NUCLEAR ENERGY ADVISORY COUNCIL
June 17, 2021 6 PM
Regular Virtual Meeting

MINUTES

Members Present
Rep Kevin Ryan, Chair
Alternate Chair Mr. Jeffrey Semancik representing DEEP Commissioner Dykes
Mr. Craig Salonia Mr. James Sherrard
Mr. R. Woolrich Mr. Bill Sheehan

Members not present:
Mr. A. Jordan

1. **Call to Order of Meeting**
   Council Chair Ryan called the meeting to order at 6:03 PM via webinar/telephone conference.

2. **NEAC Business**
   a. **Approval of Minutes of the March 18, 2021 NEAC meeting.**
      A motion was made to approve the minutes by Mr. Sheehan and seconded by Mr. Woolrich. Minutes were approved with no corrections with no objections.

   b. **NRC Correspondence Reviewed since past meeting.**
      The list of NRC Correspondence was reviewed. One comment from NEAC was related to NRC environmental qualification inspection.
      i. Millstone Power Station, Unit No. 3 - Individual Notice Of Consideration of Issuance of Amendment to Renewed Facility Operating License, Proposed No Significant Hazards Consideration Determination, Opportunity to Request a Hearing, and Order Imposing Procedures for Document Access to Sensitive Unclassified Non-Safeguards Information (EPID L-2020-LLS-0002) dated March 26, 2021.
      ii. Millstone Power Station, Unit No. 2 – Review of the Spring 2017 Steam Generator Tube Inspection Report (EPID L-2021-LRO-0006) dated April 27, 2021.
      iii. Millstone Power Station, Units 2 and 3 – Integrated Inspection Report 05000336/2021001 and 05000423/2021001 dated April 29, 2021.

c. **Other Correspondence Reviewed**
    i. UCS-RP-AR-3.21, "Advanced" Isn't Always Better Assessing the Safety, Security, and Environmental Impacts of Non-Light-Water Nuclear Reactors, Union of Concerned Scientists (Lyman) dated March 2021
d. **Council membership** – Rep Ryan discussed his efforts to get appointments for vacancies on the Council. Rep Ryan was re-appointment by the Speaker of the House of Representatives vice his previous appointment from the Majority leader of the Senate. He has provided a second candidate to Speaker Ritter for consideration, but ahs not been able to secure other.

3. **Program** – Briefing by Dr. Todd Allen, faculty member and chair of the Nuclear Engineering & Radiological Sciences Department at the University of Michigan and a senior fellow at Third Way, a DC-based think tank, supporting their clean energy portfolio, on Developments with Advanced Reactors (Dr. Allen's Bio and Meeting Presentation attached) Dr. Allen discussed:
    a. Background on the current drivers to increased interest in advanced nuclear reactors including:
        i. Emissions Imperative – Climate change concerns have increased focus on reducing carbon emissions especially in transitioning from coal to carbon free sources including renewables, carbon capture and nuclear. Recently several environmental Non-Government Organizations (NGOs) and young people are looking towards nuclear to help solve the climate crisis.
            1. Nature Conservancy and MacArthur Foundation both support
            2. Google looking to use for data centers
            3. States incenting existing nuclear to continue to operate or putting new nuclear on grid
        ii. Revenue Imperative – as more countries look to use nuclear power, there is potential for over $1 trillion in overseas commerce
        iii. Security Imperative – In the past (first generation of nuclear power plants), the US had control over who got the technology. New reactor technologies are being marketed by Russia, China, France and the South Koreans. In fact, 2/3 of all nuclear power plants under construction are Chinese or Russian design. In order to ensure plants around the world are safe and not used for development of nuclear weapons, we want them built to US standards.
        iv. Resilience Imperative – in order to ensue reliability of the US electric grid, nuclear power is needed to ensure we are not over-reliant on any single fuel source or intermittent fuel sources.
        v. Social Imperative – Need to change the narrative to improve acceptance.
    b. Insights on what has changed in recent years with respect to nuclear.

i. Expanded product from electricity only to needed for process heat for industries such as petrochemical and hydrogen production. Existing Arizona and Minnesota nuclear plants have entered into studies with Department of Energy (DOE) to produce hydrogen. Since this heat often requires temperatures in excess of light water reactor (LWR) steam, advanced reactors being considered.
ii. Changes in business model. In the past, nuclear industry has relied on government to develop and test reactors then hand the design over to the industry. We are now seeing a new type of nuclear product being developed by entrepreneurial companies in commercial competition with each other.
iii. Private-Public Partnership: Government incentives focused on helping commercial companies deploy new reactors.
    1. Gateway for Accelerated Innovation in Nuclear (GAIN) – DOE program to make government research facilities available to support commercial companies
    2. Nuclear Energy Innovation and Modernization Act (NEIMA) and Nuclear Energy Innovation Capabilities Act (NEICA) – legislation requiring modernization of licensing and supporting commercial industries with access to national laboratories.
        a. Nuclear Regulatory Commission (NRC) is actively doing work to regulate new reactors (non-LWRs) in a more efficient manner to reduce regulatory burden.

c. Broad Classes of New Reactors
    i. Small Modular Reactors (SMRs)
        1. Water cooled but less than 300 MWe.
        2. Business model
            a. Modular design up to 12 modules at one sight
            b. Start selling power when first module completed
            c. Reduced financial and construction risk and cost of loans
            d. Only have to shutdown one module for refueling and maintenance vice the entire site
            e. Take advantages of learning curves during construction to reduce cost of each module
            f. Allow the station to load follow
            g. Small emergency planning zones (site boundary) since each module has a smaller source term (less radioactive material)
    ii. MicroReactors
        1. 1 to 20 MWe
        2. Higher cost but useful for remote areas or military use
        3. Higher price point but cheaper and more reliable than imperoting diesel fuel

4. Being considered for serer farms
5. mobile

4. **Questions from the Council**
    a. Mr. Sheehan asked what fuels are being considered for new advanced reactors and what is the state of testing and development. Dr. Allen responded that advanced reactors designers are using several fuel types including
        i. LWR fuel – idea is that using same fuel as existing fleet of nuclear power plants will improve deployment time for LWR SMRs
        ii. TRISO (TRi-structural ISOtropic particle) fuel – mm sized fuel particles surrounded by SiC and graphite formed into either pebbles or cylindrical form. The idea is that this moves the containment to the fuel particle to contain fission products. An advantage is that it produces a lower power density so it can't easily be melted but this also requires a larger reactor. TRISO fuel has been tested in gas cooled reactors in both US and Germany. DOE ran decades-long test program. TRISO is ready for commercialization.
        iii. Metallic Fuel – cylindrical fuel in metal cladding. It has a lower melting temperature but much better thermal conductivity. The fuel and clad are typically bonded with sodium; so, it can't go directly to a repository and must be re-processed. There is enough DOE test data that some companies believe they can license it.
        iv. Liquid fuels – molten salt with nuclear fuel homogenously mixed throughout. This is more experimental with little data. The fuel is circulated along with the coolant; so, more issues with radiation levels, delayed neutrons and chemical reactions.
    b. Mr. Sheehan noted the Council had also reviewed a recent Union of Concerned Scientists (UCS) report on advanced nuclear reactors that had concerns with molten salt reactors (MSRs) and noted the US Navy had also determined that they were not viable. For MSRs, Dr. Allen noted that the DOE simulated an accident at their MSR where they turned off all reactor coolant pumps and the reactor shut itself down. Dr. Allen stated that in his experience with Ed Lyman (UCS author), he is a skeptic that doesn't always give credit for new designs.
    c. Mr. Sheehan asked if the US has the industrial base to support new reactor deployment. Dr. Allen conceded that this a current issue as the industry is overly reliant on foreign suppliers and this is complicated by US export controls. He believes that the industry and government will have to rebuild the supply chains as part of new deployments.
    d. Mr. Woolrich noted that science education, especially at high school and below has suffered and represents a barrier to understanding risks of nuclear. Dr. Allen noted that the students he talks with at the university are much more concerned with climate crisis than risks of nuclear. He also noted that University of California introduced a Nuclear Energy Boot Camp to teach nuclear technology

students about business with such topics as how to raise capital, finance and policy.

e. Mr. Woolrich asked if we have enough uranium to support new nuclear build. Dr. Allen responded that this is not an issue, but noted new advanced designs rely on a higher enrichment, up to 20% U-235. This is based on the standard tha <20% enrichment is not a proliferation risk. However, there are no current producers of this HALEU (High Assay Low Enriched Uranium), only downblends from defense programs. He believes that success fo these companies depends on our ability to make HALEU.
f. Mr. Woolrich asked what the security concerns would be for an SMR. Dr. Allen noted that they are about the same size as university test reactors that do not have emergency planning zones due to their reduced risks. He would expet similar controls – less than large LWR security forces. He noted some microreactor designs are claiming to be very mobile (truck transportable), but he thinks that is a social stretch to believe we would support that level of risk.
g. Mr. Woolrich asked about nuclear waste and what is the answer. Dr. Allen responded that some countries (Finland, Sweden) have solved this issues, there are siting processes that work better and we can safely store spent nuclear fuel until we develop a long term solution. He stated that he believes a consent based siting process is needed to get the US beyond opposition to Yucca Mountain.
h. Mr. Salonia noted that it would take an enormous number of windmills to meet our energy needs. Dr. Allen that 100% renewable would certainly be millions of windmills and that no one has yet built out renewables at scale. Mr. Semancik asked about hybrid nuclear with renewables. Dr. Allen responded that some companies such as Terrapower are proposing integrating their nuclear plants with renewables. In the case of Terrapower, they have designed an intermediate molten salt storage system that would be heated by the reactor and used to generate power when needed take advantage of wind and solar and mitigate the intermittence of those sources.
i. Mr. Semancik asked about transgenerational environmental justice – who gets the benefit and who takes the risks. Dr. Allen responded that climate change, not nuclear waste, is the biggest challenge to future generations who do not have a choice of what we do today.
j. Mr. Woolrich asked what Dr. Allen sees as the right amount of nuclear in the energy mix. Dr. Allen said he believes that we will see about 50% renewable and 20 to 40% nuclear. He also noted that he sees a trend of maximum local control of power that will be supported by SMR and microreactors.

5. **Public Comment.** There were no members of the public present.

6. **Adjournment**
   Motion was made by Mr. Sheehan and seconded by Mr. Sherrard to adjourn; no objections; unanimous vote in favor; meeting adjourned at 7:45 PM.

