ANS Webinars

Spotlight on National Labs

National Renewable Energy Lab

Wednesday, May 20

12:00 - 1:30 pm EDT

NREL
Transforming ENERGY

Panelists

1. Giulia Bisconti, Senior Advisor, U.S. Department of Energy
2. Martin Keller, Lab Director, NREL
3. Jill Engel-Cox, Director of the Joint Institute for Strategic Energy Analysis, NREL
4. Jordan Cox, Lead for the Nuclear Flexibility Campaign, NREL
5. Grant Buster, Data Scientist & Former Engineer for NuScale Probabilistic Risk Assessment, NREL
6. Mark Ruth, Hydrogen Specialist, NREL
7. Ellen Morris, Director of University Partnerships and C3E Ambassador, NREL

Giulia Bisconti

Senior Advisor, U.S. Department of Energy

Today's webinar about NREL is co-sponsored by 2 Clean Energy Ministerial (CEM) initiatives:

Nuclear Innovation: Clean Energy Future (NICE Future) initiative

- Launched at the 2018 CEM in Copenhagen by Ministers.
- Brings nuclear innovation to high-level clean energy policy discussions.
- Builds cooperation among nuclear and renewables communities.
- Questions? Contact: https://www.nice-future.org.

Clean Energy Education and Empowerment (C3E) International

- Launched at the 2010 CEM in Washington D.C. by Ministers.
- Working towards greater gender diversity in clean energy professions, recognizing that transitions to a clean energy future will only succeed if we harness all possible talent.
- Questions? Contact: e-mail C3EInternational@hq.doe.gov

NICE Future NUCLEAR INNOVATION: CLEAN ENERGY FUTURE
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

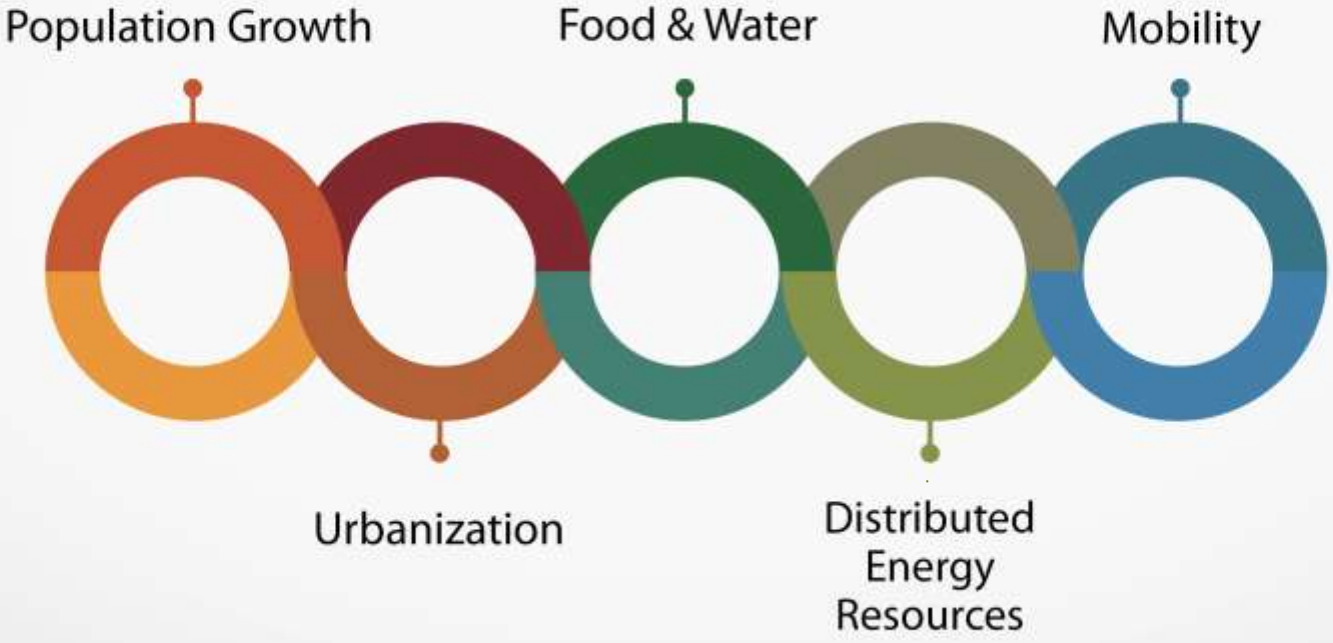
C3E INTERNATIONAL
ADVANCING GENDER EQUALITY TOGETHER
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

Dr. Martin Keller

Director, NREL

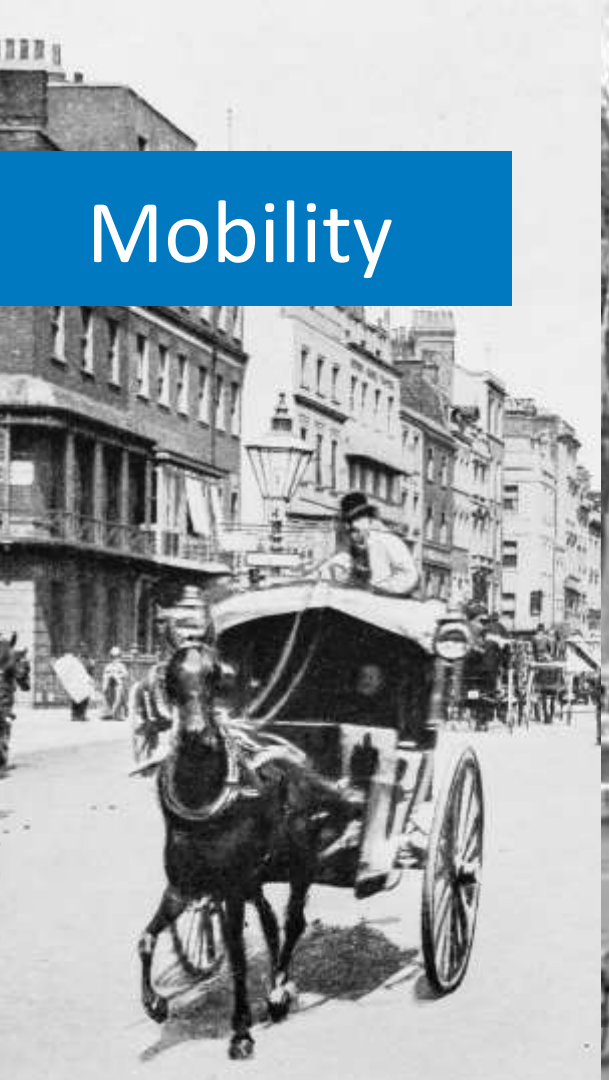
Transforming Energy through Innovation

Mega Trends


Population Growth
Food & Water
Mobility
Urbanization
Distributed Energy Resources

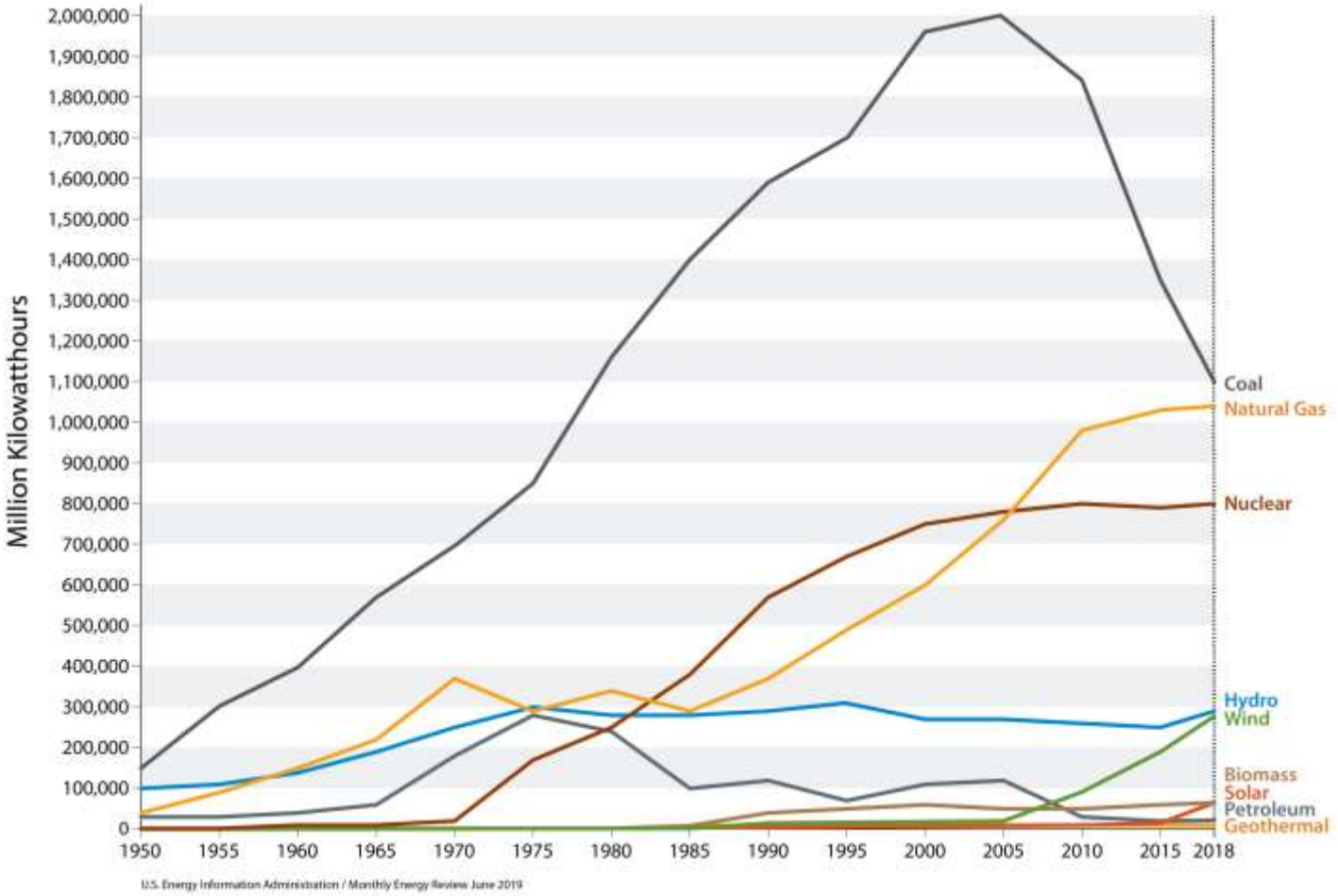
Urbanization

Mobility

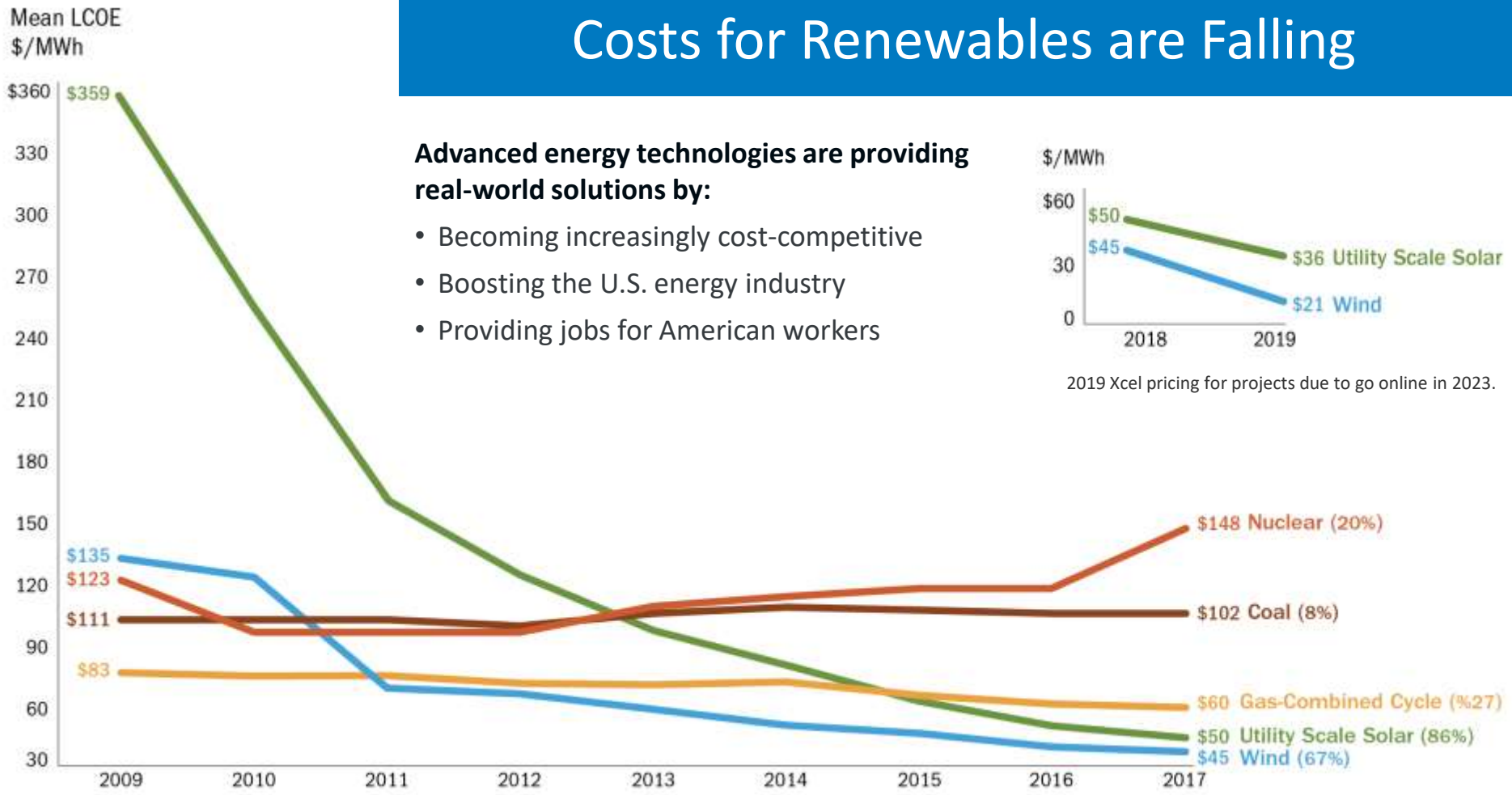


Ongoing Transformation of the Energy Supply in the United States

U.S. Power System Massive Transition



Costs for Renewables are Falling



Advanced energy technologies are providing real-world solutions by:

