DC ANS Local Section Annual Meeting Dinner Meeting

May 18, 2016

Report on DC ANS Local Section 2015-16

James W. Behrens
DC ANS Local Section Chair

2015-2016 DC ANS Local Section
Executive Committee (ExCom) Membership

Position	Name
Chair:	James W. Behrens
Vice-Chair:	Jane LeClair
Secretary & Member-at-Large:	Kevin Witt
Treasurer:	Suzanne Dennis
Immediate Past Chair:	Robert McMahon
Member-at-Large:	Gene Carpenter
Membership Chair:	Kati Austgen
Outreach Chair:	Matt Dennis
Program Chair:	Ruth Weiner
Education Co-Chair:	Jeff Gorman
Education Co-Chair:	Amber Johnson
Webmaster:	Brian Hallee

Agenda for May 18, 2016

- 7:00 to 7:20 pm Selected Summaries for Year
  - Comments by Jim Behrens, Chair and Jane LeClair, Vice-Chair
  - Comments by Kati Austgen, Membership
  - Comments by Ruth Weiner, Program

- 7:20 to 7:45 pm Science Fairs, Science Festival and 2016 Scholarship
  - Comments by Jeff Gorman and Amber Johnson, Education Co-Chairs
  - Comments by Matt Dennis, Outreach

- 7:45 to 8:30 pm Presentation by ANS President/President-Elect
  - Introduction by Ruth Weiner, Program
  - Guest Speakers: Gene Grecheck, ANS President and Andy Klein, President Elect

ExCom Meetings & Dinner Meetings 2015-2016 Schedule

- Begin New Year on July 1, 2015

Date	Activity
July 29, 2015	Ex Com Meeting
August 27, 2015	Ex Com Meeting
September 9, 2015	DC ANS Dinner Meeting/NEI
September 24, 2015	EX Com Meeting
October 6, 2015	DC ANS Dinner Meeting/NCI
October 28, 2015	Ex Com Meeting
November 8-12, 2015	ANS Winter Meeting/DC
December 15, 2015	DC ANS Dinner Meeting/Rockville

ExCom Meetings & Dinner Meetings 2015-2016 Schedule

- Begin New Year on January 1, 2016

Date	Activity
January 20, 2016	DC ANS Dinner Meeting/Rockville
January 27, 2016	Ex Com Meeting
March 16, 2016	Ex Com Meeting
March 23, 2016	DC ANS Dinner Meeting/Rockville
April 27, 2016	Ex Com Meeting
May 18, 2016	DC ANS Dinner Meeting/NRC Annual Meeting/Rockville
June 30, 2016	Year Ends

Report on DC ANS Local Section Elections 2016-2017

Jane LeClair
DC ANS Local Section Vice Chair

2016-2017 DC ANS Local Section
Executive Committee (ExCom) Membership

Position	Name
Chair:	Jane LeClair
Vice-Chair:	Jeff Gorman
Secretary:	Lindsey Cook
Treasurer/Immediate Past Chair:	Jim Behrens
Members-at-Large:	Gene Carpenter & Kevin Witt
Membership Chair:	Kati Austgen
Outreach Chair:	Matt Dennis
Program Chair:	Ruth Weiner
Education Chair:	Amber Johnson
Webmaster:	Brian Hallee

Membership

Kati Austgen
Membership Chair

Programs

Ruth Weiner
Program Chair

XSTEM & USA Science and Engineering Festival
ANS Outreach XSTEM Workshop and Festival Booth April 14-17, 2016

Matt Dennis
Outreach Chair

ANS Outreach

- XSTEM Workshop
  - Three stations: radiation detection, Skittles half-life, and radiation safety
  - 150 middle and high school students attended
- ANS Outreach Booth
  - 365,000 Festival expo attendees
  - DCANS volunteers handed out bookmarks, radiation dose charts and instructional packets
  - Demonstrated Civil Defense detectors, Van de Graff generator, and naturally occurring radioactive material

- Thanks to Matt Dennis, Jeff Gorman, Travis Dietz, Amber Johnson, Azizuddin Khawja, Anthony Kluk, Nicole Vanagas, Kati Austgen, John Boska, Dawn Jacobs and Jennifer Wacker

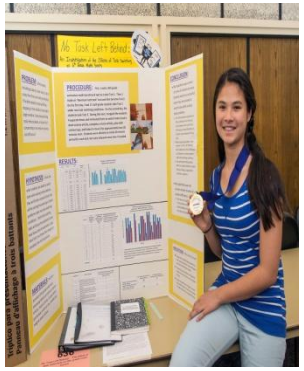
#SCIFEST

ANS

At the Booth

ANS

Science Fairs



Jeff Gorman & Amber Johnson
Education Committee Co-Chairs

Judged at 5 local school system science fairs

- Montgomery County Science Fair
- Fairfax County Regional Science and Engineering Fair
- Northern Virginia Regional Science and Engineering Fair
- Prince George's Area Science Fair
- Howard County STEM Fair

Judging Emphasis

Emphasis in judging of projects was placed on:

- Nuclear science and technology
- Power generation

- Other projects of scientific interest were also considered

Montgomery County Science Fair

ANS Judges: M. Cullingford, P. Rohr, A. Levin, & K. Witt

Award Level	Student	School	Project Title
1st	Kenneth Jiang	Poolesville High School	Improving the Efficacy of the Bumps Data Fitting and Uncertainty Estimation
2nd	Mary Chang, Emily Chen & Kaylen Pak	Takoma Park Middle School	Effect of Environmental Radiation on the Number of People Who Develop Cancer
3rd	Rohan Dixit	Poolesville High School	Increasing Safety & Accuracy in Automation Systems with Real-Time Robot

Fairfax County Regional Science and Engineering Fair

ANS Judge: A. Johnson

Award Level	Student	School	Project Title
1st	Sarah Cole	Marshall High School	Effect of Irradiation on Growth of Raphanus Sativus Seeds
2nd	Ryan Kelley and Gregory Waldron	Madison High School	The Effect of Lantern Mantle Size on Visible Radiation

Northern Virginia Regional Science and Engineering Fair

ANS Judge: J. Gorman

Award Level	Student	School	Project Title
1st	Henning Brennan	Yorktown High School	Investigation of Oscillating Water Columns
2nd	Cory E. Dudka	Washington-Lee High School	Using Piezoelectric Elements to Harness the Potential Energy of Turbulent Airflow
3rd	Conor M. Riordan	H-B Woodlawn Secondary School	Wind Turbines

Prince George's Area Science Fair

ANS Judge: J. V. Gilbert

Award Level	Student	School	Project Title
1st	Jay Lee	Great Mills High School	Creating a 3D Spherical Printer
2nd	Allyson Myers	Capitol Heights High School	The Balance of Power and Death
3rd	John Bubser and Catherine Bubser	Northern High School	Water Wheel: Bigger Isn't Always Better

Howard County STEM Fair

ANS Judge: J. V. Gilbert

Award Level	Student	School	Project Title
1st	Eric Kim	Dunloggin Middle School	Making a Swarm of Robots
2nd	Annie Liu	Dunloggin Middle School	Do Corrosive Substances Really Rust Your Nails?
3rd	Ayesha Nabiha	Ellicott Mills Middle School	The Effect of Social Media/Internet on the Human Brain

Presentation by ANS President/President Elect

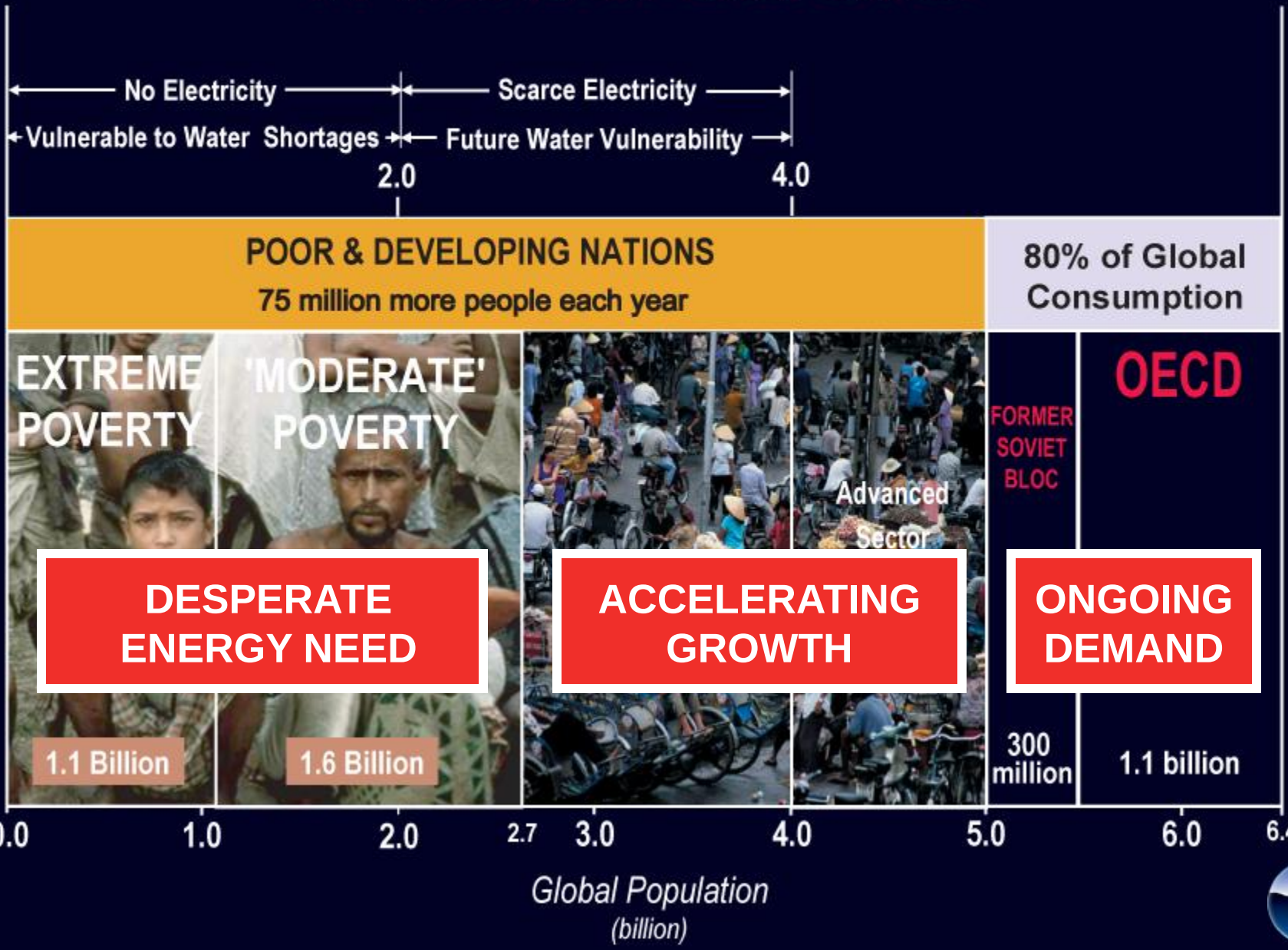
Introduction: Ruth Weiner, Program Chair
Eugene S. Grecheck, President 2015-2016
Andrew Klein, President Elect 2016-2017