Dr. Todd Allen – Bio

Dr. Todd Allen is currently a faculty member and chair of the Nuclear Engineering & Radiological Sciences Department at the University of Michigan and a senior fellow at Third Way, a DC-based think tank, supporting their clean energy portfolio. He was the Deputy Director for Science and Technology at the Idaho National Laboratory from January 2013 through January 2016. Both the INL and Third Way positions occurred while on leave from the University of Wisconsin. Previously, he was a professor in the Engineering Physics Department at the University of Wisconsin, a position held from September 2003 through December 2018. In addition to his teaching and research responsibilities at Wisconsin, he was also the Scientific Director of the Advanced Test Reactor National Scientific User Facility, centered in Idaho Falls, Idaho, at the Idaho National Laboratory. He held that position from March 2008-December 2012. He was also the Director of the Center for Material Science of Nuclear Fuel, a Department of Energy-sponsored Energy Frontier Research Center. Prior to joining the faculty at the University of Wisconsin, he was a Nuclear Engineer at Argonne National Laboratory-West in Idaho Falls. His doctoral degree is in Nuclear Engineering from the University of Michigan (1997). Prior to graduate work, he was an officer in the United States Navy Nuclear Power Program.

21ST CENTURY NUCLEAR ENERGY

JUNE 2021, TODD ALLEN, PROFESSOR & SENIOR FELLOW

FASTEST PATH TO ZERO
UNIVERSITY OF MICHIGAN

WHAT DO WE WANT IN OUR FUTURE?

VS.

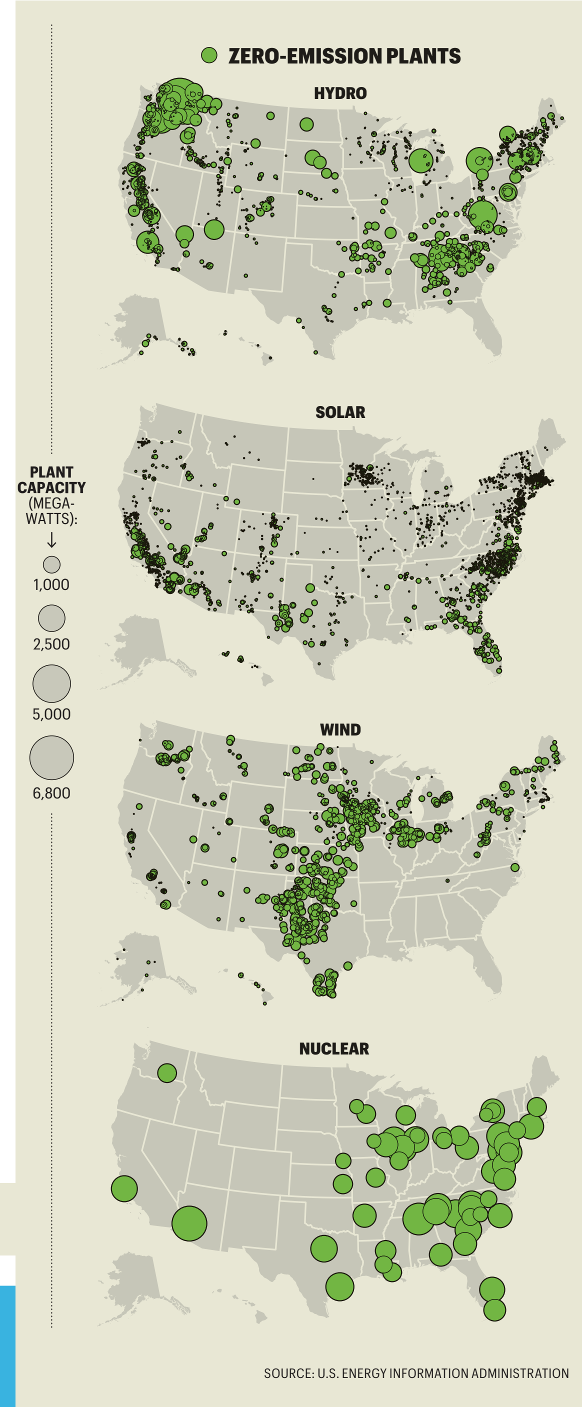
- Water purification
- Sanitation
- Irrigation
- Heating & air conditioning
- Vaccinations
- Pharmaceuticals
- Homes

- Clean
- Affordable
- Resilient
- Equitable

NUCLEAR ENERGY IS A BIG DEAL

~20% of US electricity

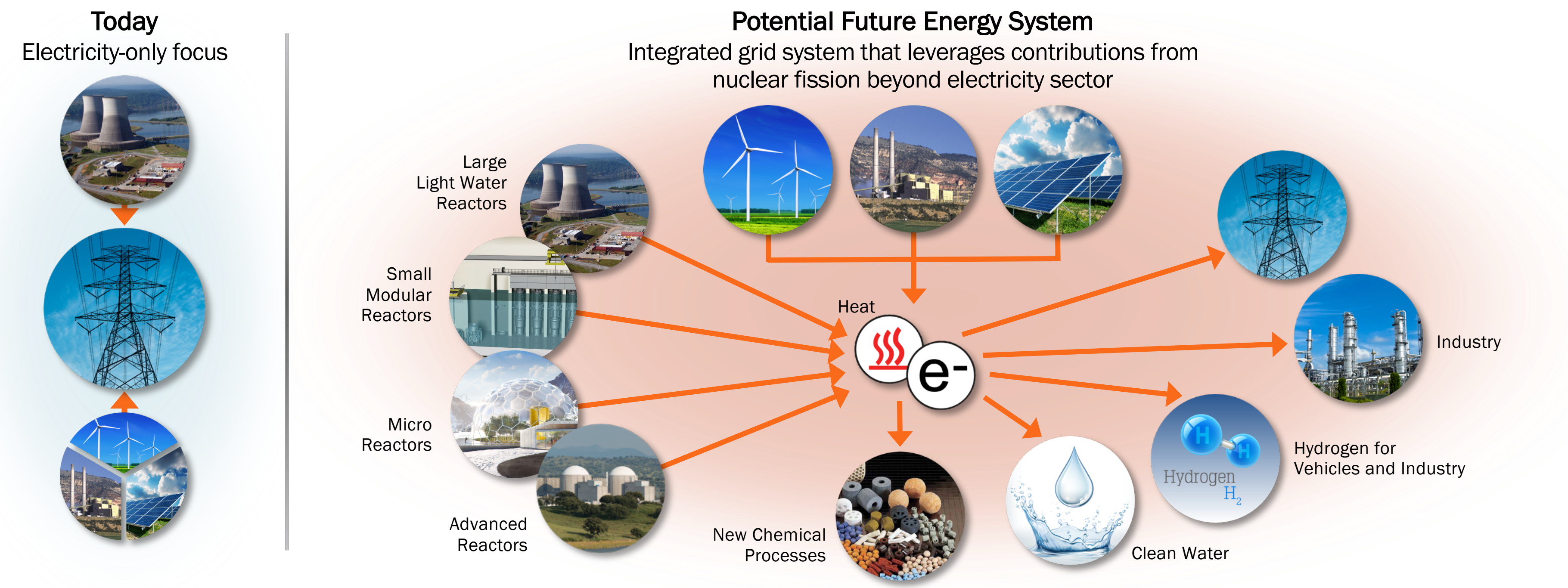
~55% of the carbon-free electricity



116 FORTUNE NOVEMBER 2020

ENERGY REIMAGINED

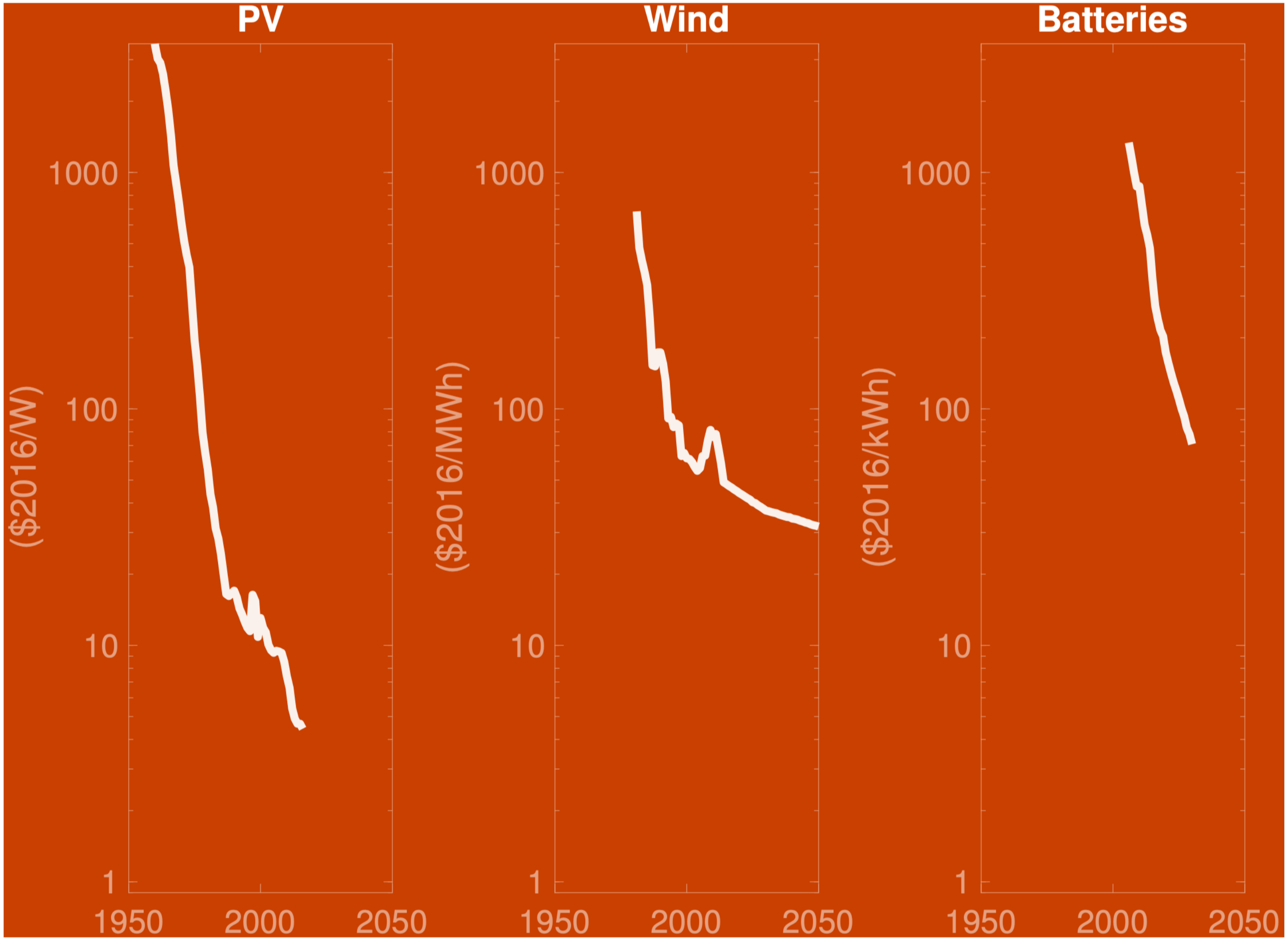
Maximizing energy utilization, generator profitability, and grid reliability and resilience through novel systems integration and process design



