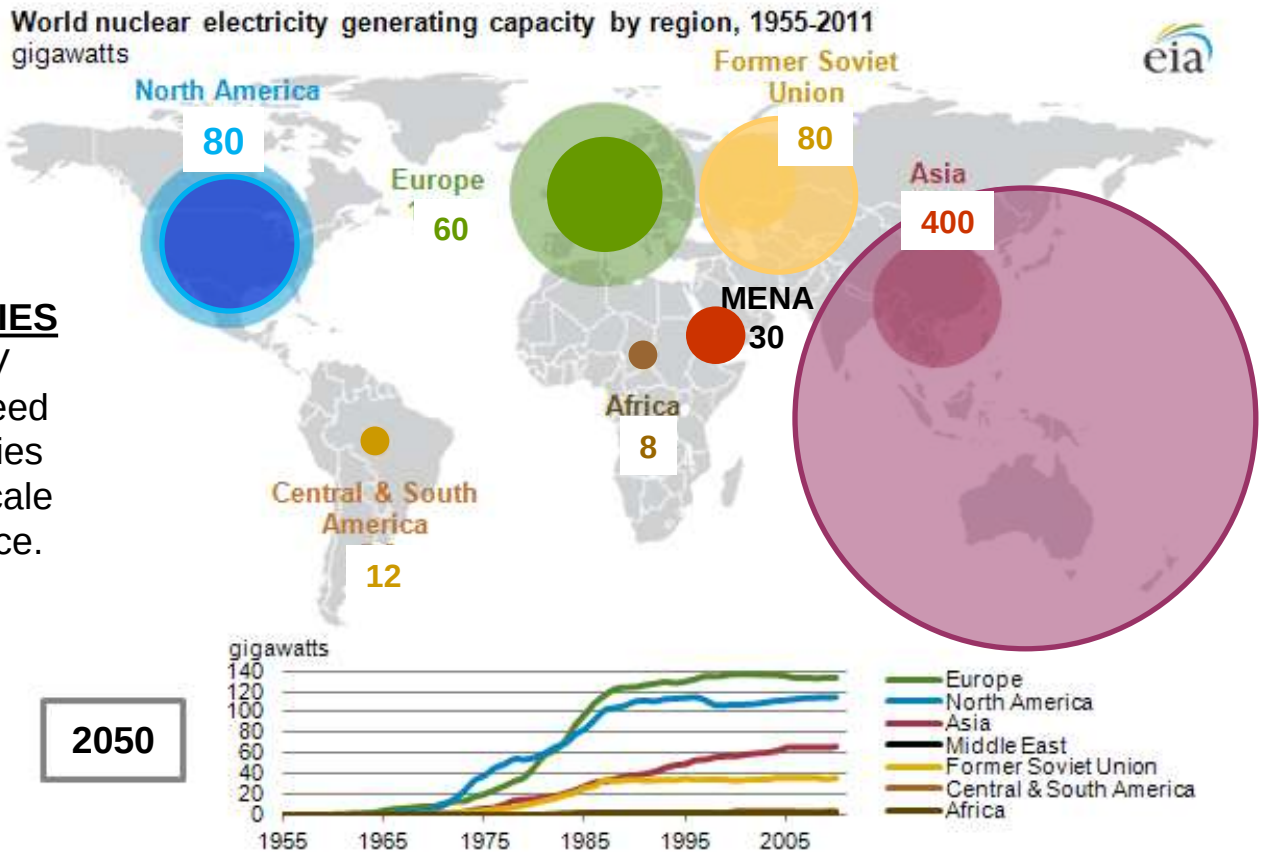
Projected

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

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

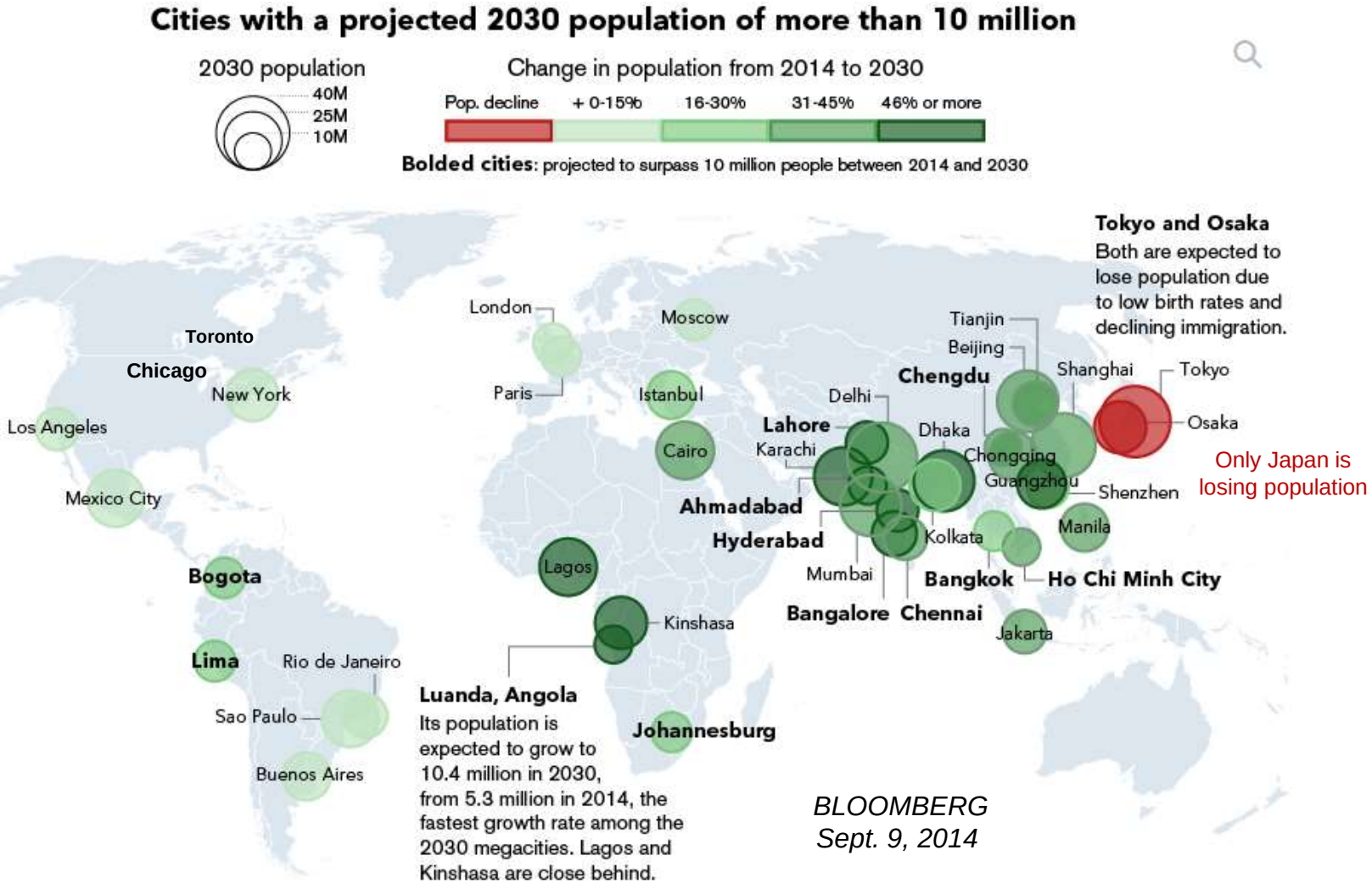
SMRs / Gen IV reactors can feed many more cities sooner, at a scale they can finance.

Projected

670 GW TOTAL

(IAEA mid-range) 400 to 900 GWs

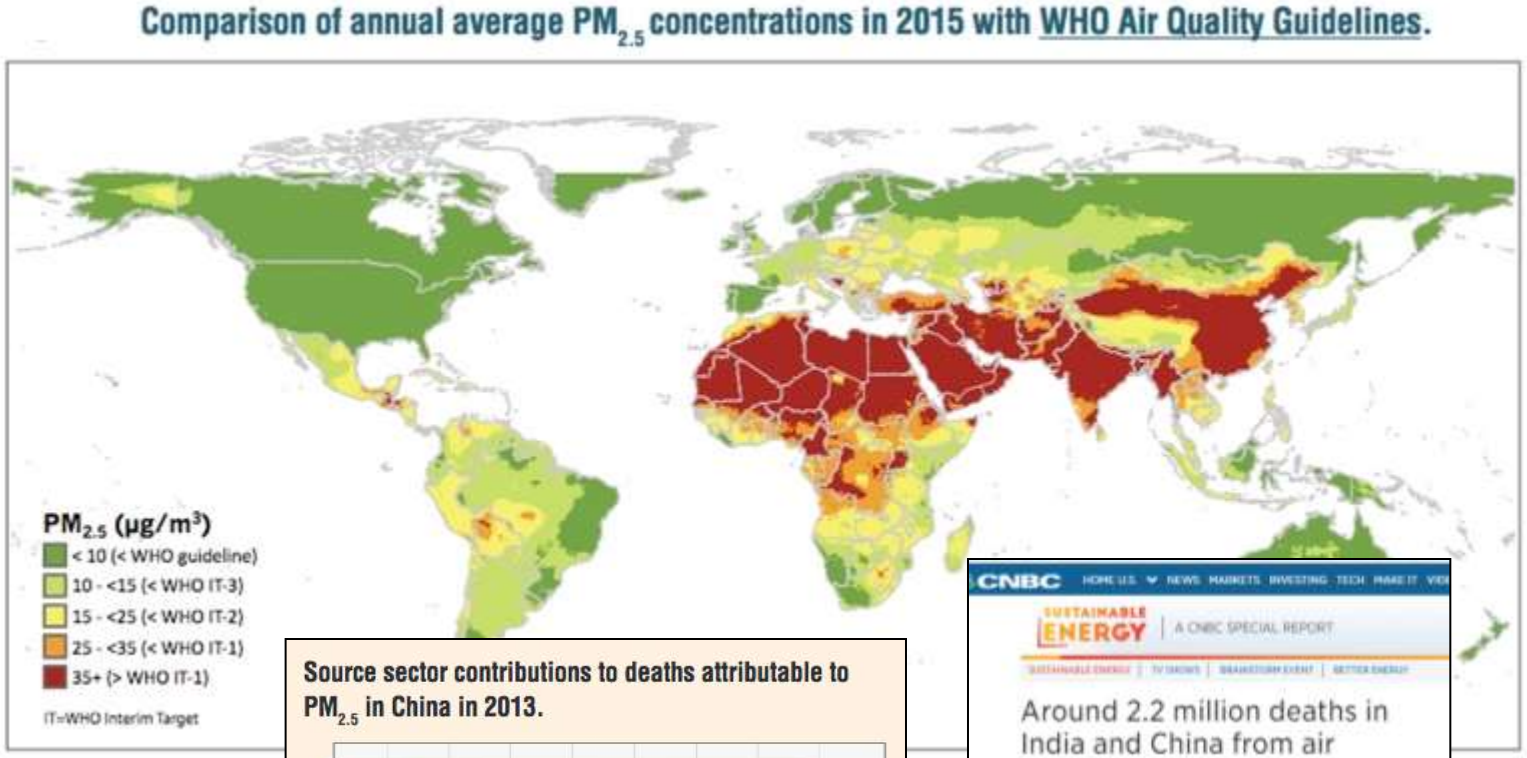
Largest cities by 2030 concentrated in Asia



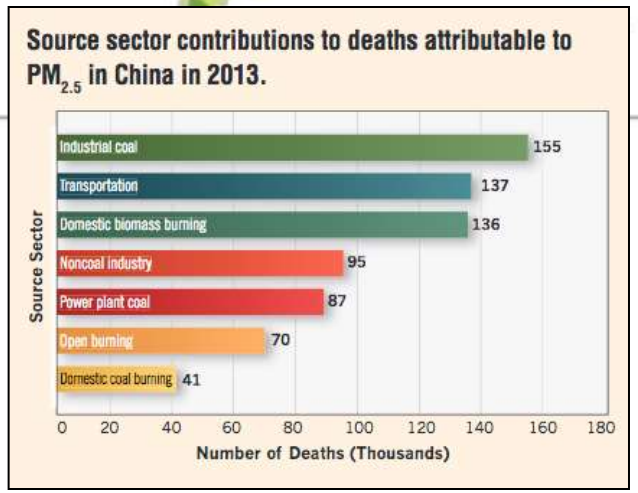
BLOOMBERG
Sept. 9, 2014

www.bloomberg.com/infographics/2014-09-09/global-megacities-by-2030.html

Driver for Nuclear in Asia: Deadly PM 2.5 Pollution



www.meo.life/state-of-global-air-2017/



Global Covenant of Cities not waiting for UNFCCC

Urban Emissions

Regional Networks

Shared Solutions

Local Resilience & Adaptation

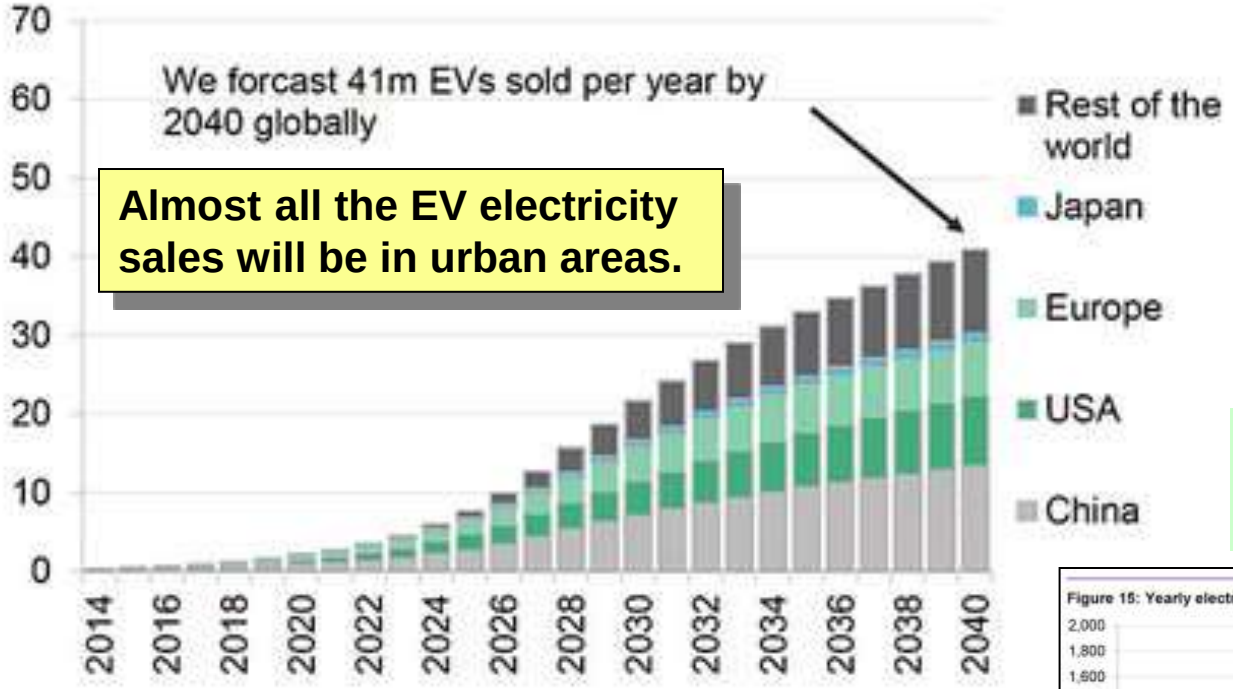
www.globalcovenantofmayors.org/about/

Feb. 2016 forecast

EV Growth matches timeline for Advanced Nuclear

Figure 11: BNEF global EV sales forecast by geography, 2015–2040 (m vehicles per year)