Climate Change and Beyond: Challenges and Opportunities

Washington DC Local ANS Section
May 18, 2016

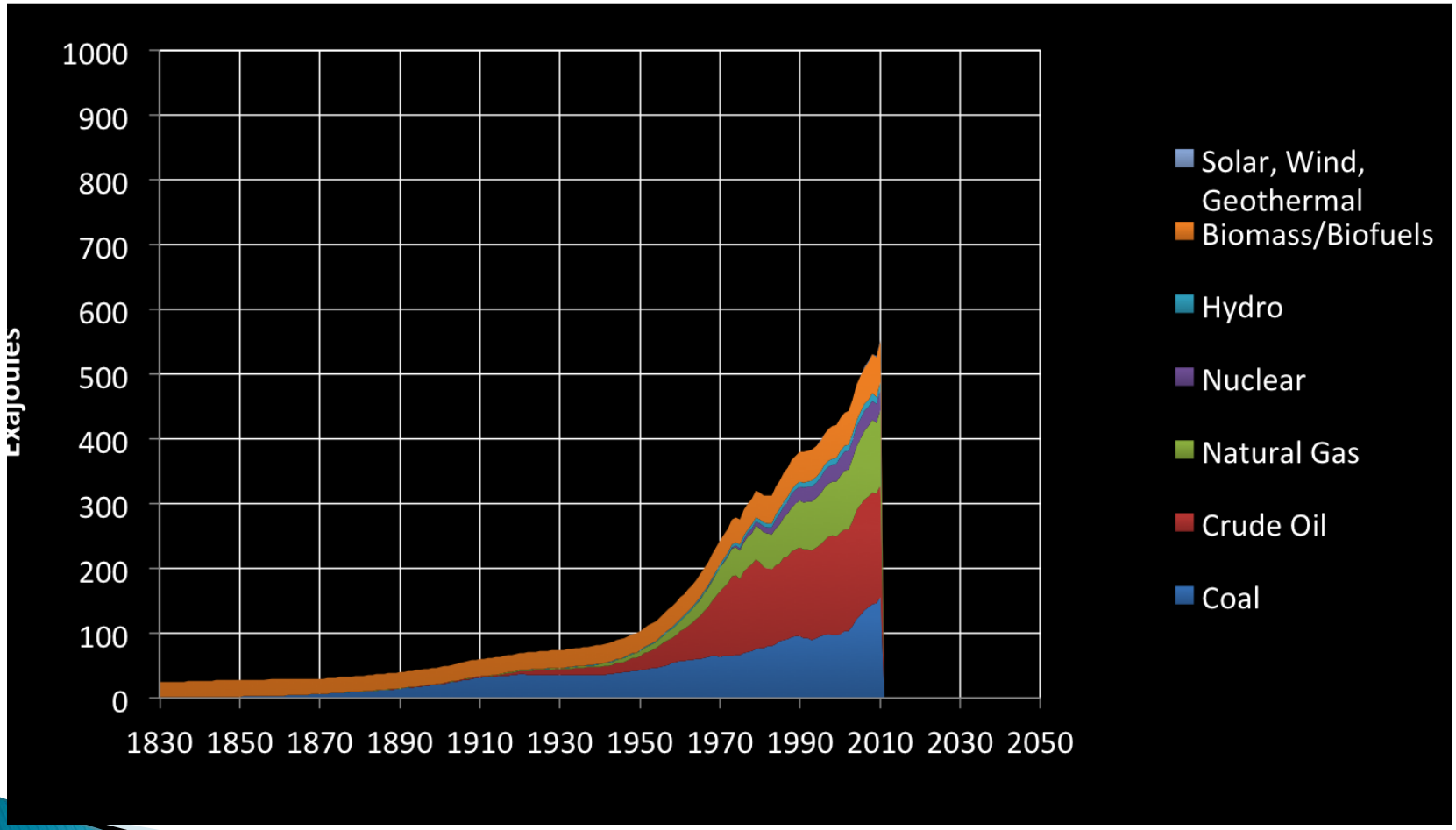
Eugene S. Grecheck
ANS President

A World of Extremes



Source: WNA

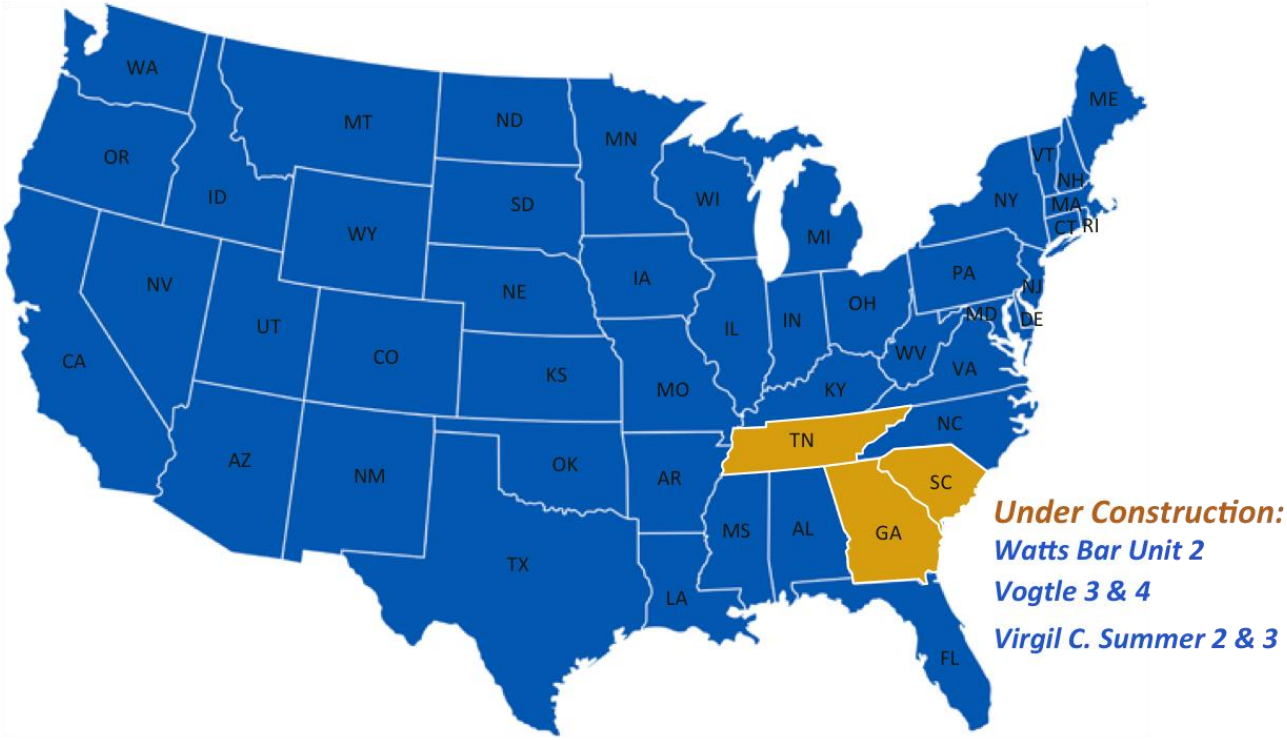
World Primary Energy Consumption



Five US nuclear units shut down since 2013

Fitzpatrick scheduled to close January 2017
Pilgrim to shut down in 2017 or 2019
Oyster Creek scheduled to close in 2019
Ft. Calhoun recommended for closure 2016
Clinton, Quad Cities threatened

Five New Units Under Construction in the US



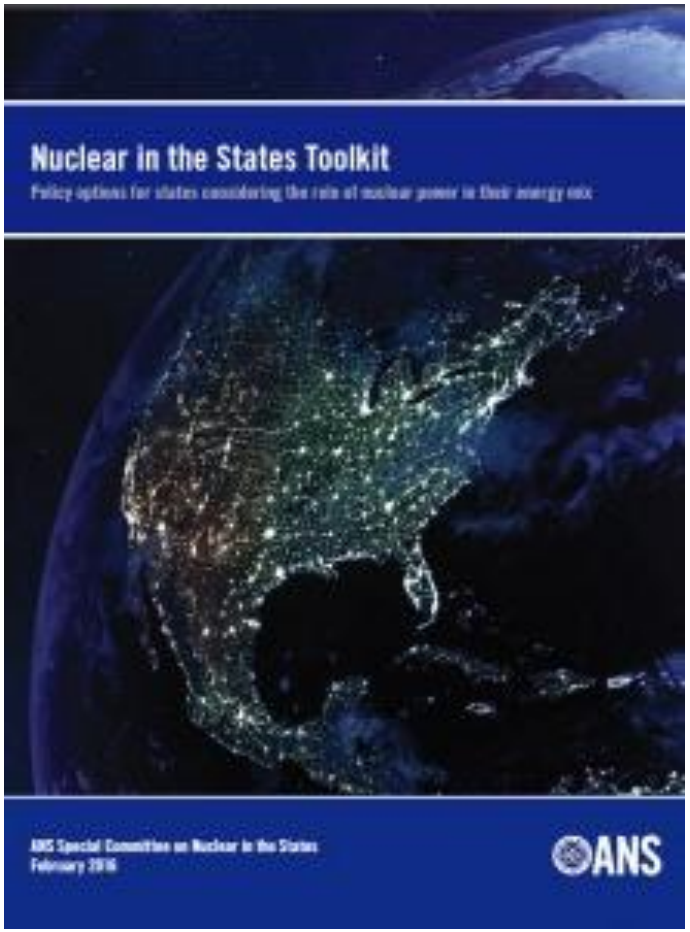
Source: NEI - Nuclear Units Under Construction Worldwide

So, What's Happening?

- Deregulated markets in US do not recognize emissions reduction or even capacity factors
- Price of natural gas
- Overall slowing of demand growth
- More operating units at risk
- No credit for operating plants in the EPA CPP

Operating Units Are National Assets

- Two thirds of US CO_2 free generation
- High capacity factors
- Fuel on site provides additional reliability during major weather events
- Premature shutdowns have major negative effects on local communities and economy
- ANS Nuclear in the States Toolkit provides options for states to consider
- See http://nuclearconnect.org/issues-policy/nuclear-policy-in-the-states



A Mixed Message Internationally

- China planning as many as 5 new reactors per year
- Germany continues its plan to shut down all its nuclear units
- New units under construction in UAE and planned in Middle East
- Interest in South Asia, Africa and South America
- Russia positioning itself as a major exporter of nuclear technology

Some Glimmers of Rationality?

- EPA CPP does provide credit for new nuclear (but not existing)
- White House Summit (November 2015); clear declaration of the need for nuclear
- Wisconsin Legislature repeal of nuclear prohibition
- NY State PUC staff statement
- DOE Summit on Improving Economics of Operating Plants May 19

COP 21: Another Big Step

- Annual UNFCCC conference
- Nov 30-Dec 11, 2015
- First time goal of legally binding carbon emission reductions
- Many geopolitical issues
- First time technology neutral (no renewal of COP-6 nuclear exclusion)
- Climate scientists nuclear declaration
- ANS was there

PARIS2015
UN CLIMATE CHANGE CONFERENCE

Nuclear for Climate: a Major Presence at COP21

- Over 150 nuclear societies from around the world common position
- All nations should be free to choose from all available energy sources
- Nuclear is the most reliable large scale source of carbon free energy
- Climate goals cannot be met without nuclear
- Excellent attendance and interest at N4C booths

Communicating the Nuclear Imperative

- Slow, tentative growing political support
- President's Science Advisor at COP 21
- Multiple Senators at Third Way summit in DC in January
- Congressional participation expected May 19 at DOE summit
- Al Gore?

The Path Forward May Not Be Familiar

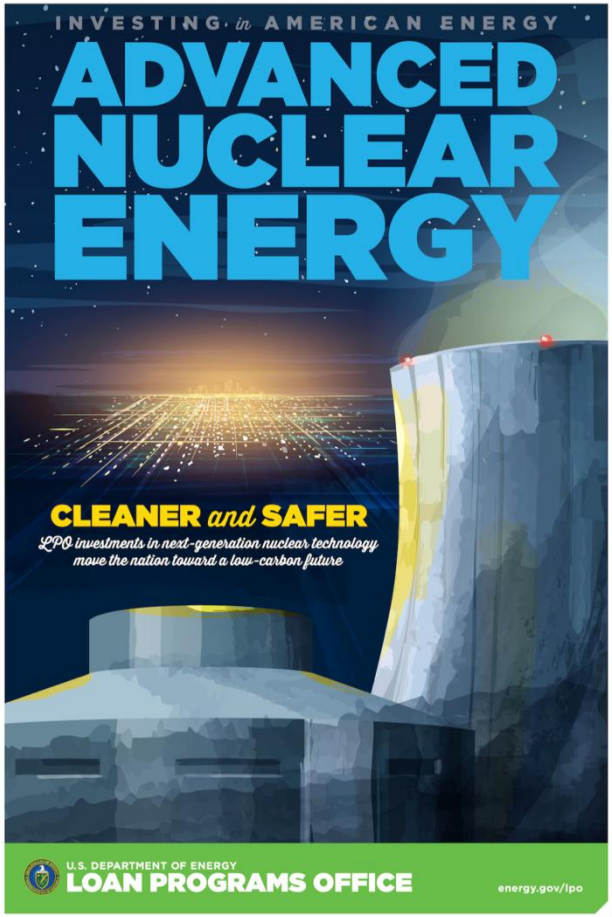
- The “gas bubble” will probably be with us for a while…this is good news for the US economy overall
- Large scale coal plant retirements are probable
- Will there be a carbon policy?
- Are there better technological options?

Innovation is long overdue in nuclear

- Present designs fundamentally the same for 60 years
- Long standing low government funding for nuclear technology research
- No other technology would be expected to be competitive for this long
- Venture capital beginning to take notice of opportunities

Innovation Is the Key

- DOE initiatives
  - GAIN
  - Facilitating access to national lab assets
  - Advanced technology cost sharing
  - INL prototype siting approval (NuScale)
- Political support



Facing realities

- Massive amounts of new, clean energy are needed for the world
- Any attempts to meet CO_2 reduction targets must include nuclear
- Wishful thinking, or waiting for hoped for technical solutions, will not be successful
- A time for re-dedication to science and innovation

What Can You Do?

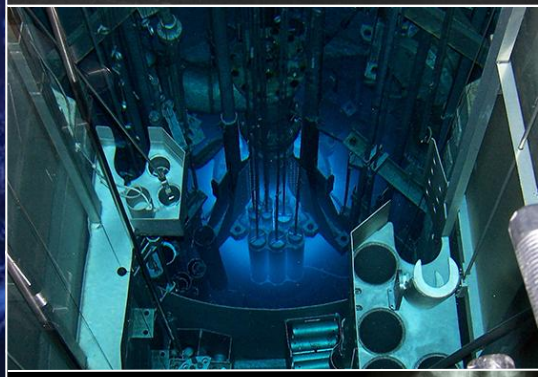
- Share the message: social media, letters to editor, etc
  - The World Needs Nuclear!
- Share the link: www.nuclearconnect.org
- Be a part of the public discussion—why is our energy future not part of the current election debate?
- Challenge junk science wherever you encounter it
- Be proud of who you are and what you do
- Join, renew and recruit for ANS!

The People of the World Deserve Better than Anti Nuclear Politics

The WORLD needs NUCLEAR

NUCLEAR needs the American Nuclear Society

ANS



Development of Advanced Nuclear Technologies

Andrew C. Klein, PhD, PE

- Andrew C. Klein, PhD, PE

- Vice-President/President-Elect of ANS
- Editor, *Nuclear Technology*
- Professor of Nuclear Science and Engineering
- Oregon State University

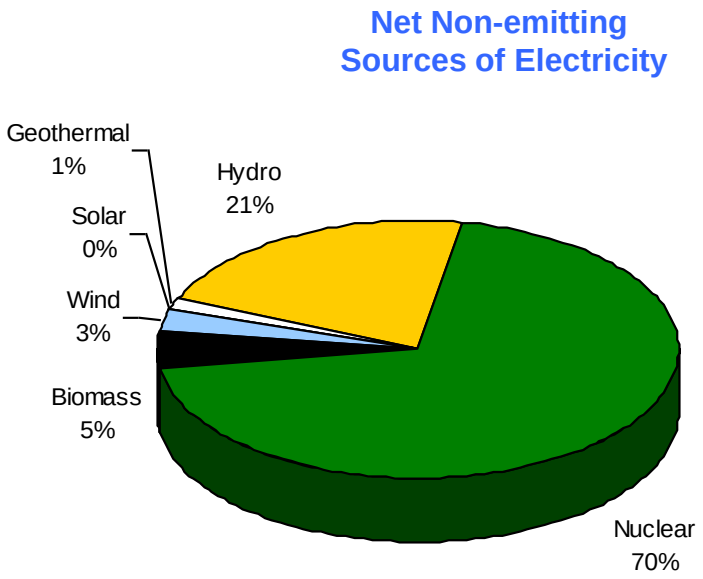
- May 2016

Nuclear Energy: Still Going Forward

- The Importance of Nuclear Energy
- Evolution of Nuclear Power
- Small Modular Reactors
- Advancing Advanced Reactors
- Grand Challenges for Nuclear Technologies
- What can you do?