Flexible Generators ❖ Advanced Processes ❖ Revolutionary Design

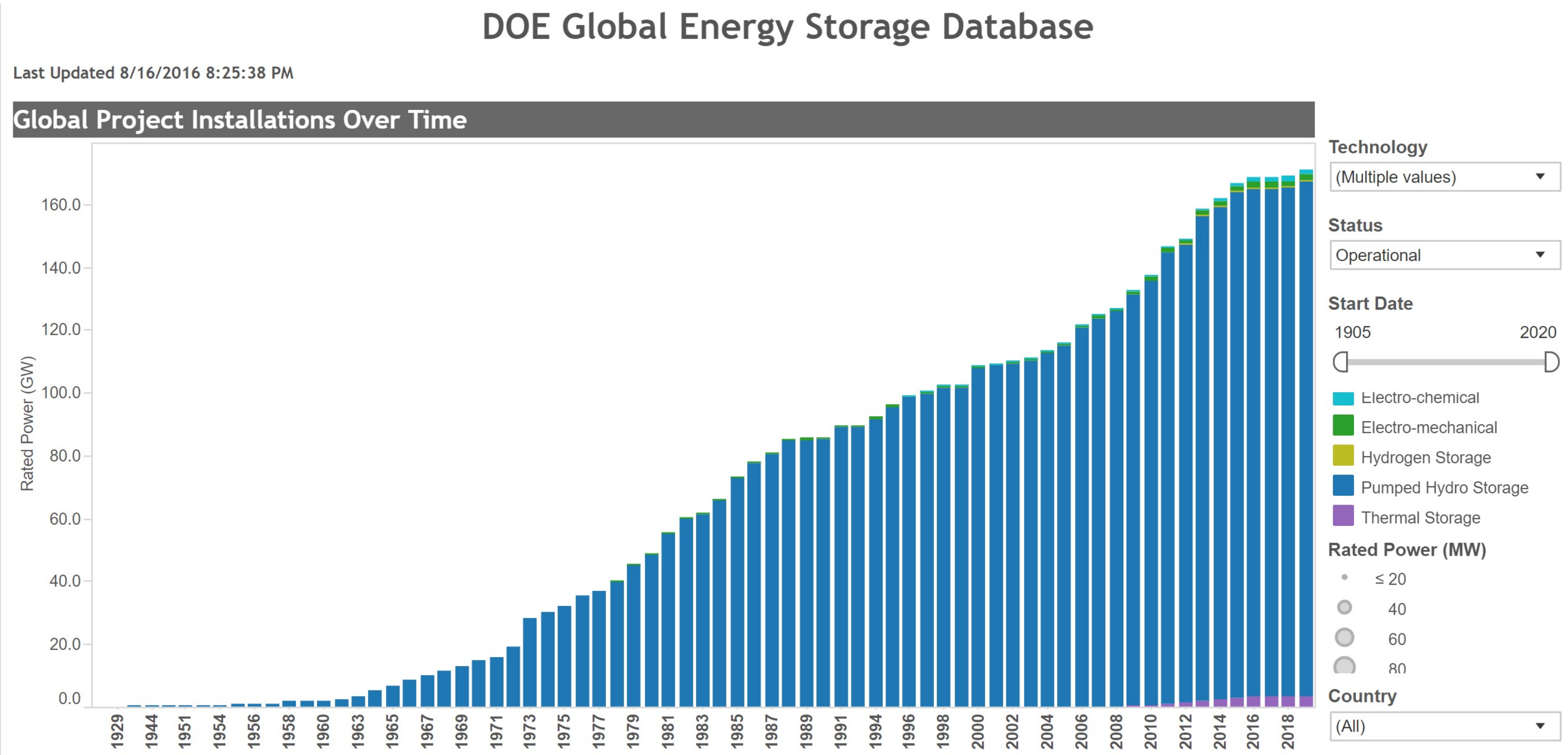
Courtesy Shannon Bragg-Sitton, Ph.D., Idaho National Laboratory

DROPPING PRICES FOR RENEWABLES



Courtesy Greg Nemet, Ph.D., University of Wisconsin

STORAGE

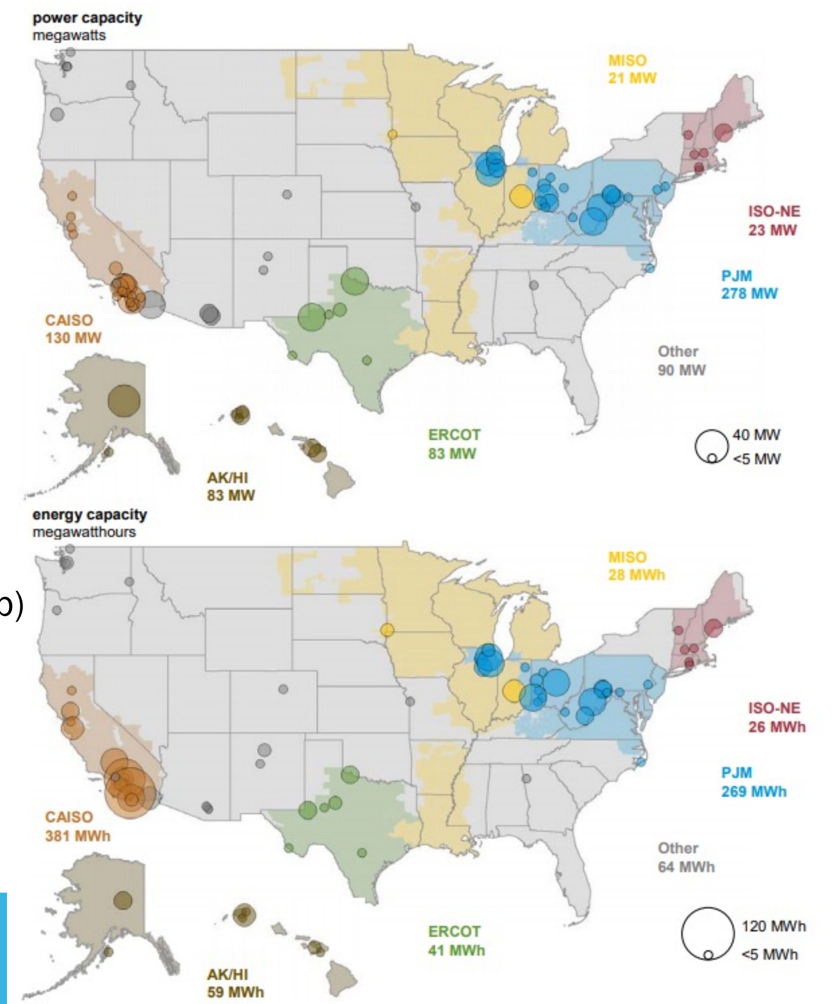


Source: DOE, 2018

NEW ENERGY STORAGE TECHNOLOGIES ARE BECOMING INCREASINGLY WIDESPREAD.

As of 2017, more than 700 MW of utility-scale batteries installed in United States

Some states now have battery mandates (CA, MA)



Sources: EIA (right), BNEF (top)

CONNECTED DEVICES

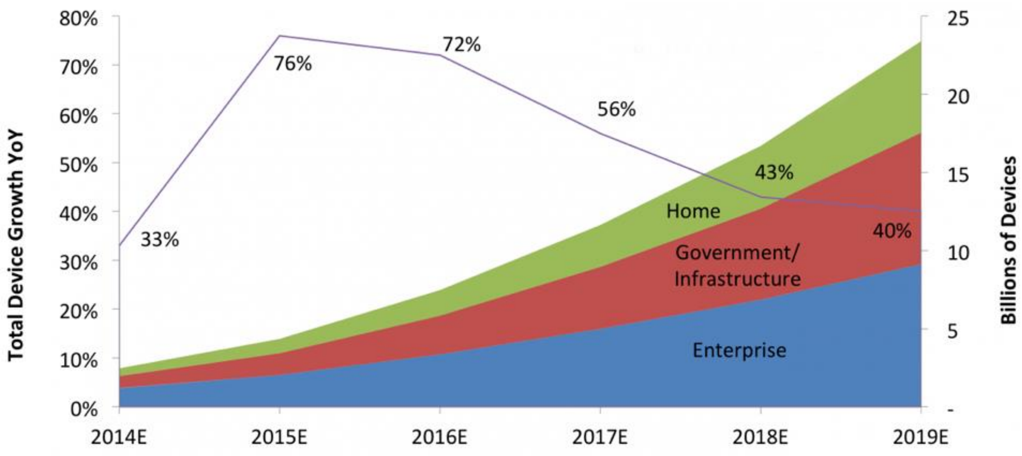
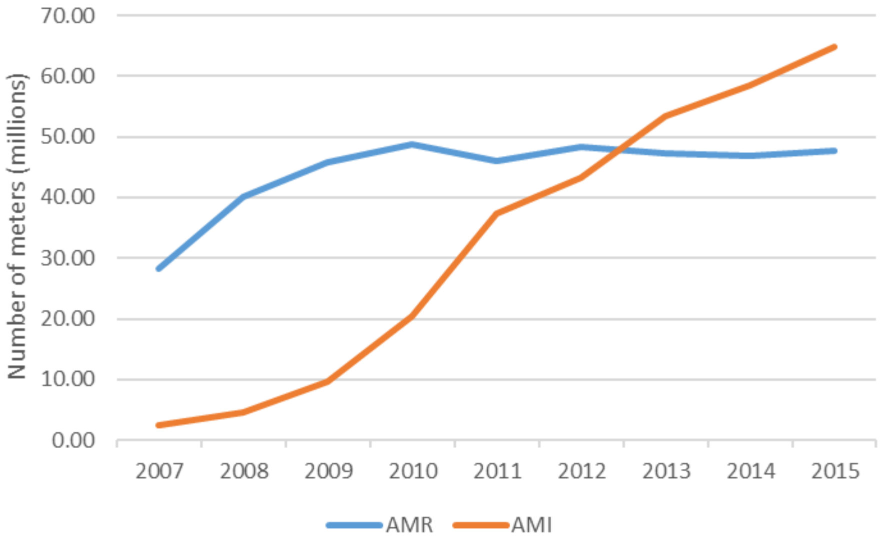


