



Building a Just Transition to a Sustainable Energy Future

ASME ES 2021 15th International Conference on Energy Sustainability

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June 18, 2021

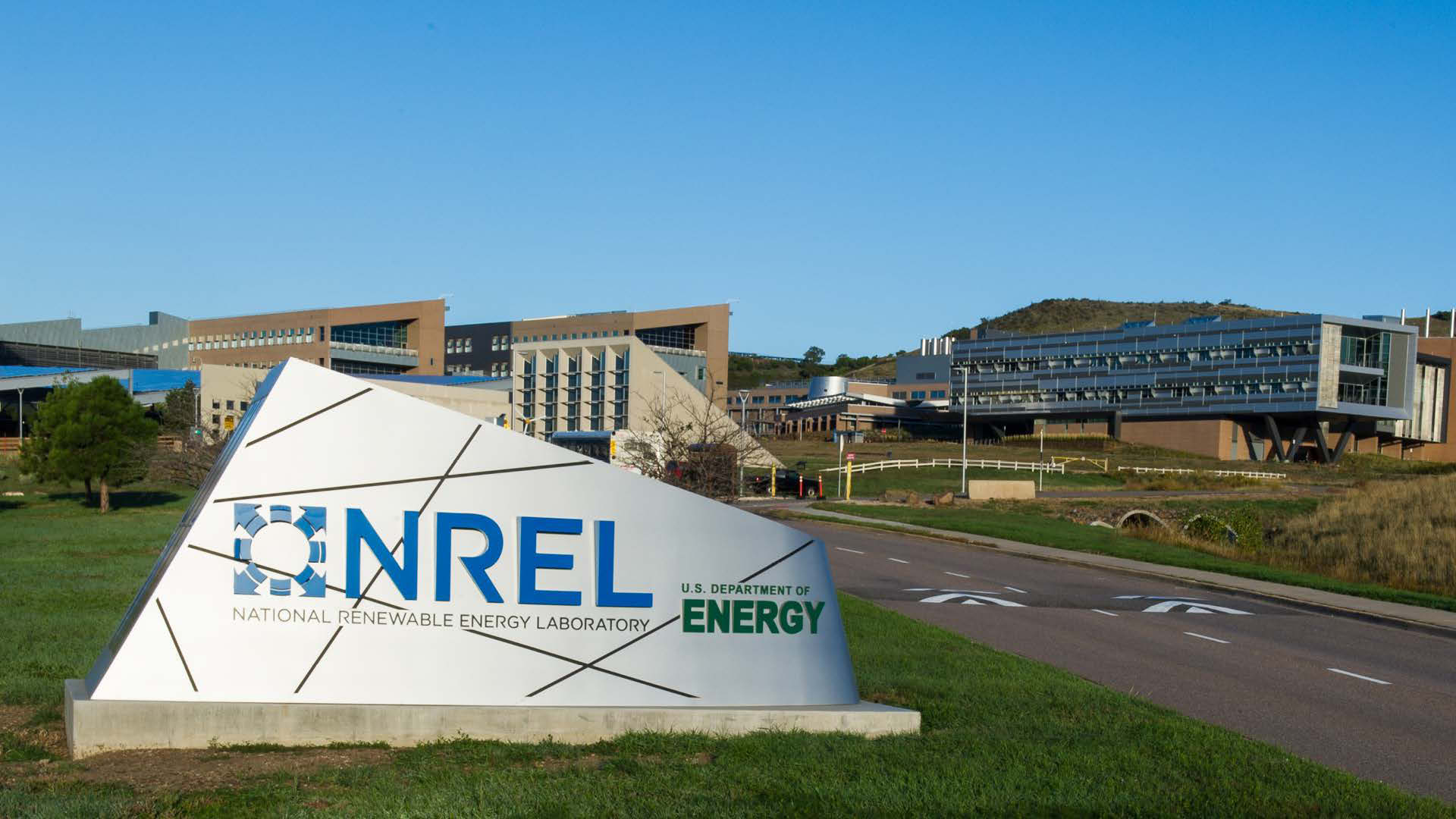




NREL

NATIONAL RENEWABLE ENERGY LABORATORY

U.S. DEPARTMENT OF
ENERGY



NREL at-a-Glance

2,926

Workforce, including

219 postdoctoral researchers

60 graduate students

81 undergraduate students



World-class

facilities, renowned
technology experts

More than
900

Partnerships

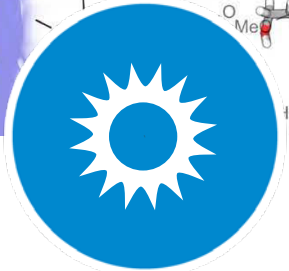
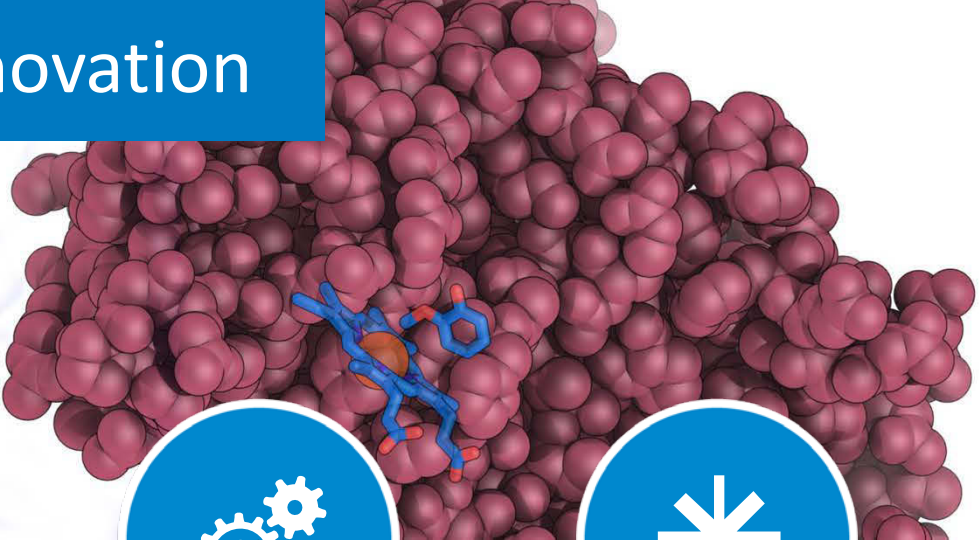
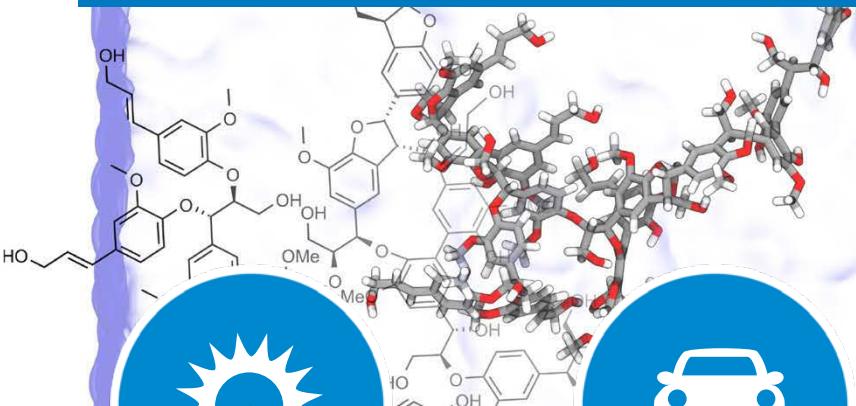
with industry,
academia, and
government



Campus

operates as a
living laboratory