Nuclear – Important, Clean Energy Source

- **Nuclear power is the clean, reliable, expandable base load energy source**
  - **Provides over 70% of U.S. emission-free electricity**
  - **Avoids about 600 MMTCO$_2$ each year**
  - **Helps reduces overall NOx and SOx levels**



So, What's Happening?

- Deregulated markets in US do not recognize emissions reduction or even capacity factors
- Price of natural gas
- Overall slow demand growth
- Five units in US shut down since 2013
- Three more already scheduled
- More operating units at risk
- No credit for operating plants in the EPA CPP
- Only five new units presently under construction
- Little recognition of the vital role nuclear plays in reducing emissions

Some Glimmer of Rationality?

- EPA CPP does provide credit for new nuclear
- White House Summit (November 2015); clear declaration of the need for nuclear and innovation
- Wisconsin and Kentucky Legislatures repeal of nuclear prohibition
- NY State PUC staff statement

Fight to Save US Nuclear Plants

- ANS Nuclear In the States Toolkit
- DOE-NE Workshop – May 19th
- Save US Nuclear activities
  - Environmental Progress
  - Third Way
  - Breakthrough Institute
  - Clean Air Task Force
  - Others

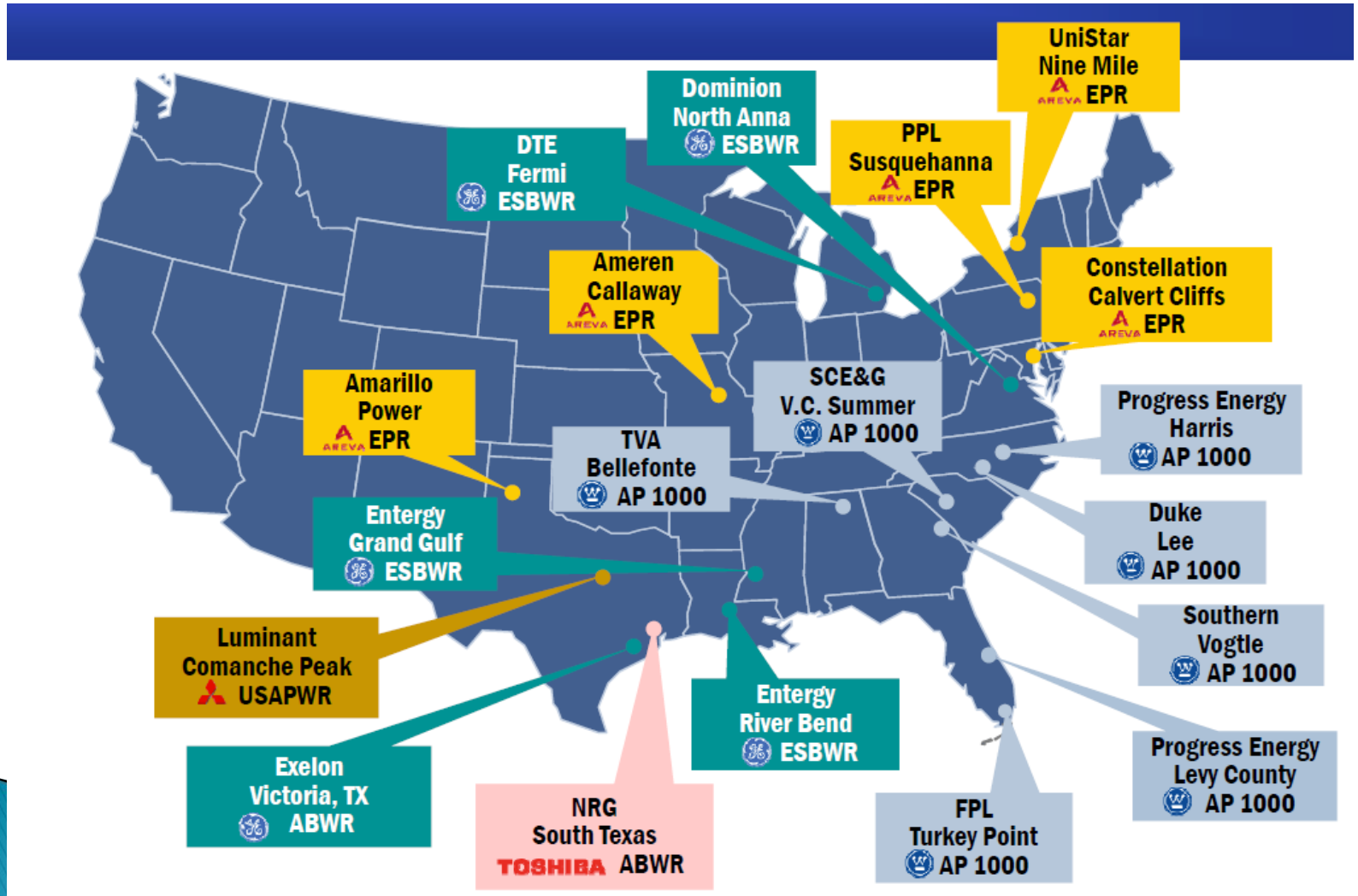
Nuclear In the States Toolkit

- **Policy options for States considering the role of nuclear power in their energy mix**
- Policy pathways to support the current nuclear fleet
- Goal is to prevent early plant retirements
- Comprehensive overview of a wide range of policy and other options
  - Federal-level initiatives such as federal tax credits
  - Community-level options like public hearings
  - Policy tools
  - Market-based tools
- State policymakers determine methods to best fit their goals
  - Policy
  - Environmental
  - Energy
  - Economic
- Each State faces a different set of circumstances regarding nuclear power

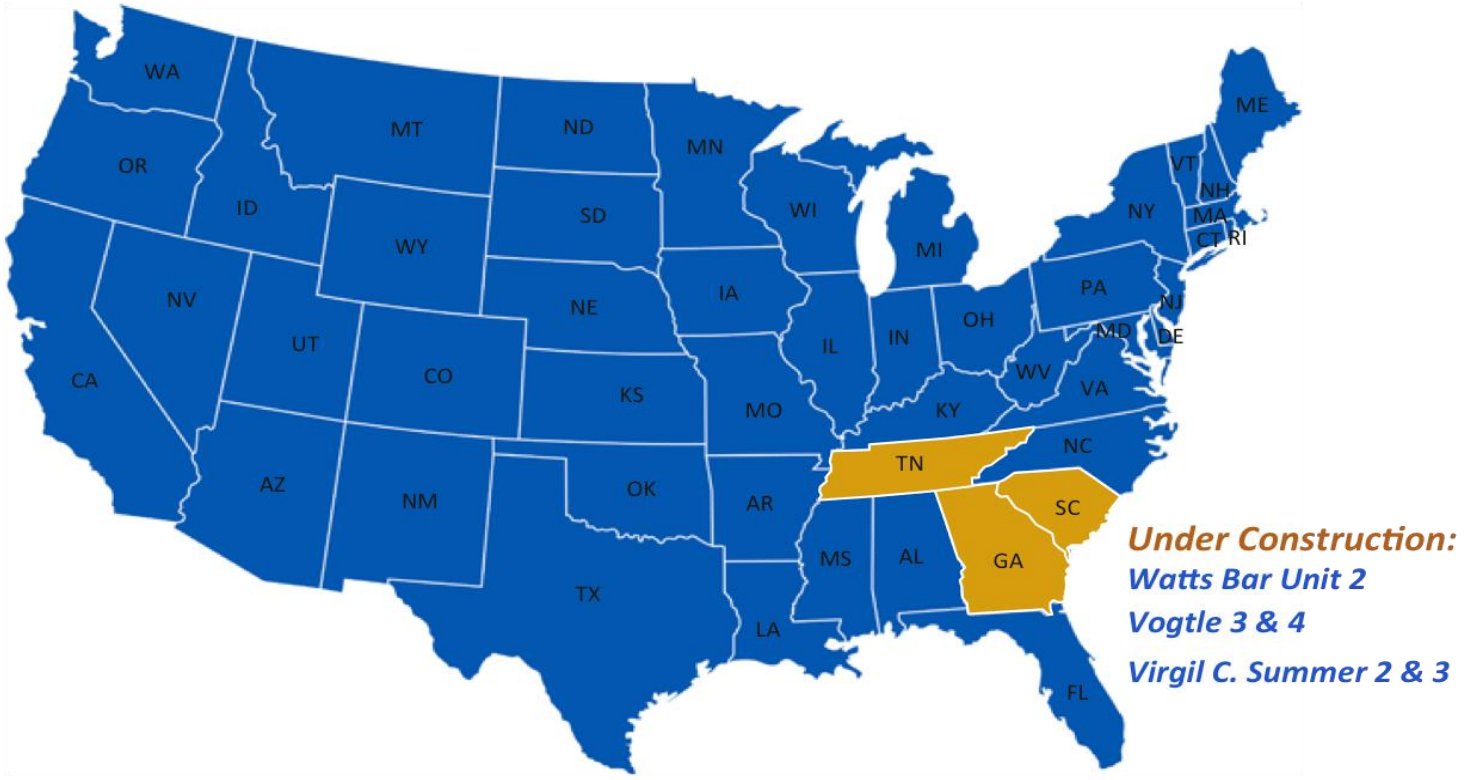
Toolkit Elements

- Increase Nuclear Plant Revenue/Revenue Certainty
  - Power Contracts
  - Low-Carbon Portfolio Standard
  - Carbon Tax
  - Nuclear Portfolio Standard
  - Clean Air Portfolio Standard
- Public Hearings/Meetings
- Clean Power Plan Implementation
- Industry Consolidation
- Public/Government Ownership
- Lower Costs
- Capacity Markets
- Electricity Markets
- Return to Economic Regulation
- Others

Outlook on New Construction



Five New Units Under Construction



Source: NEI - Nuclear Units Under Construction Worldwide

Challenges to New Construction

- High capital costs ($8-12 billion)
- Used fuel issues
- Availability of nuclear qualified components
- Availability of skilled personnel
- Lengthy licensing and construction schedule
- Cost and schedule performance
- Public concerns/misunderstandings
- Price/availability of natural gas

Advanced Nuclear Technologies

- **Opportunities**
  - Highly Efficient Technologies
  - New Instrumentation and Control Strategies
  - Modular Construction
  - Preapproved Sites
  - Dramatically Reducing Waste Production
  - Proliferation Resistant
  - New Markets

- **Challenges**
  - Different Operations and Industry Comfort?
  - New Licensing Strategies/Requirements?
  - Inexperience with New Technologies?
    - Industry?
    - Regulator?
    - Workforce?
  - Turning the Economy of Scale on it's Head?

Advanced Nuclear Technologies

- Many recent new and old ideas

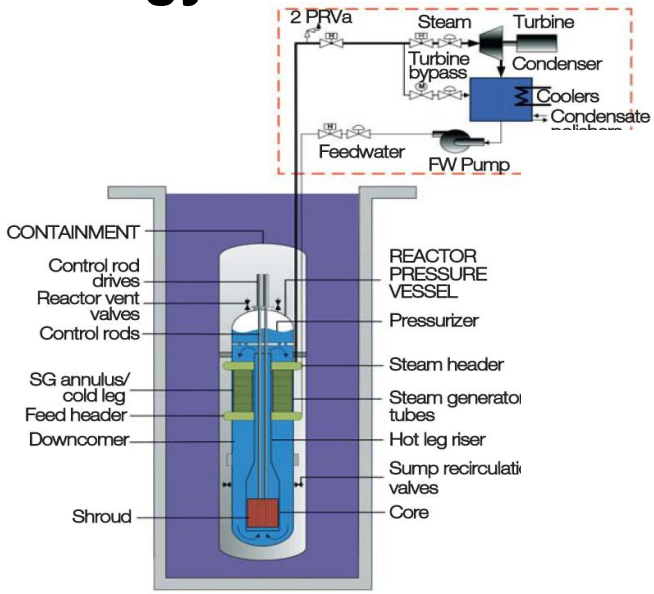
- Small Modular Reactors
- Advanced Reactors
- Innovative Nuclear Concepts
- Innovative Development Constructs
- Innovative Nuclear Business Models

Small Modular Reactors

- Small Modular Reactors (SMRs) are being developed for deployment around the world
  - Offer enhanced passive safety features and promise lower construction and financing costs
  - Domestic market focused on replacement of 600+ smaller, aging coal fired plants
  - Export market focused on emerging economies with smaller grids

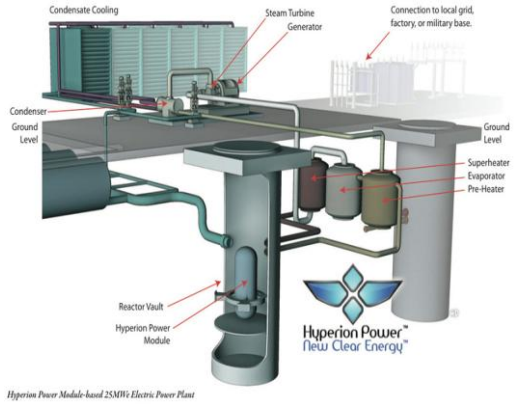
Benefits of SMRs

- **SMRs potential for changing social and energy supply paradigms is compelling**
  - **Jobs**
  - **US goods and services**
  - **National Security and energy policy**
  - **Climate change benefits**
  - **Complement large reactor programs**