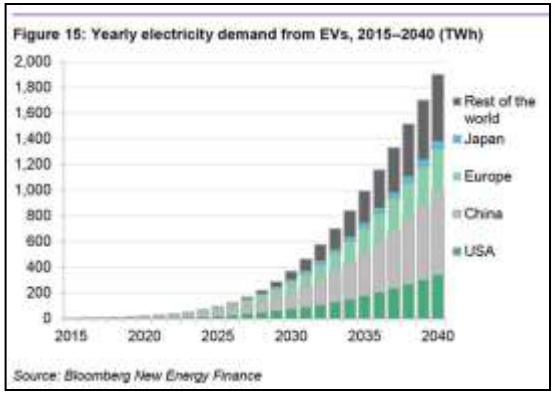
FEB. 2016:
Plug-in hybrids + Battery EVs



Source: Bloomberg New Energy Finance, Marklines

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.

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



https://about.bnef.com/blog/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/

Emerging Markets: Look at Urban Clusters

McKinsey&Company

A clustering approach can help companies target consumers more effectively in Chinese cities, some of which are economically larger than entire European countries.

2010 GDP for urban clusters in China vs selected countries, $ billion

Urban clusters in China and their hub cities

Clusters are grouped by size, based on average 2015 urban GDP estimates

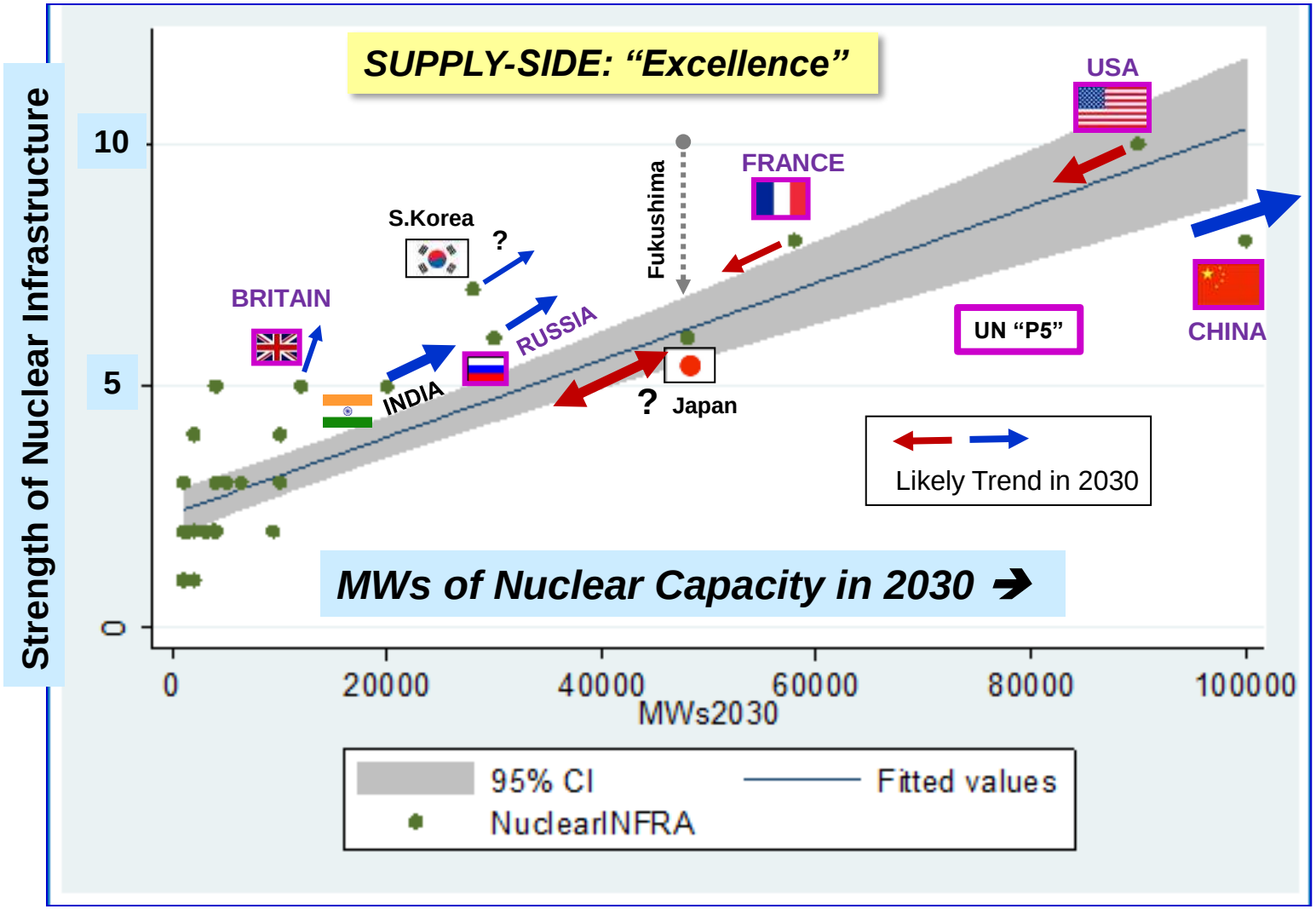
Urban clusters in Asia comprise larger economies than some EU countries, and will see much more growth.

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

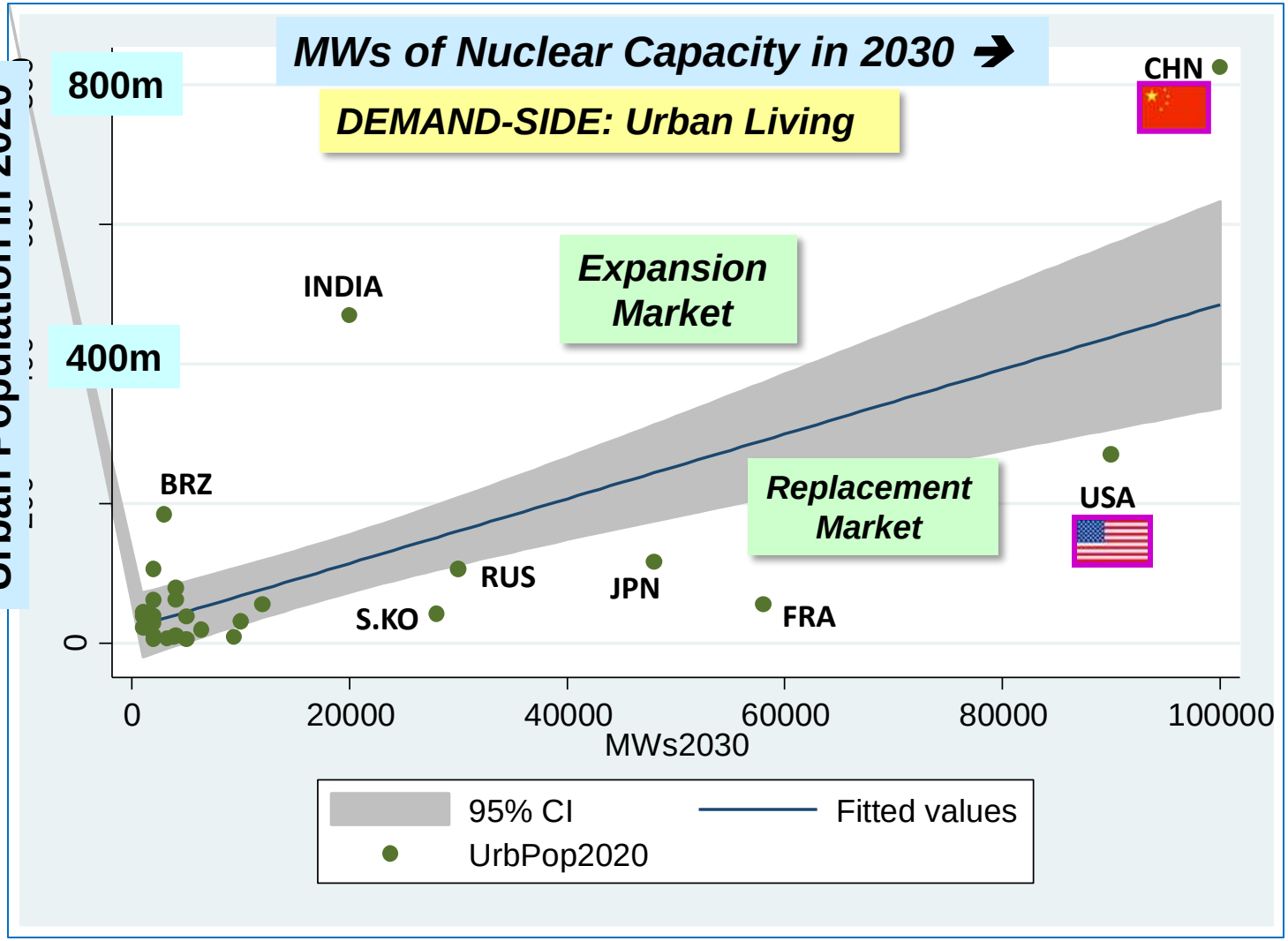
*China will need **hundreds** of SMRs or Adv Reactors.*

www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/winning-the-30-trillion-decathlon-going-for-gold-in-emerging-markets