NREL Science Drives Innovation



Renewable Power

- Solar
- Wind
- Water
- Geothermal



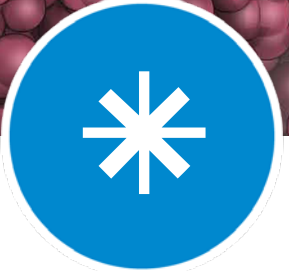
Sustainable Transportation

- Bioenergy
- Vehicle Technologies
- Hydrogen



Energy Efficiency

- Buildings
- Advanced Manufacturing
- Government Energy Management



Energy Systems Integration

- Grid Integration
- Hybrid Systems
- Security and Resilience



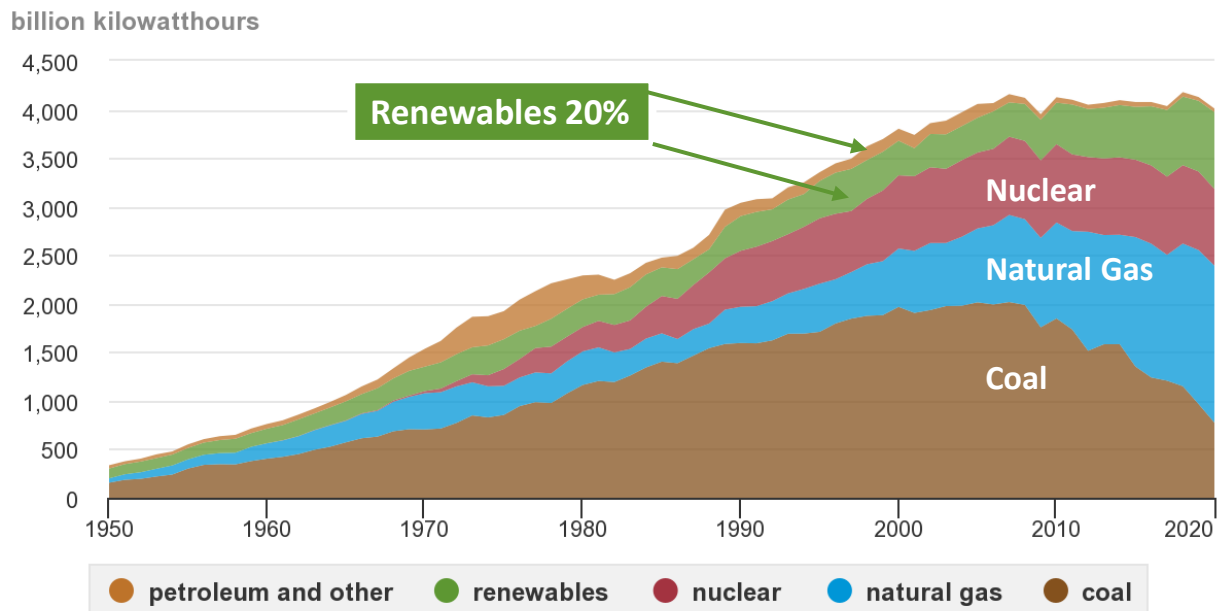
Put the United States on an irreversible pathway to achieve a carbon-free electricity sector by 2035 and a 100% clean energy economy by 2050

U.S. Electricity Supply is Shifting

During the last 12 years:

- Coal has declined.
- Gas and renewables have increased.
- Nuclear and hydro have remained steady.