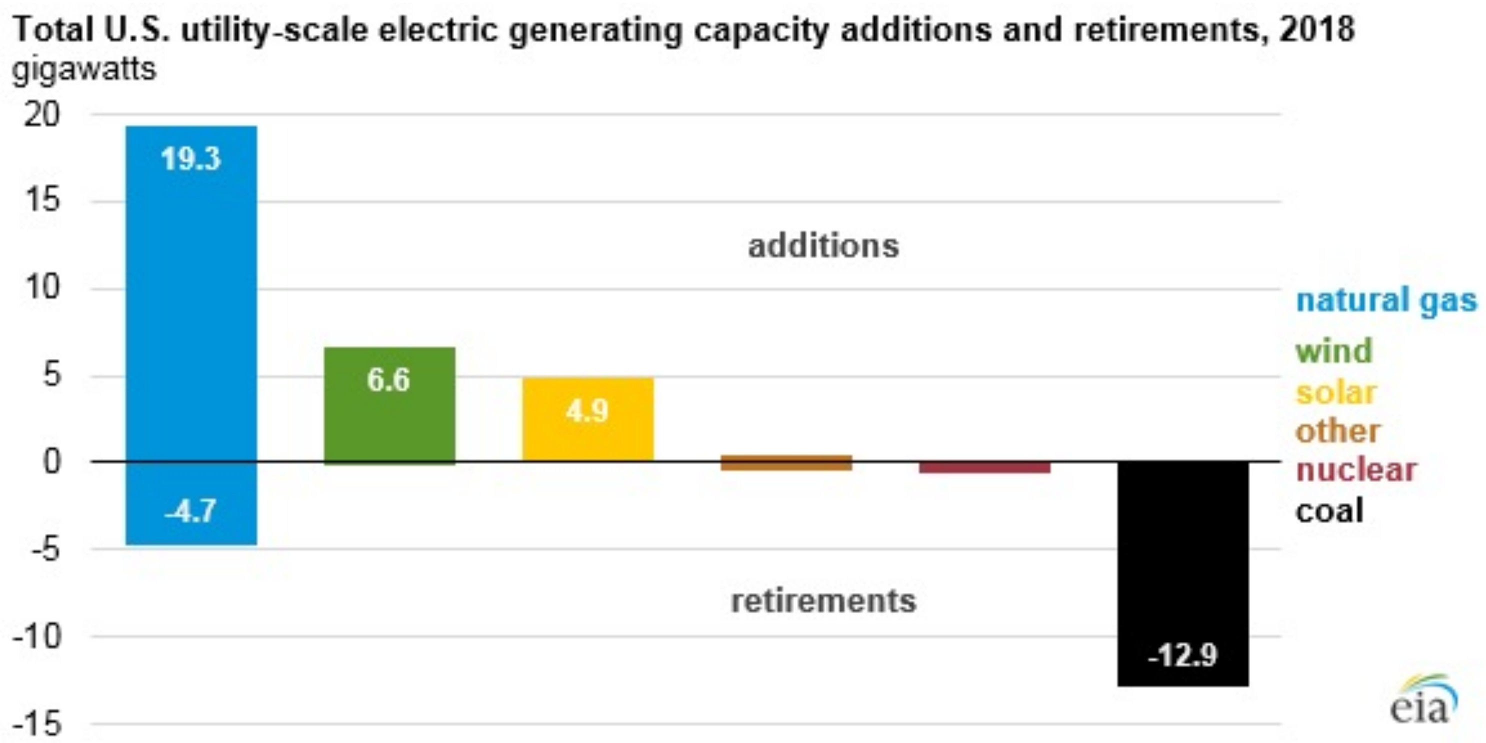
Figure ES1. Estimated number of installed IoT devices by sector. *Source:* Greenough 2014.