Leaders in Nuclear Infrastructure + MWs in 2030



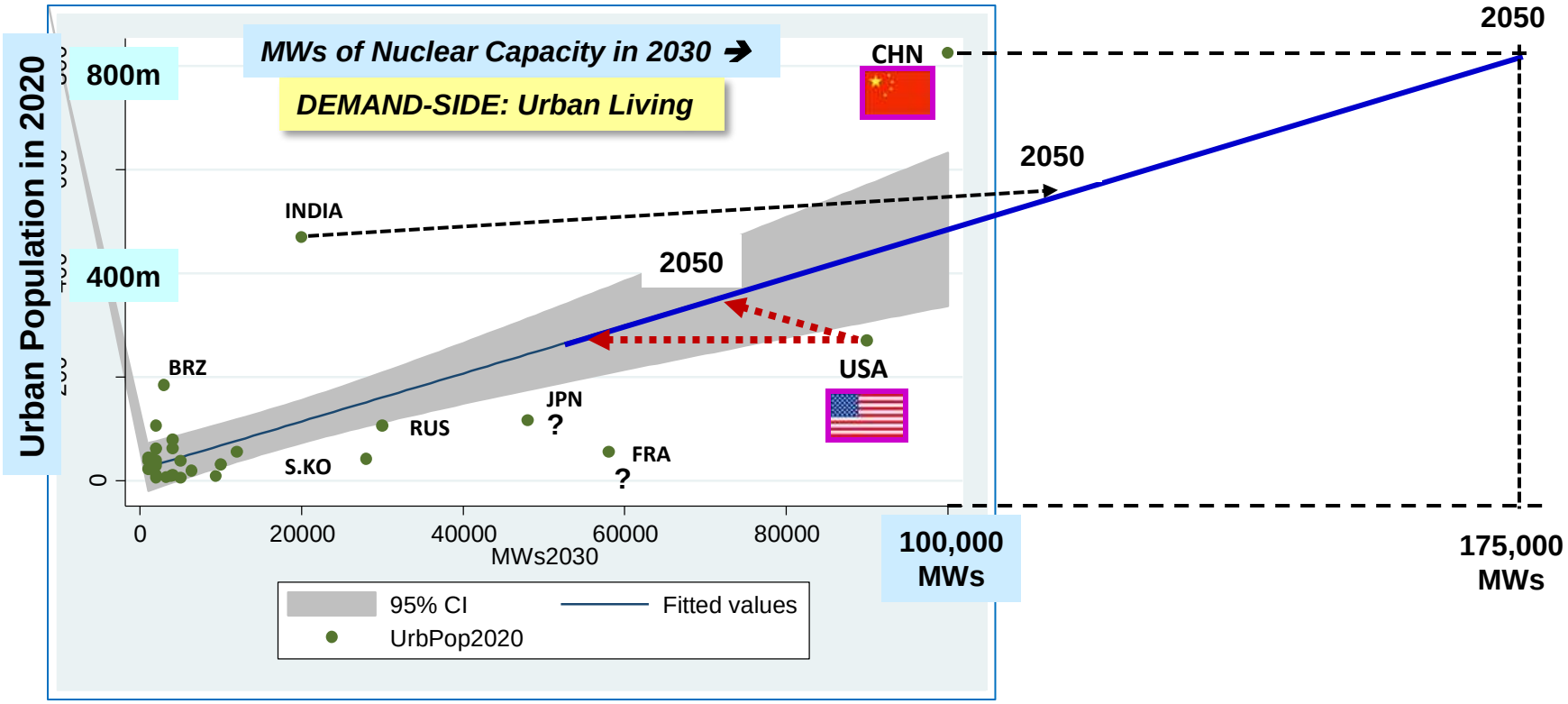
Urban Population in 2020 vs MWs in 2030



Urban Population in 2020 vs MWs in 2030

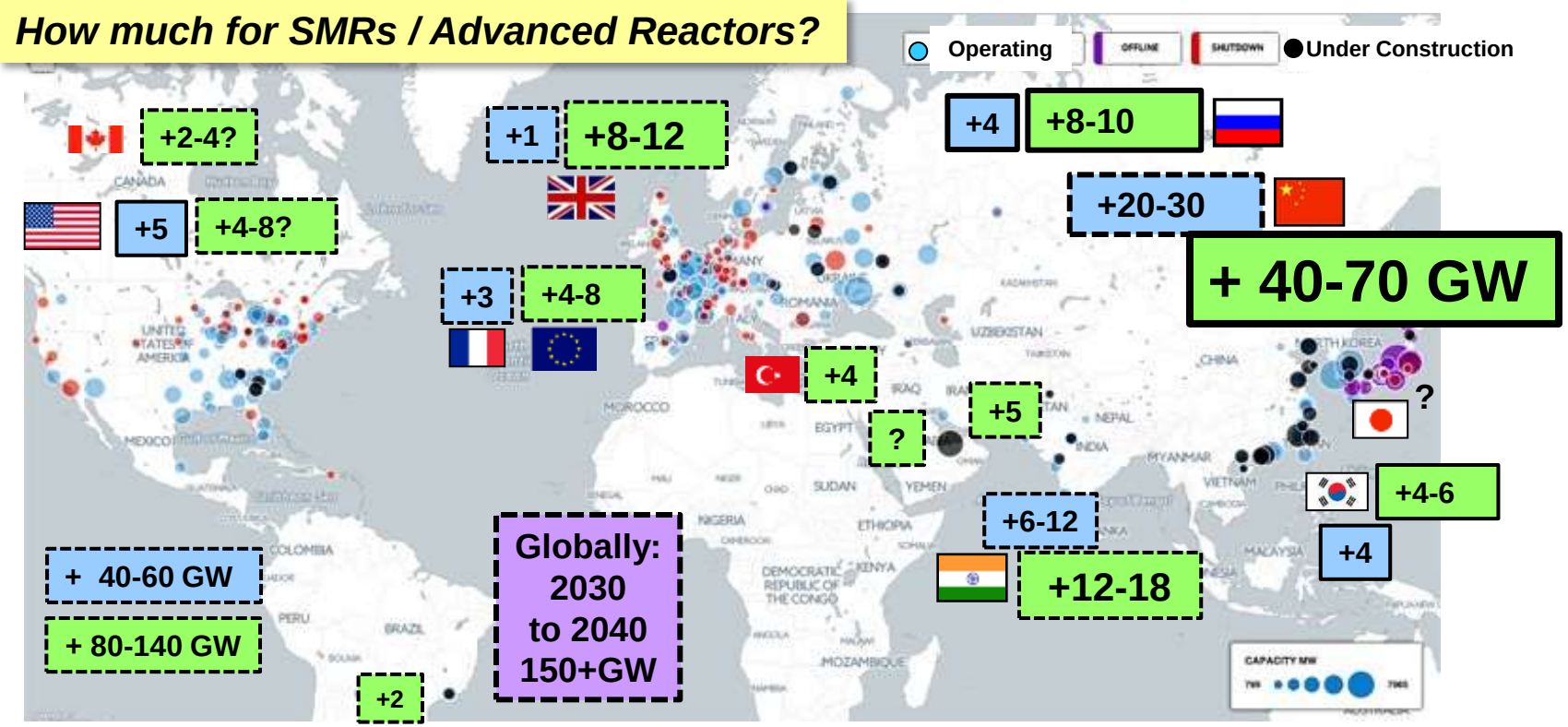
Several Observations:

1) ***Given <u>growing</u> 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?



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

GW by 2020 **GW by 2030**

Some open bidding

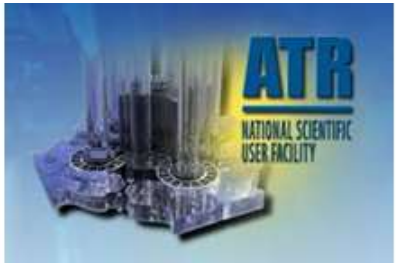
More nationalized

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

WNA: www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx

National Strategies shaped by Supply/Demand Factors

SUPPLY (20th Century)…



"Technology Push"

…DEMAND (21st Century)

"Market Pull"

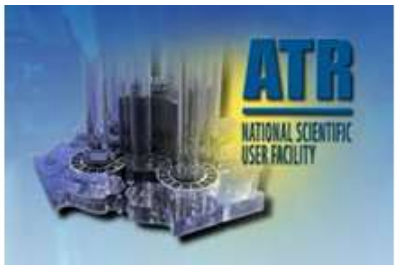
Historical Factors for Nuclear Leadership: SUPPLY

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



ORISE: Nuclear Engineering recovered from 2001 low point, dip in 2009

Nuclear engineering degrees, 2006–2016

Year	B.S.	M.S.	Ph.D.
2016	621	355	161
2015	652	363	147
2014	627	322	169
2013	655	362	147
2012	610	333	119
2011	524	277	113
2010	443	303	113
2009	395	233	87
2008	454	260	127
2007	413	227	89
2006	346	214	70

https://orise.orau.gov/about/media-center/news-features/2017/nuclear-engineering-degrees-report-2016.html

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

- **D1 Growing population overall (demographics)**
- **D2 Current dense, urban electric loads (large cities today)**
- **D3 Advanced industrial and manufacturing base**
- **D4 Rising per capita energy use (vs. OECD average)**
- **D5 Higher natural gas prices (nuclear competitiveness)**
- **D6 Significant air pollution (need for clean energy options)**
- **D7 Future growth in urban load (urbanization rate)**
- **D8 Policies and regulations favoring reduced emissions**

Supply / Demand Factors and National Strategies

21st Century, Post Cold War

DEMAND-SIDE INTENSITY ➔

HIGH

Nuclear navy
Nat'l Labs
Engineering
Reactor operations
Fuel cycle

20th Century SUPPLY SIDE INTENSITY

LOW

- Strong nuclear infrastructure
- Stagnant load growth
- Already "developed" (OECD)
- Low fossil fuel prices
- Fragmented utility sector

Restruc-turing

- Population growth, "Developing"
- Rising consumer energy demand
- High fossil fuel prices, imports
- Large, burgeoning cities (urbanization)
- Significant Industrialization driving demand

Renaissance "Heavy"

- Declining (aging) population
- Energy use declining (EE)
- Anti-nuclear politics / policy
- Not investing in nuclear training, infrastructure

ROLL BACK

- Population growth
- Lower fossil prices
- Growing cities
- Need for desalination
- No nuclear infrastructure

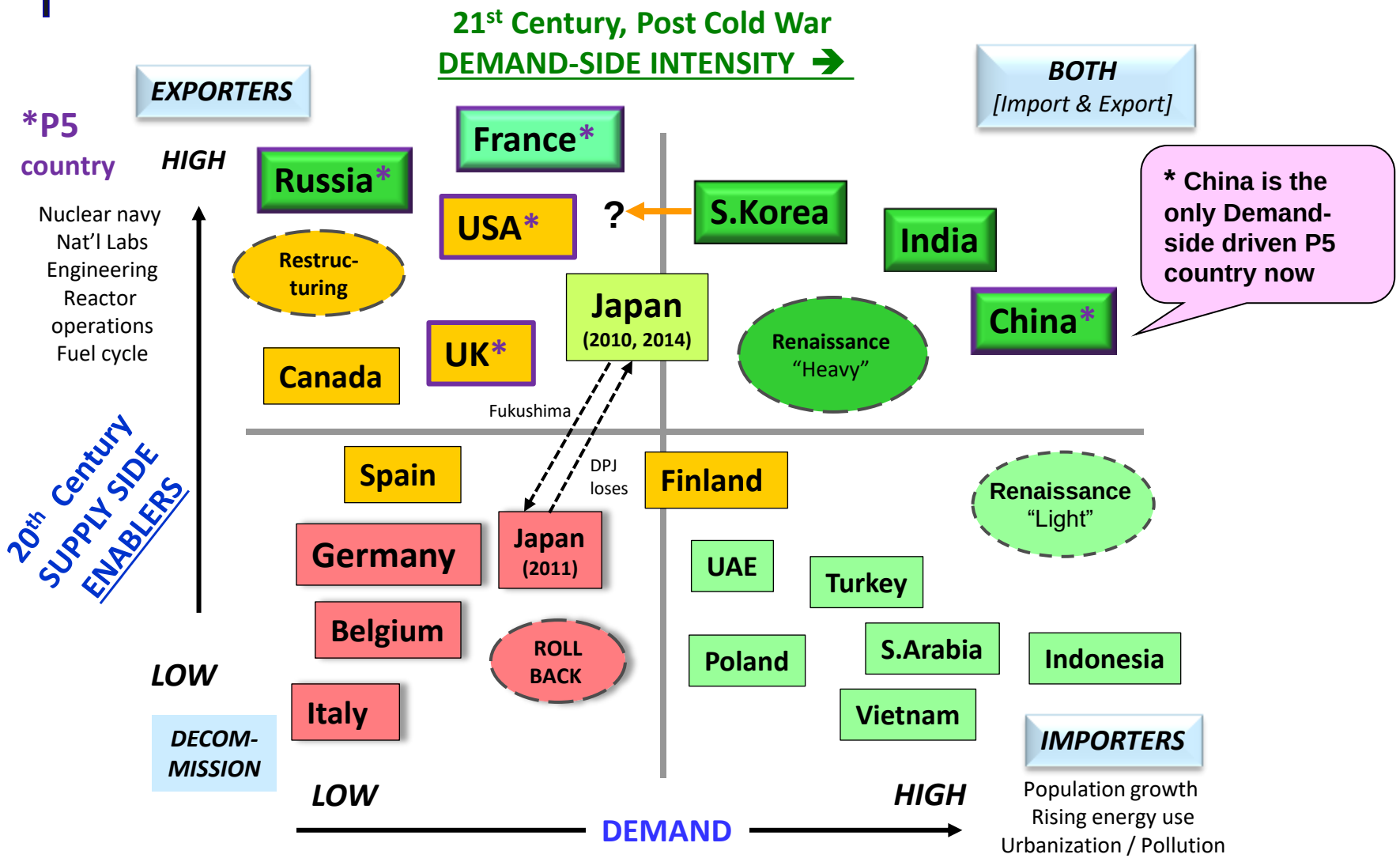
Renaissance "Light"

LOW ——— **DEMAND** ——— **HIGH**

Population growth
Rising energy use
Urbanization / Pollution

Part II: "Redefining Leadership in Nuclear Energy Markets"

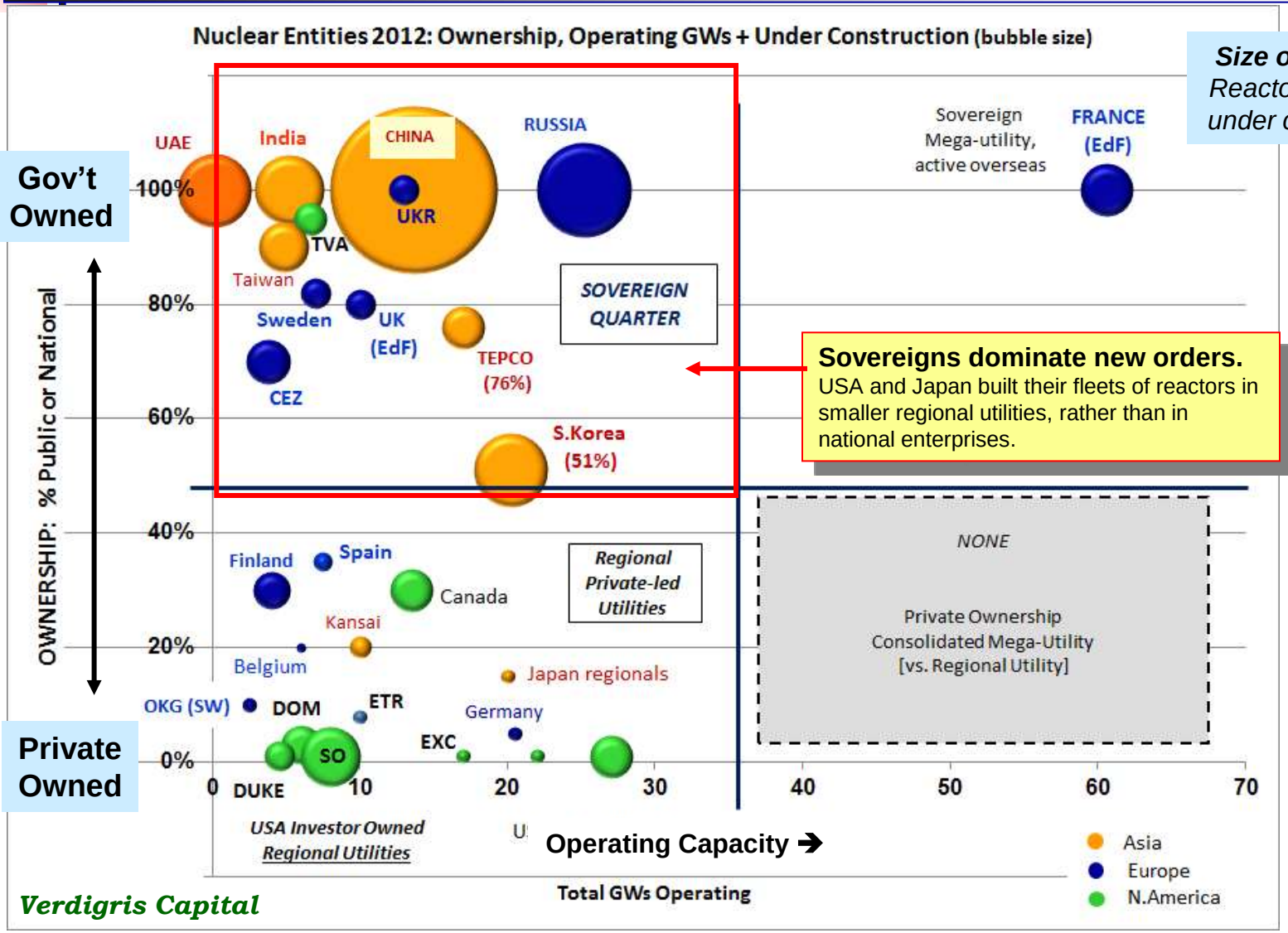
Supply vs Demand Factors and National Strategies



http://ebionline.org/updates/2320-nuclear-energy-remains-vital-to-urban-energy-reliability