U.S. electricity generation by major energy source, 1950-2020



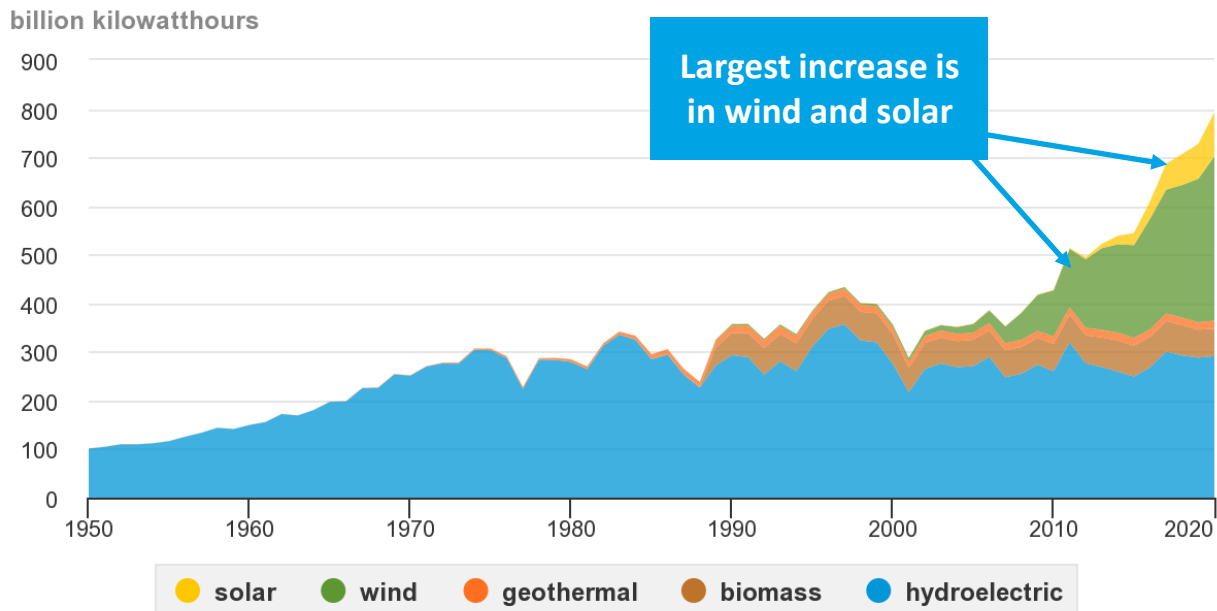
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 7.2A, January 2021 and *Electric Power Monthly*, February 2021, preliminary data for 2020.

Renewables are Increasing in the U.S. Electric Power Mix

In 2020, about 20% of annual electricity was from renewable sources.

- 8.4% Wind
- 7.3% Hydro
- 2.3% Solar
- 1.4% Biomass
- 0.5% Geothermal

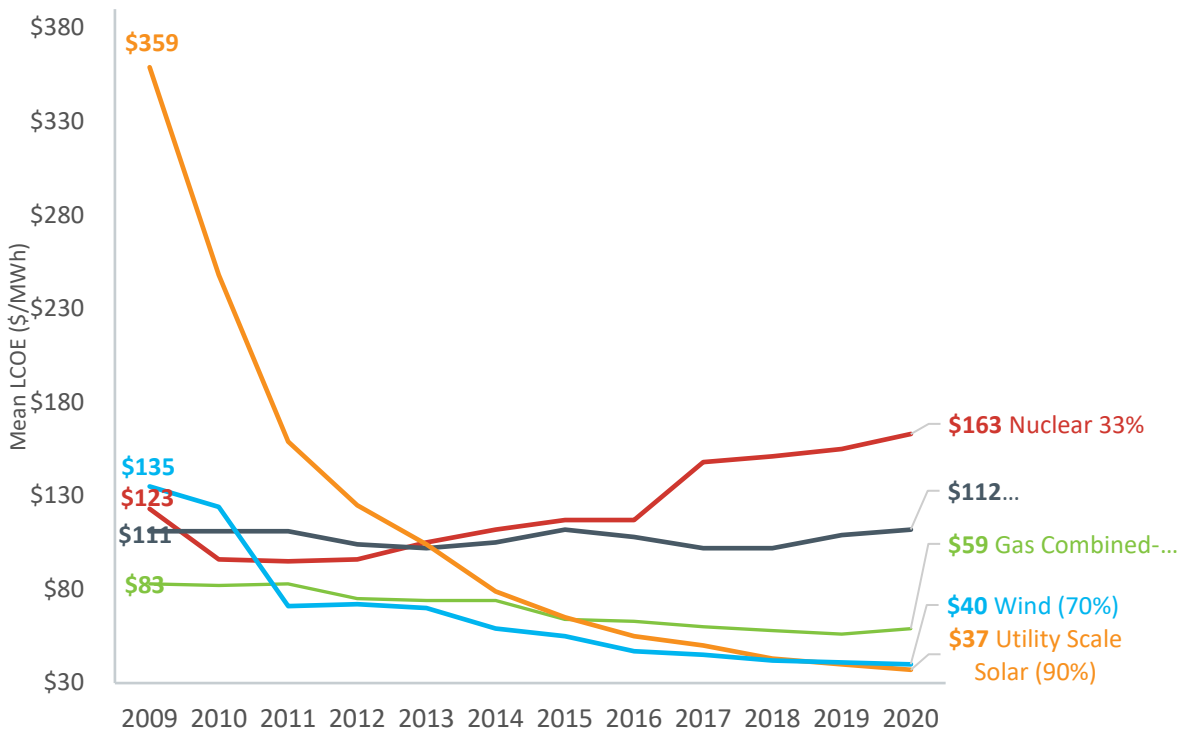
U.S. electricity generation from renewable energy sources, 1950-2020



Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 7.2A, January 2021 and *Electric Power Monthly*, February 2021, preliminary data for 2020.