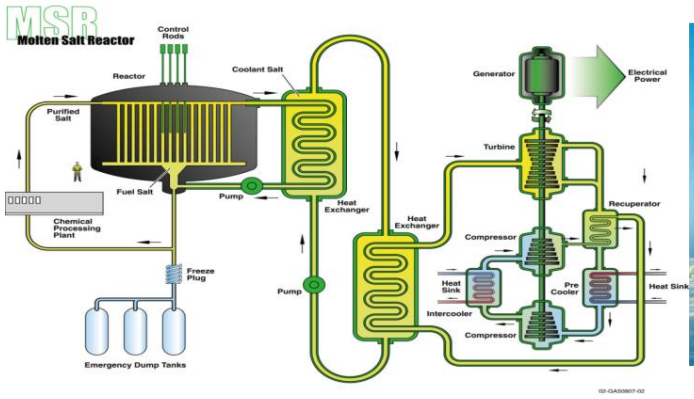


NuScale Integral PWR

SMR licensing must address technology-neutral Issues

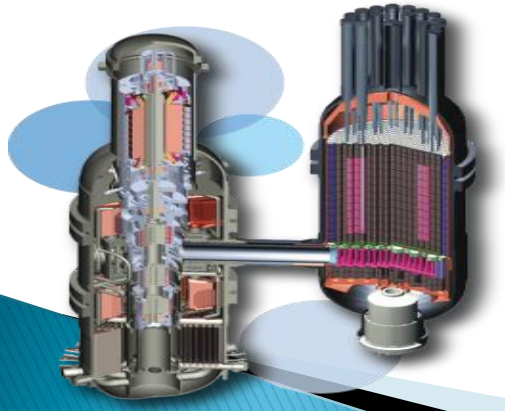


Hyperion Reactor

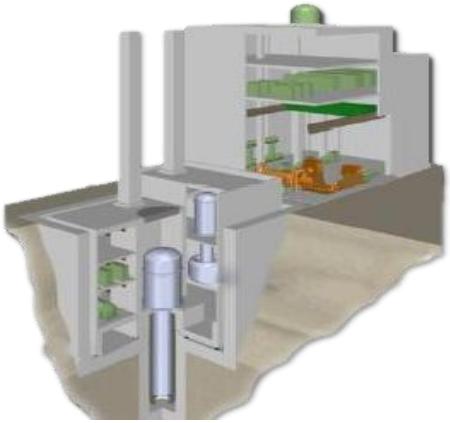


Molten Salt Reactor

KLT-40 Icebreaker Reactor
(35 Mwe floating nuclear power plant)



General Atomics MHR

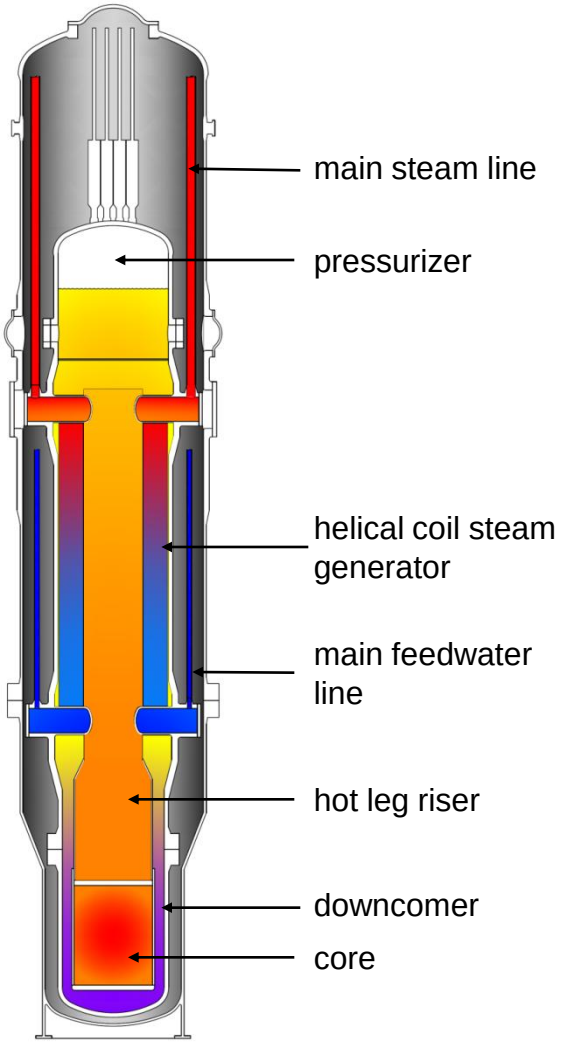


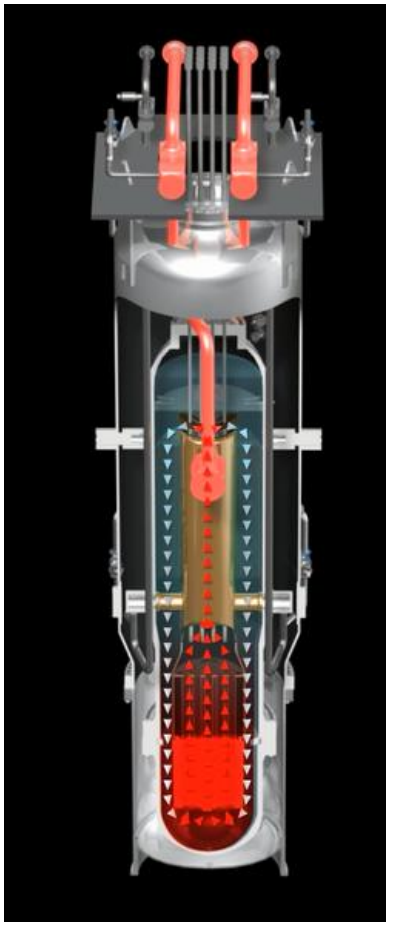
Toshiba 4S (10 to 50 MWe) Sodium-cooled

PBMR (165 MWe)

NuScale Reactor Design Features

- Primary side
  - Natural circulation
  - Integral pressurizer
  - No Reactor Coolant Pumps
- Secondary side
  - Feedwater plenums
  - Two helical steam generators with large surface area per volume to maximize thermal efficiency
  - Steam plenums



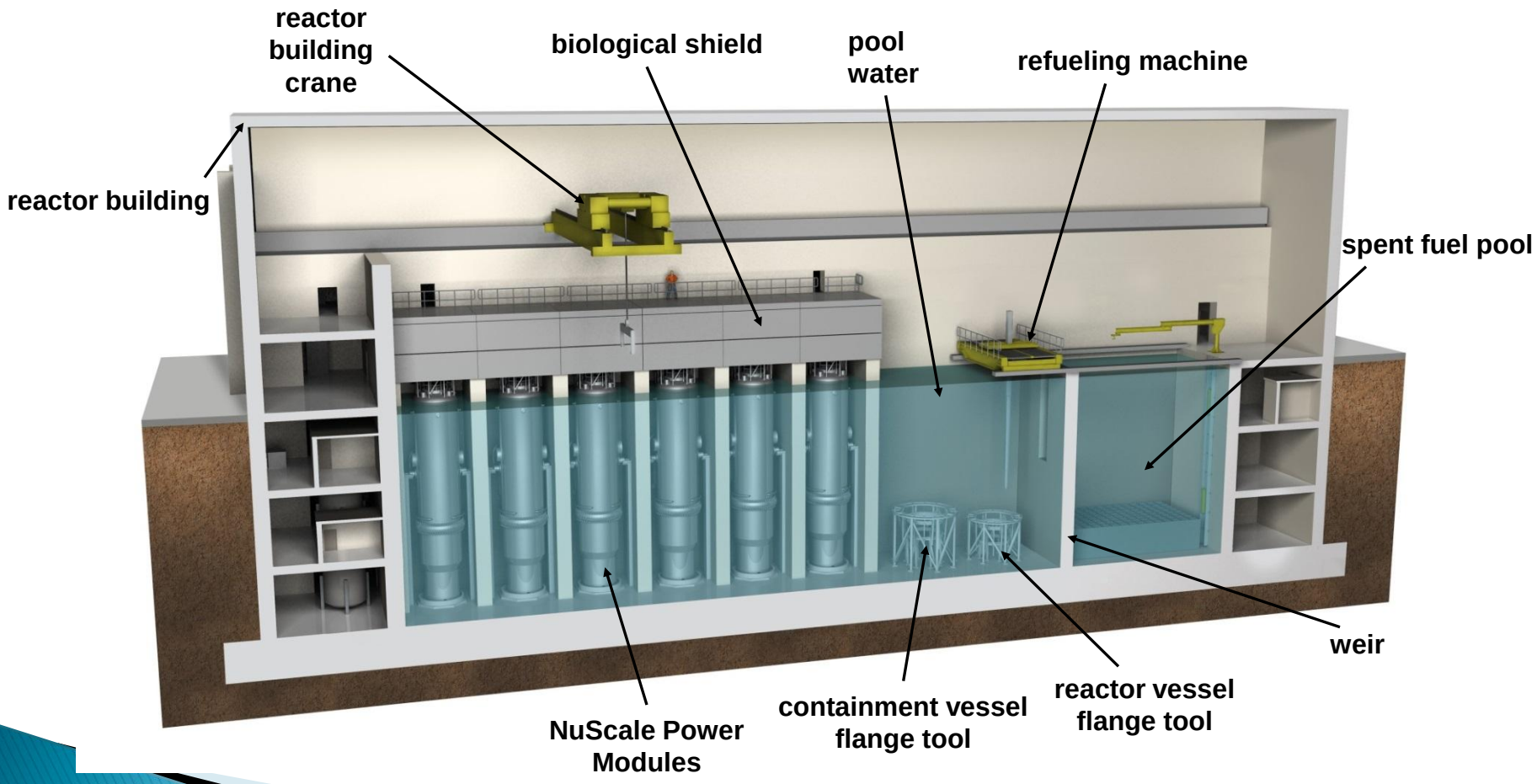


primary coolant flow path

NuScale Power™

Reactor Building Cross-Section

Reactor building houses reactor modules, fuel pool, and reactor pool

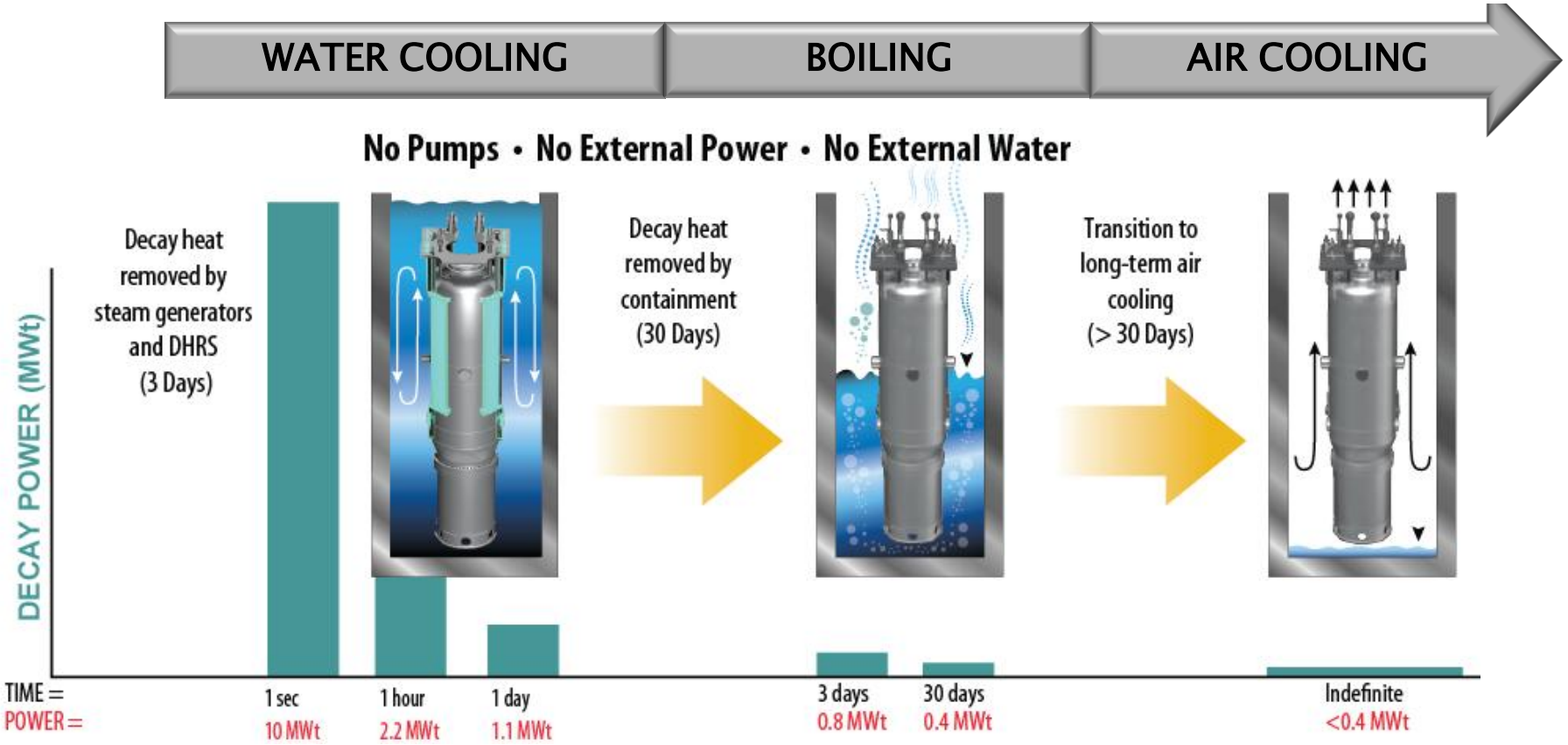


NuScale Power™

Response to Loss of All Power

Stable Long-Term Cooling Under all Conditions

Reactor and nuclear fuel cooled indefinitely without pumps or power



** Based on conservative calculations assuming all 12 modules in simultaneous upset conditions and reduced pool water inventory*

NuScale Integral System Test Facility @ Oregon State University

NuScale Power™

Advancing Advanced Reactors

- Generation IV Designs and Concepts
  - US Department of Energy
  - International Development
  - Large Companies – Private Investments
  - Startup Companies – Venture Capital

Advanced Reactor Missions

- Process heat applications including cogeneration
- Actinide management to extend fuel resource utilization
- Reduce the nuclear waste burden
- Integration of with intermittent energy sources for reliable energy systems
  - Hybrid Energy Systems

Technology Innovations

- Reduction of capital cost and improvement of thermal energy conversion
- Incorporation of passive safety features
- Advanced fuels
  - Dissolved
  - Particle
  - Metallic
  - Ceramic
- Cladding innovations enabling high burnup, extensive actinide destruction, and enhanced accident tolerance
- Advanced power conversion systems (Brayton, supercritical CO_2) to improve overall energy conversion efficiency and reduce water usage

Gateway for Accelerated Innovation in Nuclear (GAIN)

- New DOE-NE approach
- Provide the nuclear community with access to the technical, regulatory, and financial support necessary to move innovative nuclear energy technologies toward commercialization
- Ensure continued safe, reliable, and economic operation of the existing nuclear fleet

DOE-NE Demonstration & Test Reactor Assessment Program

- Demonstration Reactor Concepts
  - Sodium-Cooled Fast Reactor
  - High Temperature Gas-Cooled Reactor
  - Lead-Cooled Fast Reactor
  - Molten Salt-Cooled Reactor
- Test Reactor Concepts
  - Sodium-Cooled Fast Test Reactor
  - Helium-Cooled Thermal Test Reactor

International Advanced Reactor Developments

- Sodium fast reactor demonstration reactor projects
  - Russia (880 MWe BN-800)
  - India (500 MWe PFBR)
  - China (Experimental Fast Reactor (CEFR) in operation since 2010)
  - Japan (restart of Japan Experimental Fast Reactor (JOYO) test reactor and Monju demonstration reactor)

- Sodium fast reactor design projects
  - Korea (150 MWe PGSFR)
  - France (300 MWe ASTRID)

- High temperature gas-cooled reactor projects
  - China (building two-unit 250 MW pebble bed)
  - Eastern Europe (ALLEGRO fast-spectrum gas-cooled reactor study)

International Advanced Reactor Developments

- Lead-cooled fast reactor project
  - Russia (BREST-300 design project, aiming for 2020 operation)

- Subcritical accelerator-driven test projects
  - Belgium (85MWth Multi-purpose hYbrid Research Reactor for High-tech Applications (MYRRHA) design project)
  - Russia (study phase)
  - European Union (study phase)

- Molten salt reactor projects
  - China (2 to 10 MW molten salt pebble bed reactor)
  - Europe (study phase)
  - Russia (study phase)

Technical Grand Challenges for Nuclear Technologies

- Approach by ANS membership to identify the technical Nuclear Grand Challenges
- Grass-roots efforts to be conducted through ANS Professional Divisions & utilize ANS Collaborate
- Initiated in Fall of 2016 – Stay Tuned!
- Final list announced in June 2017

What Can You Do?