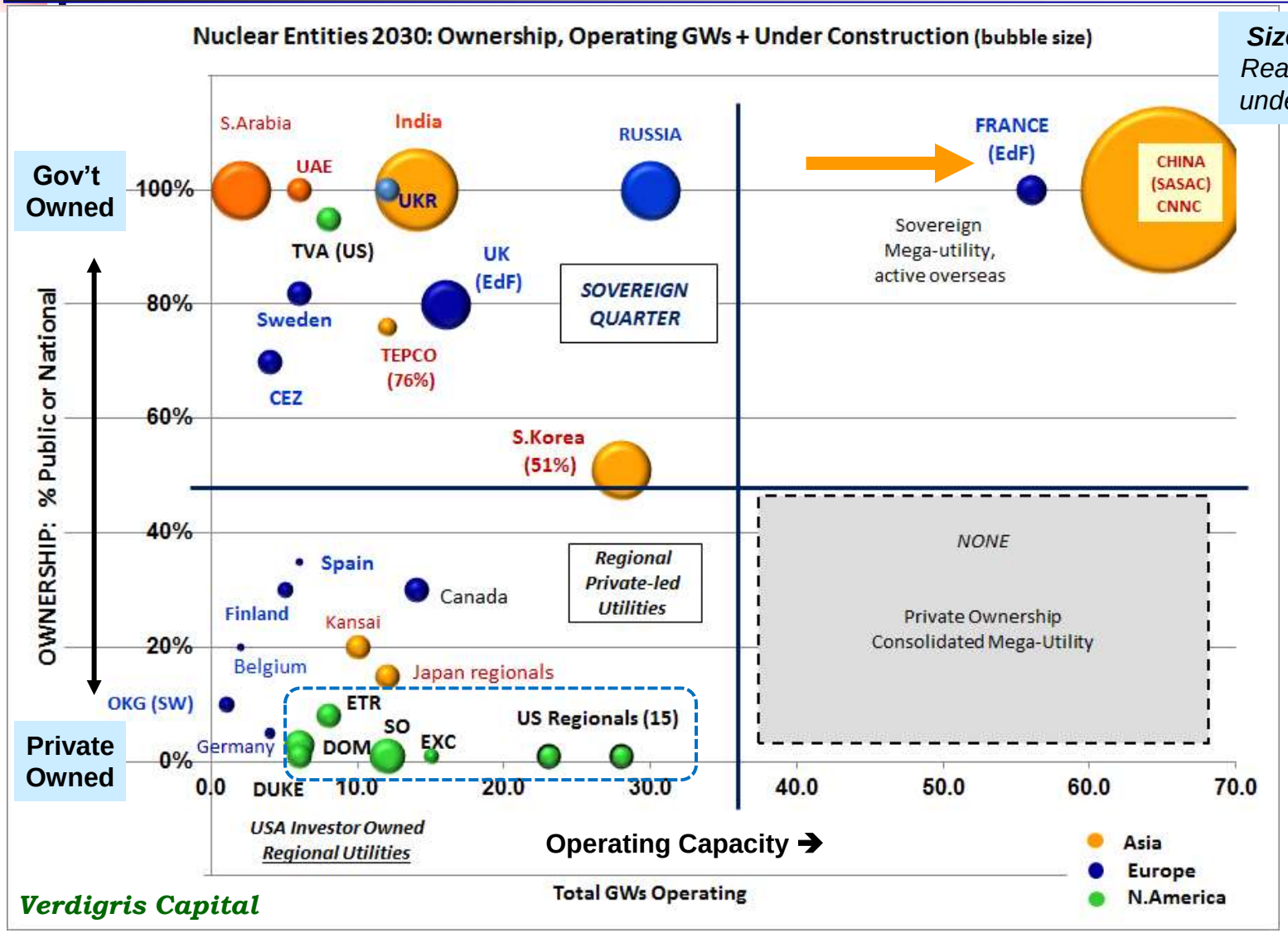
New construction of reactors is primarily a Sovereign decision, more than mere economics.

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

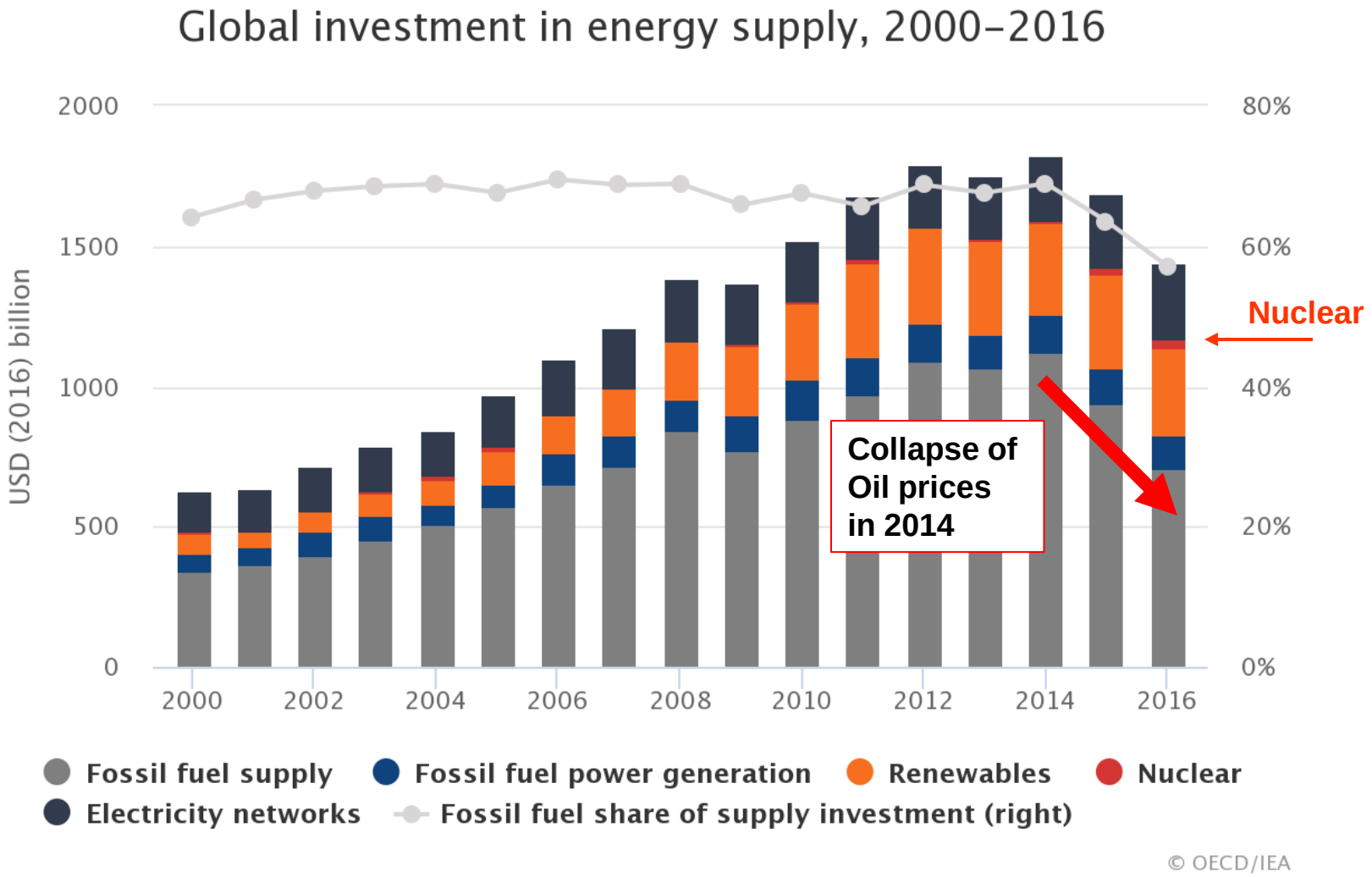


Asia, MidEast continue to dominate new construction

Sovereign Nuclear Energy Landscape 2030



IEA: Global Investment in Energy since 2000

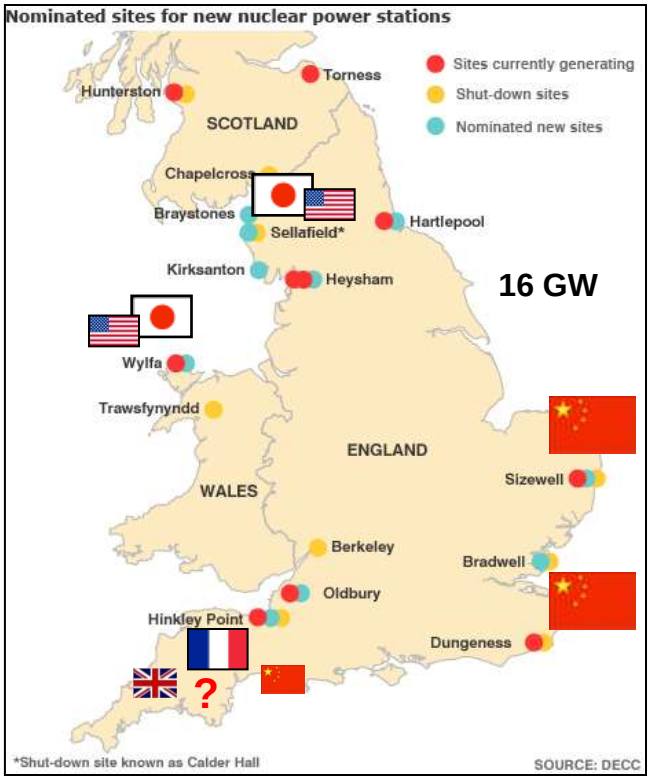


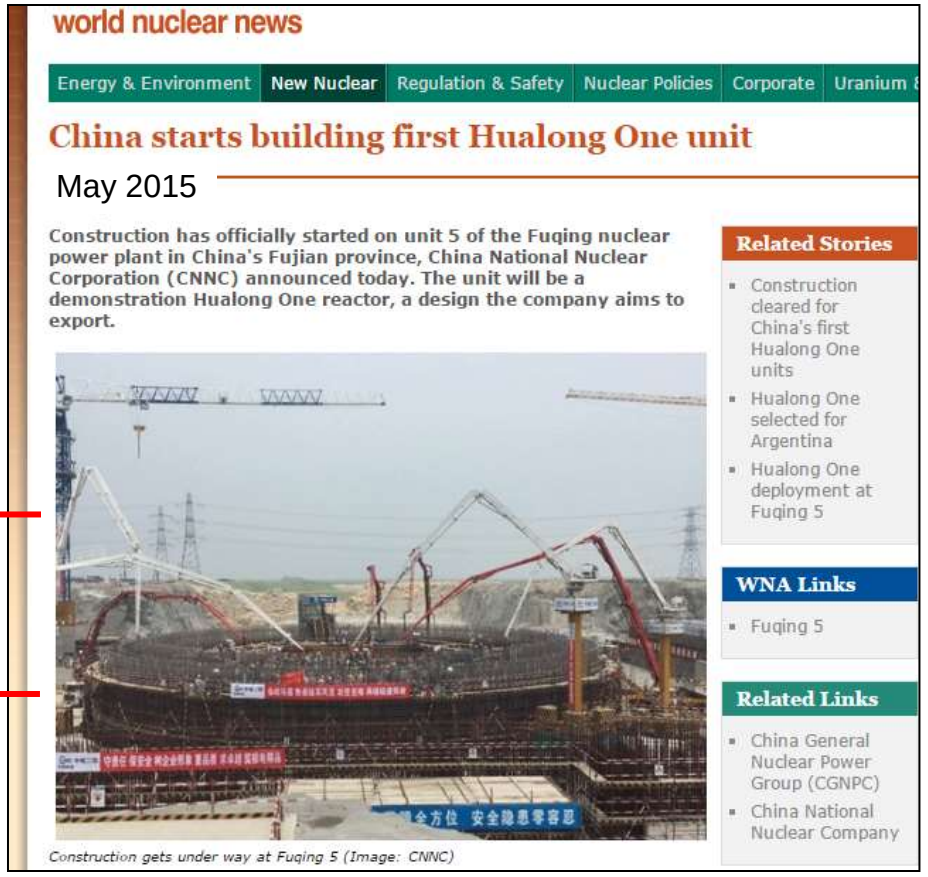
Britain: Near-term export market– who wins?

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

BBC

UK: Go-ahead for 10 nuclear stations





Financing Models Vary; Sovereigns Dominate

	LOW GROWTH, OECD Economies	HIGH GROWTH, Developing Economies
Nat'l Govt Lead	F1) Sovereign Financing for replacement reactors (OECD) -- incentives for GHG savings	F2) Sovereign Financing for high growth urbanization [National Utility ownership]
	E) French Exeltium model -- Industrial User Consortium -- Sovereign EPC / Vendor [EDF]	G) Nat'l Vendor EQUITY for Export [Rosatom, China Nuclear, EDF] -- with Export Credit Agencies -- TRI-LATERAL Gov't deal
Private Industry Lead	B) Nordic Consortia model Customer consortium with off-take. Owners = Off-takers	C) Industry Team bid overseas with Export Credit Agencies (ECA)
	A) Corporate balance sheet [US, Japan utility model.]	D) Project financing with Gov't support [Tax subsidies, Gov't loans, Feed-in-tariffs]

www.world-nuclear-news.org/V-Innovative-ways-of-funding-nuclear-power-projects-18021601.html