Rapid growth predicted for connected devices for energy efficiency



Smart meters surpass traditional one-way meters for home energy use monitoring

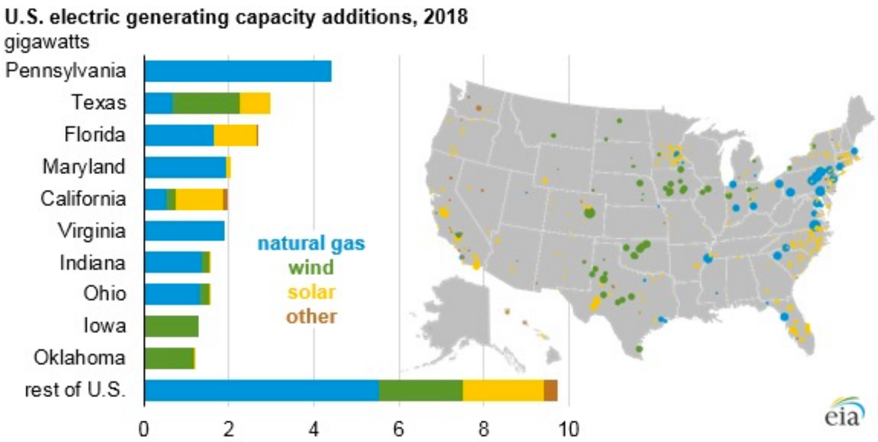
ENERGY ADDITIONS

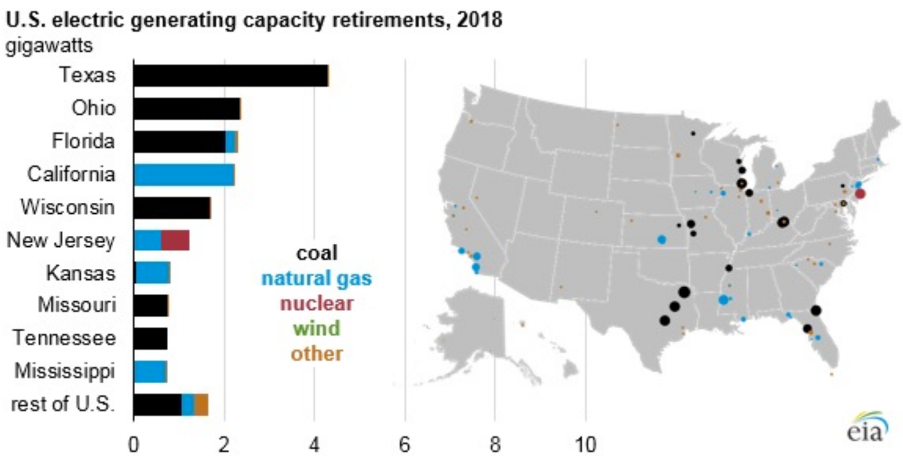


Source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*

MARCH 11, 2019

CHANGING ENERGY MIX

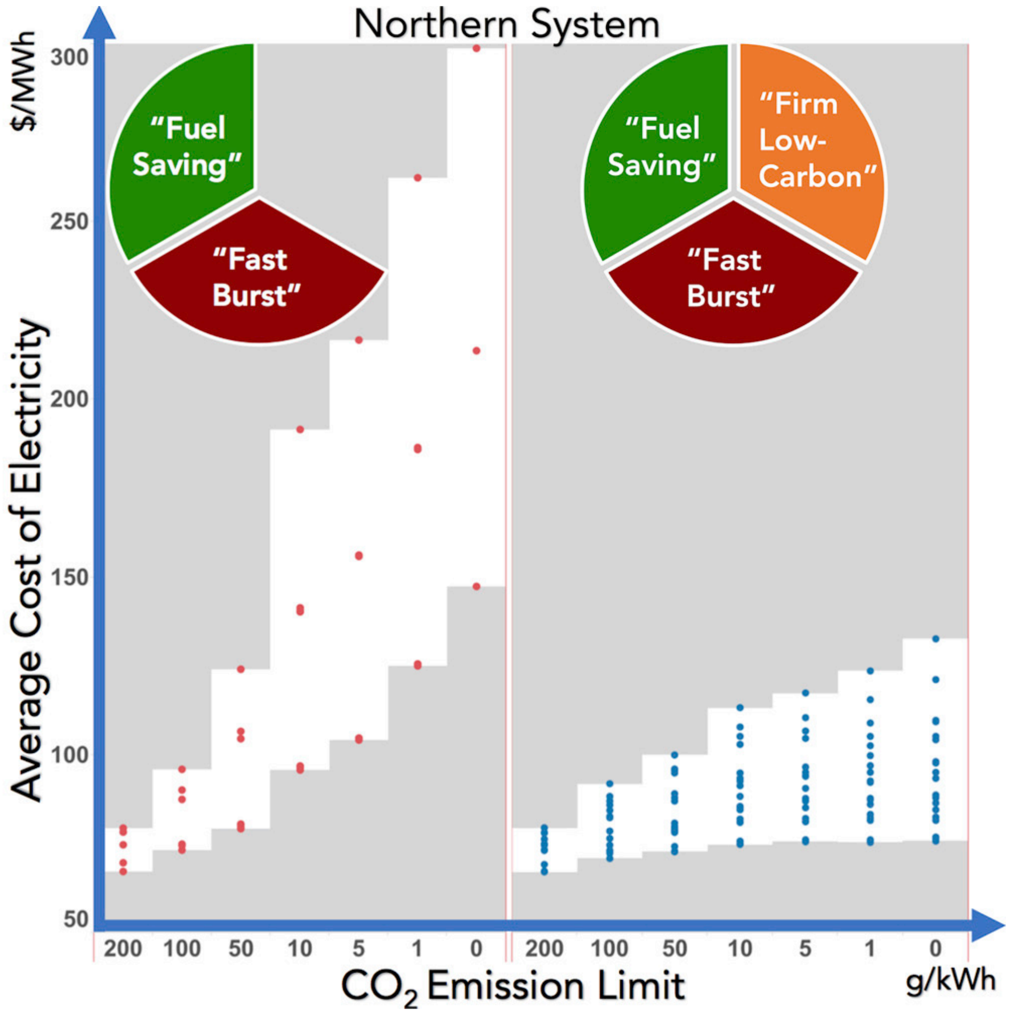




Source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*

MARCH 11, 2019

COST IMPERATIVE-SYSTEM MIX

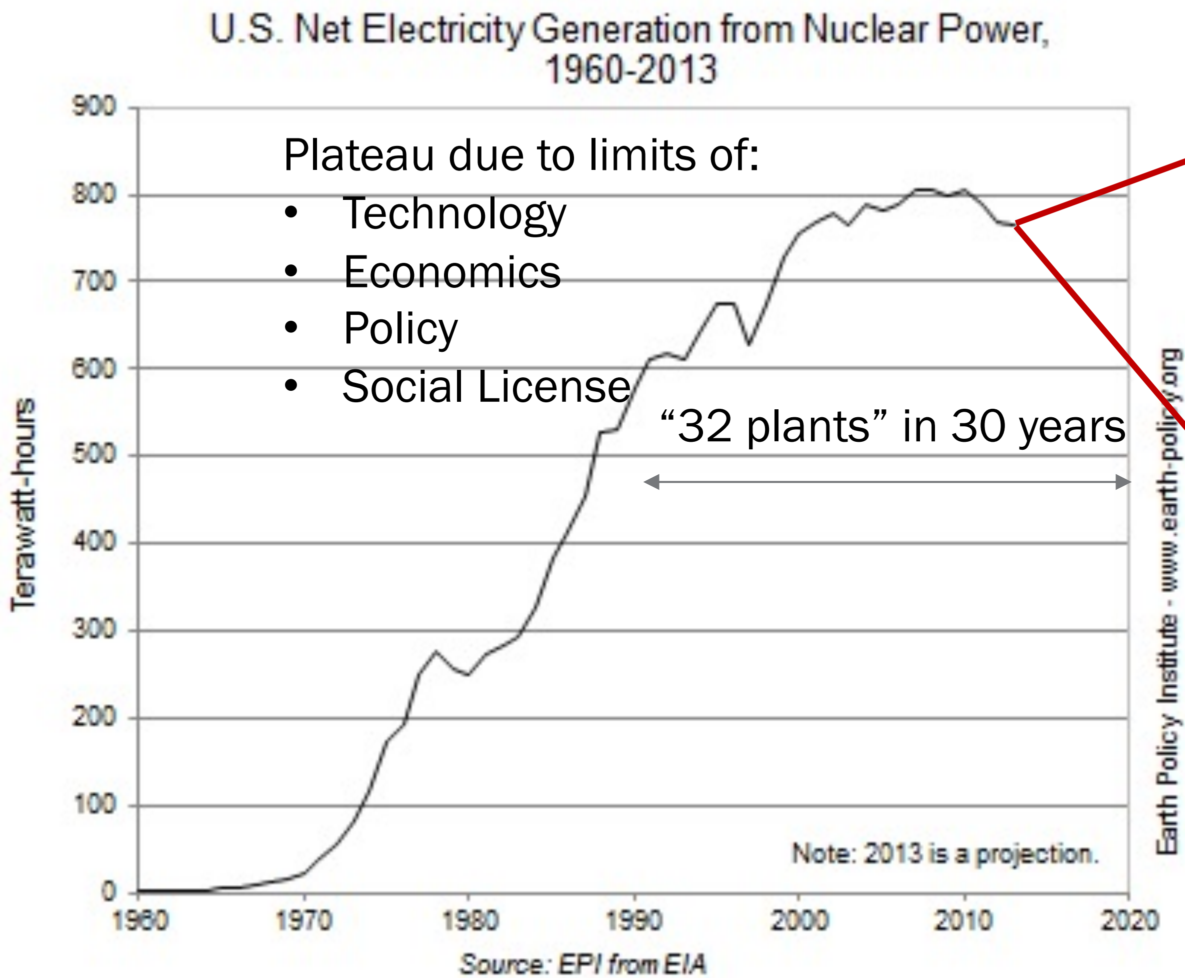


Models indicate that overall system cost is lower if a mix of zero carbon production sources are combined

Sepulveda et al. Joule 2018

WHAT DOES NUCLEAR TECHNOLOGY LOOK LIKE?

TRAJECTORY OF ATOMS FOR PEACE GENERATION



Plateau due to limits of:

- Technology
- Economics
- Policy
- Social License

"32 plants" in 30 years

An "inflection?"

Due to a improved Technology, Policy Economics, and Social License approaches

A "cliff?"

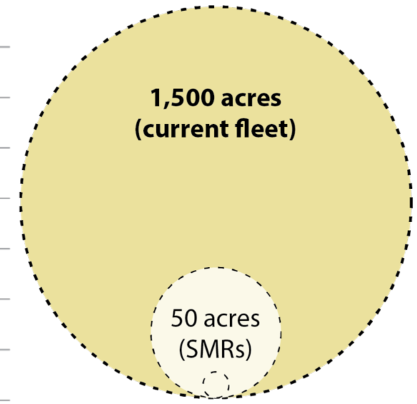
Since 2013, 6 reactors have retired prematurely (i.e., prior to license expiration) and 13 more are currently scheduled to retire prematurely

http://www.earth-policy.org/plan_b_updates/2013/update116

EXISTING NUCLEAR REACTORS

Number in operation:	**98 in U.S.**
Timeframe:	**Built in the 1950s-1980s**
Products:	**Electricity**
Megawatts:	**1,000+ megawatts**
Customers:	**Large utilities**
Emergency zone:	**10 miles**
Construction:	**Custom built on site**
Scalability:	**Difficult due to size and cost**

Footprint



Less than an Acre
(Micro Reactors)

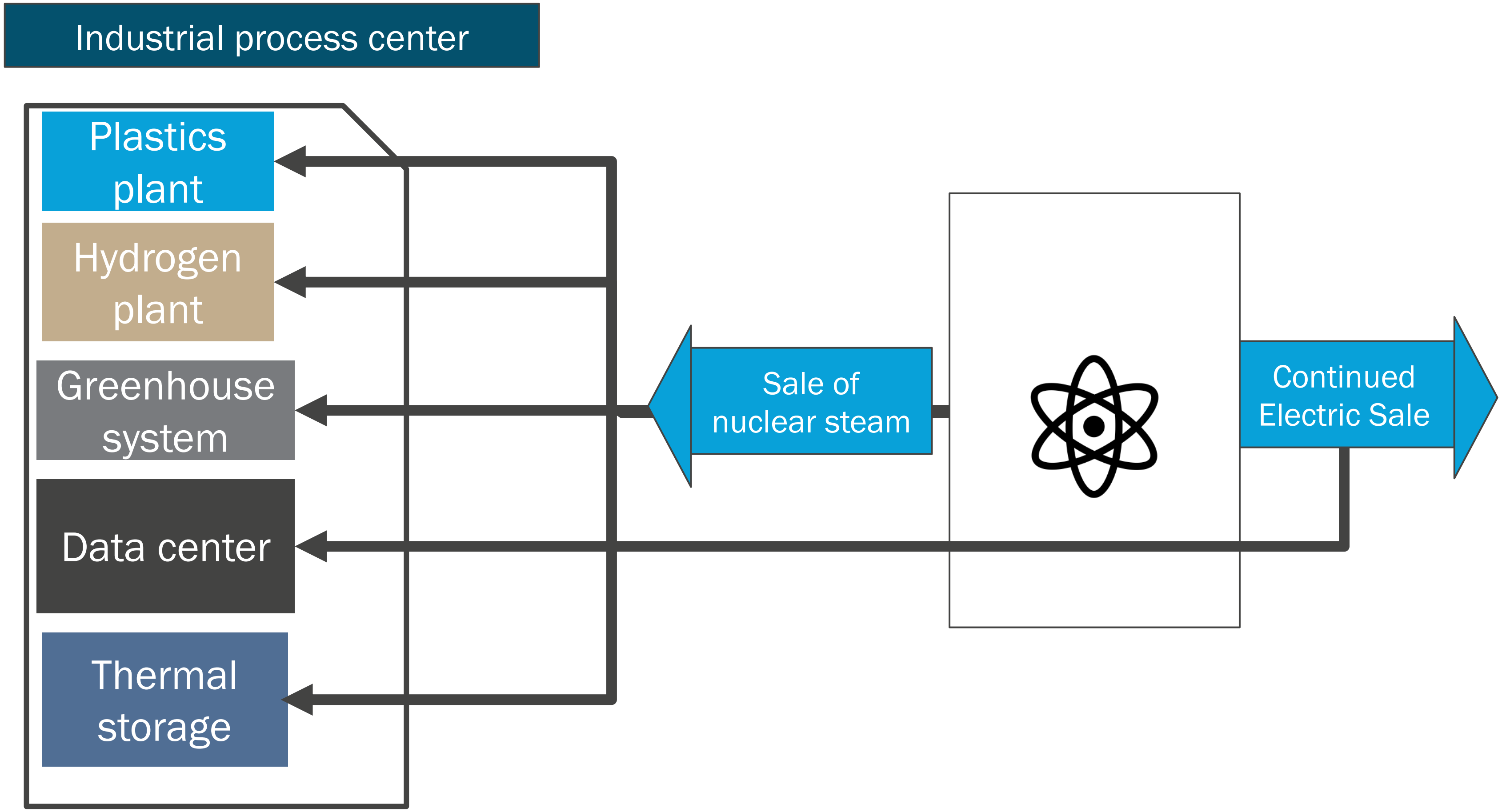
Applications:
Baseload electricity; 24/7

Did you know? In November 2018, the Union of Concerned Scientists recommended federal and state governments adopt policies to preserve the low-carbon electricity the current fleet of nuclear reactors provides.

Courtesy Shannon Bragg-Sitton, Ph.D., Idaho National Laboratory

NUCLEAR REPURPOSING

Reconfigure one or more of Exelon's nuclear plants to sustainably enhance their long-term value, by producing new products – not just electricity; for example, by providing steam to industrial partners.