- Becoming increasingly cost-competitive
- Boosting the U.S. energy industry
- Providing jobs for American workers

2019 Xcel pricing for projects due to go online in 2023.

Source: *Lazard's 2017 Levelized Cost of Energy Analysis,* Version 11, 2 November 2017

NREL at a Glance

2051

Employees, plus

219 postdoctoral researchers
60 graduate students
81 undergraduate students

World-class

facilities, renowned technology experts

about 900

Partnerships

with industry, academia, and government

Campus

operates as a living laboratory

NREL Science Drives Innovation

Renewable Power

Solar

Wind

Water

Geothermal

Sustainable Transportation

Bioenergy

Vehicle Technologies

Hydrogen

Energy Efficiency

Buildings

Advanced Manufacturing

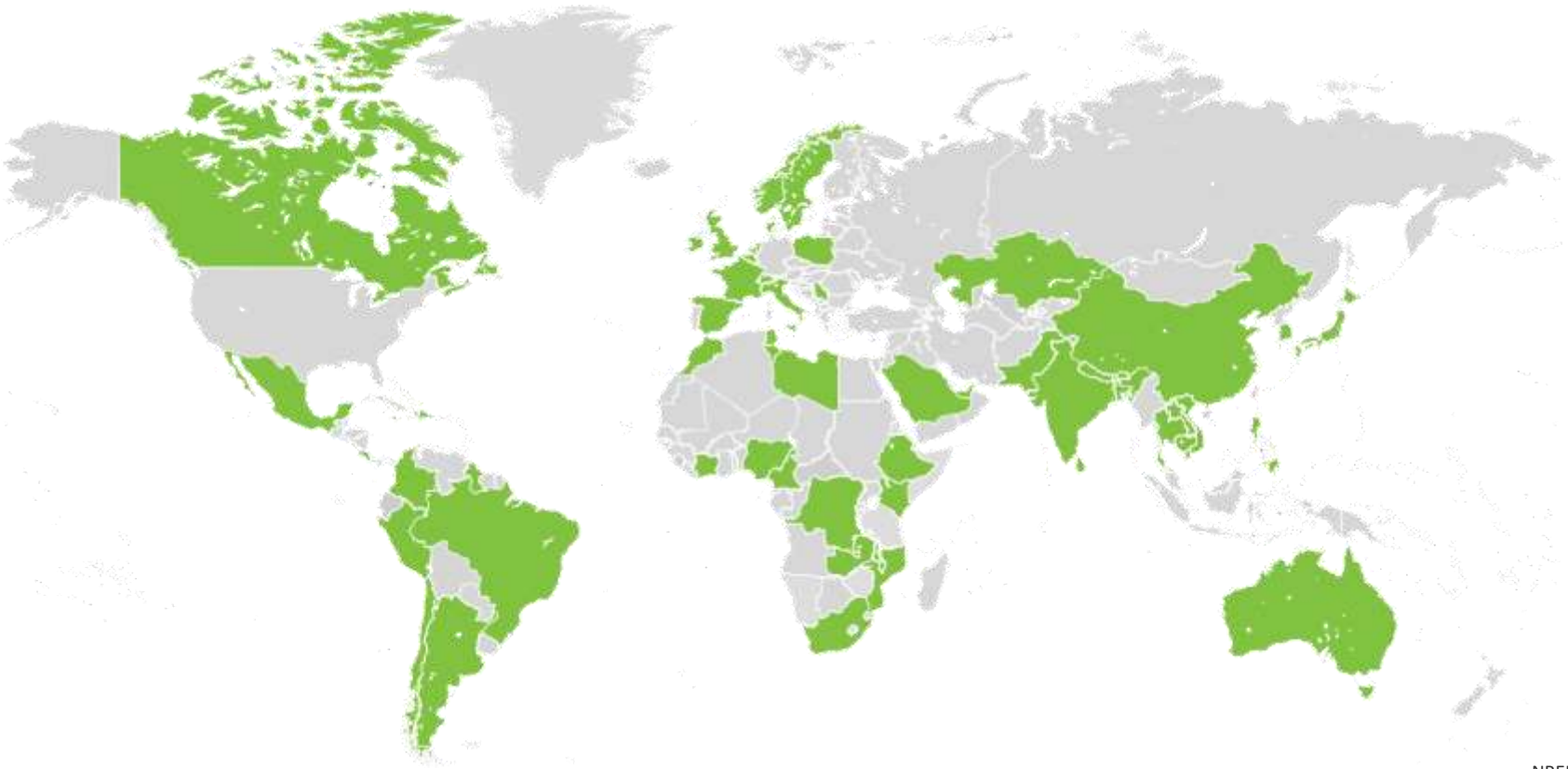
Government Energy Management

Energy Systems Integration

Grid Integration

Hybrid Systems

NREL Participating in 80 Collaborations Globally



Solar Research

Understanding how to achieve affordable and dispatchable solar generation systems that operate as a typical power plant is the ultimate pinnacle for solar to achieve extremely high penetration levels in our grid system.

Research Challenges

- Develop solar interface and control technologies to enable greater grid reliability, resilience, and overall system efficiency.
- Reduce solar hardware costs through innovative materials, manufacturing, and design, and de-risk technology to reduce balance of system costs.
- Develop CSP-integrated or stand-alone thermal energy storage to provide flexible, long-duration storage needed to enable high penetrations of renewables on the grid
- Increase solar system lifetimes and performance through improved efficiency and lower degradation rates.
- Understand how to integrate and optimize solar at scale within systems such as buildings, microgrids, distribution systems, and hybrid systems.

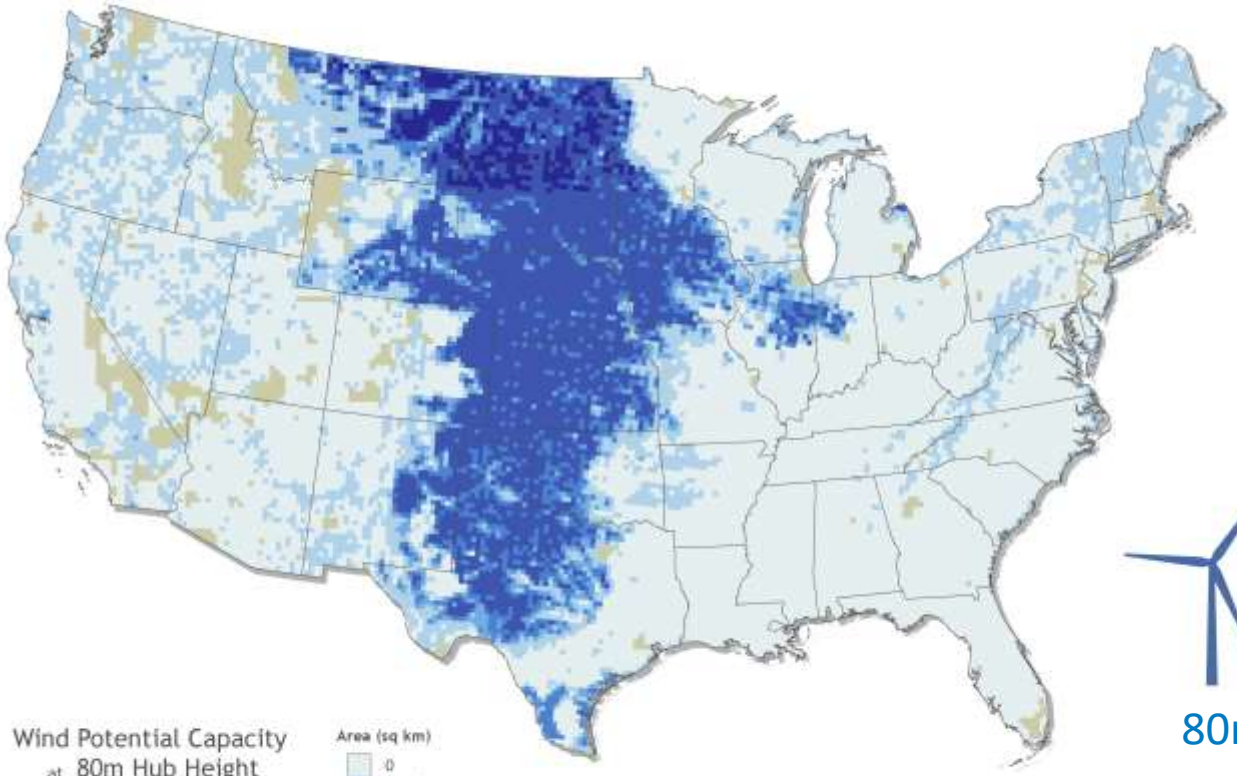
Wind Research

Enabling low-cost and accessible wind energy by joining forces with DOE, industry, and interagency and state partners to advance scientific knowledge and technological innovation.

Research Challenge

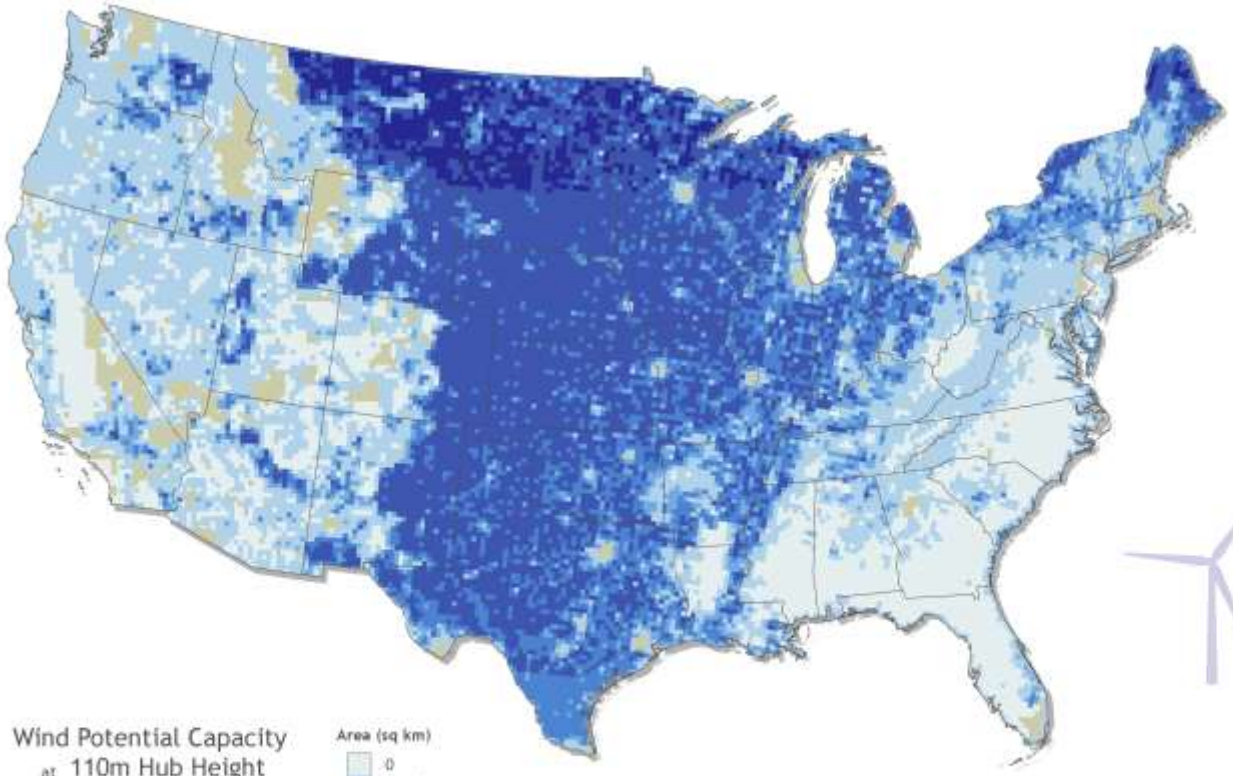
- Validate multiple wind technologies at scale to achieve an integrated energy system that can meet the complex energy challenges of the future.
- Develop taller wind turbines with larger rotors to capture greater wind resources at higher elevations and lower the levelized cost of wind energy.
- Develop innovations for offshore wind such as floating platforms, scaling solutions for larger offshore designs, advanced turbine controls, and lightweight drivetrains.
- Optimize power output across the entirety of a wind plant instead of at the individual-turbine level.