Nuclear Sales and Finance… with Sovereigns

Nuclear power is uniquely MORE regulated by Gov'ts

Increasingly…

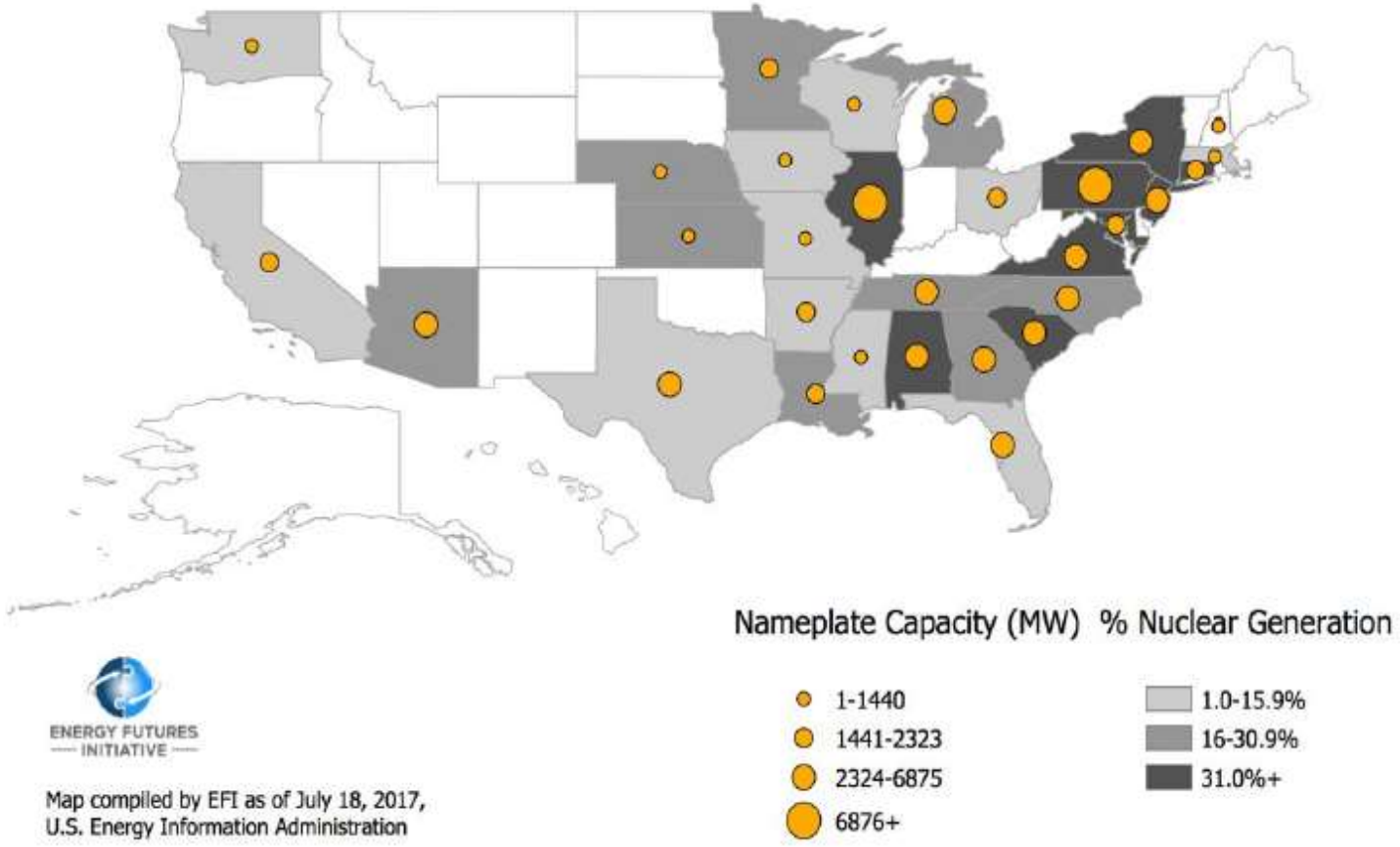
- The reactor CUSTOMER will be a **Sovereign Gov't**
- Projects will involve or be led by **Sovereign Suppliers**
- FINANCING will be arranged with **Sovereign Sources**
- FUEL will be managed with **Sovereign Entities**
- Electric RATES will be set by negotiation with **Gov't…** and likewise transmission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

There will never be a "level playing field" with nuclear. Sovereign Govts do NOT just "leave nuclear to the market".

US Reactor Capacity by State, 2017

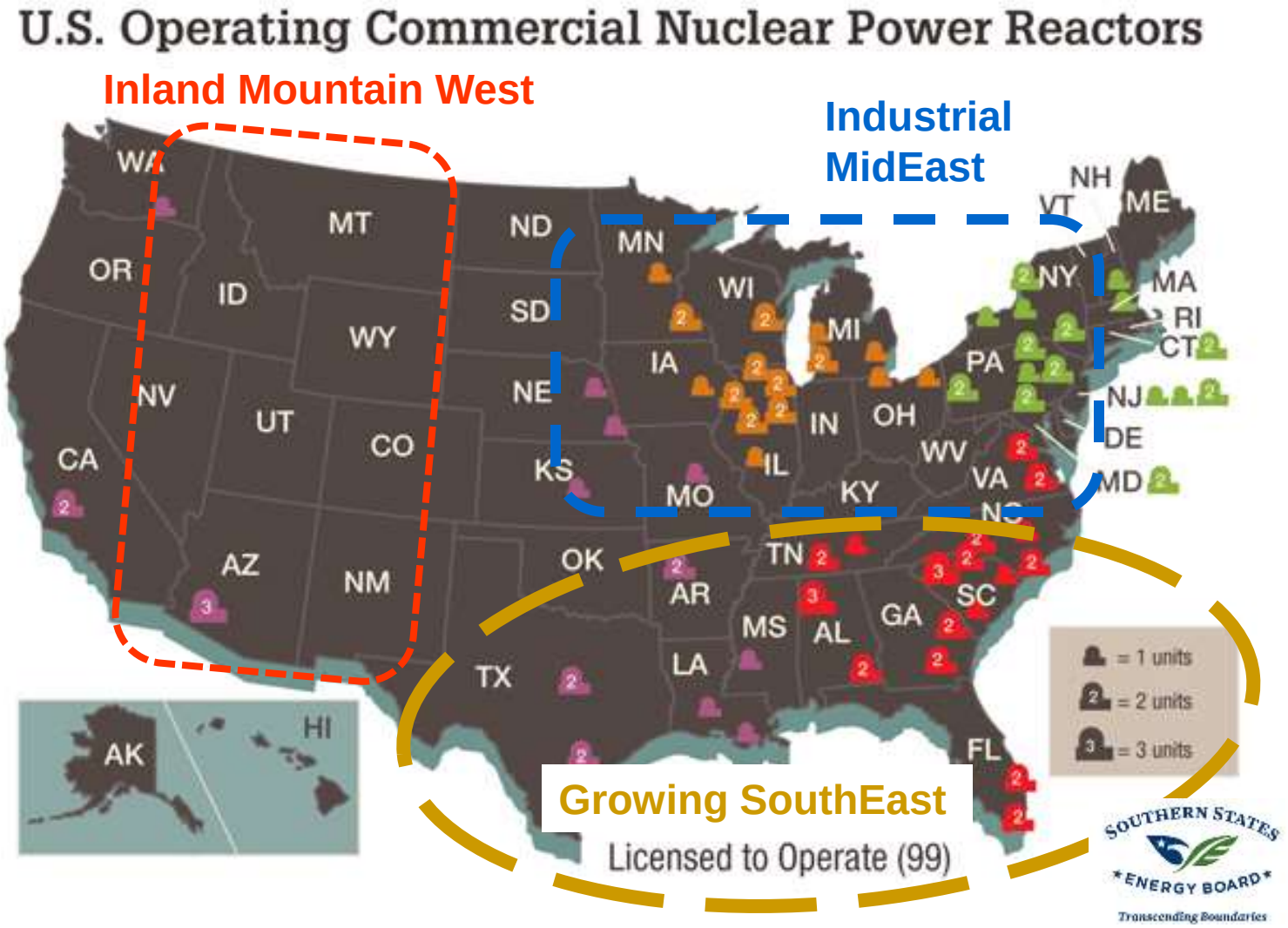
Figure 13. Active Commercial Nuclear Reactors and Generation by State, 2017

Most of US nuclear capacity is East of the Mississippi River near cities.



https://energyfuturesinitiative.org/news/2017/8/15/efi-releases-nuclear-energy-enterprise-study

NRC: US Operating Reactors, 2015



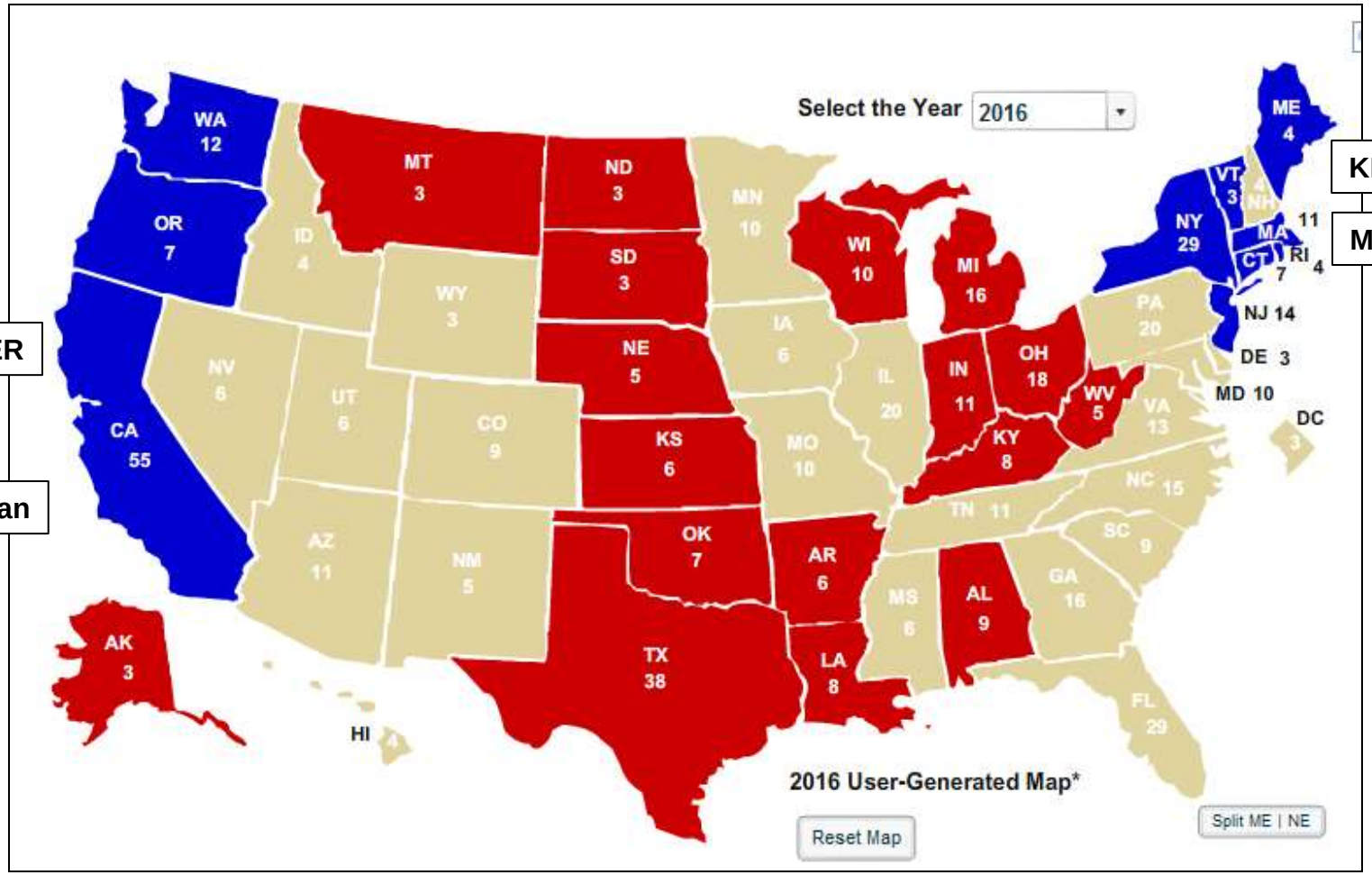
US Regions: Population and Growth

Million KWhs/Day	2000	2008	2016	Change	Change
SATL (MD, VA, WV, NC, SC, GA, FL)	797	942	974	177	22.2%
ESC (AL, MS, TN, KY)	289	328	328	39	13.5%
WSC (TX, OK, AR, LA)	489	536	593	104	21.3%
Subtotal: Southeast	1,575	1,806	**1,895**	**320**	20.3%
ENC (OH, IN, IL, MI, WI)	453	520	513	60	13.2%
WNC (IA, MN, MO, NB, ND, SD, KS)	240	283	291	51	21.3%
MidATL (NY, NJ, PA)	308	361	362	54	17.5%
Subtotal: Industrial MidEast	1,001	1,164	**1,166**	**165**	16.5%
Subtotal: Inland Mountain West (CO, WY, MT, NM, AZ, UT, NV, ID)	200	257	**268**	**68**	34.0%

https://dubsism.wordpress.com/2012/11/20/your-updated-ncaa-conference-re-alignment-risk-map/

USA Divided on Clean Power Plan…

Blue states sued EPA to regulate GHGs. **Red** (fossil) states sued EPA to roll it back.



KERRY

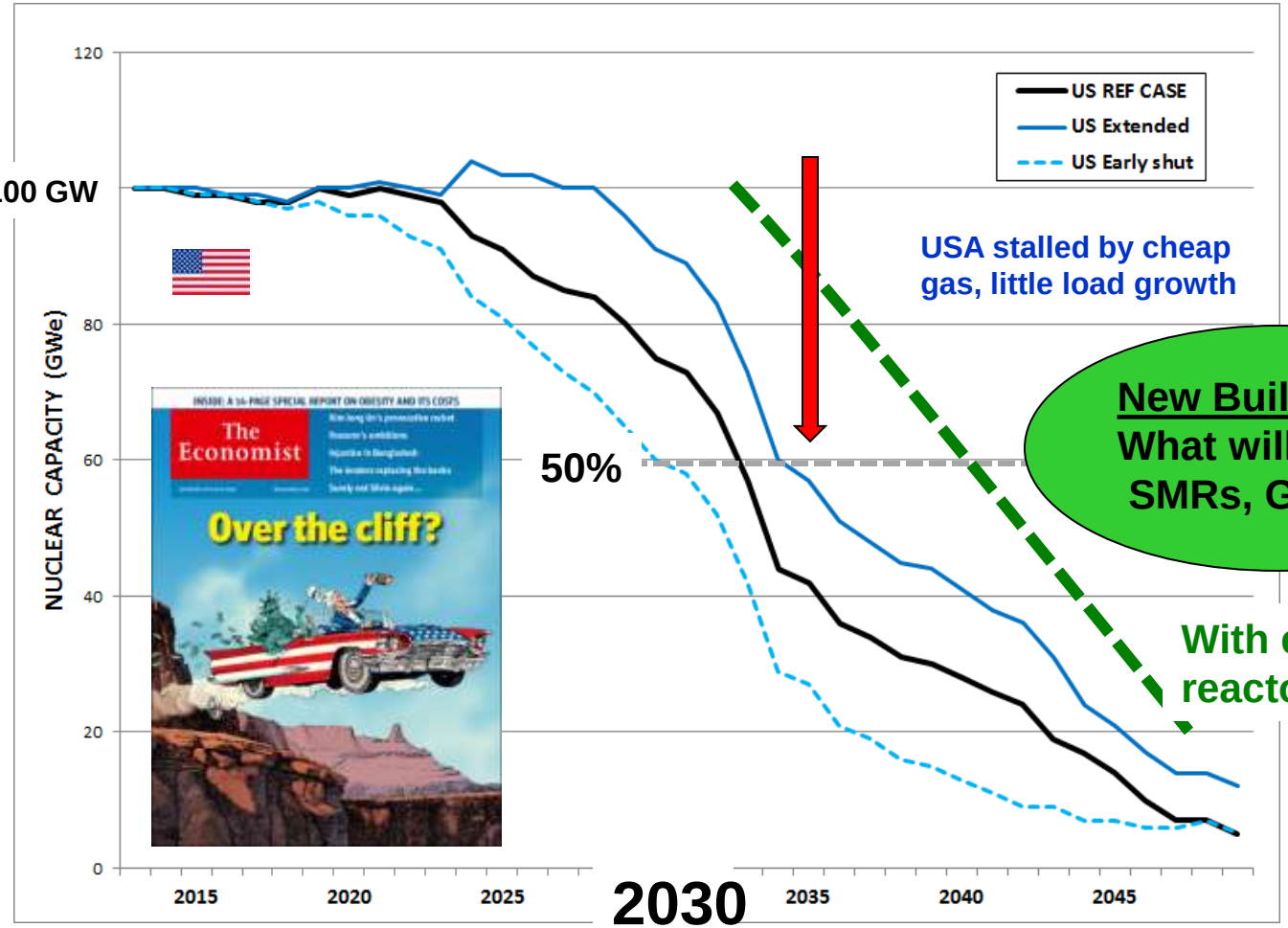
Markey

BOXER

Waxman

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.