- Share the message: social media, letters to editor, etc.
  - The World Needs Nuclear!
- Share the link: www.nuclearconnect.org
- Be involved:
  - Washington Internships for Students of Engineering (WISE)
- Be a part of the public discussion:
  - Why is your energy future not part of the current election debate?
- Challenge bad science wherever you encounter it
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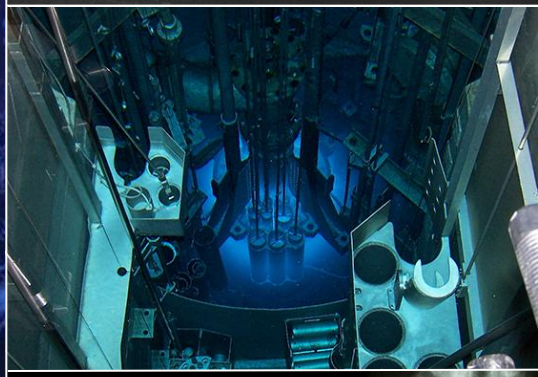
- Join, renew and recruit for ANS!

The WORLD needs NUCLEAR

NUCLEAR needs the American Nuclear Society

ANS



Washington Internships for Students of Engineering (WISE)

- Nine-week program in Washington, D.C. sponsored by a consortium of professional societies
  - Focus: Technology policy—i.e., the intersection between technology and the political process
  - Primary audience – rising seniors, but grad students (especially first year) will be considered, too
  - Seminars and meetings at government agencies in the Washington area
  - Individual research project on a technology policy issue of the intern's choice—20 page paper and end-of-program presentation on Capitol Hill
  - Intern class of about 12-15 students, led by Faculty-Member-in-Residence
- ANS sponsors two interns each summer
  - Office space and support provided by Nuclear Energy Institute
  - Stipend of $2100; housing provided by WISE Program in George Washington U. dormitories
  - ANS Student Membership required for sponsorship by ANS
  - Application deadline: December 31

Washington Internships for Students of Engineering (WISE)

- WISE participation can help open a wide variety of opportunities: grad school, industry and national laboratory internships, and jobs
- ANS News articles on the program appear twice each year
- ANS WISE Coordinator: Dr. Alan Levin, DOE, alevin@alum.mit.edu

- WISE website: www.wise-intern.org

"The summer I spent in the WISE program was extremely influential on my career path. After completion of my service time with the U.S. Navy and Master's Degree, I decided on a career path that would use my engineering background and interest in public policy gained from the WISE program and had the opportunity to join the U.S. Nuclear Regulatory Commission."

--Chris Henderson, U.S. NRC resident inspector and 1998 ANS WISE intern

Closing

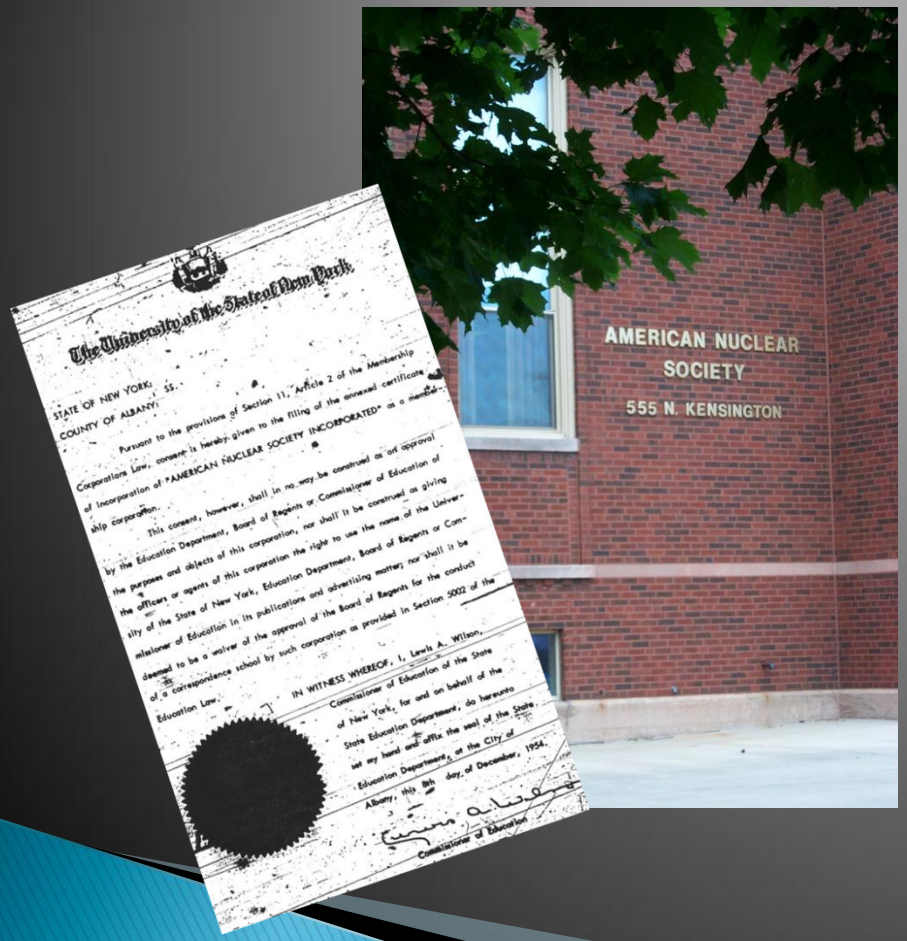
Development of Advanced Nuclear Technologies

- Andrew C. Klein, PhD, PE

- Vice-President/President-Elect of ANS
- Editor, *Nuclear Technology*
- Professor of Nuclear Science and Engineering
- Oregon State University

- May 2016

About ANS



- Founded in December 1954
- Creates a forum for knowledge sharing
- Convenes countless conferences
- Stimulates discussion and debate among professionals
- Fosters interest in the profession
- Provides recognition for excellence
- Influences the conversation about nuclear with those outside the field

Some Vital Statistics

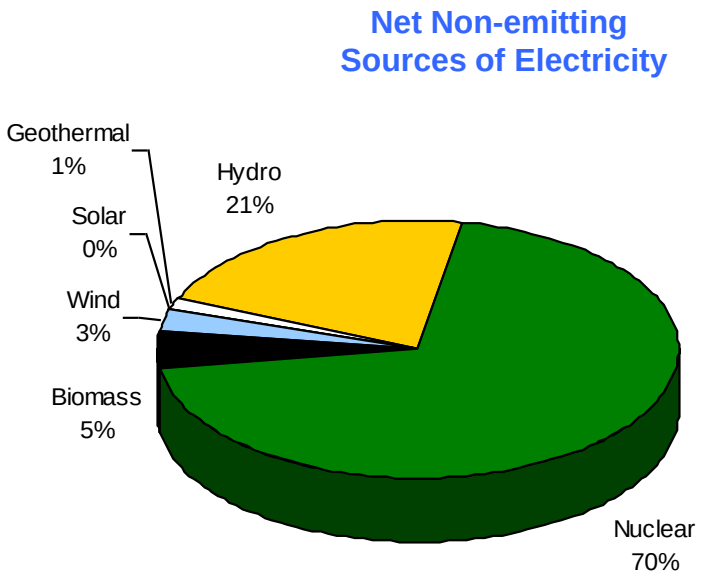
- Almost 10,000 individual members
- Nearly 100 organizational members
- International alliances, bilateral agreements with some 30 nuclear societies outside the U.S.
- Over 60 local sections (including 9 outside the U.S.)
- 20 specialty professional divisions and technical groups including the Young Members Group
- More than 30 local student sections

Nuclear Energy: Still Going Forward

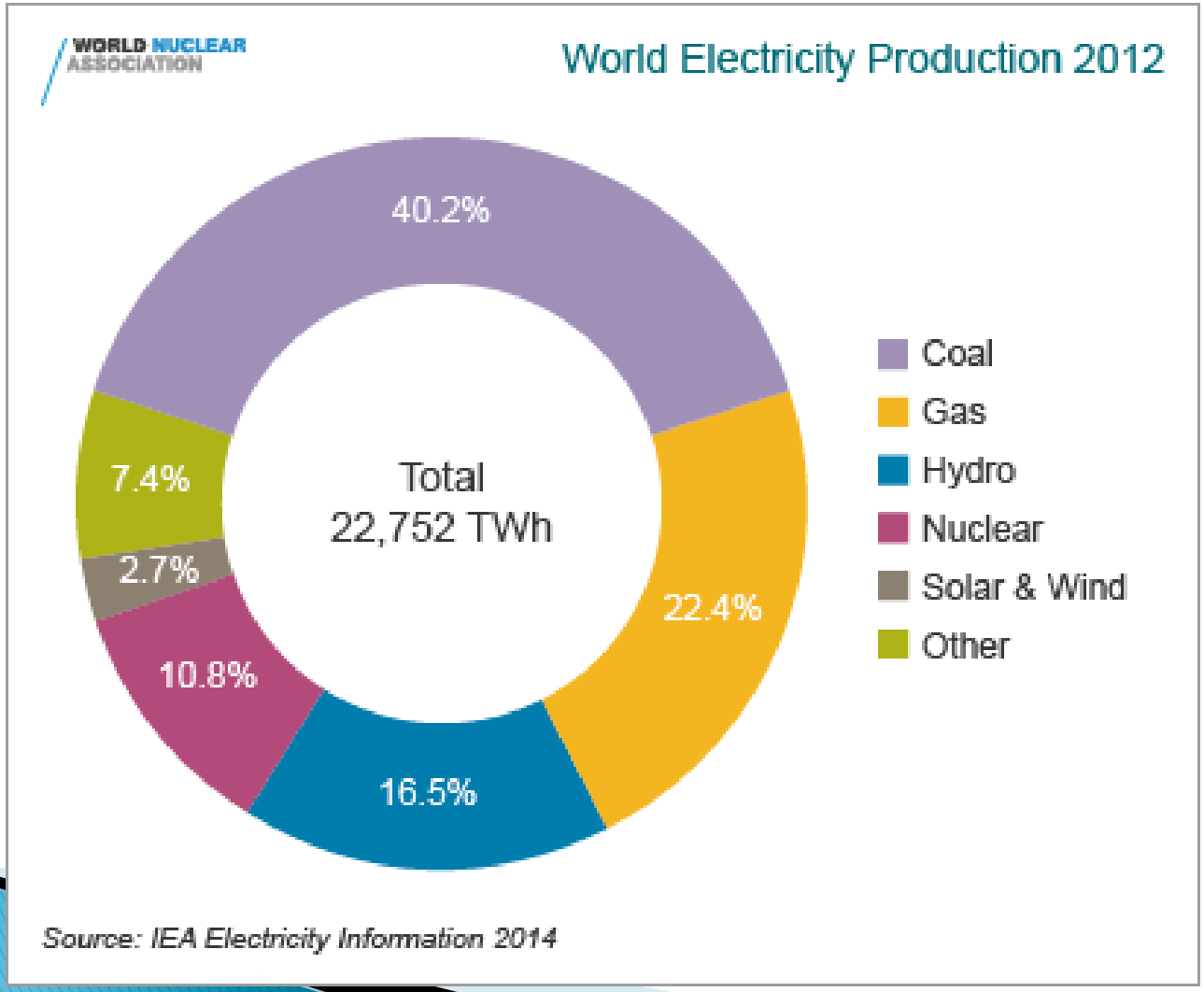
- The Importance of Nuclear Energy
- Evolution of Nuclear Power
- Small Modular Reactors
- Advancing Advanced Reactors
- Grand Challenges for Nuclear Technologies
- What can you do?