Wind Energy Potential Capacity at *80m Hub Height*



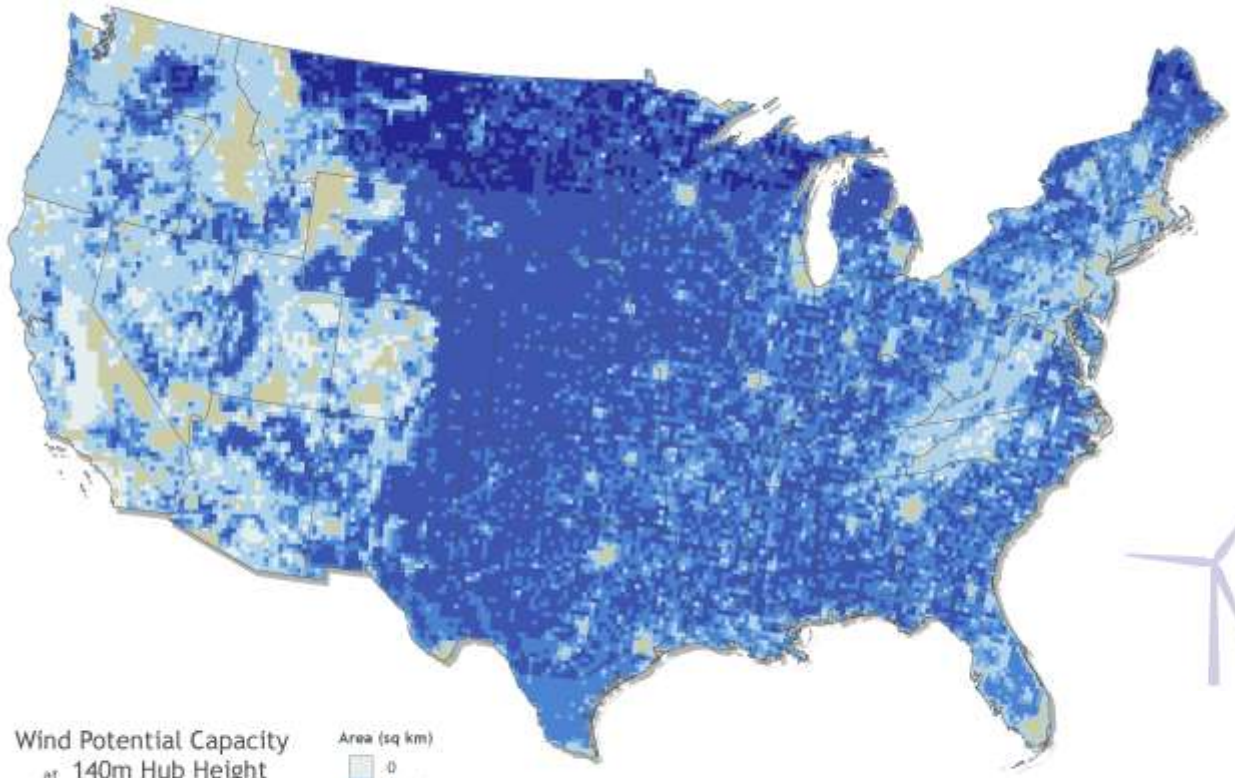
80m

Wind Energy Potential Capacity at *110m Hub Height*



110m

Wind Energy Potential Capacity at *140m Hub Height*



140m

Geothermal

Geothermal provides both heat and power—24 hours a day, 7 days a week—increasing grid reliability and security, with the smallest footprint of any renewable. Reducing costs and enabling geothermal anywhere can increase deployment nearly 26-fold by 2050.

Research Challenge

- Reduce well field development costs through increased drilling efficiency and drilling rates and reduced material construction costs.
- Enable development of geothermal anywhere through new technologies such as Enhanced Geothermal Systems (EGS) or Advanced Geothermal Systems (AGS).
- Economically recover lithium and other critical minerals from geothermal brines to meet U.S. and global demands.
- Identify the feasibility of hybrid geothermal-solar systems and subsurface thermal energy storage.

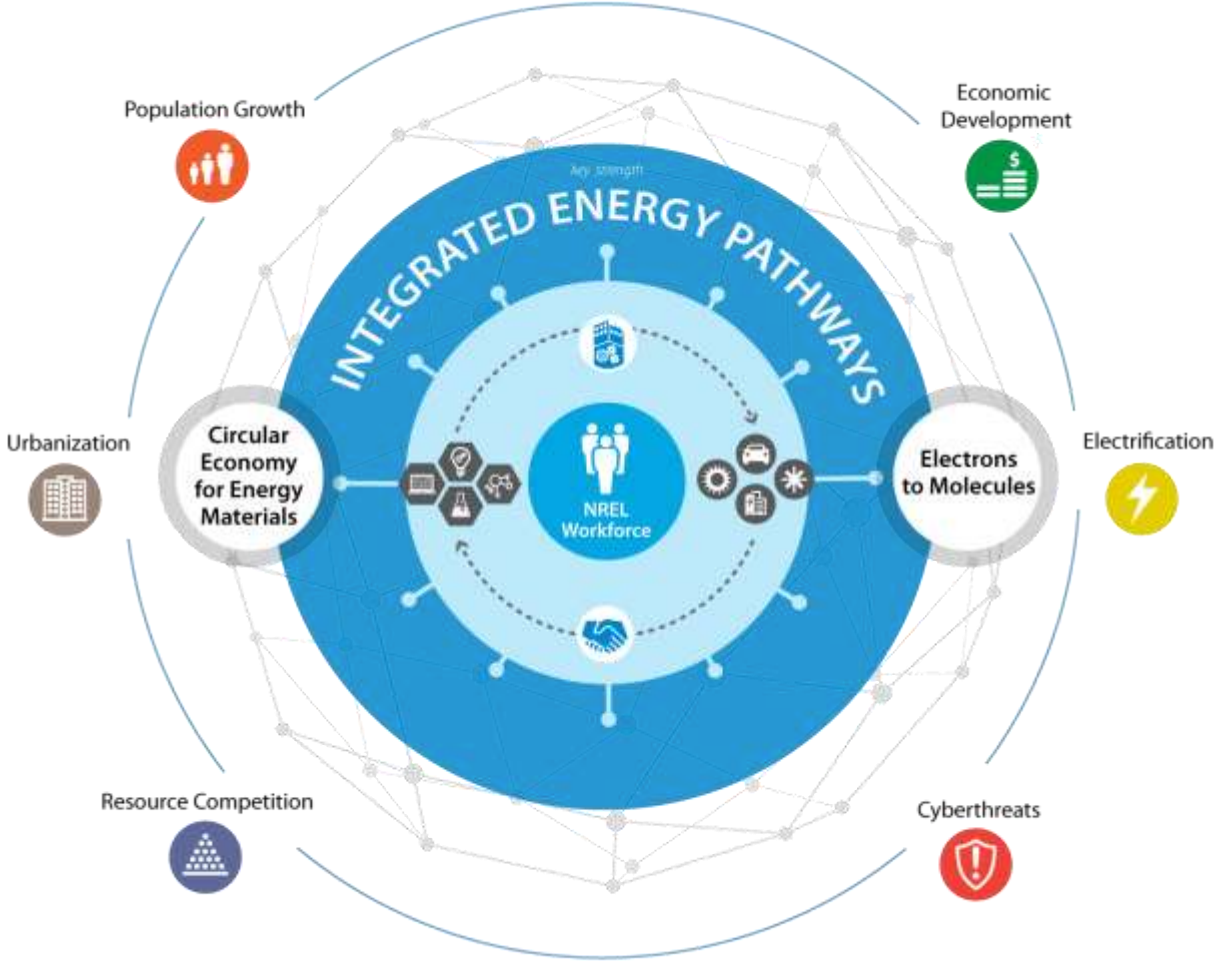
Looking to the Future

Environmental Scan: Observations Toward 2040

Assumptions that Guided NREL's Strategy Formulation:

- Growth of energy use in the developing world will far outpace growth elsewhere.
- Global renewable power demand will grow.
- Urbanization trends will dominate new infrastructure growth.
- Electrification and electric vehicle adoption will grow strongly.
- Demand for high-density liquid fuels will grow.
- Digitization, data, decentralization will be strong drivers of energy transition.

NREL Strategy



NREL's Three Critical Objectives

Integrated Energy Pathways

Develop the foundational knowledge and technologies to optimize the integration of renewables, buildings, energy storage, and transportation—modernizing our energy systems and ensuring a secure and resilient grid.

Electrons to Molecules

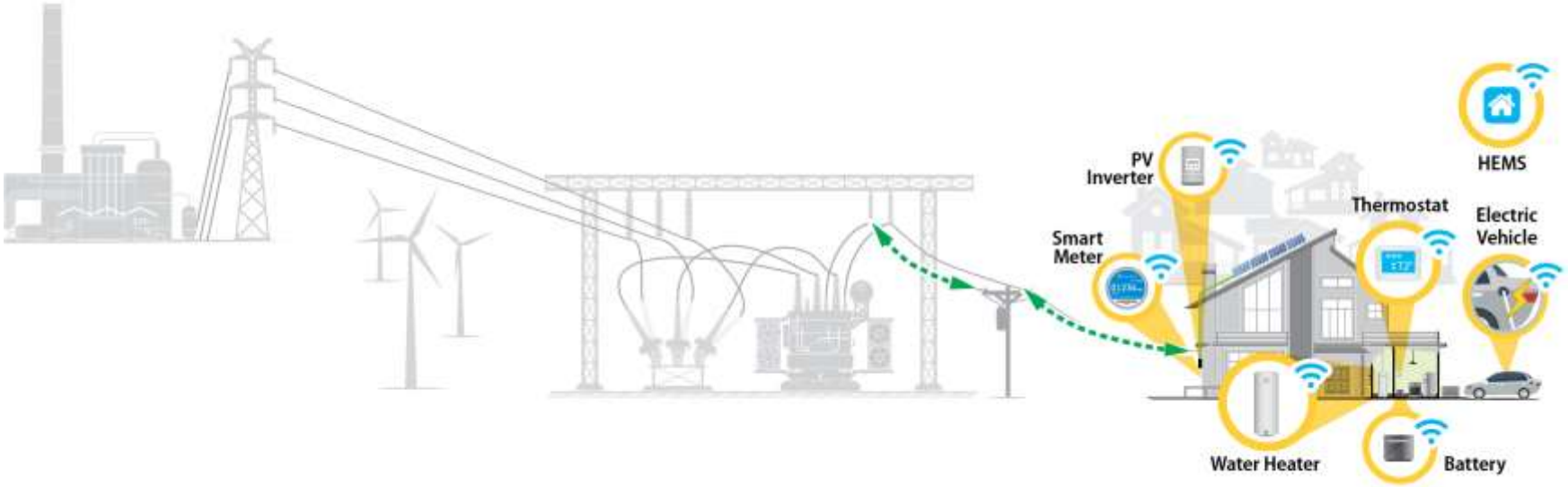
The conversion of electricity and small waste gasses (e.g. CO_2, H_2O, N_2) into chemical bonds for the purposes of chemical, material, or fuel synthesis and/or energy storage.

Circular Economy for Energy Materials

Establishing the foundational knowledge/technology for design, recycle, reuse, remanufacture, and reliability for energy-relevant materials and processes.