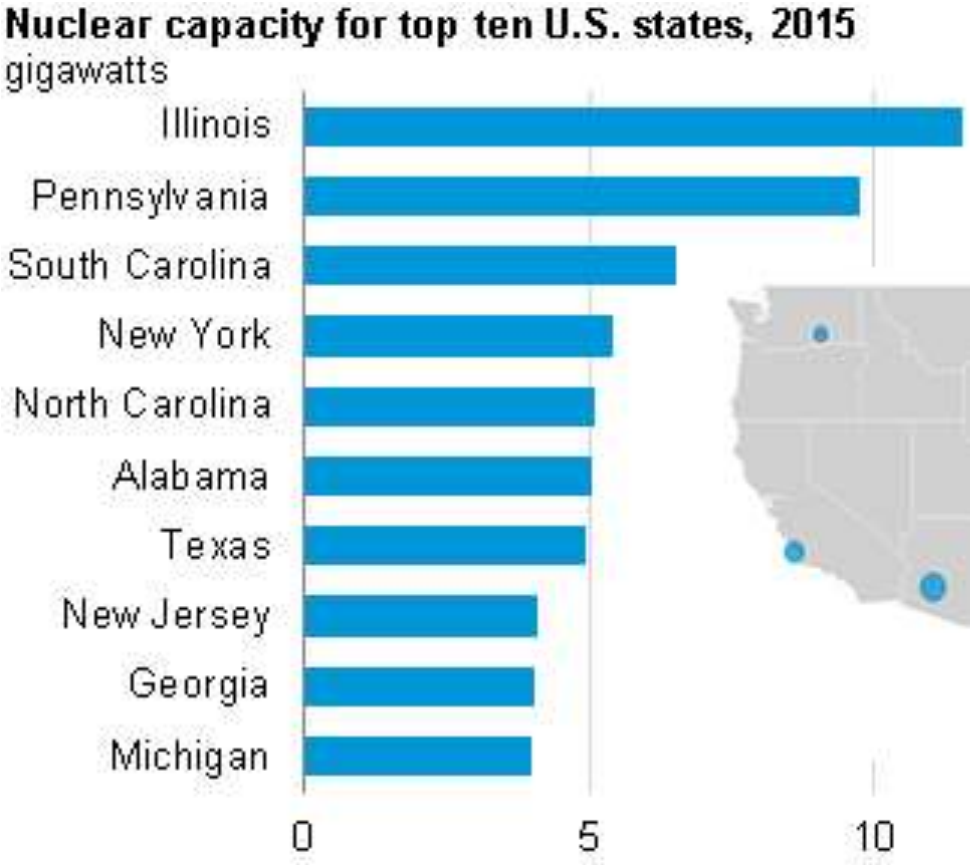


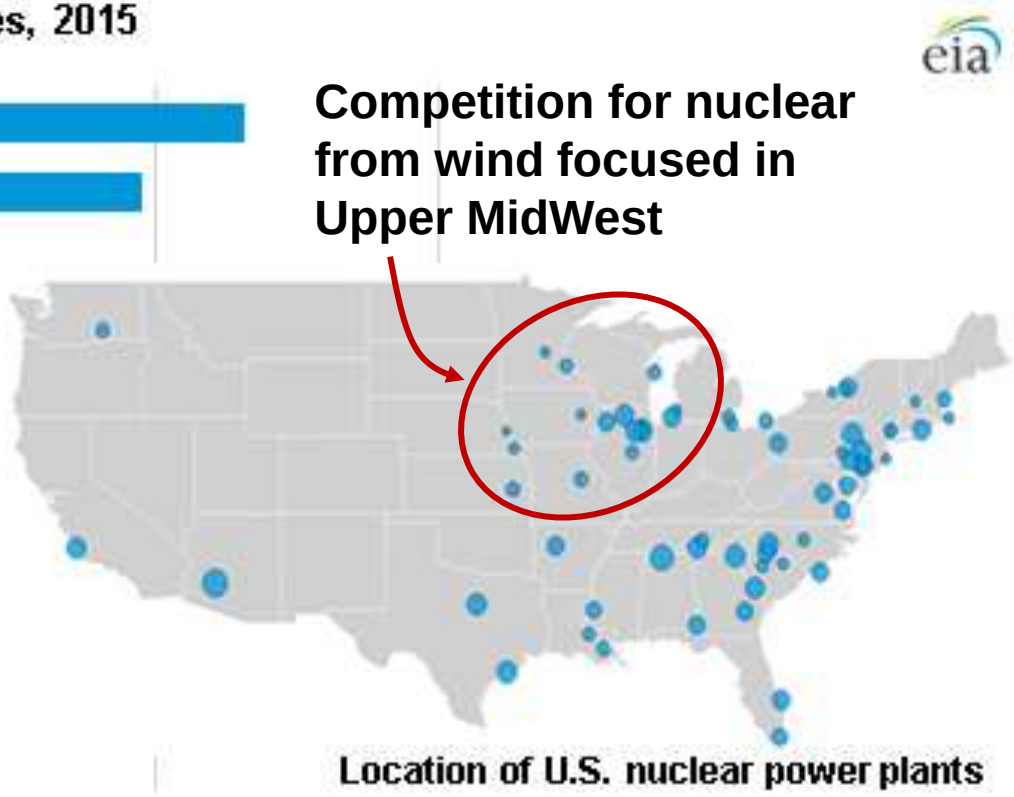
Sources: IAEA, WNA 2012

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

US Strategy…? Regional Differences are Severe

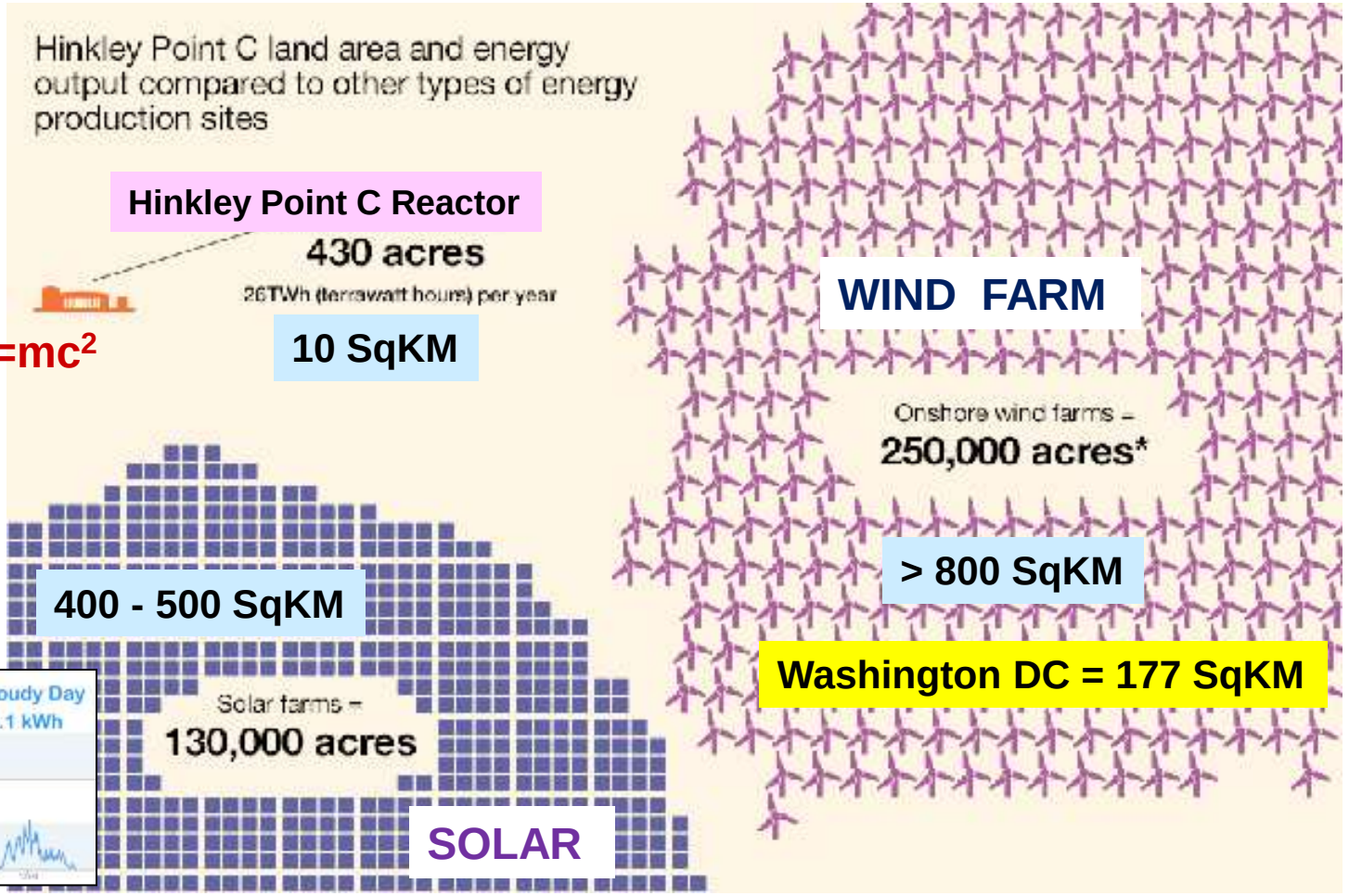
Large regional disparity in impact of Nuclear Power hinders a National Strategy politically.





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.



Large Reactors: Multi-$billion cost overruns…

Toshiba's Record Fall Highlights Nuclear Cost Nightmare

Bloomberg Technology

by **Mark Chediak**

December 27, 2016, 1:30 PM EST *Updated on* December 28, 2016, 2:21 AM EST

Time to shift to GenIV

Bigger… is no longer better?

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.

Flamanville fiasco: The story of France's nuclear calamity

Feb. 2017

The construction site at Flamanville in northern France. Will it ever be completed? Photo: Charly Triballeau

Sen. Alexander, 2015: "A USA without Nuclear Power" ?

PRESS RELEASE, Feb. 5, 2015

NEI: Sen. Alexander's Nuclear Energy Push Comes at Important Time

http://globenewswire.com/news-release/2015/02/05/703643/10118895/en/Sen-Alexander-s-Nuclear-Energy-Push-Comes-at-Perfect-Time-NEI-Says.html

WASHINGTON, DC (GLOBE NEWSWIRE) -- Sen. Lamar Alexander (R-Tenn.), chairman of the Senate Appropriations Subcommittee on Energy and Water Development, made a major energy policy speech today at the Nuclear Energy Institute. Painting a grim picture of "The US Without Nuclear Power," Alexander outlined policy prescriptions to keep nuclear energy a vital element of a diverse U.S. energy portfolio.

Transcript of Alexander's Speech: **"The United States without Nuclear Power"**

www.nei.org/News-Media/Speeches/Sen-Lamar-Alexander,-%E2%80%9CThe-United-States-Without-Nu

"We're about to take a year-long look at all this. Our subcommittee will begin expanded oversight with budget hearings in February and March, and then in April we'll turn toward a series of hearings about the future of nuclear power in our country – and what it would be like for the US to be without it.

POLICY DISCUSSION

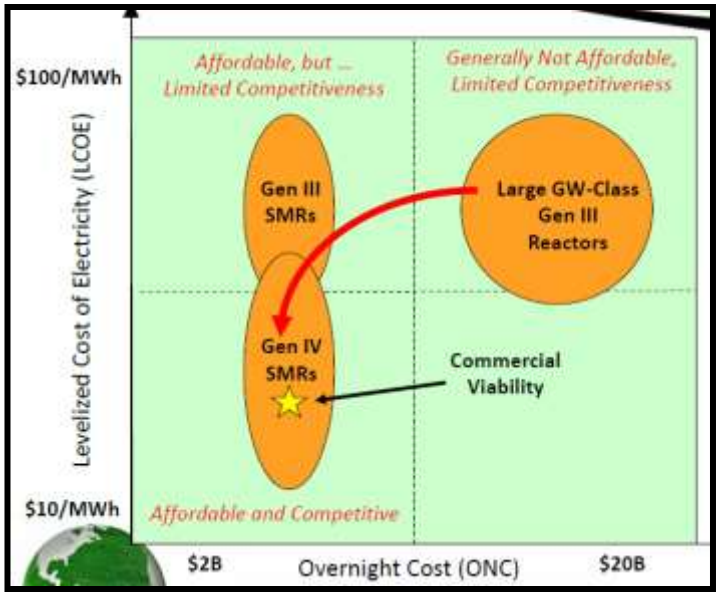
1) **Build more nuclear reactors – "I have proposed that we build 100 new reactors."**
2) Solve the nuclear waste stalemate – "Yucca Mountain can and should be part of the solution."
3) Relieve the burdens of excessive regulation – "make sure it's not an undue burden."
4) Tax reform to balance the portfolio – Renewable sources cannot be the only low emissions sources.
5) Double energy R&D – "Important technological advances involve some government-sponsored R&D."
6) Encourage energy diversity – "We need more than one way of producing reliable, base-load power."