Cost of Renewables Continues to Fall

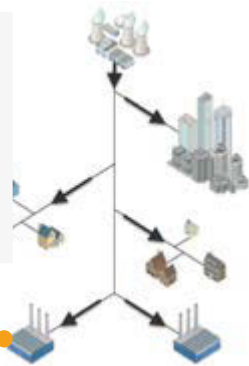
Utility-scale wind and solar are
the most cost-competitive forms
of new energy.



Transformation of the Electric Power System

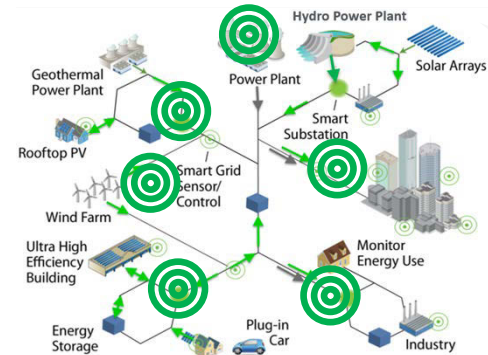
Current Power System

- Large Central-Station, Synchronous Generation
- Central Control
- Dispatchable Generation Follows Demand



- **Decarbonization** - Increasing levels of wind and solar – variable and power electronics based
- **Digitization** - More use of communications, controls, data, and information (e.g., smart grids) – need to make interoperable and cybersecurity

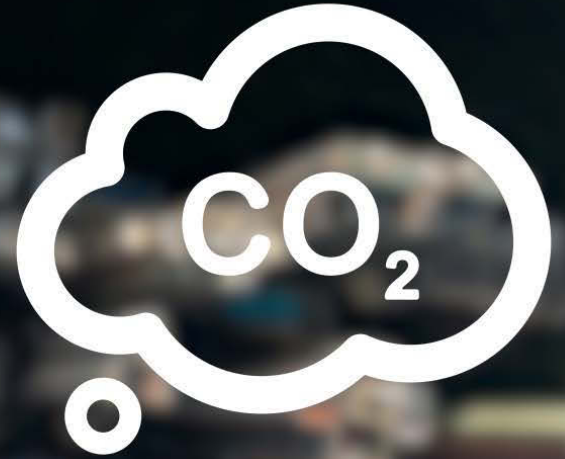
Future Power System



- More Variable Renewables
- More Power Electronics
- More Information
- More Distributed

- **Distributed** - Other new distributed technologies: EVs, distributed storage, flexible/controllable loads
- **Interdependent** - Increasing interdependencies between electricity grids and other infrastructures (e.g., gas, communications, transportation)

**39% OF TOTAL
ENERGY USE**



**74% OF NATION'S
ELECTRICITY**

**35% OF
CARBON
EMISSIONS**



Building Technologies Advancing the Clean Energy Transition

RDD&D of “technologies, techniques, tools and services that enable high-performing, energy-efficient and demand-flexible residential and commercial buildings in both the new and existing buildings markets, in support of an equitable transition to a decarbonized energy system by 2050, starting with a decarbonized power sector by 2035.”

Low Carbon Grid Requires a Fresh Approach to Behind-the-Meter Solutions



Building +

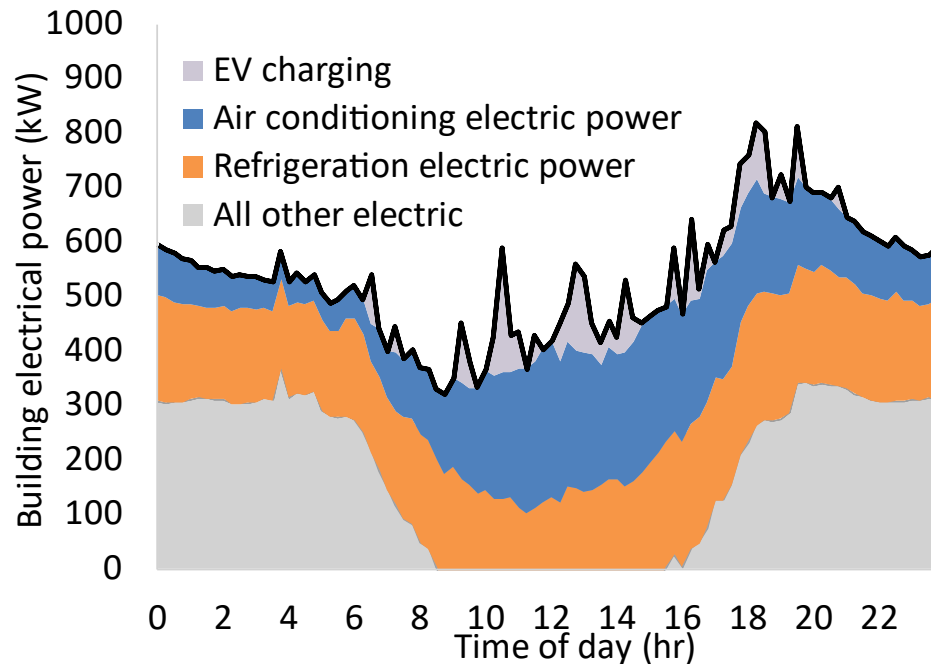


PV +



EV charging

Smart buildings, electric vehicles, solar energy, battery storage, and thermal storage can be integrated and optimized to address current industry needs.