Nuclear – Important, Clean Energy Source

- **Nuclear power is the clean, reliable, expandable base load energy source**
  - **Provides over 70% of U.S. emission-free electricity**
  - **Avoids about 600 MMTCO$_2$ each year**
  - **Helps reduces overall NOx and SOx levels**

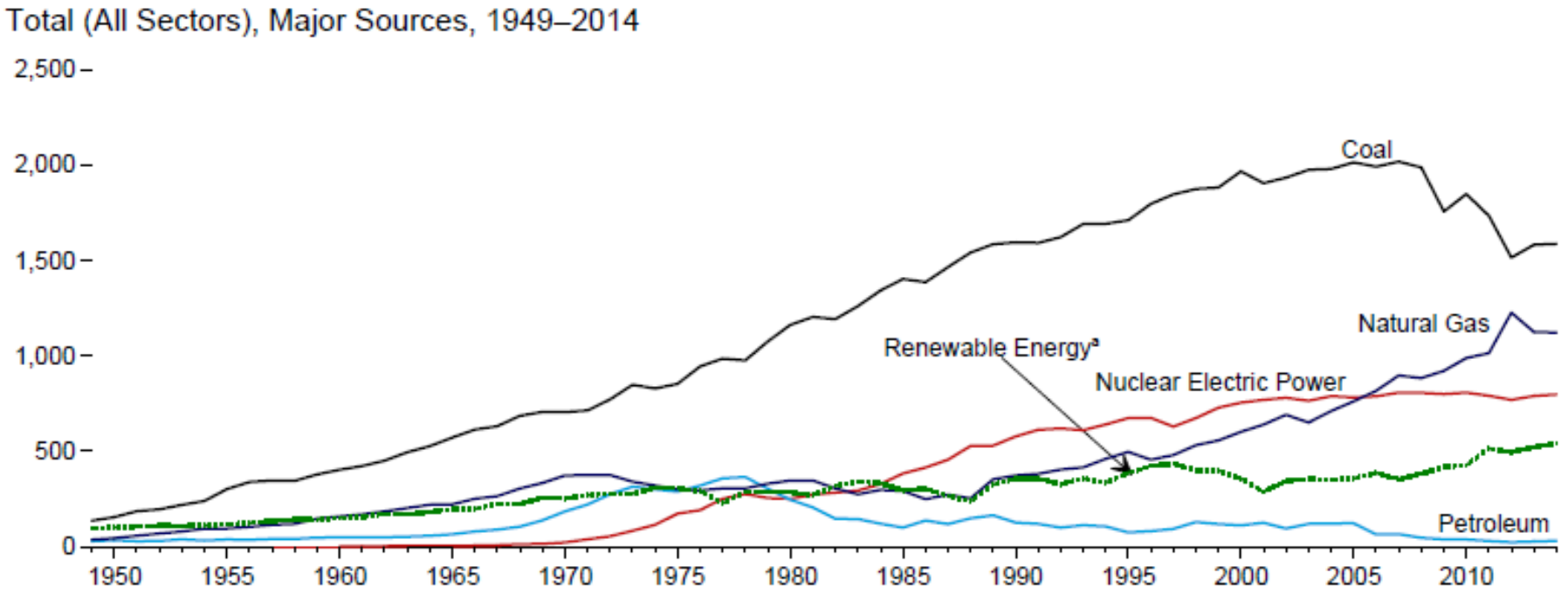


Current Energy Consumption is Carbon Based



WNA, 2014

Electricity Net Generation
(Billion kW-Hrs)



Source: Monthly Energy Review, US Energy Information Administration, March 2015

So, What's Happening?

- Deregulated markets in US do not recognize emissions reduction or even capacity factors
- Price of natural gas
- Overall slow demand growth
- Five units in US shut down since 2013
- Three more already scheduled
- More operating units at risk
- No credit for operating plants in the EPA CPP
- Only five new units presently under construction
- Little recognition of the vital role nuclear plays in reducing emissions

US nuclear units shut down since 2013

Fitzpatrick scheduled to close January 2017
Pilgrim to shut down in 2019
Oyster Creek scheduled to close in 2019

Some Glimmer of Rationality?

- EPA CPP does provide credit for new nuclear
- White House Summit (November 2015); clear declaration of the need for nuclear and innovation
- Wisconsin and Kentucky Legislatures repeal of nuclear prohibition
- NY State PUC staff statement

Fight to Save US Nuclear Plants

- ANS Nuclear In the States Toolkit
- DOE-NE Workshop – May 19th
- Save US Nuclear activities
  - Environmental Progress
  - Third Way
  - Breakthrough Institute
  - Clean Air Task Force
  - Others

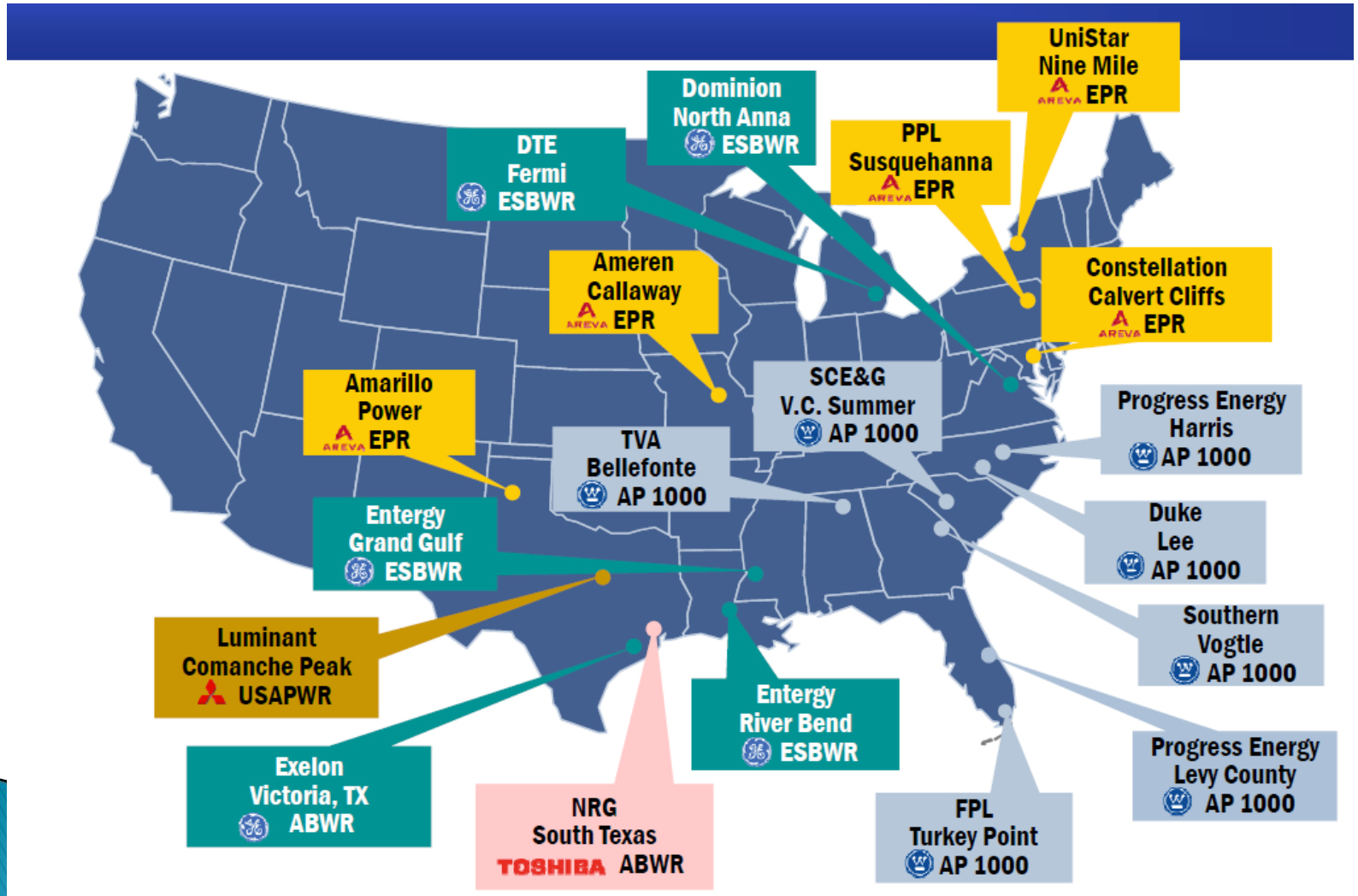
Nuclear In the States Toolkit

- **Policy options for States considering the role of nuclear power in their energy mix**
- Policy pathways to support the current nuclear fleet
- Goal is to prevent early plant retirements
- Comprehensive overview of a wide range of policy and other options
  - Federal-level initiatives such as federal tax credits
  - Community-level options like public hearings
  - Policy tools
  - Market-based tools
- State policymakers determine methods to best fit their goals
  - Policy
  - Environmental
  - Energy
  - Economic
- Each State faces a different set of circumstances regarding nuclear power

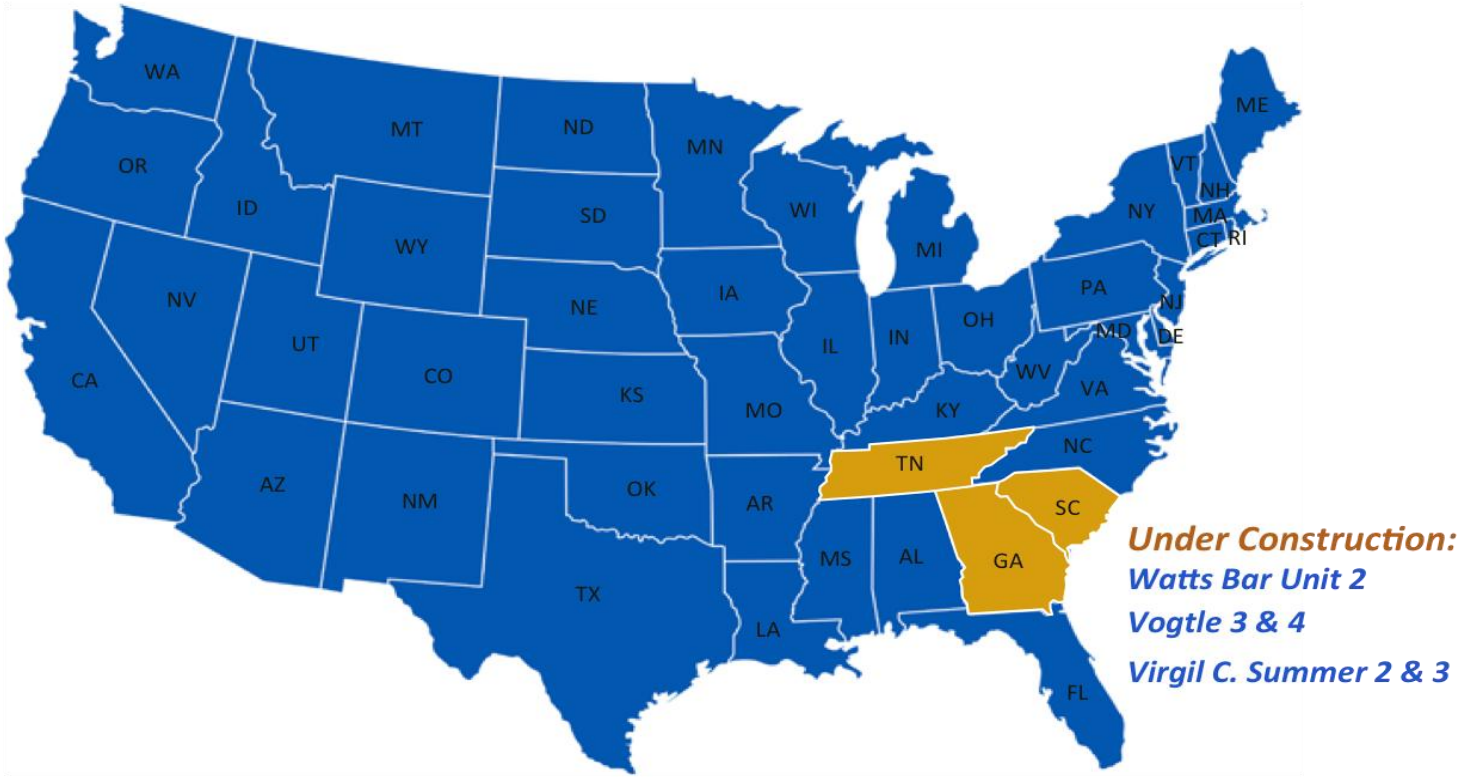
Toolkit Elements

- Increase Nuclear Plant Revenue/Revenue Certainty
  - Power Contracts
  - Low-Carbon Portfolio Standard
  - Carbon Tax
  - Nuclear Portfolio Standard
  - Clean Air Portfolio Standard
- Public Hearings/Meetings
- Clean Power Plan Implementation
- Industry Consolidation
- Public/Government Ownership
- Lower Costs
- Capacity Markets
- Electricity Markets
- Return to Economic Regulation
- Others

Outlook on New Construction



Five New Units Under Construction



Source: NEI - Nuclear Units Under Construction Worldwide

Challenges to New Construction

- High capital costs ($8-12 billion)
- Used fuel issues
- Availability of nuclear qualified components
- Availability of skilled personnel
- Lengthy licensing and construction schedule
- Cost and schedule performance
- Public concerns/misunderstandings
- Price/availability of natural gas

Advanced Nuclear Technologies

- **Opportunities**
  - Highly Efficient Technologies
  - New Instrumentation and Control Strategies
  - Modular Construction
  - Preapproved Sites
  - Dramatically Reducing Waste Production
  - Proliferation Resistant
  - New Markets

- **Challenges**
  - Different Operations and Industry Comfort?
  - New Licensing Strategies/Requirements?
  - Inexperience with New Technologies?
    - Industry?
    - Regulator?
    - Workforce?
  - Turning the Economy of Scale on it's Head?