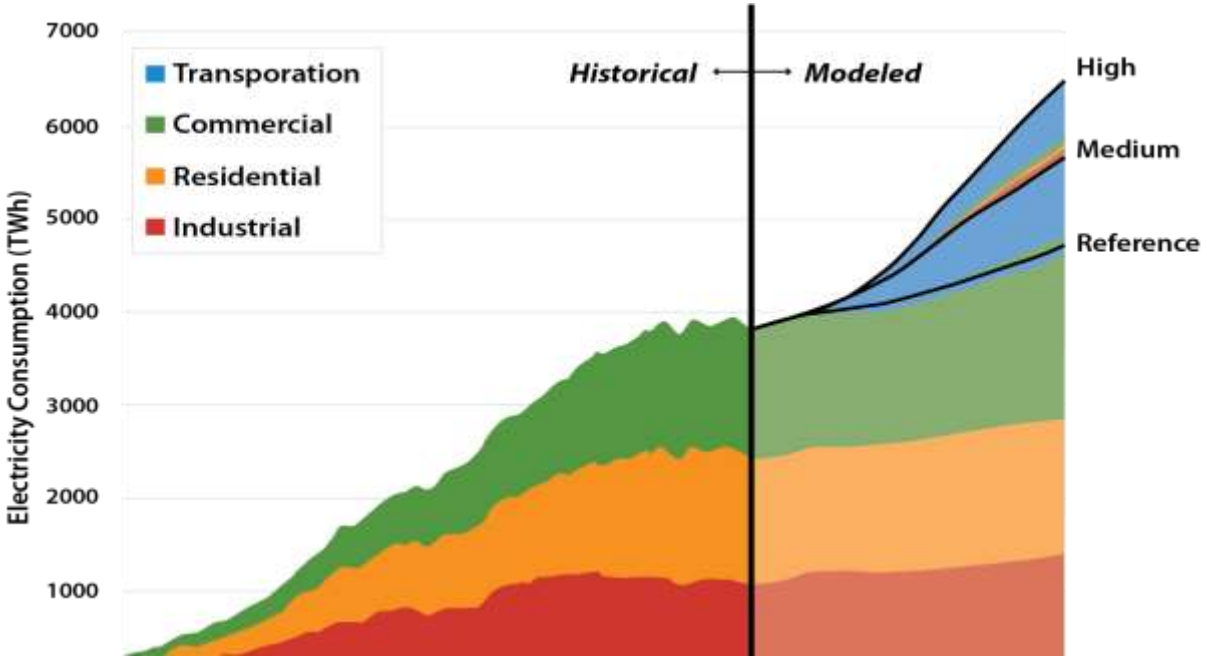
Integrated Energy Pathways

How We Use Electricity is Changing



Electricity Consumption 1950–2050

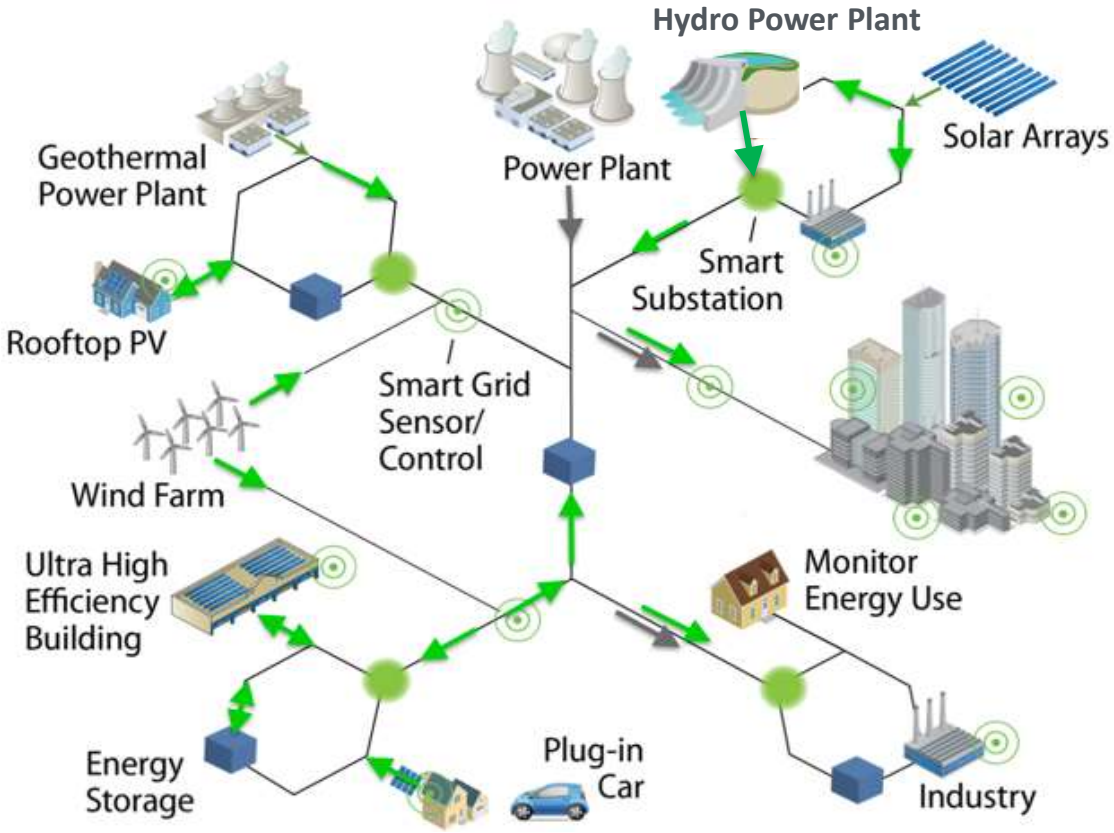
Historical and Projected Annual Electricity Consumption



Moderate technology advancements are shown. Slight adjustments were made to the modeled industry consumption estimates for 2017 – 2020 to align them with available historical data.

Source: Electrification Futures Study, *NREL*, 2018

Future Energy System

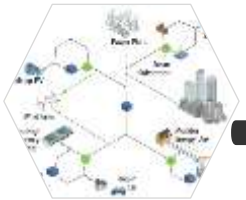


- The future energy system will integrate all types of energy systems and be more complex, distributed, and interdependent.
- If designed properly, it will also be more efficient, resilient, and affordable.

Creating Autonomous Energy Systems

Applications

Power Grids



Transportation

Buildings

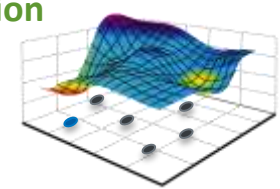
Wind Plants

Common Problems:

- Real-time controls and optimization
- Hundreds to millions of control points
- Asynchronous data and communications
- Multi-domain systems (complex) and stochastic systems (variable renewables, consumer/occupant behavior)