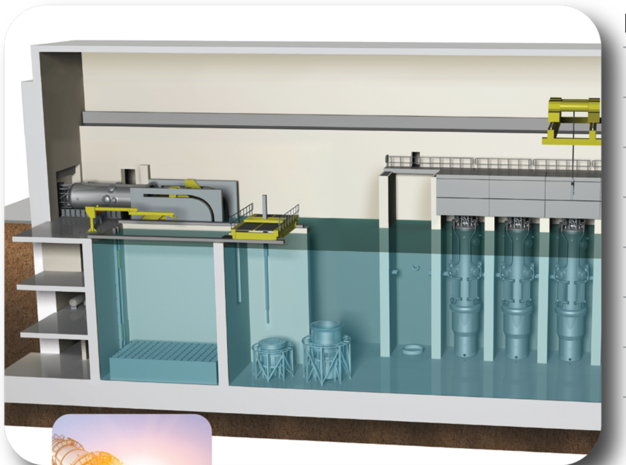


U.S. NUCLEAR

third way
fresh thinking

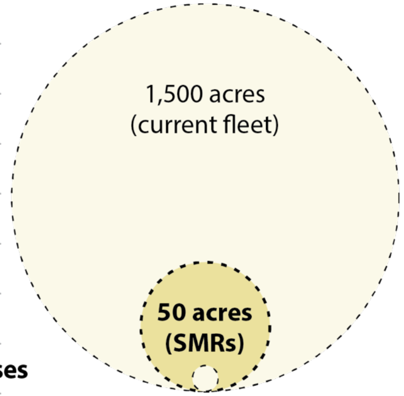
Advanced Reactor Companies

SMALL MODULAR REACTORS



Number in operation:	**None***
Timeframe:	**first reactors expected by 2024**
Products:	**Electricity, heat, and steam**
Megawatts:	**60-300 megawatts per module**
Customers:	**Large utilities; municipalities; industry**
Emergency zone:	**.19 miles**
Construction:	**Factory built; assembled on site**
Scalability:	**Reactor modules added as demand increases**

Footprint



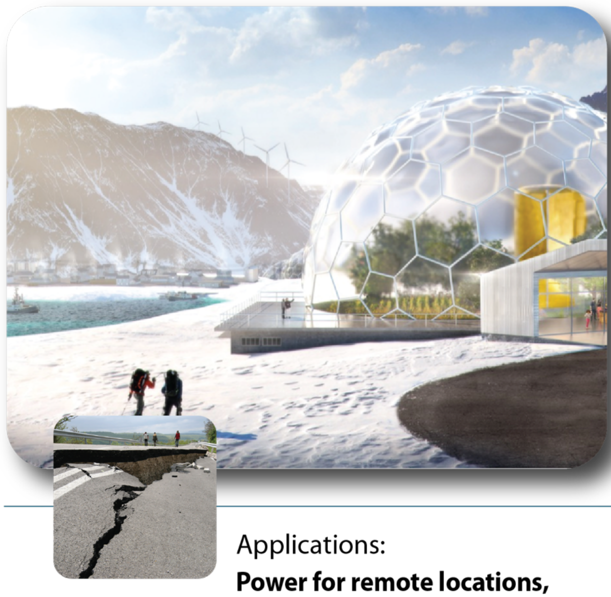
Less than an Acre
(Micro Reactors)

Applications:
Baseload electricity, industrial electricity, industrial processes such as hydrogen production

**First SMR in U.S. is currently going through regulatory approval and siting process; UAMPS proposing 12-module SMR in Idaho using NuScale technology.*

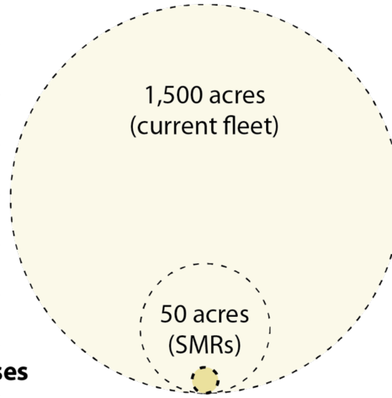
Courtesy Shannon Bragg-Sitton, Ph.D., Idaho National Laboratory

MICROREACTORS



Number in operation:	**None in the U.S.**
Timeframe:	**first reactors expected by 2025**
Products:	**Electricity, heat, and steam**
Megawatts:	**20 megawatts or less**
Customers:	**Military; municipalities; industry**
Emergency zone:	**less than .19 miles**
Construction:	**Factory built; assembled on site**
Scalability:	**Reactor modules added as demand increases**

Footprint



Less than an Acre
(Micro Reactors)

Applications:
Power for remote locations, maritime shipping, military installations, mining, space missions, desalination, disaster relief

Sen. Lisa Murkowski, R-Alaska, April 14, 2019 Op-Ed in the Anchorage Daily News.

Improvements in nuclear technology "are enabling the emergence of so-called "microreactors" that could be a perfect fit throughout our state. As the name suggests, these smaller reactors can be right-sized for dozens of Alaska communities and will have off-grid capability that could solve the challenge of providing clean, affordable energy in our remote areas."

Courtesy Shannon Bragg-Sitton, Ph.D., Idaho National Laboratory

THE IMPERATIVES FOR NUCLEAR ENERGY

THE EMISSIONS REDUCTION IMPERATIVE

Supply chains + Add to myFT

Blue chips act to cut supply chain greenhouse gas emissions

Rolls-Royce, Nestlé and Panasonic among larger companies taking action

Michael Pooler JANUARY 29, 2018 2

…mpanies taking serious action to tackle greenhouse gas …y chains has doubled, according to research by an …

…luding Rolls-Royce, Nestlé and Panasonic were among …d with taking an "industry-leading" approach on the …profit that collected data on behalf of 99 of the world's …nisations.

THE WALL STREET JOURNAL.

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Levi's Plans to Slash Emissions in Global Supply Chain by 2025

The apparel giant aims to reduce greenhouse gas emissions at a sprawling set of factories and mills in 39 countries, sta… suppliers

Levi's will start its effort to cut greenhouse gas emissions through energy-efficiency programs at factories run by vendors in the first tier of its supply chain, such as this supplier facility in Mexico. PHOTO: PHOTO COURTESY OF LEVI STRAUSS & CO.

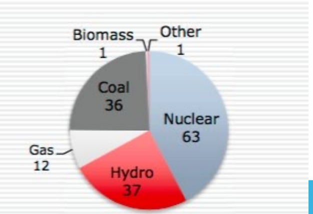
CONTENT

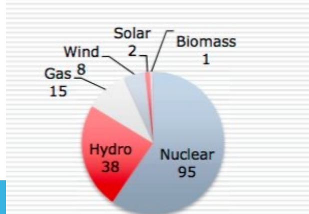
How to Provide F… Part 1

BRIEF

Asics plans to cut 55% of its supply chain carbon emissions

Ontario Transition from Coal





THE SUPPLY CHAIN IMPERATIVE

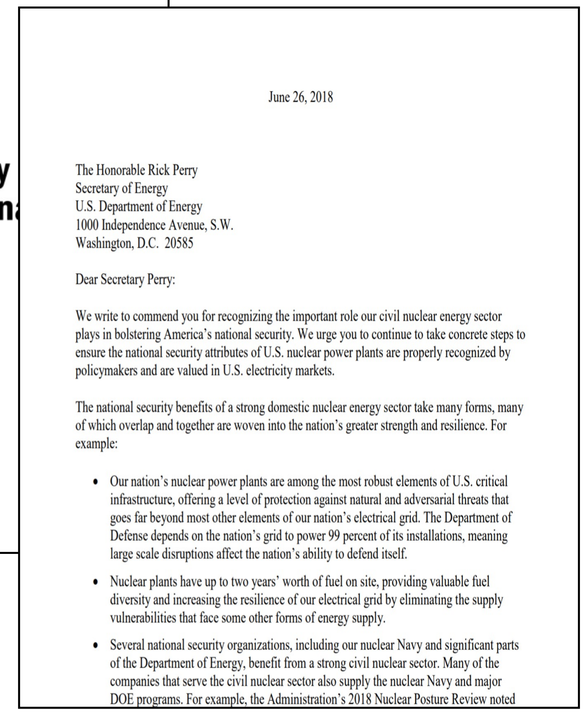
£1 trillion international new-build and decommissioning market over the next 10 years

The WNA estimates that the value of global investment in new reactor build will be of the order US$1.5 trillion (£0.93 trillion), with significant international procurement expected to be approximately US$530bn (£330bn), US$40bn (£25bn) per year through 2025.

> "We need to be clear where we own the value, understand our value proposition in nuclear and where the supply chain can improve competitiveness."
>
> **CEO, Manufacturing organisation**

Ernst & Young LLP, "Creating confident investors and competitive advantage for the UK nuclear supply chain" November 2017

THE NATIONAL & INTERNATIONAL SECURITY IMPERATIVE



June 26, 2018

The Honorable Rick Perry
Secretary of Energy
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Secretary Perry:

We write to commend you for recognizing the important role our civil nuclear energy sector plays in bolstering America's national security. We urge you to continue to take concrete steps to ensure the national security attributes of U.S. nuclear power plants are properly recognized by policymakers and are valued in U.S. electricity markets.

The national security benefits of a strong domestic nuclear energy sector take many forms, many of which overlap and together are woven into the nation's greater strength and resilience. For example:

- Our nation's nuclear power plants are among the most robust elements of U.S. critical infrastructure, offering a level of protection against natural and adversarial threats that goes far beyond most other elements of our nation's electrical grid. The Department of Defense depends on the nation's grid to power 99 percent of its installations, meaning large scale disruptions affect the nation's ability to defend itself.
- Nuclear plants have up to two years' worth of fuel on site, providing valuable fuel diversity and increasing the resilience of our electrical grid by eliminating the supply vulnerabilities that face some other forms of energy supply.
- Several national security organizations, including our nuclear Navy and significant parts of the Department of Energy, benefit from a strong civil nuclear sector. Many of the companies that serve the civil nuclear sector also supply the nuclear Navy and major DOE programs. For example, the Administration's 2018 Nuclear Posture Review noted

PRAGUE (Reuters, 14 Nov 2018) - Czech Prime Minister Andrej Babis said on Wednesday geopolitics should be a factor when the NATO and EU member country decides future nuclear power investments as the country mulls whether to build new reactors.