Evolution of Nuclear Power

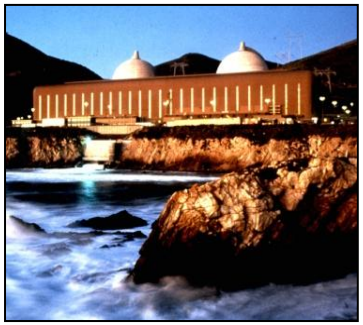
Generation I

Early Prototype Reactors

- Shippingport
- Dresden
- Fermi I
- Magnox

Generation II

Commercial Power Reactors



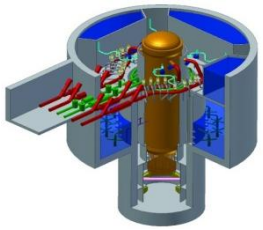
- LWR-PWR, BWR
- CANDU
- VVER/RBMK

Generation III

Advanced LWRs

- ABWR
- System 80+
- AP600
- EPR

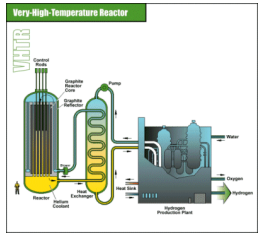
Generation III+



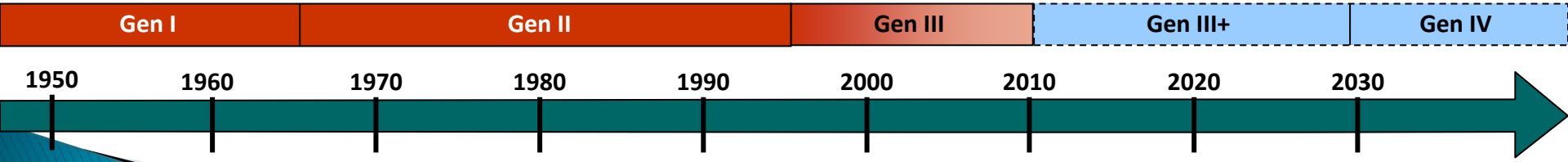
Near-Term Deployment

- AP1000
- PBMR
- SWR-1000
- ABWR-II

Evolutionary Improved Economics



- Highly Economical
- Enhanced Safety
- Minimal Waste
- Proliferation Resistant



1. U.S. Department of Energy, Gen-IV Roadmap Report

U.S. DEPARTMENT OF ENERGY

Advanced Nuclear Technologies

- Many recent new and old ideas

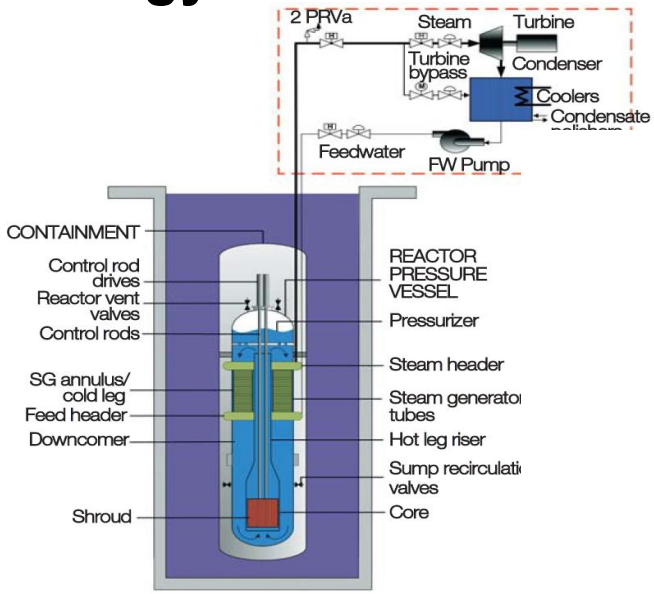
- Small Modular Reactors
- Advanced Reactors
- Innovative Nuclear Concepts
- Innovative Development Constructs
- Innovative Nuclear Business Models

Small Modular Reactors

- Small Modular Reactors (SMRs) are being developed for deployment around the world
  - Offer enhanced passive safety features and promise lower construction and financing costs
  - Domestic market focused on replacement of 600+ smaller, aging coal fired plants
  - Export market focused on emerging economies with smaller grids

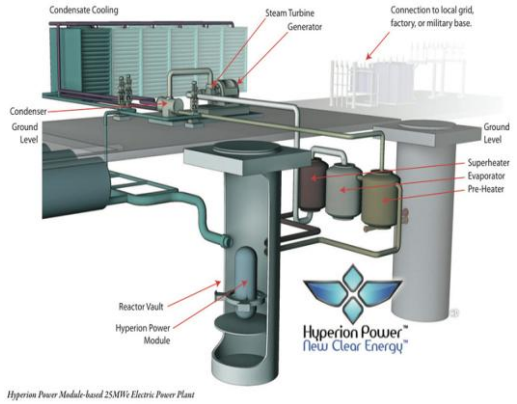
Benefits of SMRs

- **SMRs potential for changing social and energy supply paradigms is compelling**
  - **Jobs**
  - **US goods and services**
  - **National Security and energy policy**
  - **Climate change benefits**
  - **Complement large reactor programs**

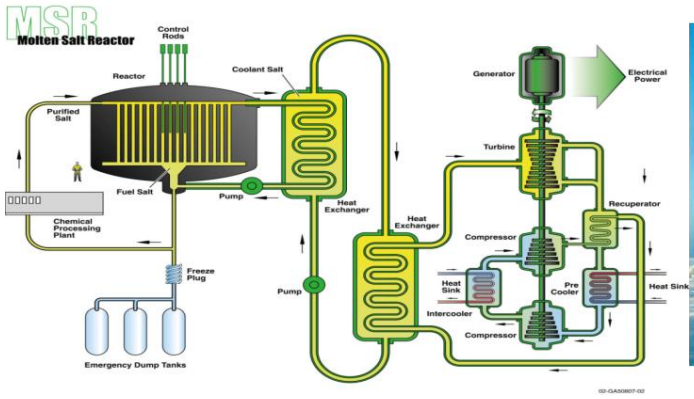


NuScale Integral PWR

SMR licensing must address technology-neutral Issues

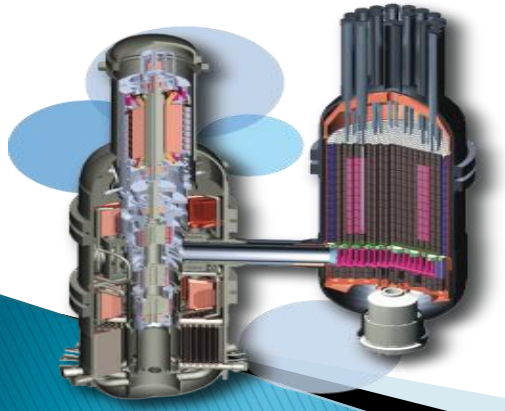


Hyperion Reactor

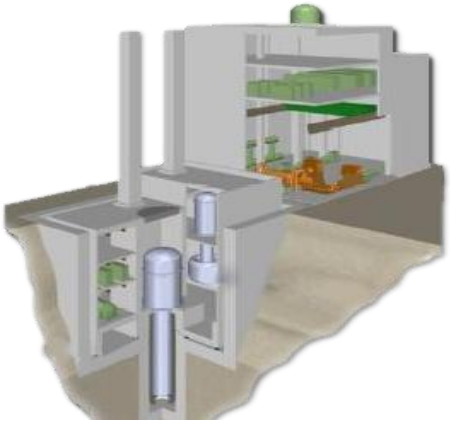


Molten Salt Reactor

KLT-40 Icebreaker Reactor
(35 Mwe floating nuclear power plant)



General Atomics MHR

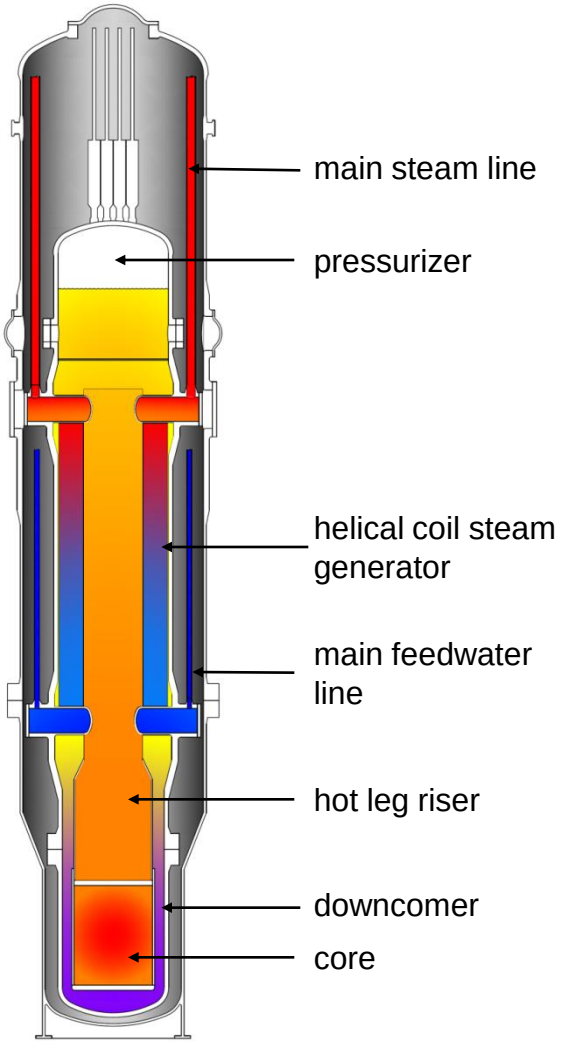


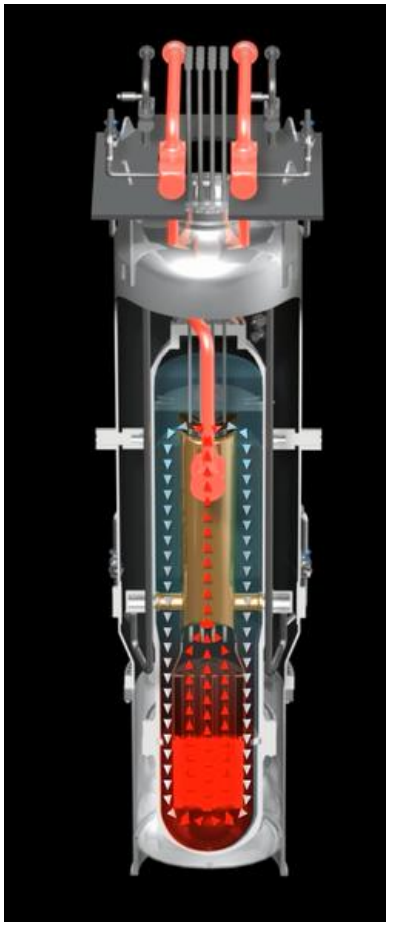
Toshiba 4S (10 to 50 MWe) Sodium-cooled

PBMR (165 MWe)

NuScale Reactor Design Features

- Primary side
  - Natural circulation
  - Integral pressurizer
  - No Reactor Coolant Pumps
- Secondary side
  - Feedwater plenums
  - Two helical steam generators with large surface area per volume to maximize thermal efficiency
  - Steam plenums