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.

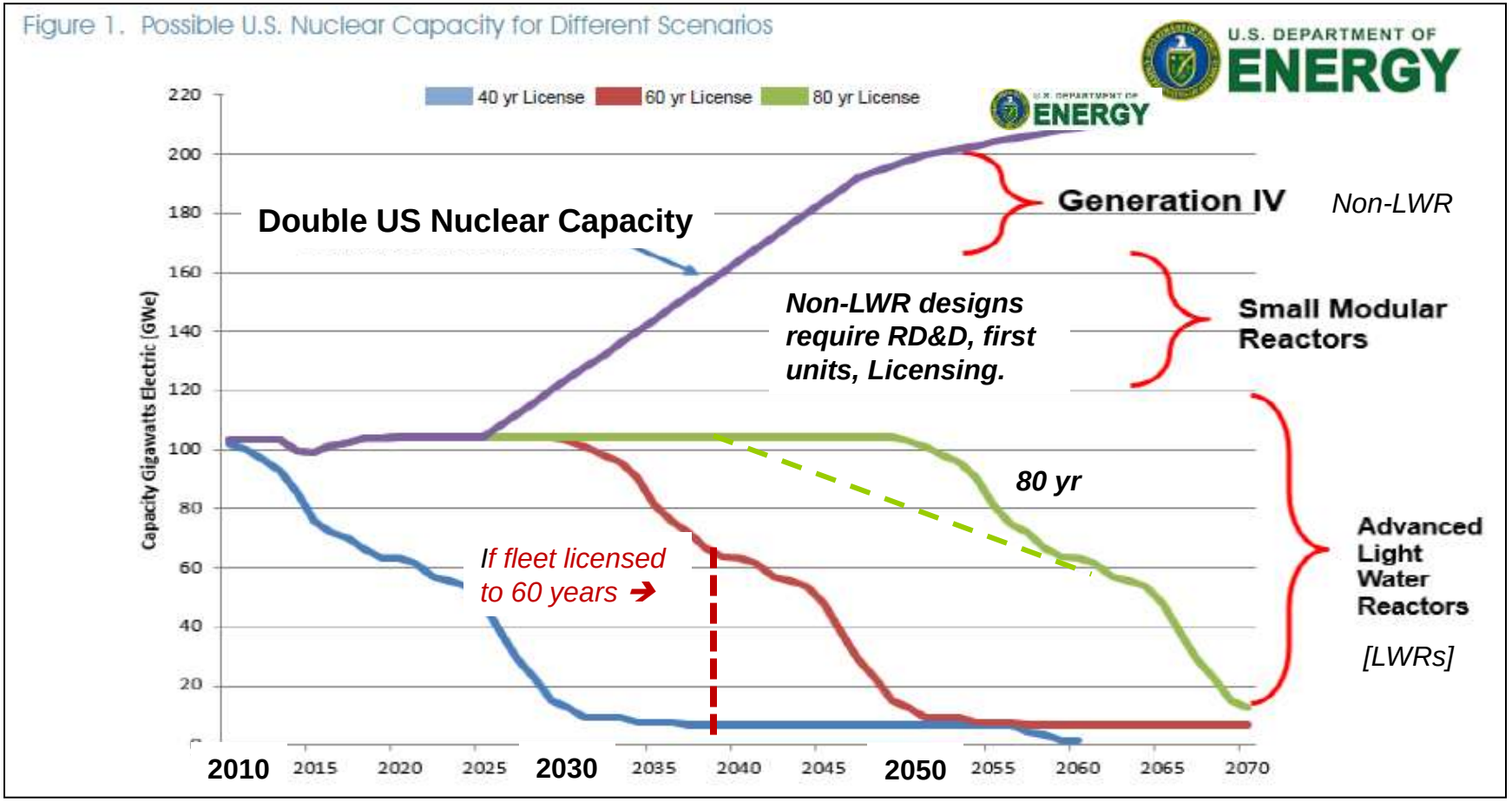


http://globalnexusinitiative.org/wp-content/uploads/2016/10/GNI_Policy_Memo_2.pdf

GNI forums: Chris Mowery, Feb. 2015

US Nuclear Capacity – SCENARIOS (Jan 2017)

Vision and Strategy for Development and Deployment of Advanced Reactors



www.energy.gov/ne/downloads/vision-and-strategy-development-and-deployment-advanced-reactors

China and Russia will not wait for USA

GIF and Gen IV: Time to pick up the pace

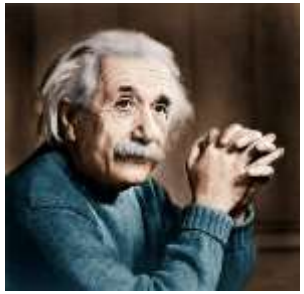
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

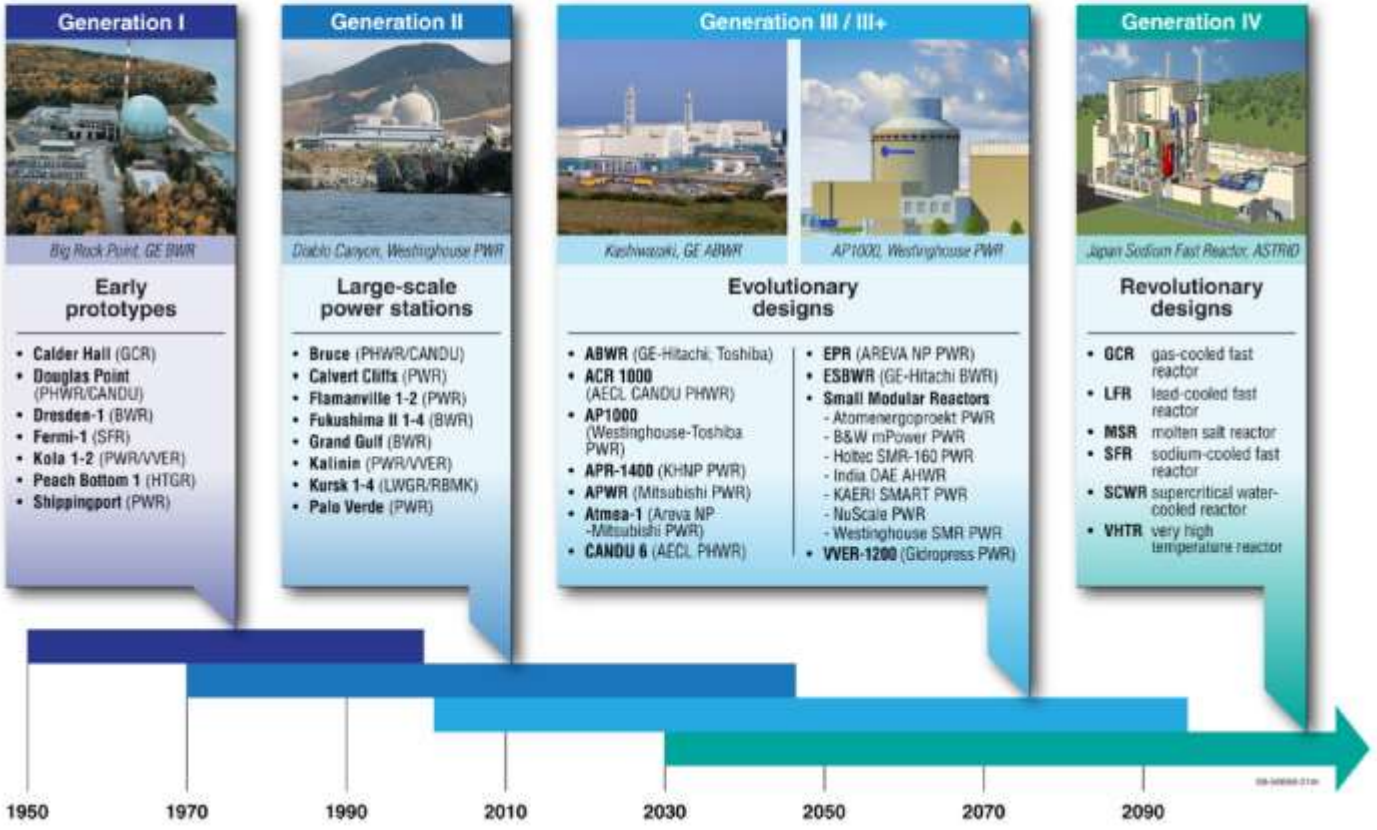
Generation IV International Forum

AMERICAN BRAND?

* Innovation
* Security & Safety
* Backed by US Govt
* "It works !"
* Public support
* Features, choices
  - Better waste mgmt
  - Less water use
  - Industrial heat

* Positive economics
  [Best value, not just cheapest product]





http://local.ans.org/trinity/files/kelly-130821.pdf

Mega-Cities need Millions of Clean Reliable MWHrs

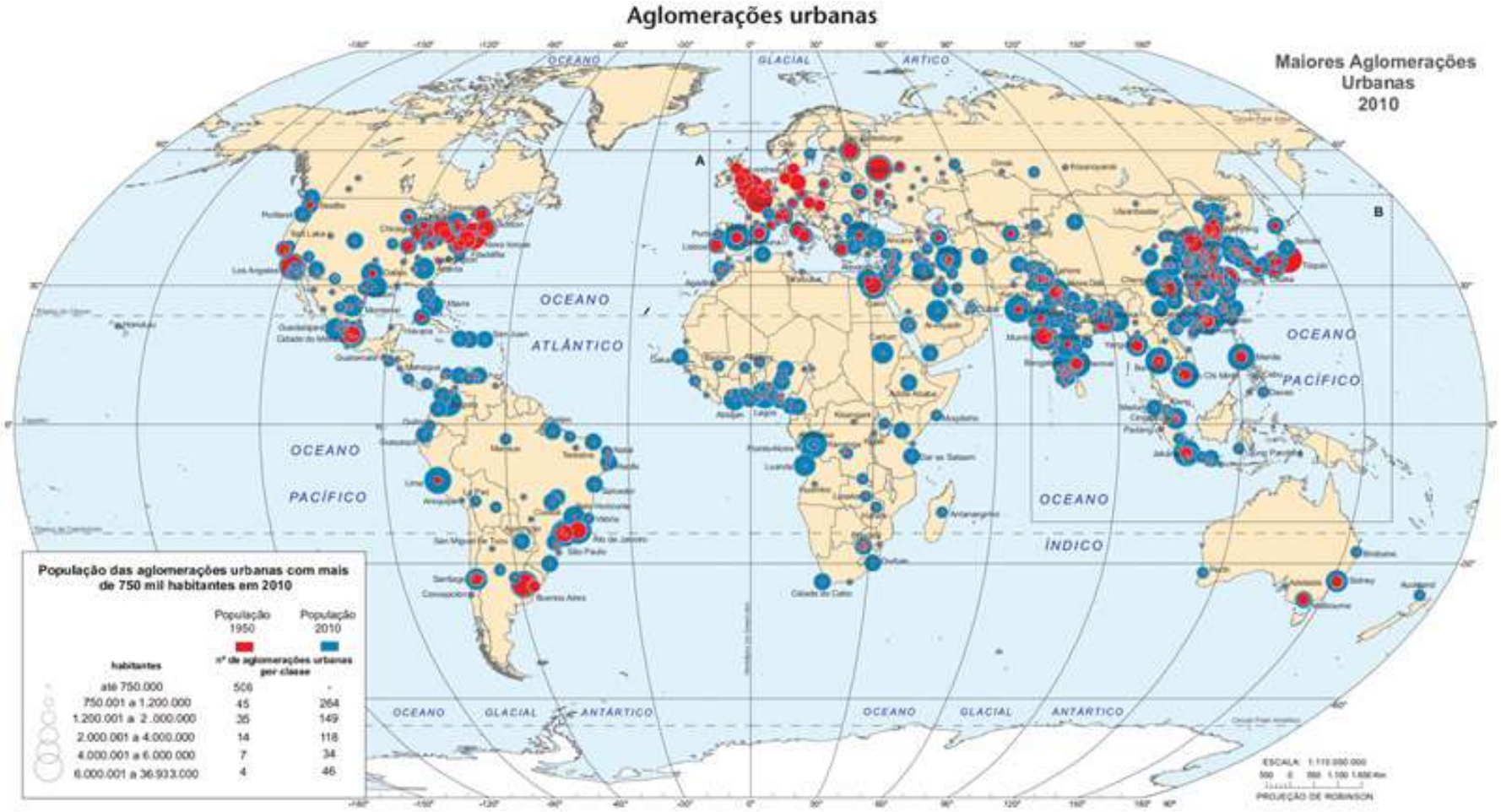
http://topxbestlist.com/largest-cities/

Curbing emissions is a big priority for Global Mayors

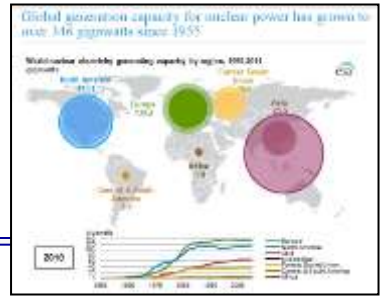
www.globalcovenantofmayors.org/

The Nuclear Sales map for the 21st Century?