CHINA

RUSSIA

NEARLY 2/3 OF ALL NUCLEAR POWER PLANTS UNDER CONSTRUCTION USE CHINESE OR RUSSIAN DESIGNS

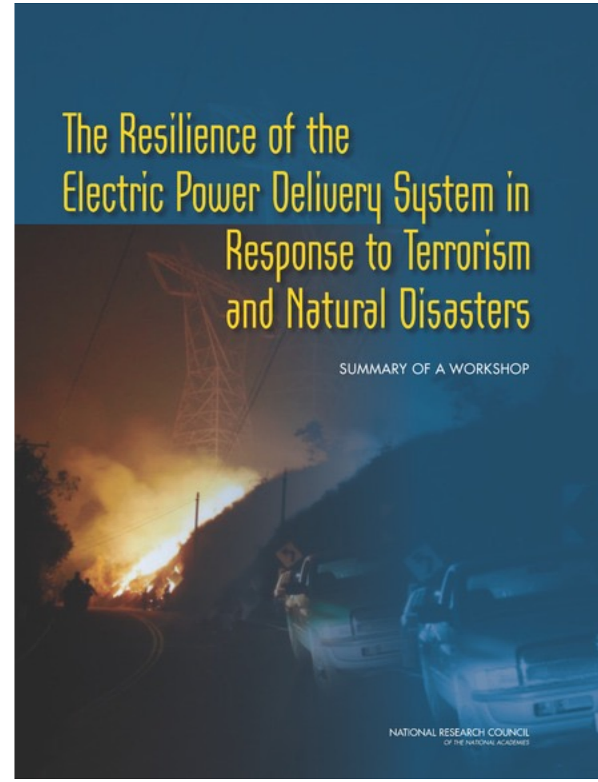
Source: International Atomic Energy Agency: PRIS Database
Updated: March 2018

NEI

THE RESILIENCE IMPERATIVE

Houston, 22 December 2016 (Argus)-The North American Electric Reliability Corporation (NERC) wants to make sure utilities, power grid operators and federal and state policymakers understand the:

- Increased risk that reliance on a single fuel presents to dependable electric service.
- Firm transportation and dual-fuel capability may be needed to reduce widespread reliability problems.



A Call to Action:

A Canadian Roadmap for Small Modular Reactors

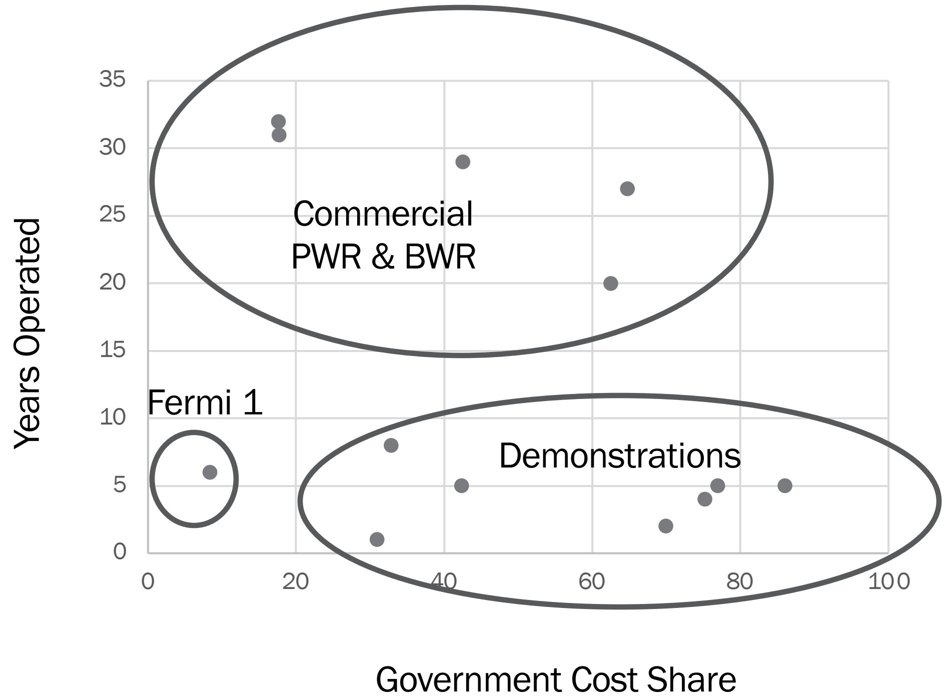
SUMMARY OF KEY FINDINGS

THE POLICY IMPLICATIONS

WHAT HAS WORKED

Table 1: Financial and Operation Summary Information for CPRDP-era Reactors [9]

Type	Reactor	Cost ($M)	Gov't Share (%)	MWe	Yrs Oper-ated
PWR	Ship-pingport	74	67.4%	60	27
PWR	Yankee Rowe	49.3	17.7%	134	31
PWR Average		61.7	42.5%	97	29
BWR	Elk River	11.4	86	22	5
BWR	Big Rock	27.8	17.6	75	32
BWR	BONUS	32.7	75.2	16.3	4
BWR	Path-finder	54	30.9	59	1
BWR	La Crosse	25	62.5	50	20
BWR Average		22.7	54.4%	44.5	12.4
Non-LWR	Fermi 1	88	8.3	80	6
Non-LWR	Hallam	68.4	69.9	40	2
Non-LWR	Piqua	16.9	76.9	11.4	5
Non-LWR	Peach Bottom	51.8	32.8	40	8
Non-LWR	CVTR	35.7	42.3	19	5
Non-LWR Avg.		52.6	46%	38.1	5.2
CPRDP Avg.		41.5	47.7%	59.9	15.5

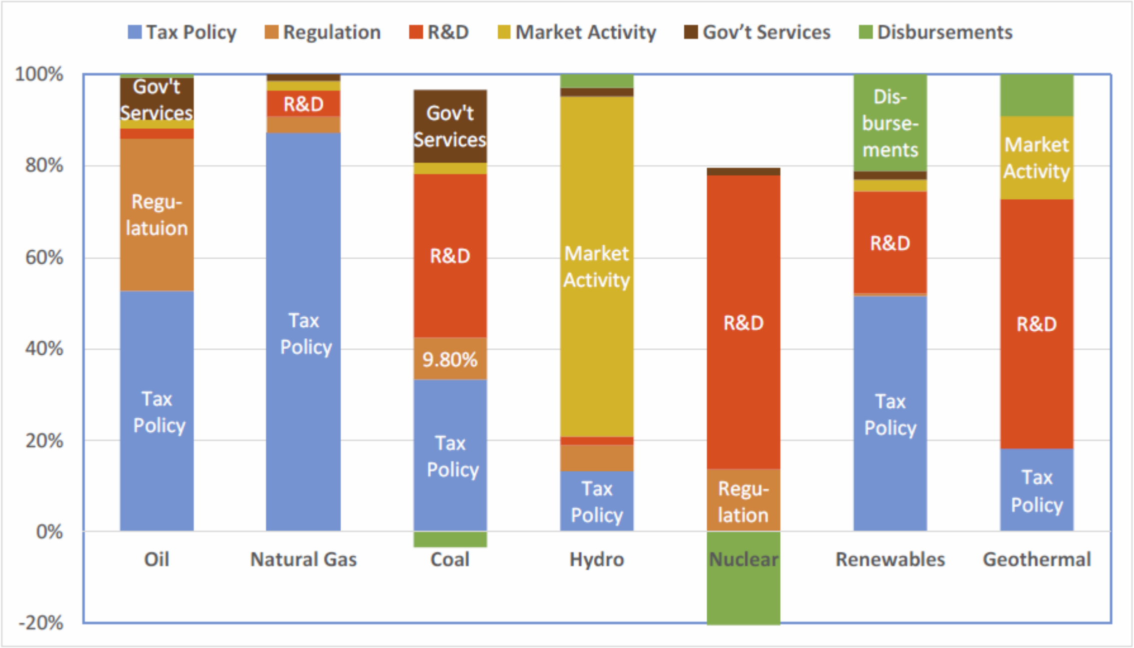


Steven Krahn[1] and Andrew Sowder

Transactions of the American Nuclear Society, Vol. 117, Washington, D.C., October 29–November 2, 2017

POLICY INCENTIVES

Exhibit 4 – Mix of Federal Expenditures for Each Energy Source



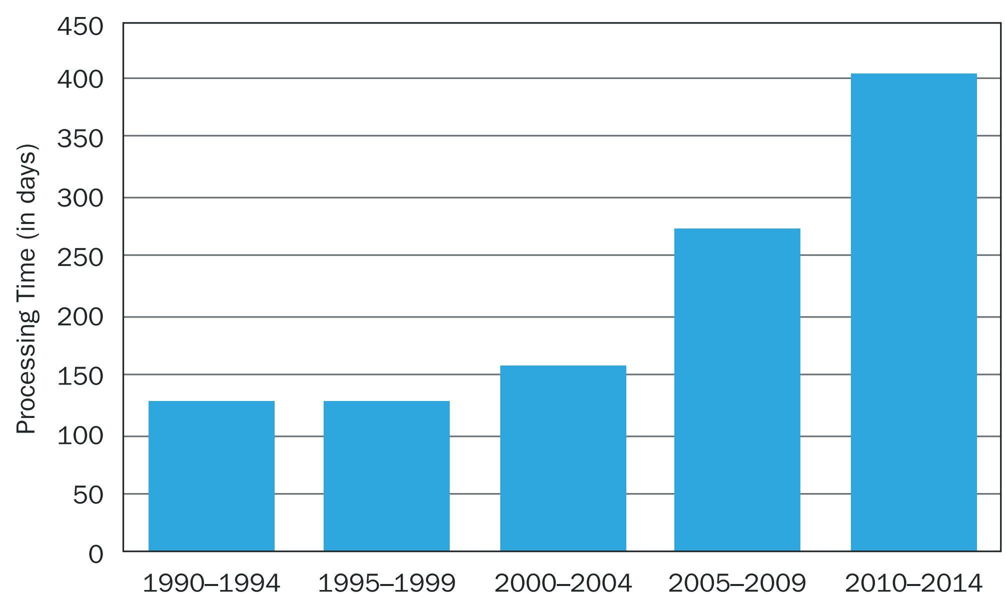
Expenditures for nuclear need better balance between R&D and tax policy

Management Information Services, May 2017 (prepared for NEI)

NUCLEAR EXPORT INCENTIVES

FIGURE 1

Average Processing Times for Specific Authorization Applications



Source: DOE reading room.