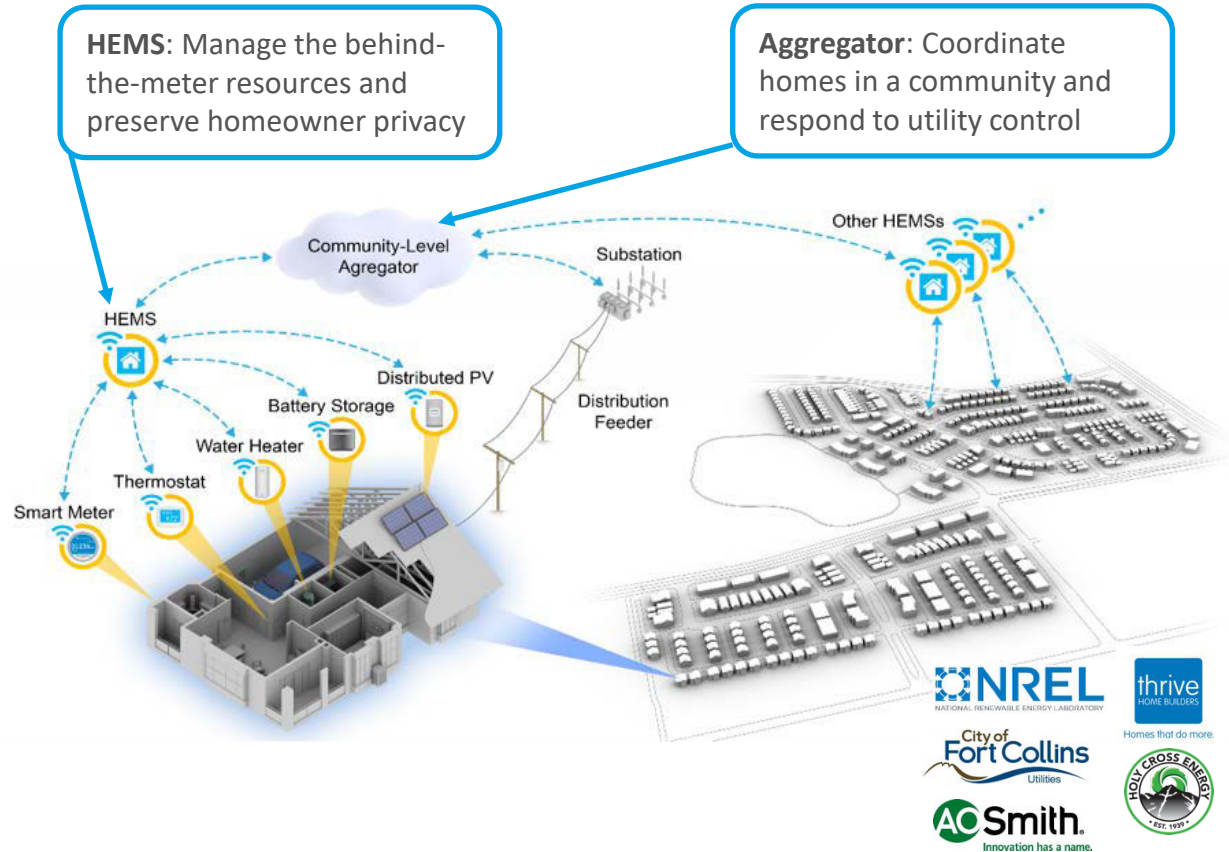
Big-box retail store with rooftop PV and 15-min electric vehicle charging

Community Scale Solutions Provide New Opportunities for Innovation at Scale

Key Features:

- Community-scale control (500 homes)
- Explicit modeling and control of reactive power and distribution feeder
- HEMS provides flexibility forecast, aggregator dispatches, flexible loads
- HEMS and aggregator updated every 15 minutes; home updated every minute

Home Energy Management System (HEMS) + Community Aggregator



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NATIONAL RENEWABLE ENERGY LABORATORY

thrive
HOME BUILDERS

Homes that do more.

City of
Fort Collins
Utilities

AC Smith.
Innovation has a name.

HOLY CROSS ENERGY
EST. 1991

LA100: Helping Cities Translate Ambition into Action

Groundbreaking Study Focused on Answering Critical Questions

- What are the pathways and costs to achieve a 100% renewable electricity supply while electrifying key end uses and maintaining the current high degree of reliability?
- What are the potential benefits to the environment and health?
- How might local jobs and the economy change?
- How can environmental justice communities benefit from and be part of the solution?