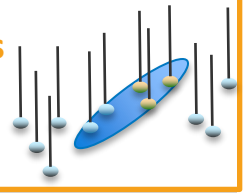
Nonlinear Control

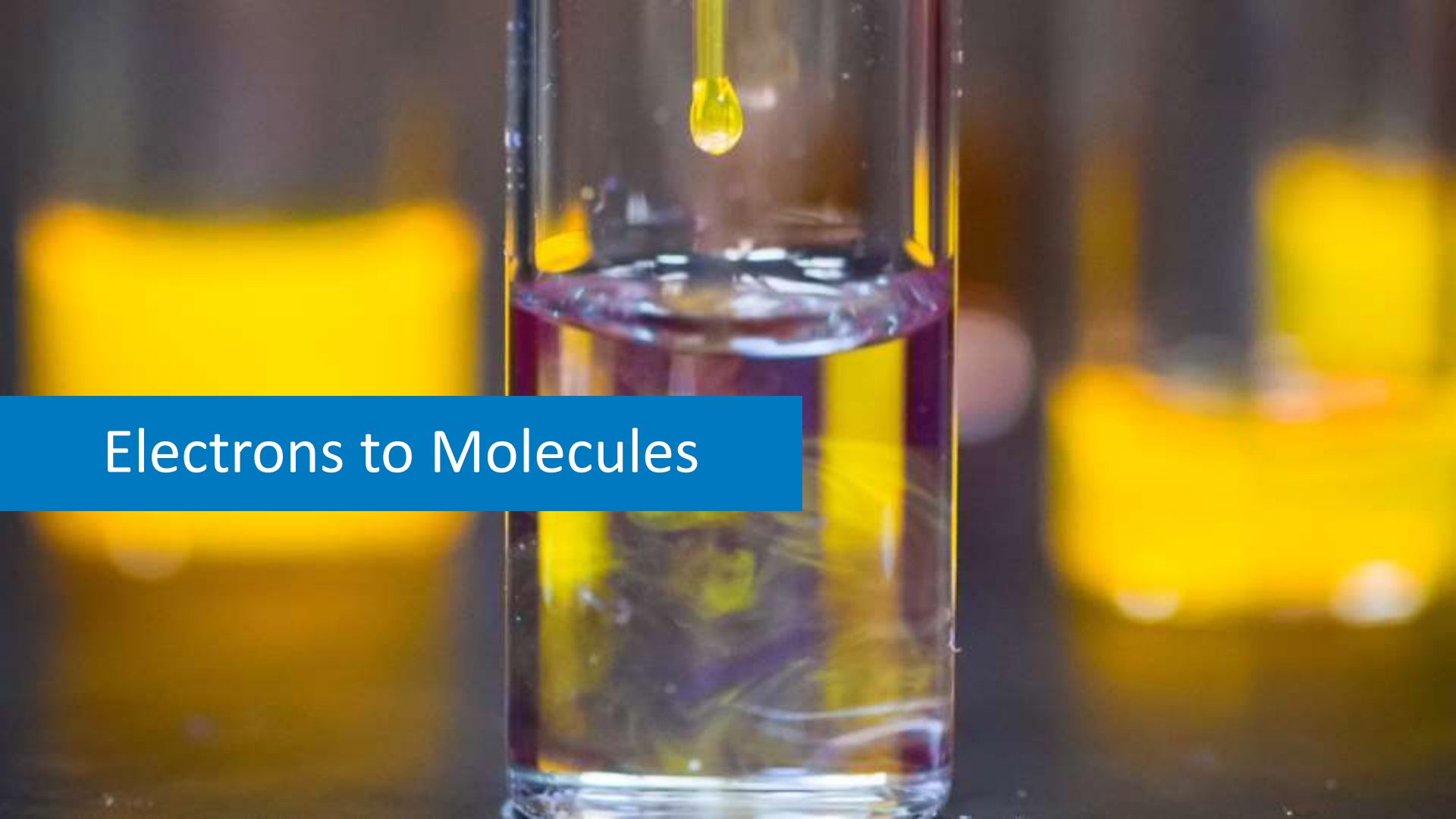
Optimization



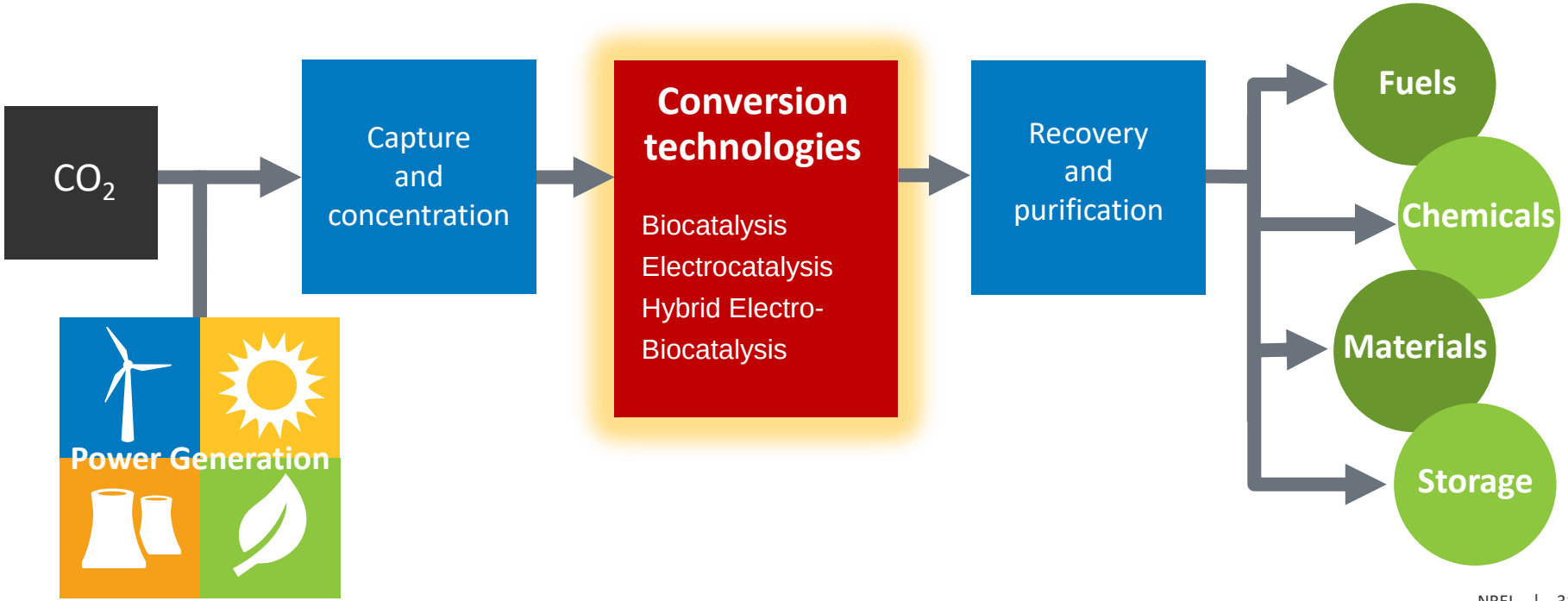
Complex Systems

Big Data Analytics




Electrons to Molecules

Utilizing Cheap, Abundant Electrons to Add Value to CO_2



Circular Economy for Energy Materials

Transitioning from a Linear to a Circular Economy

Linear

Design

Recycle
Reuse
Remanufacture

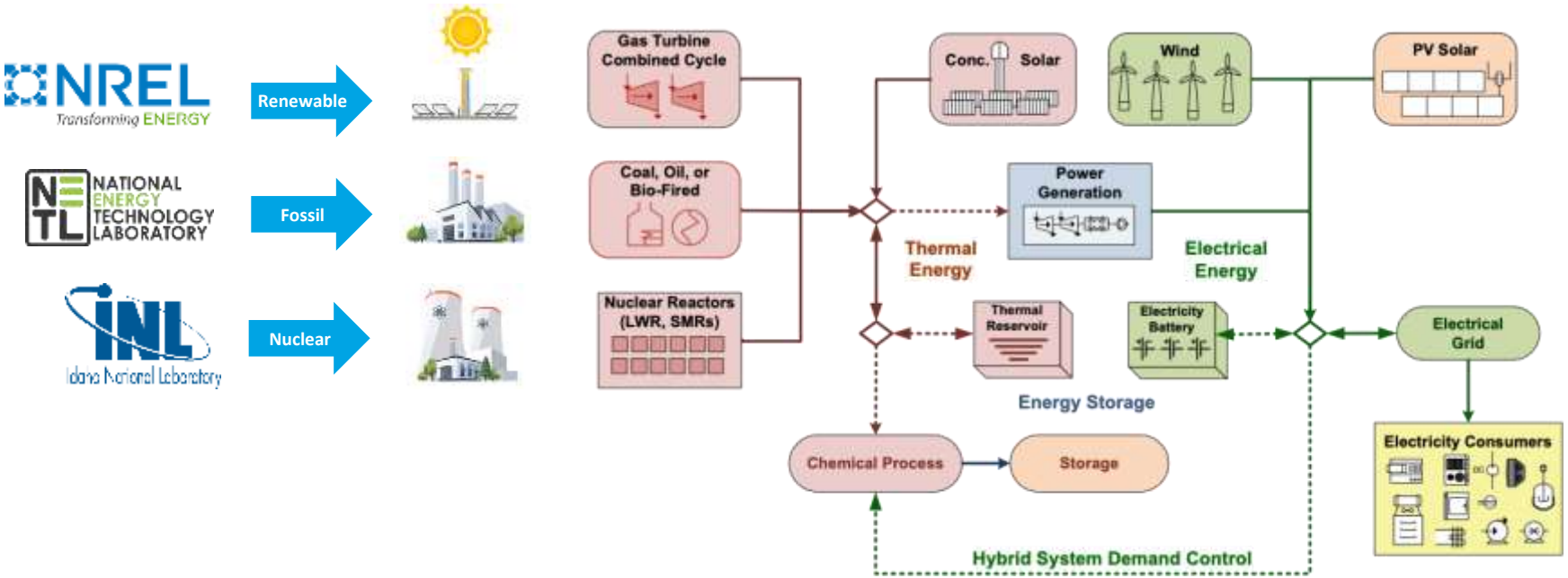
Reliability

(D R^n R)

Circular

Tri-Laboratory Collaboration

Three national labs working together to develop new energy technologies, and providing solutions for complex, multi-disciplinary challenges.

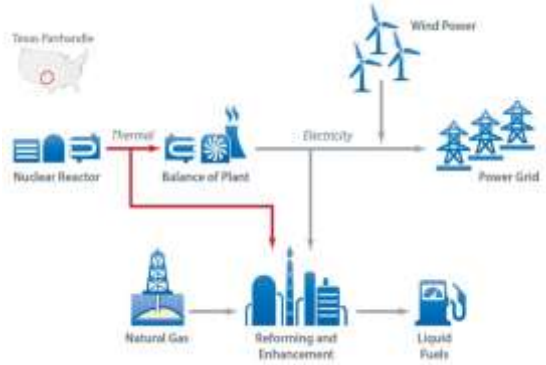


Nuclear-Renewable Hybrid Energy Systems

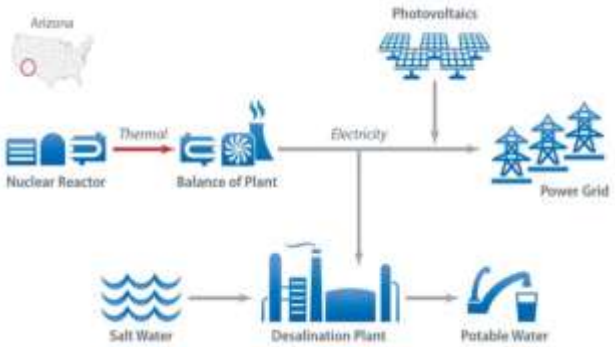
NREL and Idaho National Lab (INL) lead innovative analysis on nuclear and renewable energy and how they work together to decarbonize energy systems, including:

- System configurations
- Operations
- Product options (heat, power, fuels)
- Value streams
- Economics & investment

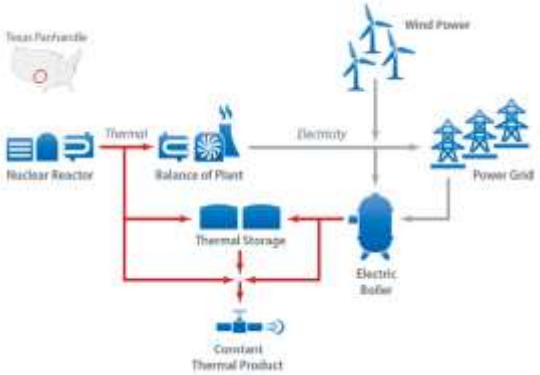
Liquid Transportation Fuels



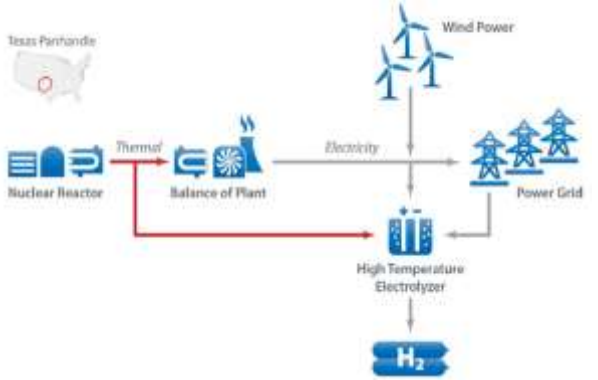
Reverse Osmosis Desalination



Thermal Energy in an Industrial Park



Hydrogen Production



Sources:
Ruth, Mark, et al, *The Economic Potential of Nuclear-Renewable Hybrid Energy Systems Producing Hydrogen*, 2017, NREL/TP-6A50-66764.

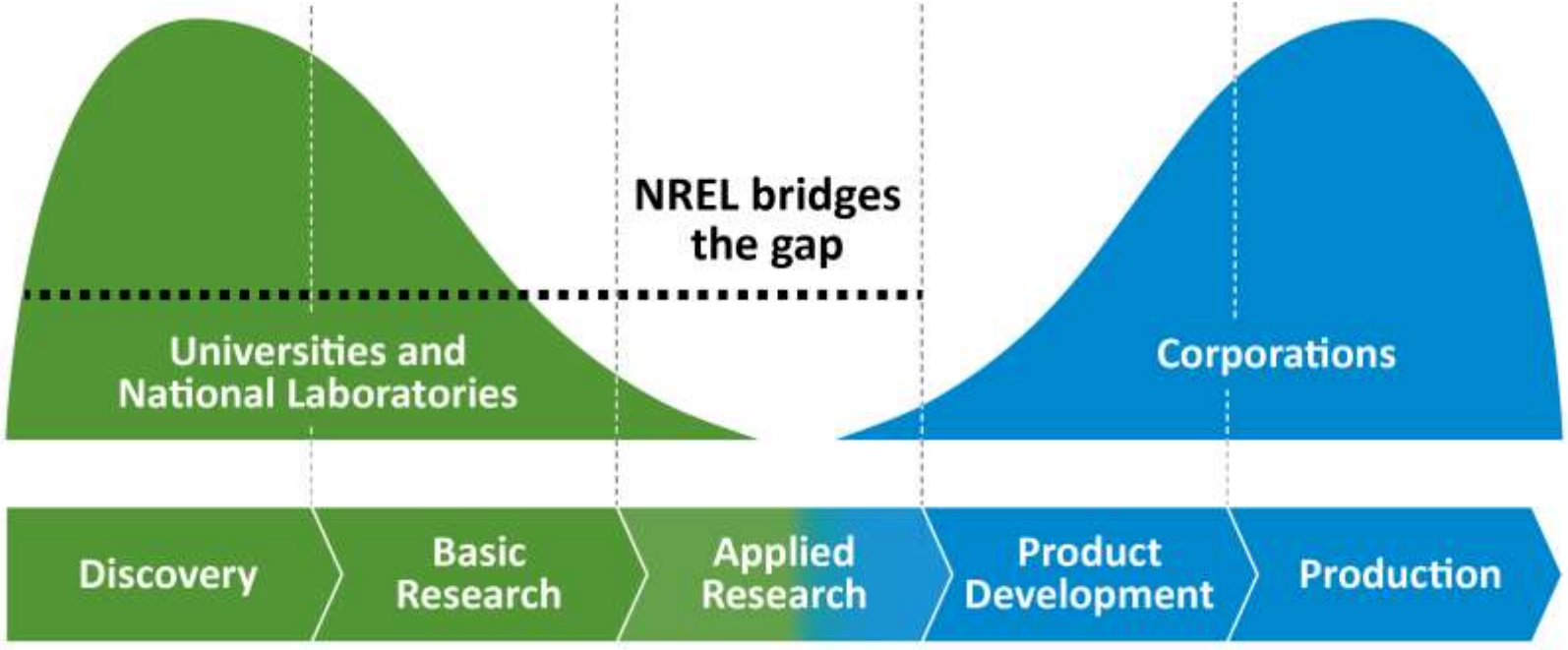
The Economic Potential of Three Nuclear-Renewable Hybrid Energy Systems Providing Thermal Energy to Industry, 2016, NREL/TP-6A50-66745.

The Economic Potential of Two Nuclear-Renewable Hybrid Energy Systems, 2016. NREL/TP-6A50-66073.

Partnering for Impact

NREL Reduces Risks in Bringing Innovations to Market

- Bridging the gap from basic science to commercial application.
- Forward-thinking innovation yields disruptive and impactful results to benefit the U.S. economy.
- Accelerating time to market delivers advantages to American businesses and consumers.



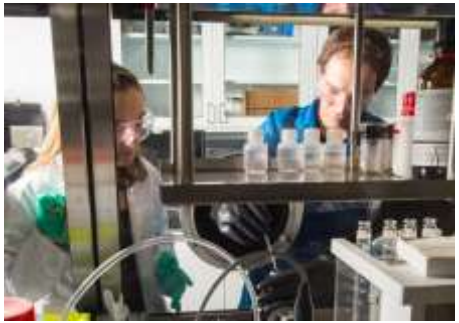
Partnering for Impact

ExxonMobil

Powering Business Worldwide

WELLS FARGO

This is a 10-year $100 million partnership that is intended to fill gaps in traditional energy approaches. Our scientists and engineers are collaborating to conceive and create solutions for today's energy challenges.



Shell Gamechanger Powered by NREL is our five-year multi-million-dollar partnership program with Shell. We have branded the program GCxN, and it focuses on battery longevity and advanced smart grid controls.

NREL and Eaton are working together in the ESIF on grid intelligence, distributed energy resource management, advanced energy storage systems, virtual modeling and analysis, high-performance computing and other research.

Our Innovation Incubator (IN_2) is expanding this scalable model to other partners and technologies and growing to a multiyear, $30 million program.