Nuclear Innovation Alliance, Enabling Nuclear Innovation Part 810 Reform

2015/2016 PIVOT

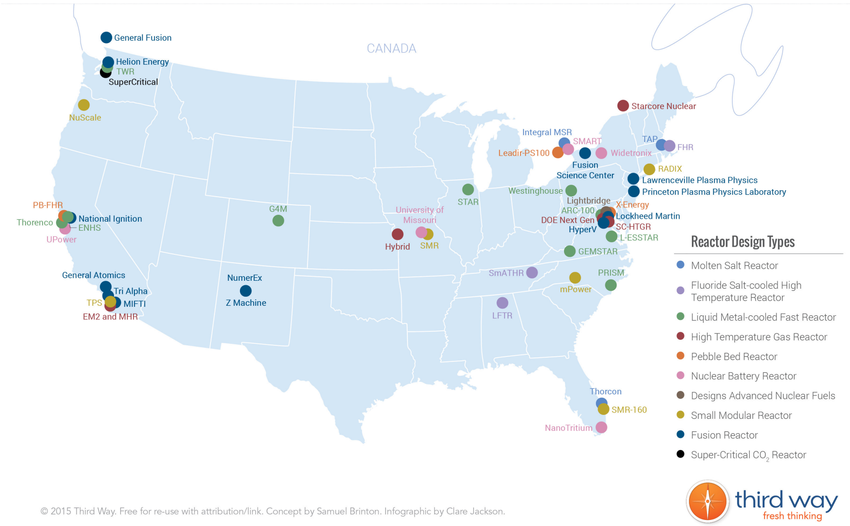
The 2015/2016 Pivot:

- GAIN
- NEIMA/NEICA
- Clean Energy Standards
- NRIC
- Nuclear Reimagined
- Advanced Reactor Companies
- NGOs (Third Way, CATF, BTI, Good Energy Collective, NIA, Global Nexus Initiative, Energy for Humanity)
- ARPA-E
- Nuclear Energy Bootcamp
- Fastest Path to Zero

Figure 3: Nuclear Plants Closing in Restructured States

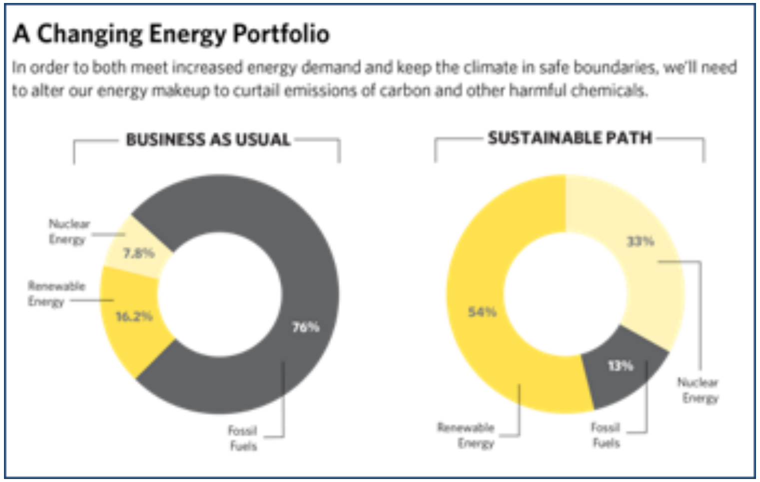
Source: Don Moul, President and CNO, First Energy. Testimony to Nuclear Energy Caucus (4/17/18)

Advanced Reactor Companies



THE SOCIAL LICENSE IMPERATIVE

THE SOCIAL LICENSE IMPERATIVE



Source: The Nature Conservancy, The Science of Sustainability, 2018

Google

Moving toward 24x7 Carbon-Free Energy at Google Data Centers: Progress and Insights

Introduction

In recent years, Google has become the world's largest corporate buyer of renewable energy. In 2017 alone, we purchased more than seven billion kilowatt-hours of electricity (roughly as much as is used yearly by the state of Rhode Island[1]) from solar and wind farms that were built specifically for Google. This enabled us to match 100% of our annual electricity consumption through direct purchases of renewable energy; we are the first company of our size to do so.

Reaching our 100% renewable energy purchasing goal was an important milestone, and we will continue to increase our purchases of renewable energy as our operations grow. However, it is also just the beginning. It represents a head start toward achieving a much greater, longer-term challenge: **sourcing carbon-free energy for our operations on a 24x7 basis.**

Meeting this challenge requires sourcing enough carbon-free energy to match our electricity consumption *in all places, at all times.* Such an approach looks markedly different from the status quo, which, despite our large-scale procurement of renewables, still involves carbon-based power. Each Google facility is connected to its regional power grid just like any other electricity consumer; the power mix in each region usually includes some carbon-free resources (e.g. wind, solar, hydro, nuclear), but *also* carbon-based resources like coal, natural gas, and oil. Accordingly, we rely on those carbon-based resources — particularly when wind speeds or sunlight fade, and also in places where there is limited access to carbon-free energy. Carbon-free or not, around-the-clock electricity is the fuel that enables us to continuously deliver Google search results, YouTube video plays, Google Cloud Platform services, and much more without interruption.

OCTOBER 2018

The Nuclear Power Dilemma

Declining Profits, Plant Closures, and the Threat of Rising Carbon Emissions

Steve Clemmer
Jeremy Richardson
Sandra Sattler
Dave Lochbaum

November 2018

Union of Concerned Scientists

It's Time for Environmentalists and the Energy Industry to Work Together (Time Magazine, October 12, 2018)

MacArthur Foundation

Exelon.

NICE Future
Nuclear Innovation: Clean Energy Future

THE DIVERSITY IMPERATIVE

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- Fastest Path to Zero

FOR OUR OWN SUCCESS, BE DIVERSITY CHAMPIONS

ADVANCED NUCLEAR CAMPAIGN

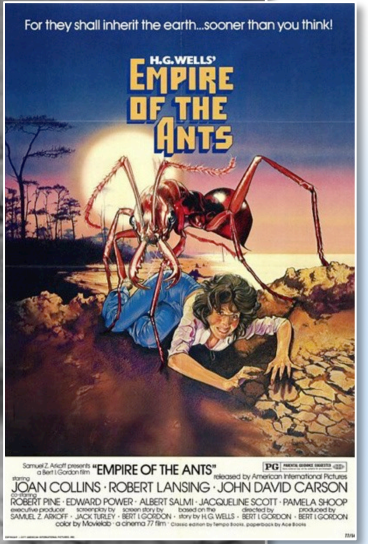
Todd Allen

Senior Fellow, Third Way

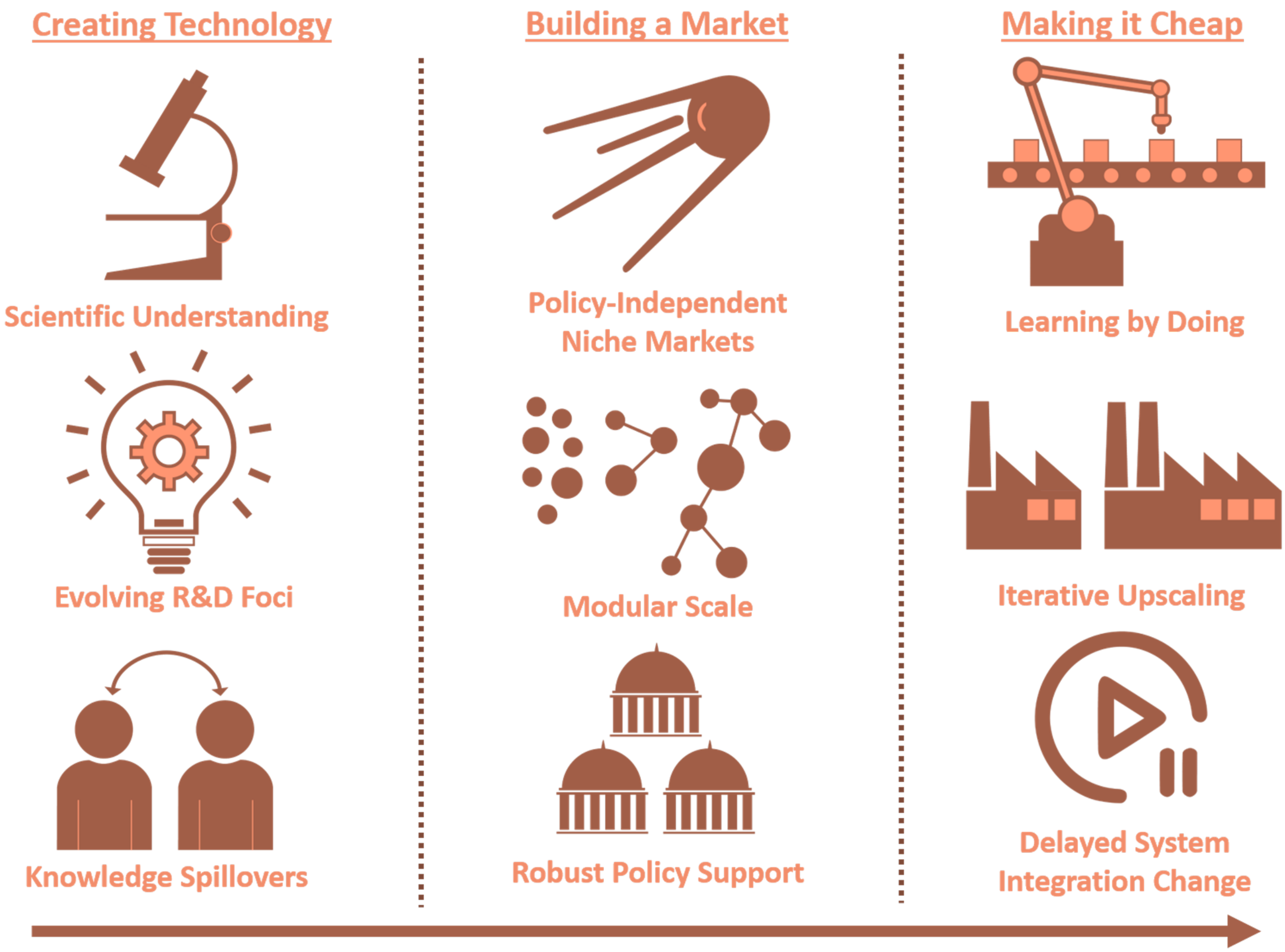
tallen@thirdway.org

THEM: GIANT MUTANT ANTS (1950S)

A first entertainment use of radiation-induced mutant creatures



ACCELERATING THE PV MODEL



Source: Nemet (2019). *How Solar Became Cheap: A Model for Low-Carbon Innovation*, Routledge.