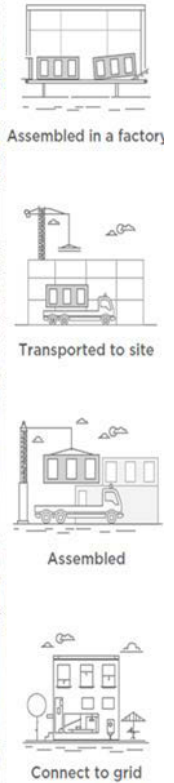
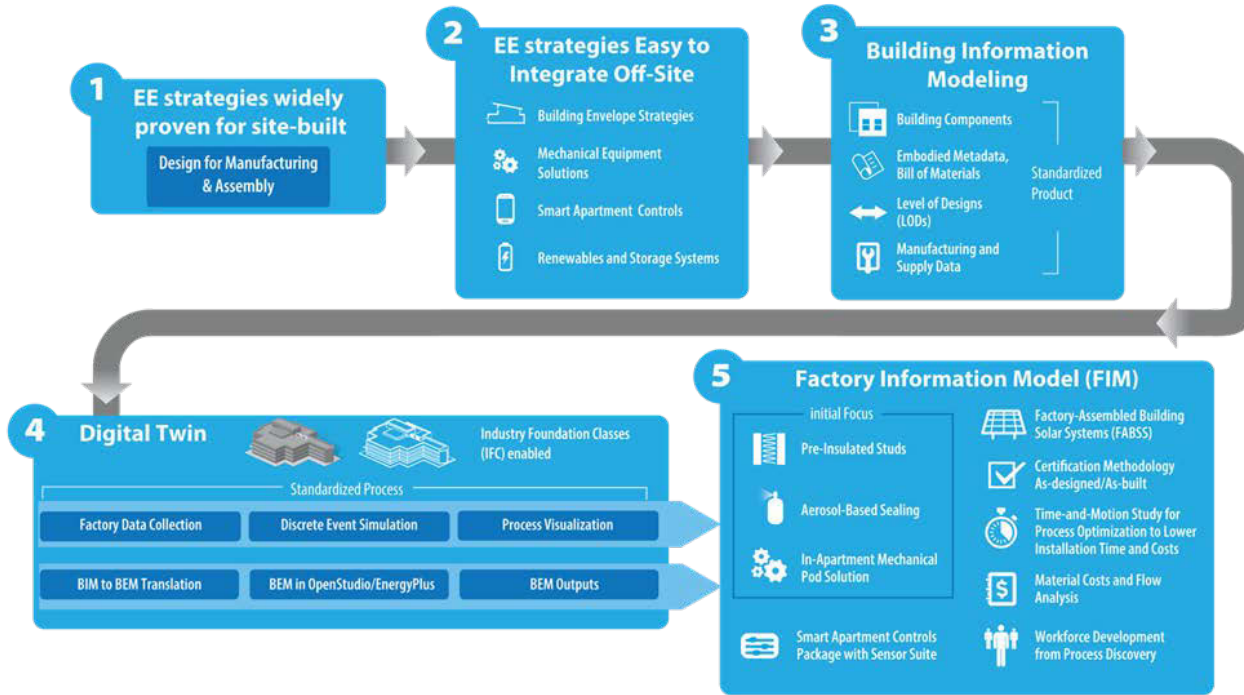
“With help of NREL’s brilliant scientists, the LA100 study is proof that the clean energy transformation is not only possible, but preferable, for all those who want cleaner air, high-quality jobs, and cheaper utility bills,” said Secretary of Energy Jennifer M. Granholm. “DOE invites all of America’s cities and utilities to join the vanguard of this revolution, so that together we can tackle the climate crisis, create an economic renaissance, and help every community see and feel the benefits of a greener future.”

Modernized Construction Practices are Needed

According to a McKinsey study, labor productivity in the construction industry has remained stagnant during the past 80 years.



Industrialized Construction Assessment Framework



Advanced Building Construction is Paving the Way for an Industrialized Future

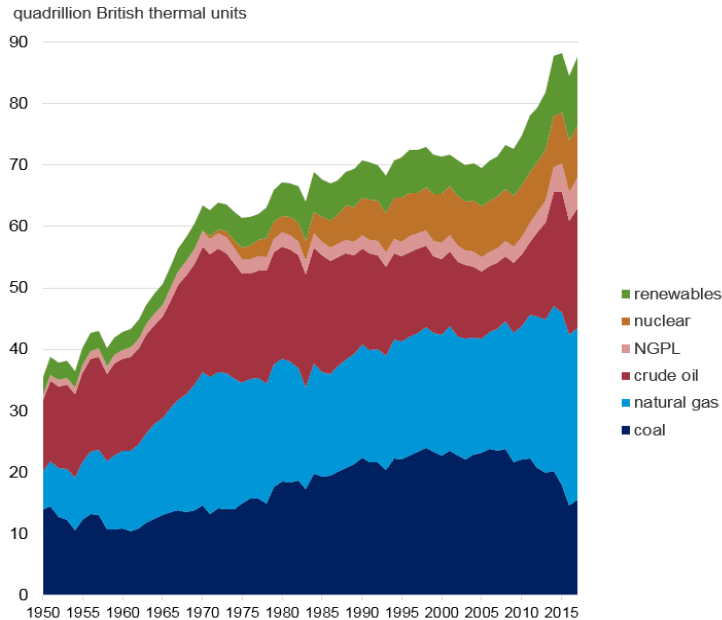
Integrating low-carbon solutions into highly productive U.S. construction practices for new buildings and retrofits

However...

- A sustainable energy future for all means clean energy for all.
- Traditional approaches to RDD&D have not achieved equitable outcomes.
- Re-imagined approaches must equitably distribute benefits and address challenges of underserved communities.

Clean energy is growing

U.S. primary energy production by major sources, 1950-2017



Note: NGPL is natural gas plant liquids.

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.2, April 2018



THE WHITE HOUSE



Administration Priorities COVID-19 Briefing Room Español

BRIEFING ROOM

FACT SHEET: President Biden Takes Executive Actions to Tackle the Climate Crisis at Home and Abroad, Create Jobs, and Restore Scientific Integrity Across Federal Government

JANUARY 27, 2021 • STATEMENTS AND RELEASES

President Biden set ambitious goals that will ensure America and the world can meet the urgent demands of the climate crisis, while empowering American workers and businesses to lead a clean energy revolution that achieves a carbon pollution-free power sector by 2035 and puts the United States on an irreversible path to a net-zero economy by 2050. Today's actions advance those goals and ensure that we are tapping into the talent, grit, and innovation of American workers, revitalizing the U.S. energy sector, conserving our natural resources and leveraging them to help drive our nation toward a clean energy future, creating well-paying jobs with the opportunity to join a union, and delivering justice for communities who have been subjected to environmental harm.

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INTERIM NATIONAL SECURITY STRATEGIC GUIDANCE

MARCH 2021

OUR STRENGTH ABROAD REQUIRES US TO BUILD BACK BETTER AT HOME.

...but not for everyone



- **Black-majority census tracts installed 69% less rooftop PV** than no-majority tracts of same household income
- **Less than half of U.S. community solar projects include low-income households**
- Nearly 60% of all new solar capacity in 2018 was utility-scale PV, expanding access. However, **benefits such as lower costs are rarely transferred directly to customers**



- Since 2006, **90% of electric vehicle income credits were received by the top income** quintile.
- **Renters and those living in multi-family housing often lack access to home charging locations**, where 80% of electric vehicle charging occurs.
- **37% of rental housing units have a garage or carport** compared to 78% of owner-occupied housing.