Thank you

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NREL
Transforming ENERGY

Jill Engel-Cox

Director of the Joint Institute for Strategic Energy Analysis, NREL

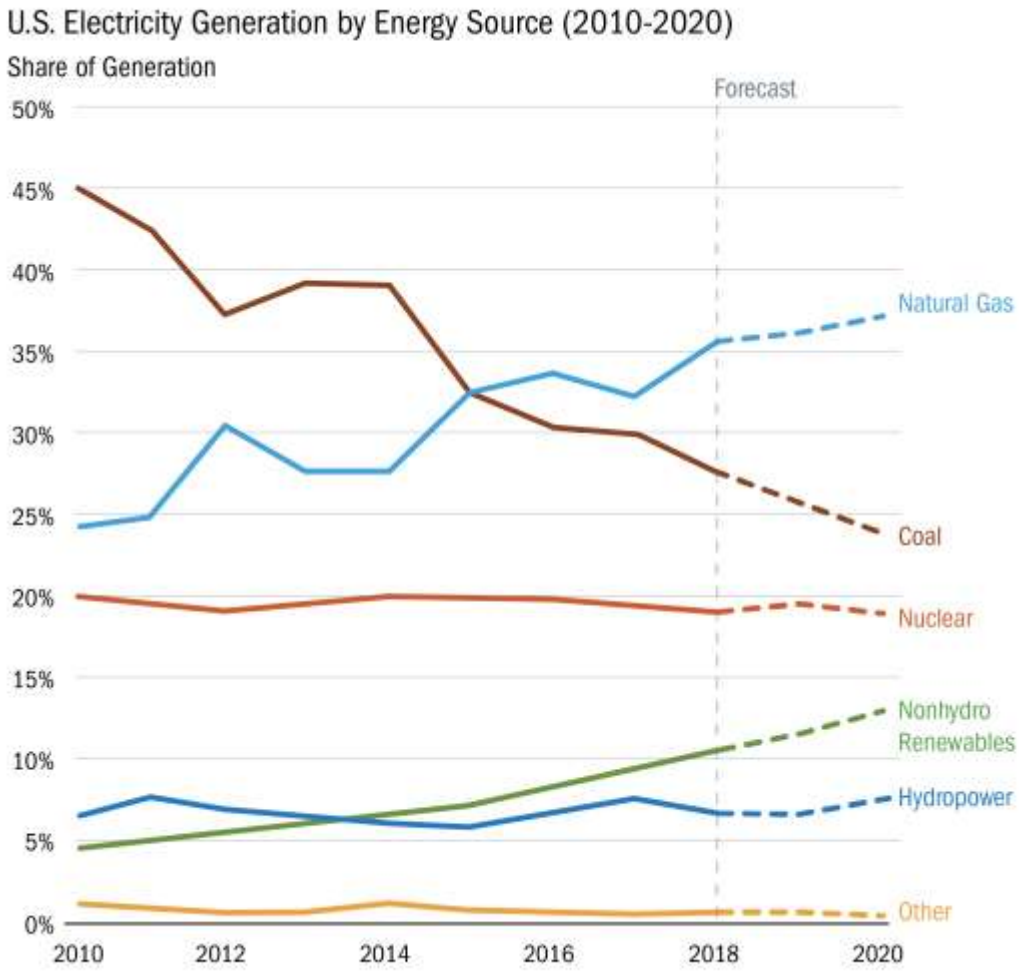
U.S. Energy Supply is Shifting

In 2019, renewable energy—not including hydropower—produced 11% of the total U.S. electricity generation. This is expected to continue to grow.

With hydropower, renewable energy is over 17%.

With nuclear (~20%), U.S. low-carbon electricity is 37%.

Source: U.S. EIA,, https://www.eia.gov/tools/faqs/faq.php?id=427&t=3



Source: United States Energy Information Agency, *Today in Energy,* 18 January 2019

NREL electricity modeling at multiple scales

Geographic scale

Global

U.S.

Regional/ Balancing Area

Generator

IAMs, CGEs
Global energy-economic-climate

SolarDS
Rooftop PV adoption

ReEDS
National policy, market, technology analysis

ABM
Agent Based Models of Customer Behavior

Capacity Expansion Models

RPM
Regional integrated resource planning

System Models

Production Cost / Grid Simulation Models

PLEXOS
Security-constrained unit commitment & economic dispatch

FESTIV
Automatic generation control (AGC) & dispatch

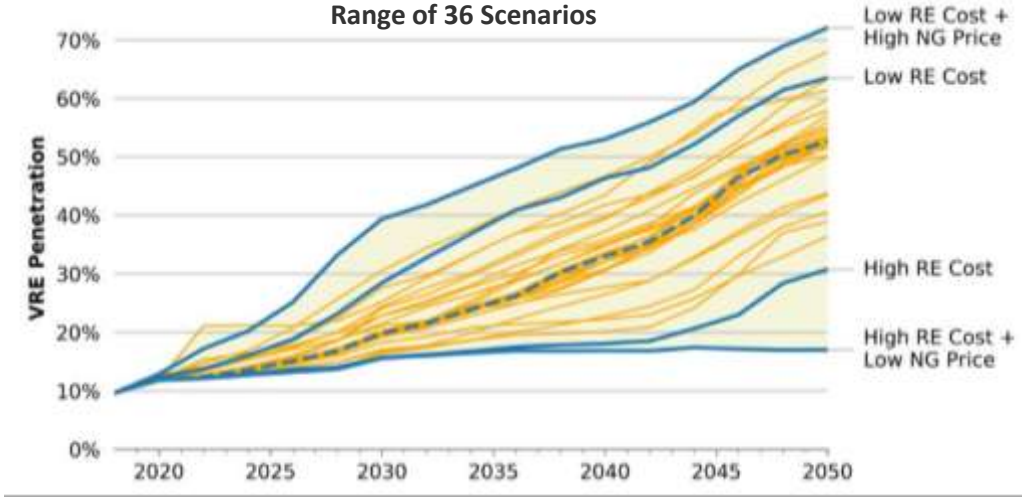
SAM
Hourly plant output

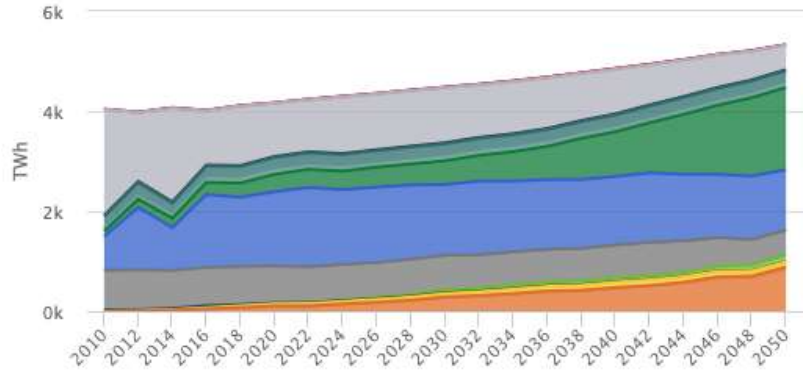
Data
wind, solar, demand, generator, transmission

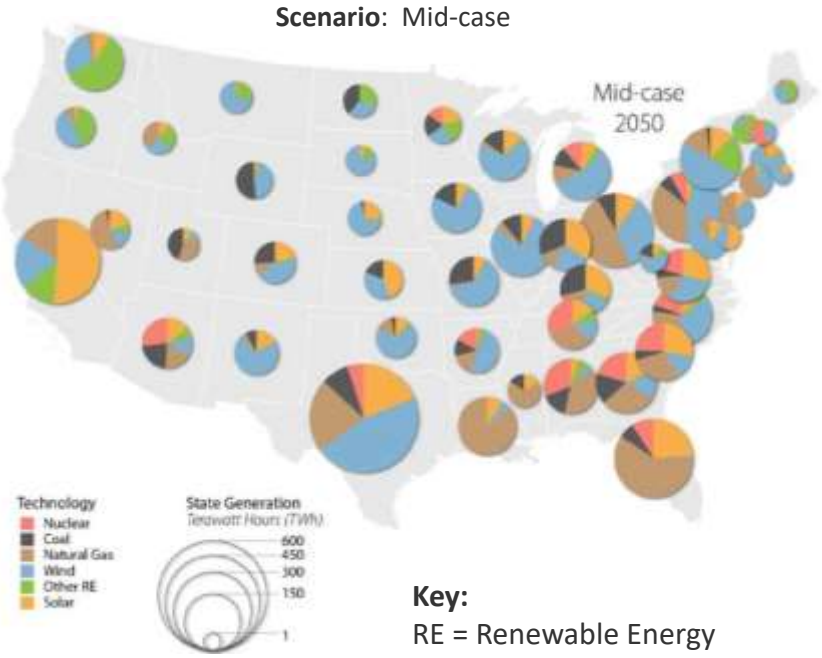
Temporal resolution

Annual | Seasonal/Diurnal | Hourly | Sub-hourly

NREL models scenarios of future electricity generation

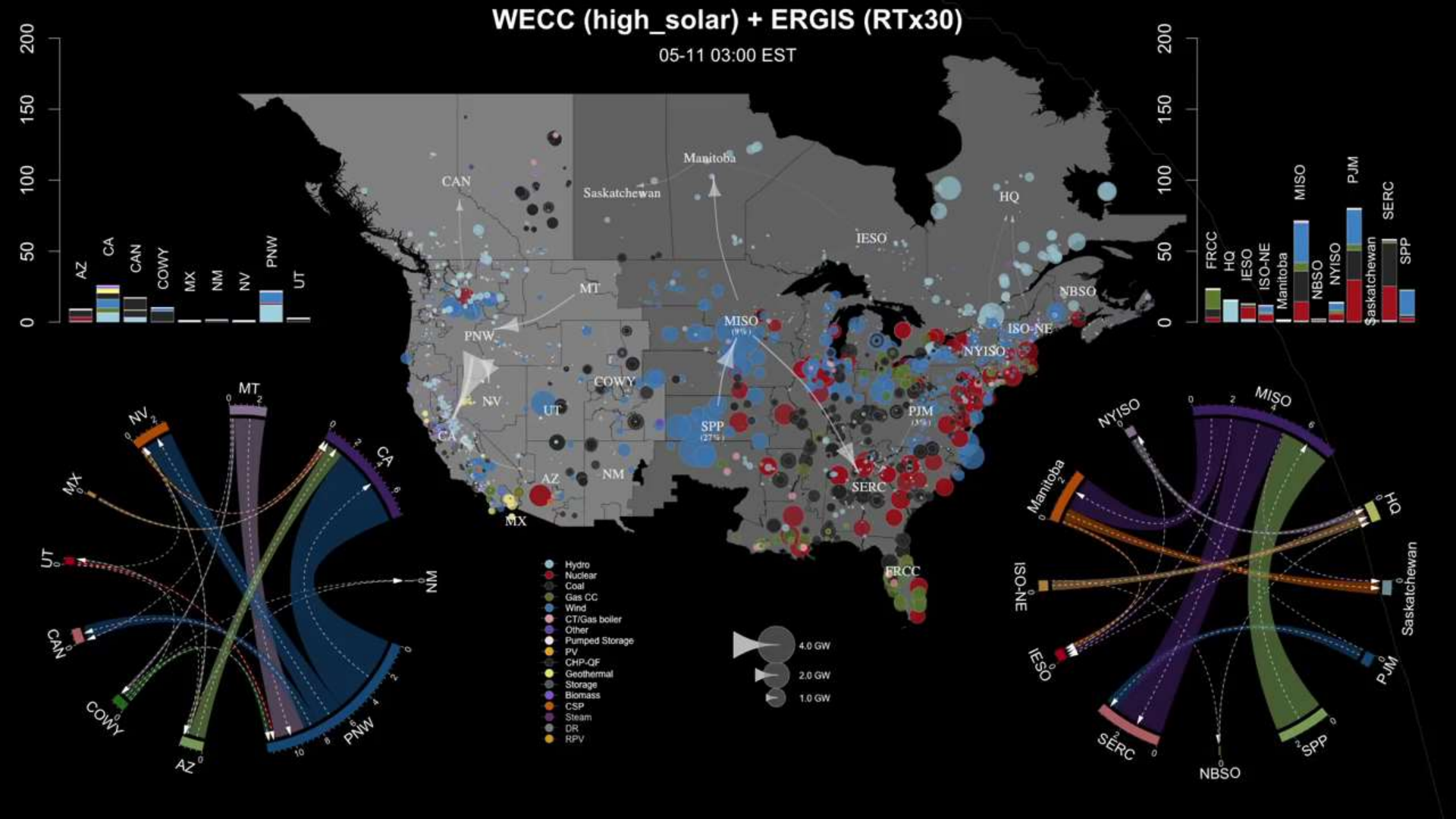






Key:
RE = Renewable Energy
NG = Natural Gas
VRE = Variable Renewable Energy

Cole, Wesley, Nathaniel Gates, Trieu Mai, Daniel Greer, and Paritosh Das. 2019. 2019 Standard Scenarios Report: A U.S. Electricity Sector Outlook, Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-74110. https://www.nrel.gov/docs/fy20osti/74110.pdf.