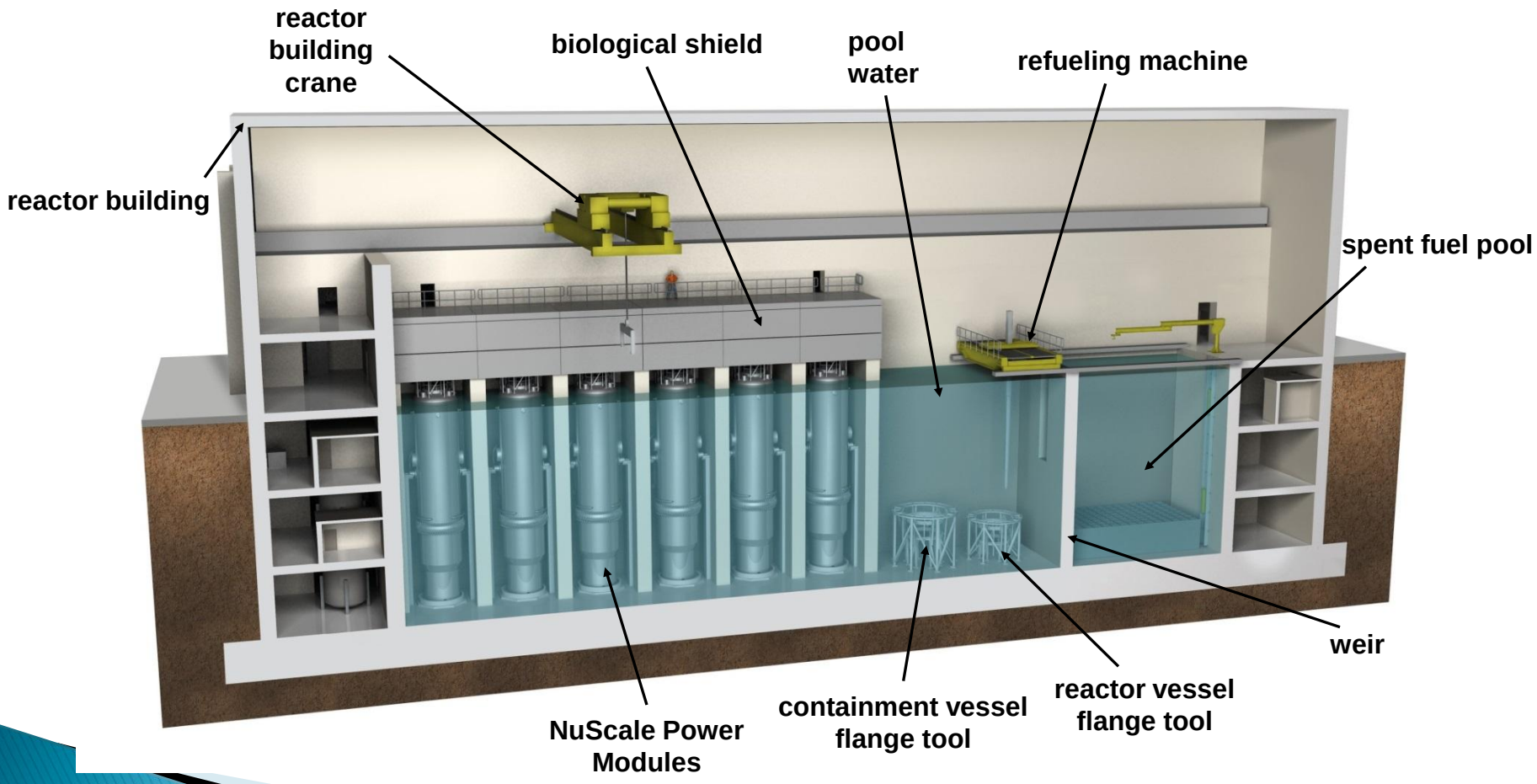


primary coolant flow path

NuScale Power™

Reactor Building Cross-Section

Reactor building houses reactor modules, fuel pool, and reactor pool

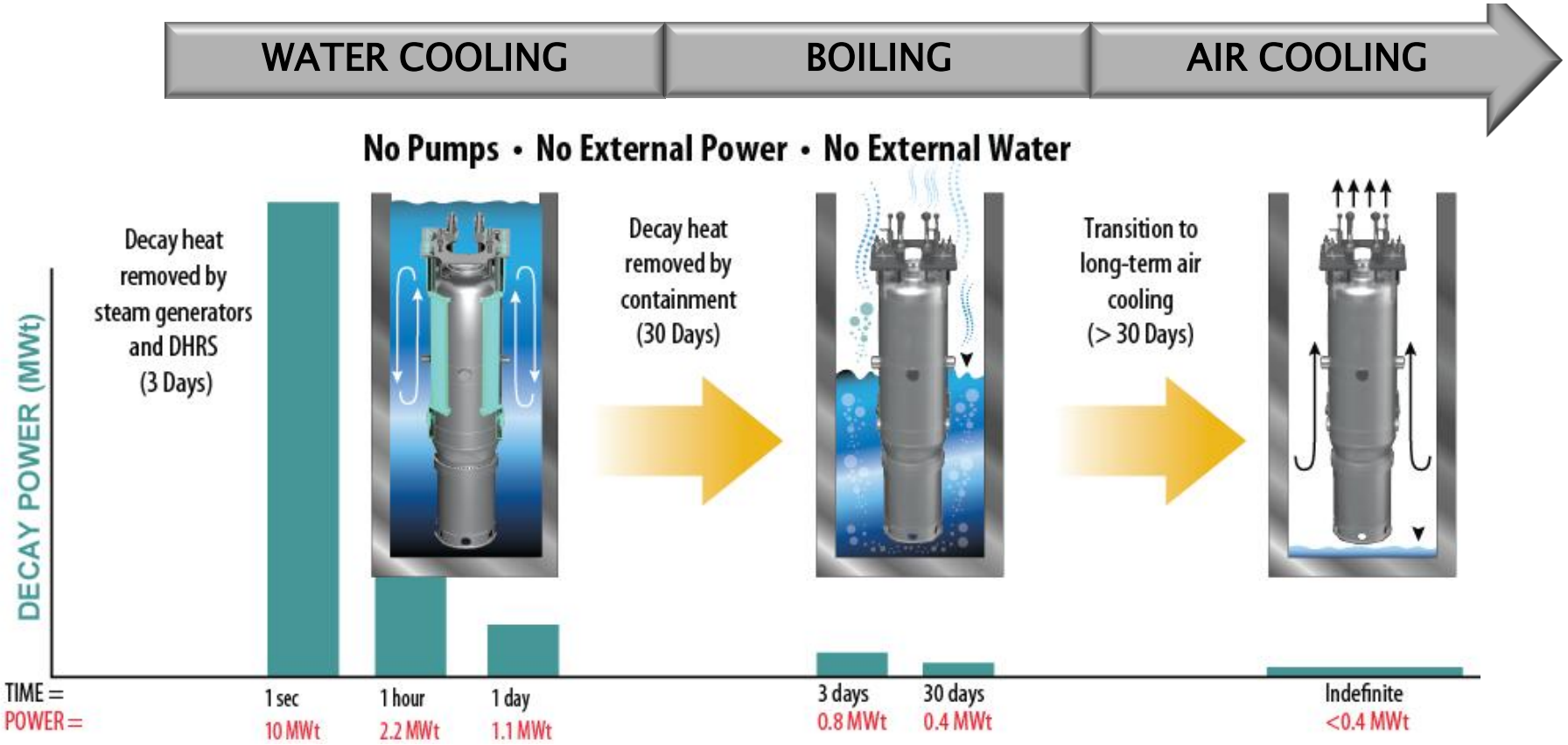


NuScale Power™

Response to Loss of All Power

Stable Long-Term Cooling Under all Conditions

Reactor and nuclear fuel cooled indefinitely without pumps or power



** Based on conservative calculations assuming all 12 modules in simultaneous upset conditions and reduced pool water inventory*

NuScale Integral System Test Facility @ Oregon State University

NuScale Power™

Advancing Advanced Reactors

- Generation IV Designs and Concepts
  - US Department of Energy
  - International Development
  - Large Companies – Private Investments
  - Startup Companies – Venture Capital

Advanced Reactor Missions

- Process heat applications including cogeneration
- Actinide management to extend fuel resource utilization
- Reduce the nuclear waste burden
- Integration of with intermittent energy sources for reliable energy systems
  - Hybrid Energy Systems

Technology Innovations

- Reduction of capital cost and improvement of thermal energy conversion
- Incorporation of passive safety features
- Advanced fuels
  - Dissolved
  - Particle
  - Metallic
  - Ceramic
- Cladding innovations enabling high burnup, extensive actinide destruction, and enhanced accident tolerance
- Advanced power conversion systems (Brayton, supercritical CO_2) to improve overall energy conversion efficiency and reduce water usage

Advancing Advanced Reactors

- High Temperature Gas Reactors
- General Atomics http://www.ga.com/energy-multiplier-module
- Areva http://us.areva.com/EN/home-3225/areva-inc-areva-htgr.html
- Hybrid Power Technologies http://www.hybridpowertechnologies.com/
- Molten Salt Reactors
- Transatomic Power http://www.transatomicpower.com/
- Terrestrial Energy http://terrestrialenergy.com/
- Oklo (formerly UPower) http://oklo.com/

Liquid Metal Reactors

TerraPower http://terrapower.com/

General Electric http://gehitachiprism.com/

Advanced Reactor Concepts http://www.arcnuclear.com

Gen4 Energy http://www.gen4energy.com/

Westinghouse http://www.westinghousenuclear.com/

Fusion Reactors

Helion Energy http://www.helionenergy.com/

Tri Alpha Energy http://www.trialphaenergy.com/

General Fusion http://www.generalfusion.com/

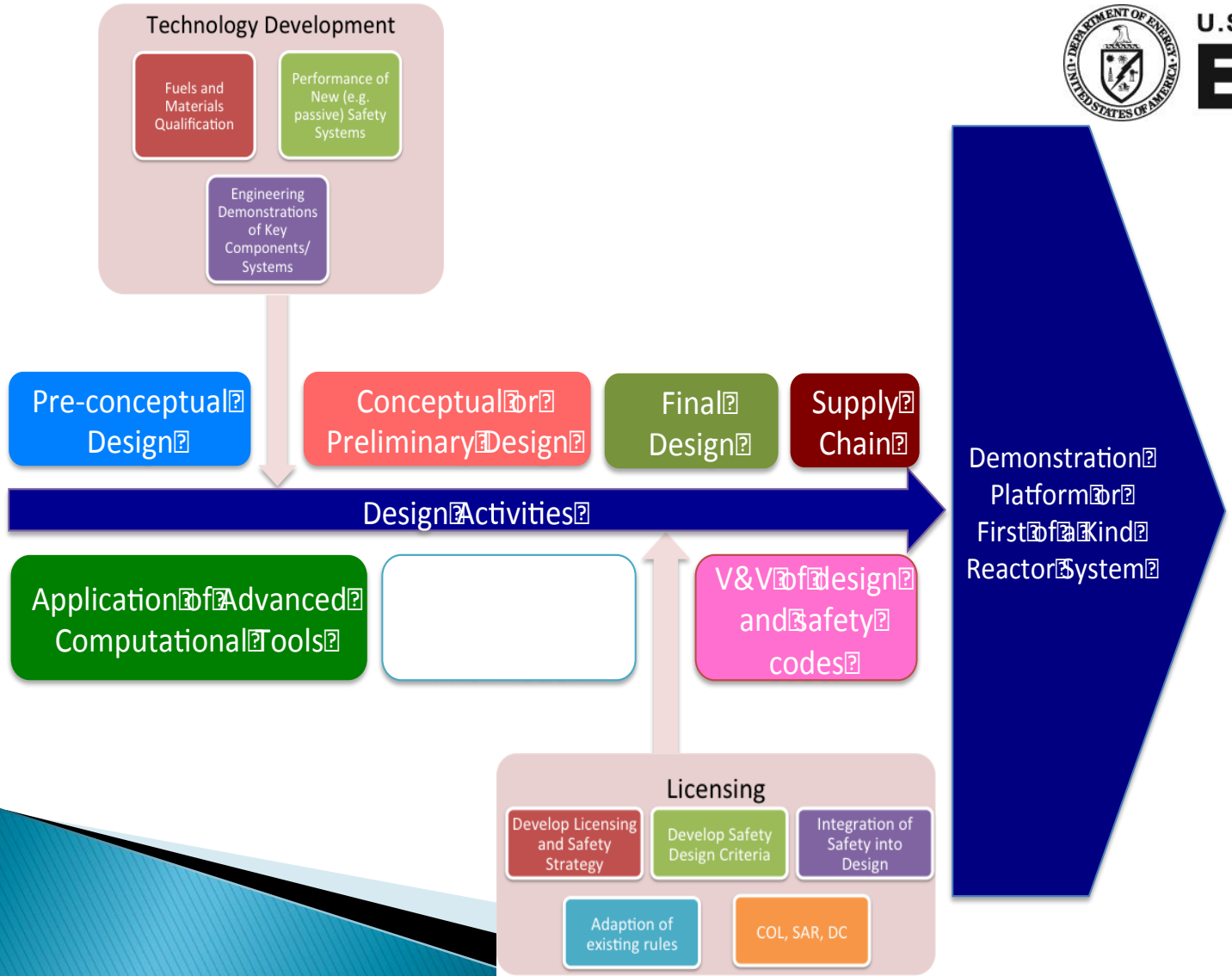
Gateway for Accelerated Innovation in Nuclear (GAIN)

- New DOE-NE approach
- Provide the nuclear community with access to the technical, regulatory, and financial support necessary to move innovative nuclear energy technologies toward commercialization
- Ensure continued safe, reliable, and economic operation of the existing nuclear fleet

DOE-NE Demonstration & Test Reactor Assessment Program

- Demonstration Reactor Concepts
  - Sodium-Cooled Fast Reactor
  - High Temperature Gas-Cooled Reactor
  - Lead-Cooled Fast Reactor
  - Molten Salt-Cooled Reactor
- Test Reactor Concepts
  - Sodium-Cooled Fast Test Reactor
  - Helium-Cooled Thermal Test Reactor

Technical, Licensing and Design Readiness



International Advanced Reactor Developments

- Sodium fast reactor demonstration reactor projects
  - Russia (880 MWe BN-800)
  - India (500 MWe PFBR)
  - China (Experimental Fast Reactor (CEFR) in operation since 2010)
  - Japan (restart of Japan Experimental Fast Reactor (JOYO) test reactor and Monju demonstration reactor)

- Sodium fast reactor design projects
  - Korea (150 MWe PGSFR)
  - France (300 MWe ASTRID)

- High temperature gas-cooled reactor projects
  - China (building two-unit 250 MW pebble bed)
  - Eastern Europe (ALLEGRO fast-spectrum gas-cooled reactor study)

International Advanced Reactor Developments

- Lead-cooled fast reactor project
  - Russia (BREST-300 design project, aiming for 2020 operation)

- Subcritical accelerator-driven test projects
  - Belgium (85MWth Multi-purpose hYbrid Research Reactor for High-tech Applications (MYRRHA) design project)
  - Russia (study phase)
  - European Union (study phase)

- Molten salt reactor projects
  - China (2 to 10 MW molten salt pebble bed reactor)
  - Europe (study phase)
  - Russia (study phase)

Technical Grand Challenges for Nuclear Technologies

- Approach by ANS membership to identify the technical Grand Challenges for Nuclear Technologies by 2030
- Grass-roots efforts to be conducted through ANS Professional Divisions & utilize ANS Collaborate
- Initiated in Fall of 2016 – Stay Tuned!
- Final list announced in June 2017

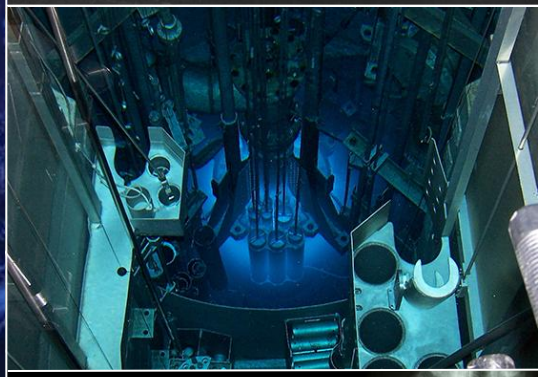
What Can You Do?

- Share the message: social media, letters to editor, etc.
  - The World Needs Nuclear!
- Share the link: www.nuclearconnect.org
- Be involved:
  - Washington Internships for Students of Engineering (WISE)
- Be a part of the public discussion:
  - Why is your energy future not part of the current election debate?
- Challenge bad science wherever you encounter it
- Be proud of who you are and what you do
- Join, renew and recruit for ANS!

The WORLD needs NUCLEAR

NUCLEAR needs the American Nuclear Society

ANS



Washington Internships for Students of Engineering (WISE)

- Nine-week program in Washington, D.C. sponsored by a consortium of professional societies
  - Focus: Technology policy—i.e., the intersection between technology and the political process
  - Primary audience – rising seniors, but grad students (especially first year) will be considered, too
  - Seminars and meetings at government agencies in the Washington area
  - Individual research project on a technology policy issue of the intern's choice—20 page paper and end-of-program presentation on Capitol Hill
  - Intern class of about 12-15 students, led by Faculty-Member-in-Residence
- ANS sponsors two interns each summer
  - Office space and support provided by Nuclear Energy Institute
  - Stipend of $2100; housing provided by WISE Program in George Washington U. dormitories
  - ANS Student Membership required for sponsorship by ANS
  - Application deadline: December 31

Washington Internships for Students of Engineering (WISE)

- WISE participation can help open a wide variety of opportunities: grad school, industry and national laboratory internships, and jobs
- ANS News articles on the program appear twice each year
- ANS WISE Coordinator: Dr. Alan Levin, DOE, alevin@alum.mit.edu

- WISE website: www.wise-intern.org

"The summer I spent in the WISE program was extremely influential on my career path. After completion of my service time with the U.S. Navy and Master's Degree, I decided on a career path that would use my engineering background and interest in public policy gained from the WISE program and had the opportunity to join the U.S. Nuclear Regulatory Commission."

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