- The **least affluent 20% of households spend a 3x greater share of income on transportation** than the most affluent 20%
- **70% of American households** live in neighborhoods where **combined housing and transportation costs are not affordable**
- **30%-45% of urban populations** exposed to **poor air quality near busy roads**
- **≈10% of people with multiple disabilities have no access to paratransit** because they live in paratransit deserts

The success of a traditional technology-centric approach is limited by socioeconomic factors.

Current Math Is Not in Our Favor to Meet Our Clean Energy Goals

100% clean energy



100% clean energy for 30% of the people



100% clean energy



100% clean energy for 100% of the people



The goal: A Clean Energy Future for All... 100% for 100%

A clean energy future is a just energy future

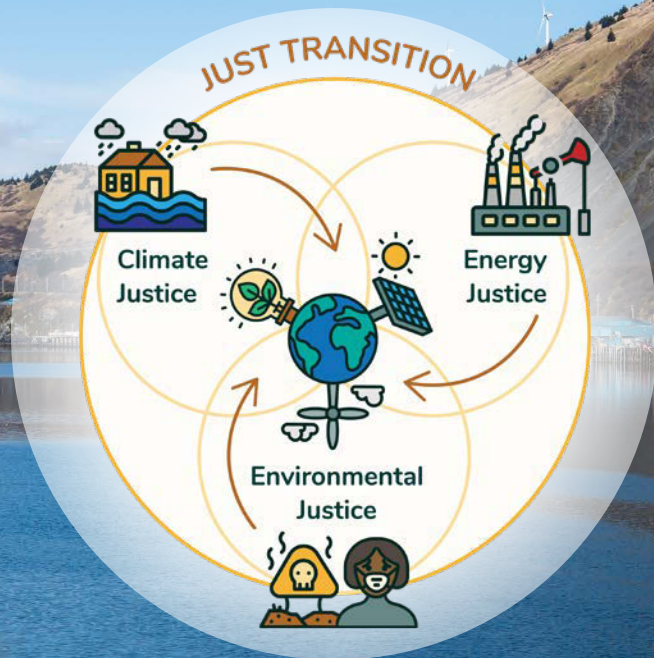
“ This is our opportunity to build the energy economy back better, in a way that **lifts up communities that have felt unseen or abandoned or left behind for too long.**”



*Secretary of Energy
Jennifer M. Granholm*

Defining Terms

Climate Justice: Remediation of the impacts of climate change on poor people and people of color, and compensation for harms suffered by such communities due to climate change (from Burkett 2008)



Energy Justice (or energy equity): The goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those historically harmed by the energy system

Environmental Justice: Recognition and remediation of the disproportionately high and adverse human health or environmental effects on communities of color and low-income communities (from Just Climate Alliance)

Graphic and language from
Initiative for Energy Justice:
<https://iejusa.org/>

Where We've Been
Successful

An Equity-Centered Technology Solution

Unalakleet,
Alaska



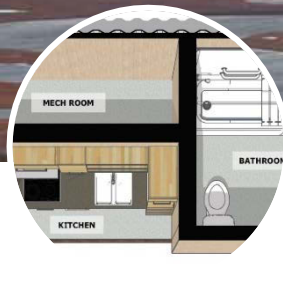
Many rural and indigenous communities experience

- Overcrowding
- Air quality problems
- Lack of water and sanitation systems
- Energy costs up to 4X national average
- Impacts of climate change



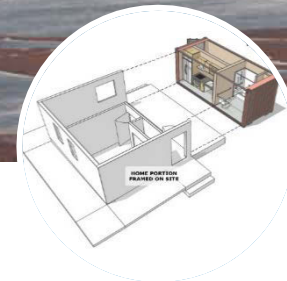
Keeping families together, elders within the community

- Mentors, teachers
- Keepers of wisdom
- Intergenerational cultural knowledge



ABC solution designed with community input

- Storage containers outfitted with energy-efficient mechanical systems
- ADA-compliant bathroom, kitchen
- Reduces energy costs by ~50%
- Provide clean, healthy, indoor air



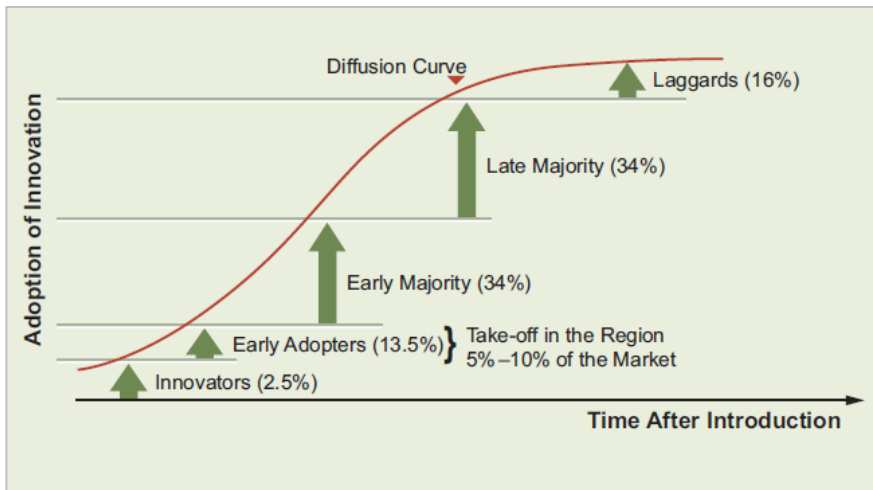
Furnished containers “plug in” to existing or newly-framed structures