WECC (high_solar) + ERGIS (RTx30)
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AZ
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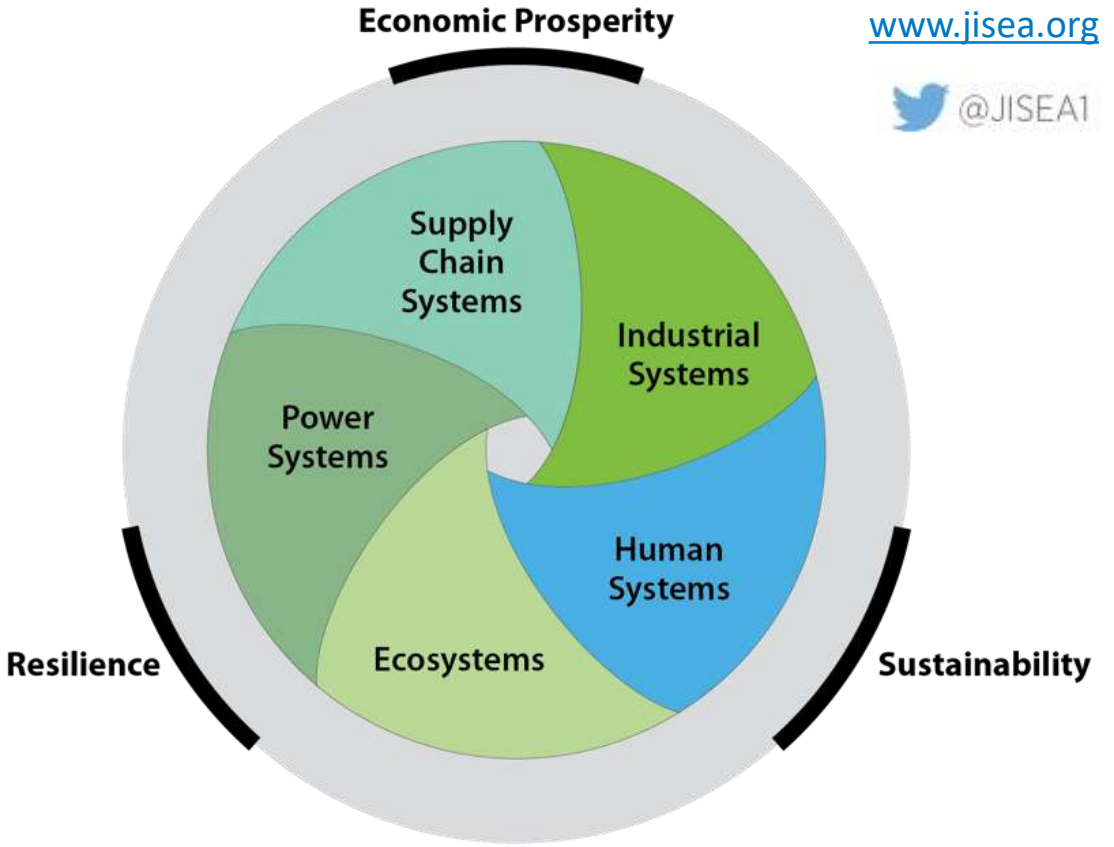
ISO-NE
Manitoba
NBSO
NYISO
Saskatchewan
MISO
PJM
SERC
SPP
Hydro
Nuclear
Coal
Gas CC
Wind
CT/Gas boiler
Other
Pumped Storage
PV
CHP-QF
Geothermal
Storage
Biomass
CSP
Steam
DR
RPV
4.0 GW
2.0 GW
1.0 GW

JISEA

Joint Institute for Strategic Energy Analysis

- Energy **System Integration** and Transformation
- Clean energy for **Industry & Agriculture**
- Advanced **Manufacturing** Analysis
- **International Collaboration** and Capacity Building



www.jisea.org

@JISEA1

Founding Partners:

NREL NATIONAL RENEWABLE ENERGY LABORATORY

COLORADOSCHOOLOFMINES EARTH • ENERGY • ENVIRONMENT

COLORADO STATE UNIVERSITY

Massachusetts Institute of Technology

STANFORD UNIVERSITY

University of Colorado Boulder

21st Century Power Partnership

A Clean Energy Ministerial (CEM) initiative focused on helping countries achieve efficient, clean, affordable and reliable power system transformation. Key areas of activity include:

Faster Learning	Developing and sharing knowledge on key topics related to power system transformation.
Better Tools	Strengthening and disseminating technical tools to accelerate policy and regulatory analysis.
Capacity Building	Bolstering the capacity of experts to advance the policies, programs, and practices.
Meaningful Partnerships	Establishing applied multilateral partnership engagements to leverage knowledge, tools, and capacity.

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

21st Century POWER PARTNERSHIP
Accelerating the transformation of power systems

https://www.21stcenturypower.org

JISEA is the **Operating Agent** for the CEM Initiative 21CPP

Nuclear Innovation: Clean Energy Future (NICE Future)

The NICE Future initiative is part of a global partnership of countries and organizations exploring the potential for nuclear power uses, innovations, and greater systems integration, to accelerate progress toward clean energy goals.

Lead Countries


Canada


Japan


USA

Participant Countries


Argentina


Poland


Romania


Kenya


Russia


UAE


UK

https://www.nice-future.org

NICE Future
Nuclear Innovation: Clean Energy Future

IAEA

iea International Energy Agency

NEA

WiN global Women in Nuclear

GEN IV

CLEARPATH

THIRD WAY

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

External Partners

International Energy Agency
OECD Nuclear Energy Agency
International Atomic Energy Agency
International Framework for Nuclear Energy Cooperation
Generation IV International Forum
ClearPath
Third Way
Energy for Humanity
Energy Options Network
Women in Nuclear Global
International Youth Nuclear Congress
Nuclear Industry Council
Nuclear Energy Institute
World Nuclear Association
American Nuclear Society

JISEA is the **Operating Agent** for the CEM Initiative NICE Future

Jordan Cox

Lead for the Nuclear Flexibility Campaign, NREL

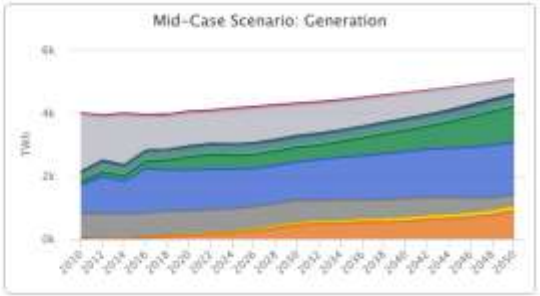
My Research

Techno-economic analysis of energy systems for both domestic and international applications.

NICE Future

Nuclear Innovation: Clean Energy Future

An Initiative of the Clean Energy Ministerial

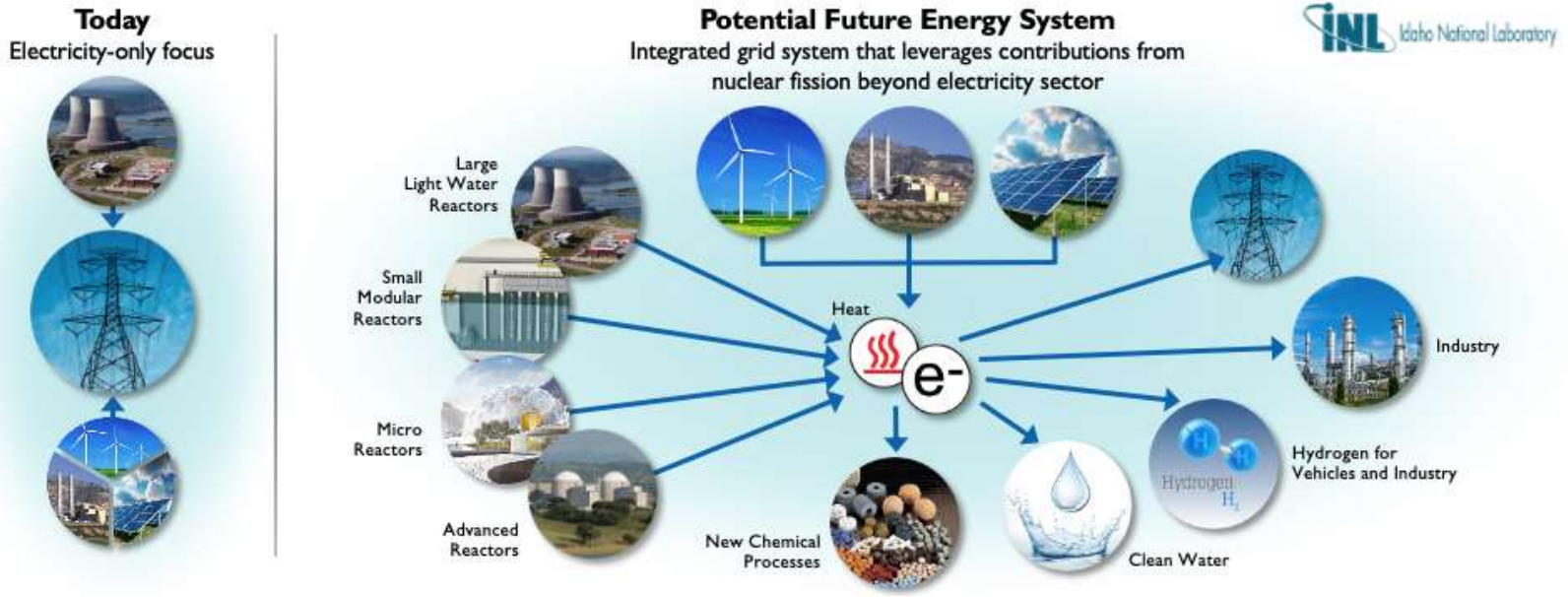


Cohen, Stuart, Jon Becker, Dave Bielen, Maxwell Brown, Wesley Cole, Kelly Eurek, Will Frazier, et al. 2019. “Regional Energy Deployment System (ReEDS) Model Documentation: Version 2018.” *Renewable Energy*, 135.

Flexible Nuclear Campaign

FLEXIBLE NUCLEAR CAMPAIGN FOR NUCLEAR-RENEWABLES INTEGRATION
A CAMPAIGN OF THE CLEAN ENERGY MINISTERIAL

The Flexible Nuclear Campaign seeks to highlight the roles that flexible nuclear energy can play in clean energy systems.



Life at a National Lab

NREL CLIMBING CLUB

NREL Transforming ENERGY

Full Spectrum Network

E-mail: jcox@nrel.gov
Twitter: @ColoradoRoux
NICE Future: https://nice-future.org/

Grant Buster

Data Scientist & Former Engineer for NuScale Probabilistic Risk Assessment, NREL

About Me

- UC Berkeley
  - Mechanical and Nuclear Engineering
- NuScale Power
  - Risk Assessment
  - Systems Analysis
  - Simulation and Modeling
- NREL
  - Data Engineering / Data Science

The National Solar Radiation Database (NSRDB)

Wind Integration National Dataset (WIND) Toolkit

Applied Data – Strategic Energy Analysis

North American Renewable Integration Study (NARIS)

Los Angeles 100% Renewable Energy Study (LA100)

Extreme Weather Events Study

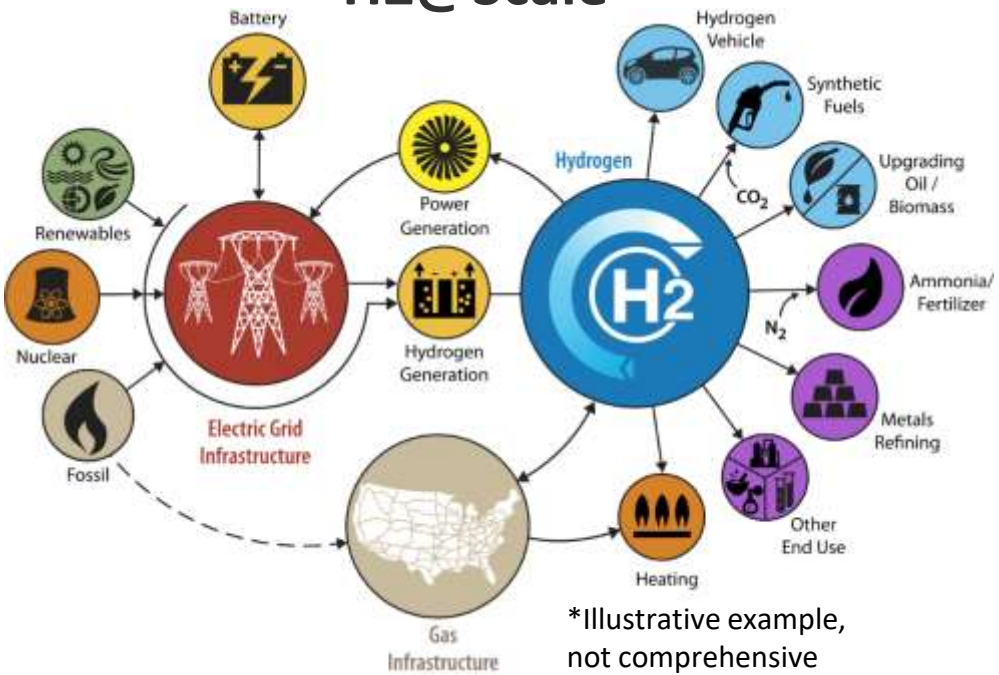
Mark F. Ruth

Hydrogen Specialist, NREL

H2@Scale: Opportunities and Challenges for Hydrogen as an Energy Intermediate

H2@Scale Concept & Potential Benefit to Nuclear Generators

H2@Scale



*Illustrative example, not comprehensive

Source: Hydrogen at Scale (H_2@Scale): Key to a Clean, Economic, and Sustainable Energy System, Bryan Pivovar, Neha Rustagi, Sunita Satyapal, Electrochem. Soc. Interface Spring 2018 27(1): 47-52; doi:10.1149/2.F04181if

