



# Today's Energy Challenges, Tomorrow's Solutions

## Integrated Energy Pathways: Modernizing Our Energy Systems

**The future will be defined not only by the need for more resilient and accessible energy, but also by greater and more varied types of demand. As our population grows and urbanization increases, so will our demand on the world's energy resources.**

NREL is meeting this challenge head-on by focusing our expertise and resources on three research areas that will accelerate the transformation of traditional energy products, practices, and industries. This requires more than simply enabling low-cost renewable and low-carbon electricity generation. It also means moving toward two-way power flow and digitization, developing new methods to convert carbon molecules derived from today's fossil fuels and use them in new ways, and rethinking how products are designed and recycled for maximum material efficiency.

NREL is Transforming Energy—how we generate, consume, store, and distribute it. And we invite you to join us in that effort.

### Research Area: Integrated Energy Pathways

Today's electric grid was built around century-old concepts and technologies, not the needs and opportunities of tomorrow's emerging system. Energy technologies have evolved in multiple sectors, leading to diversity in how and where energy is generated. This diversity has

### Integrated Energy Pathways

Generation, Storage, and Integration

System Security and Resilience

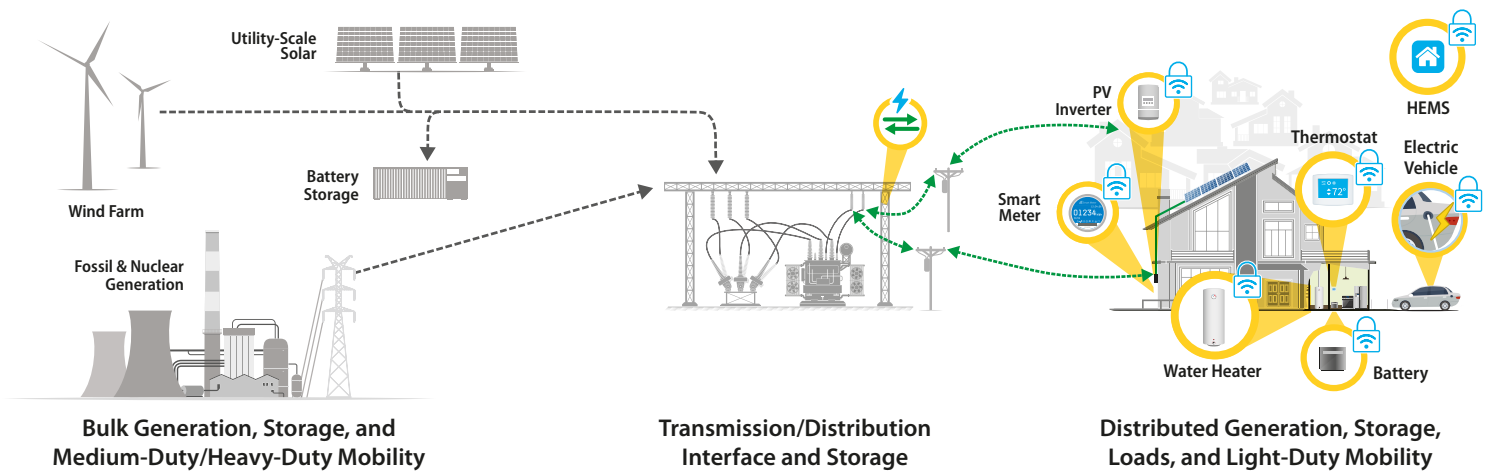
Advanced Mobility

not only turned one-way power flow on its head, but it also has opened the door to unprecedented energy resilience and efficiency as well as advanced mobility.

Through integration of energy systems, we can capture the unique value of new technologies and methods and discover the beneficial pathways at their intersection. An integrated energy system will call on creative solutions to energy storage, connections between renewable and conventional resources, and advanced controls that create greater grid security and flexibility.



# Elements Influencing Grid Modernization



NREL is at the front of this fundamentally critical research direction. We are expanding capabilities to match the growing complexity of energy systems and bringing industry perspective into the laboratory to collaboratively develop the highest-value energy pathways for tomorrow's energy system.

## The Challenge

The energy landscape is shifting dramatically across domains. Each of the following research areas is helping shape how we approach energy systems integration.

- Autonomous systems
- Advanced storage
- Interconnected security and resilience
- Integration and control of distributed systems
- Energy resilience science
- Transportation systems integration
- Medium- and heavy-duty vehicle electrification
- Charging infrastructure.

These topics are the tip of the iceberg; all energy sectors are trending toward new technologies, digital interfaces, and greater device complexity. The challenges of this transition must be met with advanced controls that match the high speed of modern assets and new methods that deliberately mix the strengths of each sector.

## How We Get There

NREL has a comprehensive plan to get us from the grid of today to the grid of tomorrow.

### Generation, storage, and integration

- Provide tools to optimize systems operations
- Enable reliable uptake of new technologies into the power system
- Optimize the integration of new technologies with existing systems.

### System security and resilience

- Pioneer resilience science and methodologies
- Fully integrate advanced cybersecurity methods and practices into power systems operations
- Develop advanced visualization that accelerates technology adoption.

### Advanced mobility

- Design more efficient and effective mobility systems
- Diversify transportation options and fuels
- Effectively use power system assets.

This effort requires a systems-wide approach, not small-scale piecemeal efforts. NREL is uniquely positioned to take on this challenge at the scale to research, develop, and validate system-level solutions.

## Working Together

These challenges require sensible solutions. Working with industry, government, research, and nonprofit partners, we can achieve them far faster and more efficiently than working on them independently.

NREL is committed to ensuring our research gets to market—where it can improve everyday life and strengthen our economy. We have nearly 900 active agreements with almost 600 partners, over half of which are private-sector companies.

Such partnerships create powerful synergies between NREL's early-stage research and industry's market-focused activities, which will unleash the creativity of both. By transforming our science, we can accelerate the development of new energy technologies through "de-risking" the early-stage research needed to innovate.

Together, we can bridge the gap from concept to market, linking our renewable energy and energy-efficient technologies with strategies to achieve real-world impact.