Major Urban Areas: 1950(red) vs 2010(blue)



SUMMARY: Global Competitive Landscape

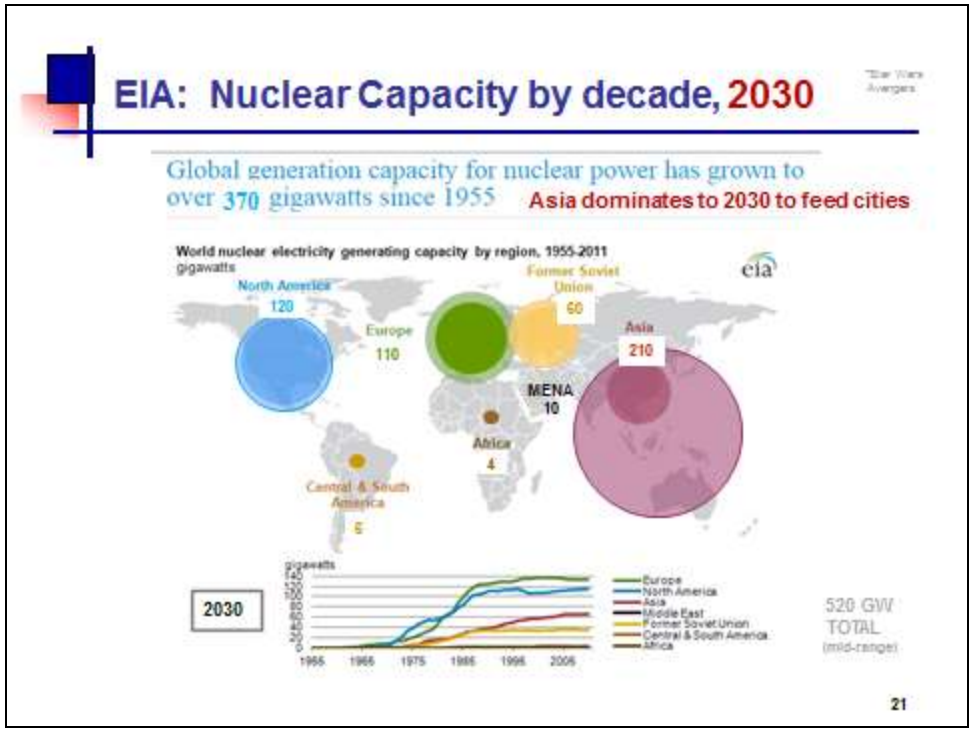


- **Most of the next wave of NEW build is overseas**
- **Several Nuclear Financing Models vie for primacy**
- **Sovereign Finance Models dominate outside USA**
- **USA Private Utility model is the *exception***
- **Cost is a major factor, but Key Risks are critical**
- **Strategic Sovereign interests 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***

QUESTIONS – DISCUSSION

"The fact is that when it comes to nuclear power we have fallen behind in pioneering the next generation. We operate the current fleet very well, but there is no clear direction coming from the federal government (Administration or Congress). We will end up as a buyer rather than a builder. The leaders are China, Russia, France, Japan, South Korea and India."

Physics Nobel Laureate Dr. Burton Richter, 9 July 2013 – Senate Forum on Nuclear Power



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http://ebionline.org/updates/2320-nuclear-energy-remains-vital-to-urban-energy-reliability

PhD student at GMU, entered Fall 2015

BIO: Andrew D. Paterson

Dept of Energy Policy Office (1997-2007)
GMU Master's in Public Policy, graduated 2015.
Scholar of the Year in the GMU Masters in Public Policy program 2013.
Admitted for PhD at GMU in Public Policy, starting Fall 2015.
Stanford University, B.A. Human Biology / Economics, 1979

Principal - Energy, Environmental Business International (www.ebionline.org)

Andrew Paterson, brings more than 30 years' experience in the energy and environmental sectors. For EBI and its financing affiliate, Verdigris Capital LLC, he advises a variety of clients and agencies on public sector and project finance. Previously he served as a Director for Econergy, a clean energy project finance group, where he managed consulting engagements on a variety of projects for energy, environmental and power sector clients, and for US EPA. During his tenure in the Policy Office of the Dept. of Energy (1997-2007) he worked as a financial adviser on structuring federal energy policy and programs, and as the lead commercial market analyst for a number of sector studies with DOE, including the "Business Case for New Nuclear Power Plants" (2001-02)

He earned a Bachelor's degree from Stanford University in Human Biology and Environmental Policy and attended the Cornell Graduate School of Business with PriceWaterhouse. He speaks on energy trends and environmental topics to a number of trade associations regularly, and co-founded the CCS Alliance in 2008.

He completed his Master's in Public Policy at GMU in May 2015, and was awarded Scholar of the Year in 2013.

In 2013 he was granted a visiting Senior Fellowship at the Atlantic Council for their Energy & Environment Program. His policy brief on "*Policy and Market Factors for National Nuclear Energy Strategies*" was selected for presentation at the World Nuclear Symposium 2012 in London, the World Energy Congress in 2013 (Seoul S.Korea), and at the Global Leaders Forum 2014 in Seoul. He has contributed in-depth to Environmental Business Journal since its founding in 1990, and presents each year at the Environmental Industry Summit.

http://www.atlanticcouncil.org/publications/reports/redefining-leadership-in-the-global-nuclear-energy-market

Appendix: Tax Incentives & Finance

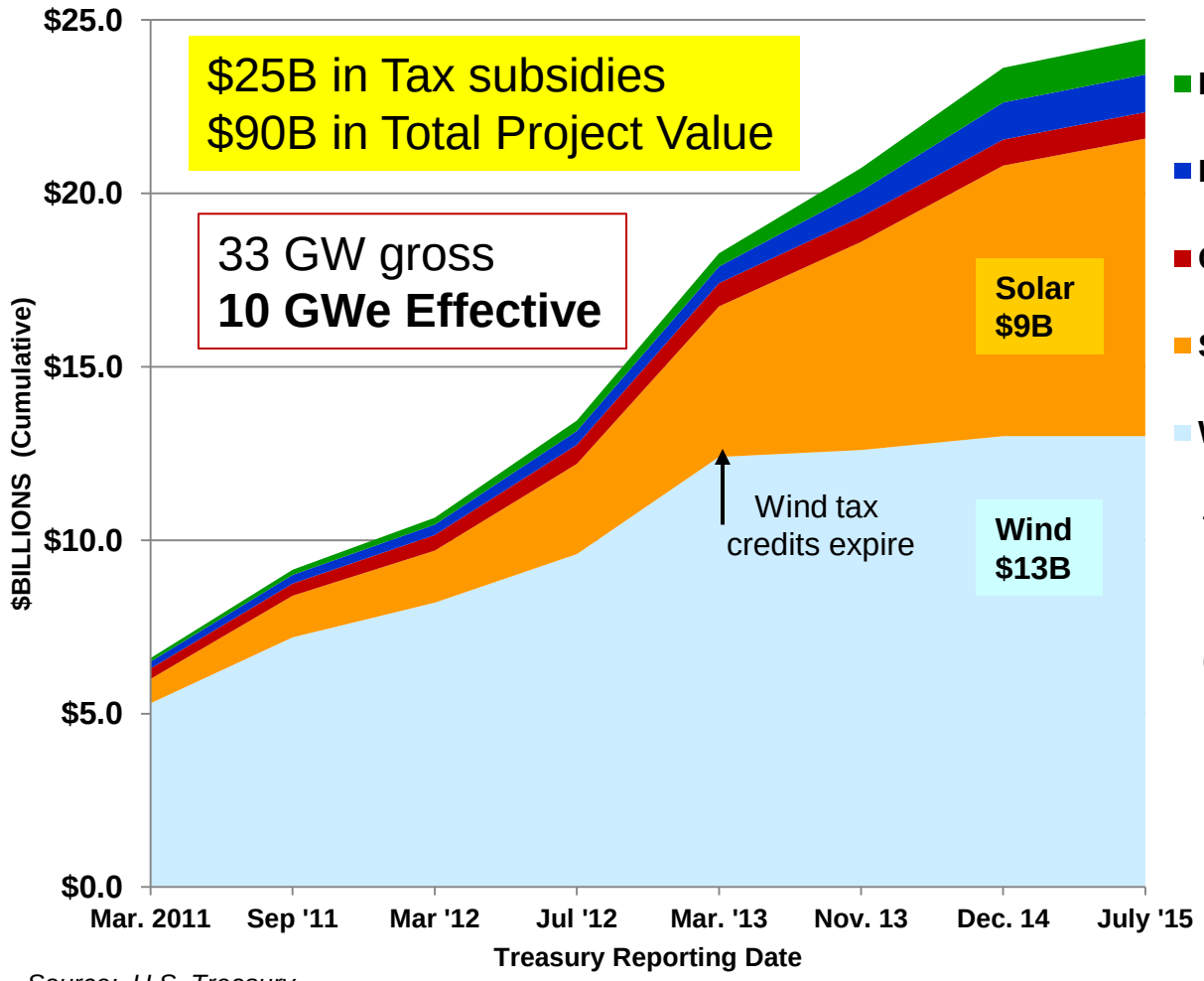
Treasury Grants for Energy, a $25B Experiment

- 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]

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)



	GW	%
Biomass	1.30	4%
Hydro,other	1.31	4%
Geo	0.76	2%
Solar	8.30	25%
Wind	21.63	65%

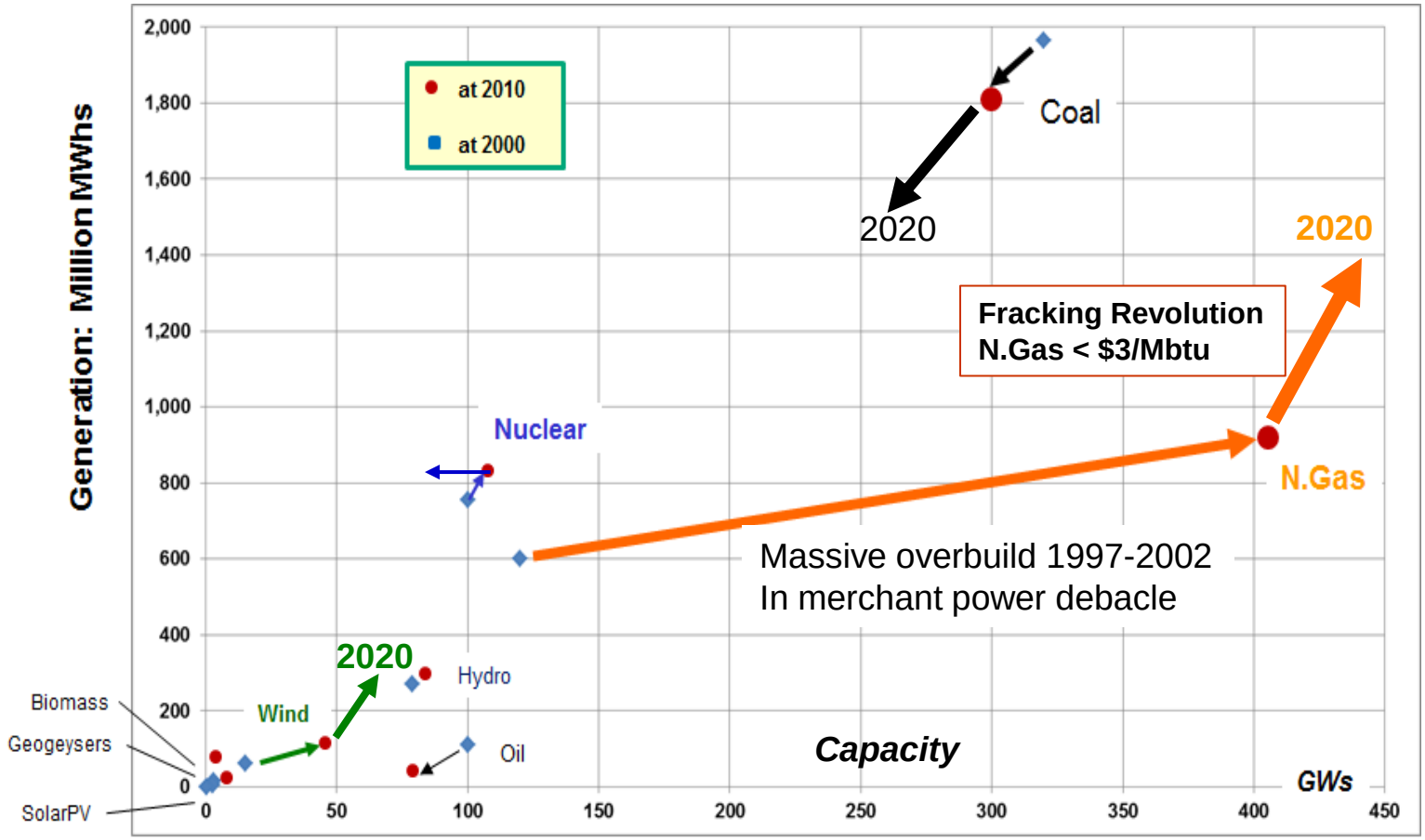
Total investment: $90.2B
($24.9B from 1603 grants)
For 10.2 GWe (net),
Or $8,900 per KWe.

Source: U.S. Treasury

http://www.treasury.gov/initiatives/recovery/Documents/STATUS%20OVERVIEW.pdf

U.S. Capacity & Generation: 2000 to 2010 to 2020

N.Gas capacity has expanded the most, some of it marginally used "peakers" from the over-build in the 1990s. Coal is sliding. Wind also expanded.

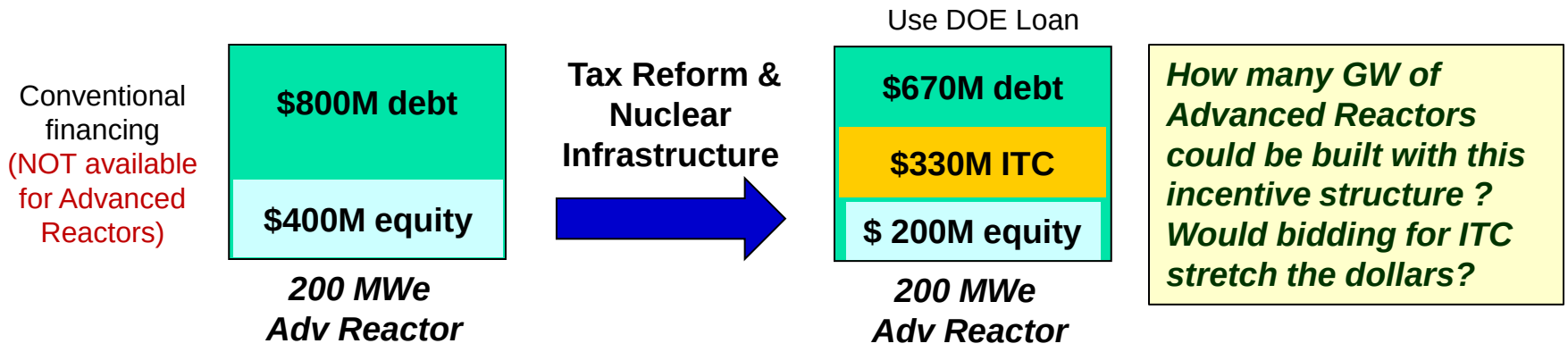


EIA: multiple reports

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]



The ASK

Policy Approaches / 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. $E = mc^2$***

Unicorn grazing on a "level playing field"

- **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 (?)**