Nuclear Hybrid Energy Systems

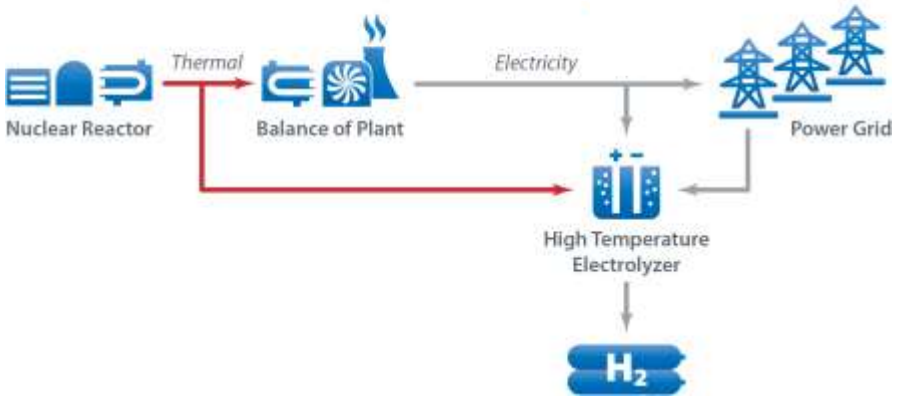
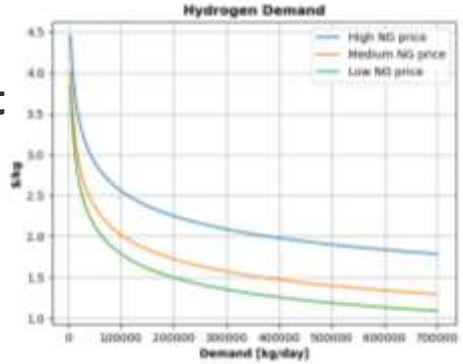


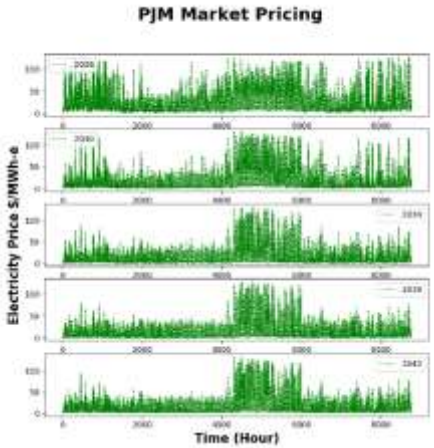
Figure Source: Ruth, Mark, Cutler, Dylan, Flores-Espino, Francisco, and Stark, Greg. The Economic Potential of Nuclear-Renewable Hybrid Energy Systems Producing Hydrogen (2017). NREL/TP-6A50-66764. http://www.nrel.gov/docs/fy17osti/66764.pdf

Cross-Sectoral Analysis Need

H_2 Market Assessment

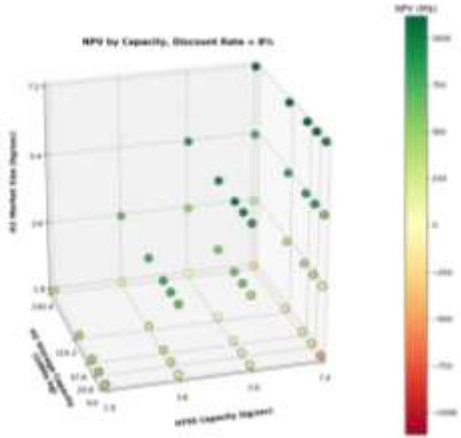


Electricity Price Estimation



Design and optimization (both capital and operating) for a hybrid nuclear-H_2 system to maximize profitability

Techno-economic Analysis

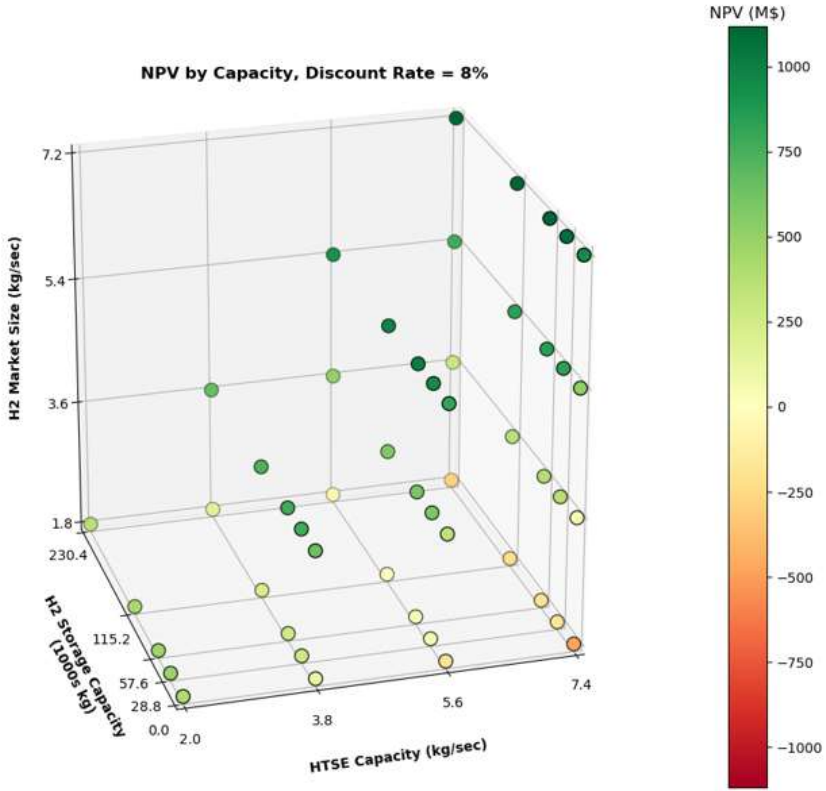


Net Present Value (NPV) Calculations

Source: Frick et al. "Evaluation of Hydrogen Production Feasibility for a Light Water Reactor in the Midwest" (2019). https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_18785.pdf

Preliminary Results & Next Steps

- 3 variables: H_2 market size, H_2 storage capacity, and electrolyzer size
- Profitability depends on:
  - hydrogen vs. electricity market prices
  - Aligning electrolyzer size with H_2 demand
  - Proper sizing of H_2 storage
- Key finding: nuclear power plants have the *potential* to substantially increase current profit margins by hybridizing and producing H_2
- Future work: Co-optimizing hydrogen markets, nuclear hybrid system design and operation, and grid operation



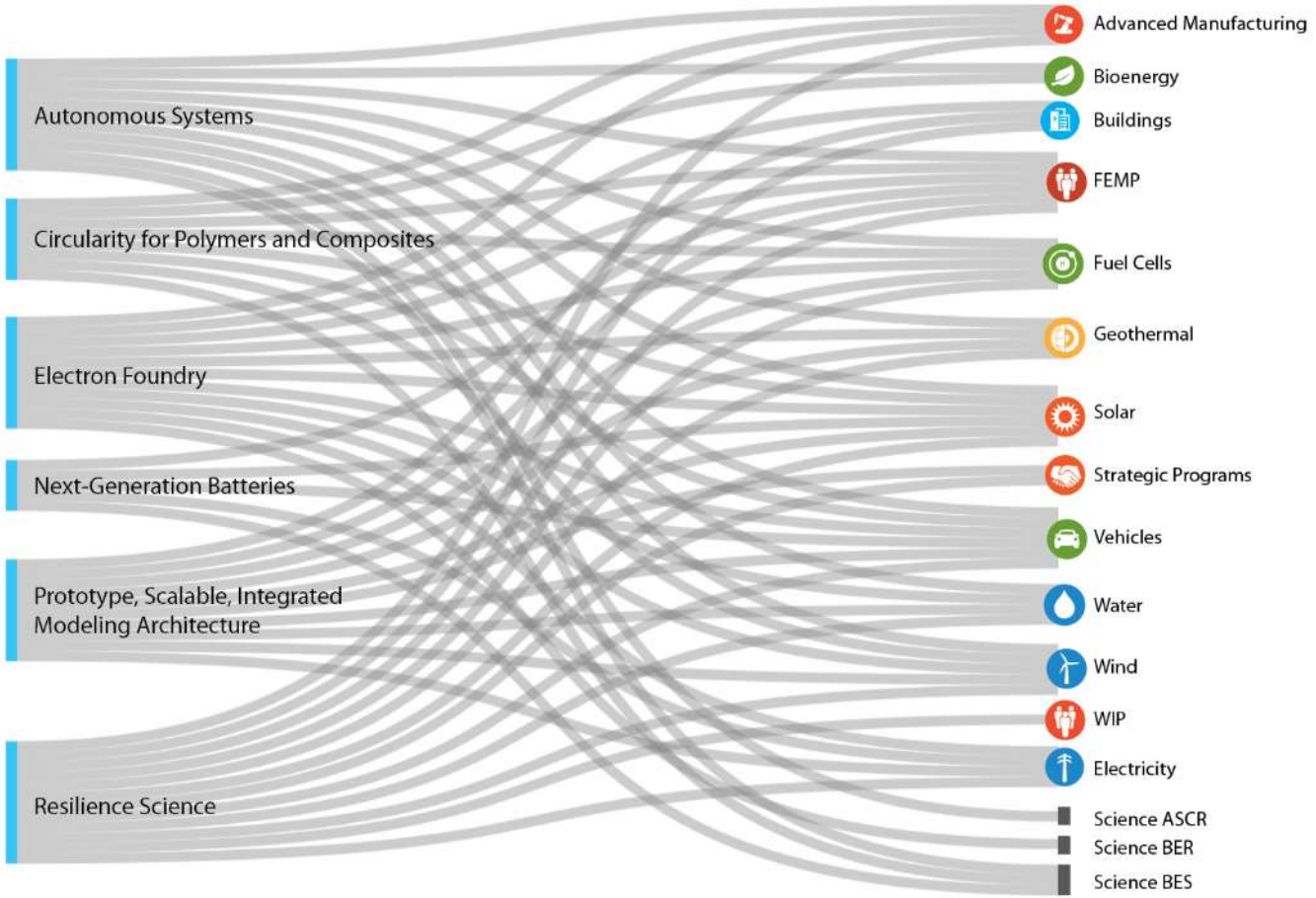
Source: Fig 46 (p.75) from Frick et al. "Evaluation of Hydrogen Production Feasibility for a Light Water Reactor in the Midwest" (2019). https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_18785.pdf

Ellen Morris

Director of University Partnerships and C3E Ambassador, NREL

Strategy for Engaging Universities in NREL Research

Creating and strengthening tie-ins with leading universities across NREL

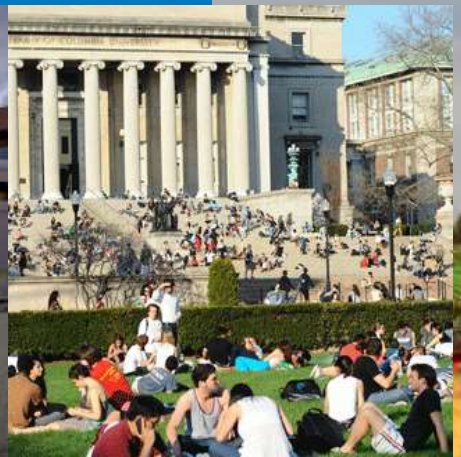


University Partnership Program

1. **Alliance** Partner University Program (APUP):
   - Colorado School of Mines
   - University of Colorado
   - Colorado State University
   - Massachusetts Institute of Technology
   - Stanford University

2. **Strategic** Partner University Program (SPUP): New expansion

3. **Cross-cutting** university engagement activities: HBCU initiative joint appointments, student/post docs exchanges, research forums



U.S. Clean Energy Education & Empowerment (C3E)

- U.S. C3E Initiative is led by the U.S. Department of Energy and in strong collaboration with MIT Energy Initiative, Stanford Energy, and the Texas A&M Energy Institute
- The goal of U.S. C3E is to close the gender gap and increase the participation, leadership, and success of women in clean energy fields
- Started as part of the Clean Energy Ministerial, U.S. C3E is now in its 9th year

C3E

Four Key Pillars of U.S. C3E

- Ambassadors: ~40 distinguished senior executives, academics, government officials, and thought leaders that serve as role models and advocates for women in clean energy
- Awards: Recognizing mid-career women who have demonstrated outstanding leadership and accomplishments in clean energy
- Symposium: Annual meeting of 250+ professionals and students across the clean energy spectrum
- Community: C3E is active on Twitter and LinkedIn to connect women working in clean energy with information, insight, and inspiration

C3E


Q&A
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June 8-11
ANS Virtual Annual Meeting

June 18 | 1:00 - 2:30 pm EDT
Webinar: Clean Energy for Industry: Case for SMRs and Microreactors in Puerto Rico