Driving Deep Decarbonization through Innovation

How PNNL contributes to decarbonization efforts at the intersection of efficiency, technology, and Earth systems

Addressing climate change while boosting equitable access to a resilient energy system requires a multifaceted strategy. PNNL is accelerating the drive toward deep decarbonization through contributions to key DOE R&D programs, cultivating partnerships with industry, and providing institutional support to entities helping to execute local clean energy strategies across the nation.

ADVANCING ENERGY EFFICIENCY

In 2019, commercial and residential buildings contributed 35% of CO_2 emissions in the United States. Reducing the carbon footprint of buildings can be achieved by using updated building energy codes and minimum efficiency standards for appliances, a proven approach to sharply reducing energy consumption and reducing emissions. Previously enacted appliance and commercial equipment standards alone avoided three billion metric tons of CO_2 emissions in 2015 while saving American consumers $63 billion. U.S. building codes enacted since 2010 have avoided 121 million metric tons of CO_2 emissions while saving Americans $20 billion. This is just a fraction of the CO_2 avoidance possible if codes and standards are advanced to net-zero objectives.

PNNL has led support of the DOE Building Energy Codes Program since its inception through a combination of research, technical analysis, and participation in established industry and stakeholder processes. PNNL also provides technical assistance to states and communities in devising and implementing their own "stretch" codes and methods to achieve even deeper reductions in emissions. PNNL combines this same expertise with unique laboratory facilities to support DOE's Appliance and Equipment Standards Program, including the development and evaluation of energy efficiency test procedures.

DECARBONIZING ELECTRICITY GENERATION

Reaching national, state, and local goals for decarbonizing the electricity grid requires the integration of clean energy resources with advanced control technologies, energy storage, and carbon capture. Researchers at PNNL are developing technology to deliver unprecedented flexibility for the electric grid, which is key to integrating distributed generating assets, responsive building loads, and new transportation electrification systems.

PNNL has pioneered an approach that applies novel, market-based distributed control and coordination techniques to engage building and industrial loads, as well as electric vehicles. Piloted with utility and industry partners as part of the nation's largest Regional Smart Grid Demonstration Project, scaling the application of these methods will enable unprecedented grid flexibility and carbon reductions—while preserving affordability and system resilience. PNNL is currently assessing the application of this approach in a market the size of Texas, at variable levels of electric vehicle and renewables penetration.

As DOE's flagship chemistry laboratory, PNNL is also working to improve existing carbon capture technologies, while developing the next generation of solvents that make capture viable. PNNL also developed the first-ever Class VI permit for carbon injection in the United States, and is now developing tools to enable real-time imaging of the subsurface that can help improve the reliability of reservoir forecasting for carbon sequestration, a key component of achieving global emissions reduction targets.

DECARBONIZING TRANSPORTATION

In 2018, transportation was the largest and fastest growing source of climate pollution in the nation. PNNL leads DOE's Battery500 program, which is doubling the energy density of today's batteries for electric vehicles so they can go twice as far on a charge while also operating safely. Already, PNNL has achieved more than 100 stable cycles in a 400 Wh/kg lithium metal battery—about 1.5 times the performance of today's commercial batteries. PNNL has also demonstrated the scalable manufacture of copper-graphene composites that exhibit 105% of the electrical conductivity of pure copper, which holds promise for reducing the overall weight of vehicle components. When it comes to the transportation modes most difficult to electrify, PNNL is proving new production routes for energy-dense fuels from alternative carbon sources that are underutilized or viewed as waste. PNNL technology is being incorporated into a 10 million gallon/year plant for sustainable aviation fuel, and another three 30 million gallon/year plants are under design. Finally, as the grid becomes greener, PNNL technologies provide opportunities for green hydrogen, and its safe use, as a fuel for trucks and as an intermediate in petroleum and biofuels production.

UNDERSTANDING THE INTERSECTION OF EARTH SYSTEMS AND ENERGY

Changes in climate affect the amount of energy needed in the United States and the ability to produce that energy. Improving projections of climate shifts, including extreme events, is essential for informing decarbonization strategies. PNNL's world-class expertise in integrated modeling of energy systems enables analyses that account for interactions among supply and demand, multiple energy technology options, alternative mitigation policies, and linkages with water, land, and climate. Capabilities range from modeling hourly regional electricity grid operations and optimal siting of specific power plants to national and international decarbonization policy, such as the quantitative analysis PNNL led to support 2016's United States Mid-Century Strategy for Deep Decarbonization and the research support for State Department negotiations related to the Paris Agreement. Better understanding of interactions between the energy system, land use, climate, and water availability will allow for better informed and more equitable carbon reduction policies.