- Costs 40% less than same house built conventionally
- 75% of new jobs are created within the community (framing & on-site construction)

“Tip of the Iceberg”



Current Approach to Market Transformation Does Not Foster a “Just Transition”



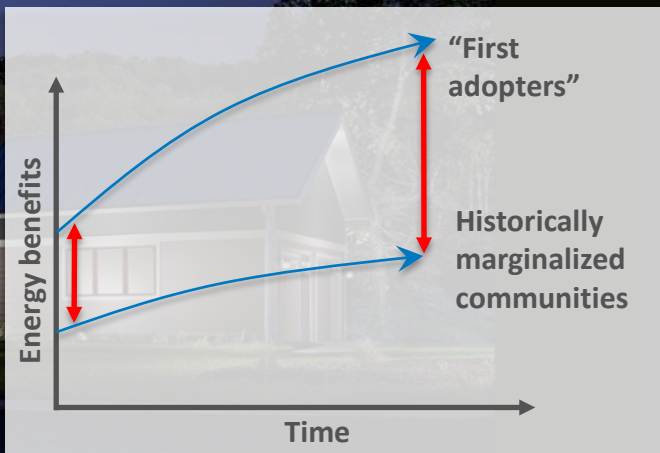
Adopter Type	Characteristics	Role and Size
Innovators • Enthusiasts	Venturesome; enjoy the risk of being on the cutting edge; demand technology	Market drivers. Want more technology, better performance. (16%)
Early Adopters • Visionaries	Well connected; integrated in the mainstream of social system; project oriented; risk takers; willing to experiment; self-sufficient; horizontally connected and act as their peers	
THE CHASM (where marketing and distribution must radically change)		
Early Majority • Pragmatists	Deliberate; process oriented; risk averse; want proven applications; may need significant support; vertically connected and act as their superiors	Followers of the market. Want solutions and convenience. (68%)
Late Majority • Conservatives	Sceptical; do not like change in general; change under pressure from the majority	
Laggards • Sceptics	Traditional; point of reference is the good old days; actively resist innovations	Economic/ power interest different from status quo? (16%)

Photo by Werner Slocum, NREL

National Research Council 2010. *Electricity from Renewable Resources: Status, Prospects, and Impediments*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/12619>.

We need clean energy innovation for all people.

Our Current Approach Results in “Trickle-Down” Clean Energy



We must re-imagine research, development, demonstration, and deployment to reverse the trend of clean energy solutions that increase inequities.

Historical Inequities Present Unique Development, Analysis, and Demonstration Challenges



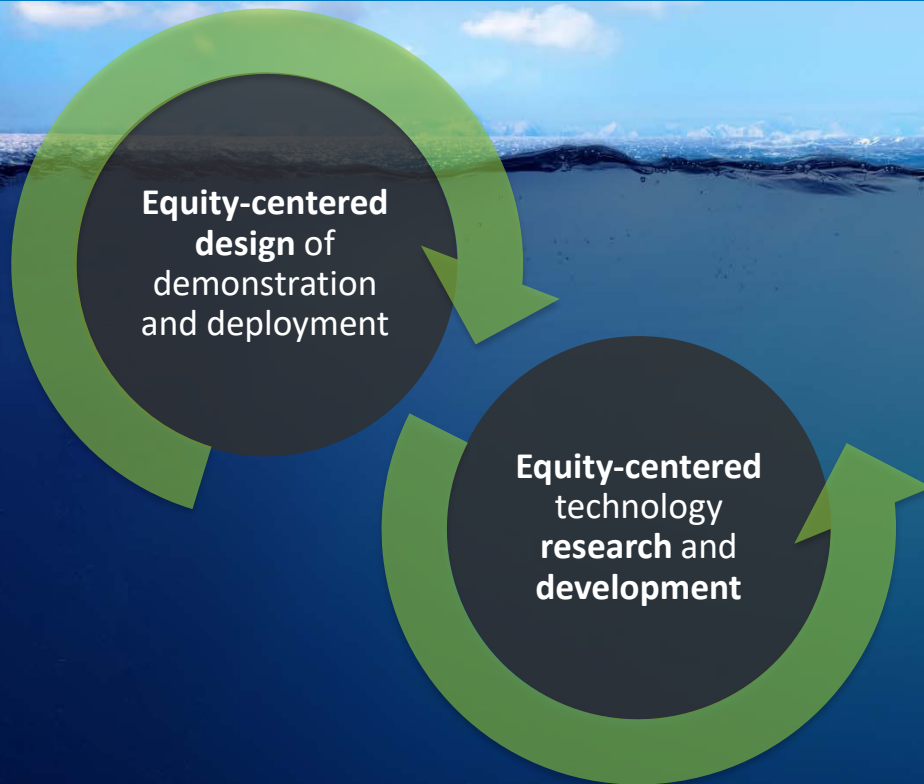
Southern Company's Smart Neighborhood in Birmingham, Alabama



Oak View neighborhood in Huntington Beach, California

If we do not intentionally identify and address unique challenges, solutions and plans will not scale and achieve national impact.

Expand Equity-Centered Deployment + Learnings Inform RDD&D



Bringing Capabilities Together to Expand Deployment



Stakeholder engagement and agency



Analytic insights, models, tools, and data sets

+



Solutions, technologies, and integration



Action plans and implementation



Community-driven national impact

An American flag is planted in a field of tall grass. The sun is setting behind the flag, creating a bright glow and long shadows. The sky is filled with dramatic, dark clouds, and rays of light are visible breaking through them. The overall scene is patriotic and serene.

Thank You!

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