The U.S. energy system requires secure and reliable management, and commercial cloud services offer promising benefits compared to on-premises solutions. *Photo courtesy of iStock, 989624498*

NREL Project CloudZero

CloudZero is evaluating the secure management of complex energy systems from the cloud.

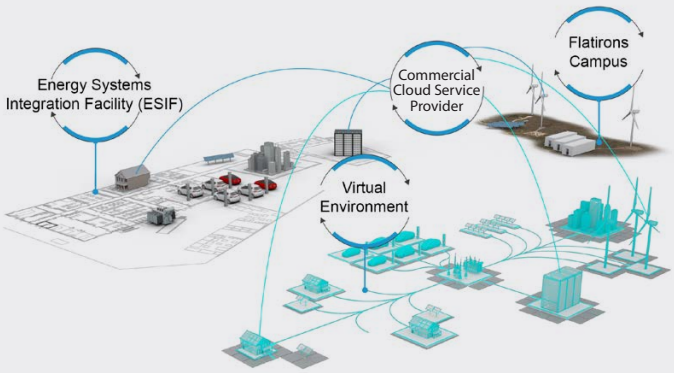
Commercial cloud services will become increasingly prevalent in the distribution grid of the future. New concepts such as virtual power plants and aggregators are using cloud services, and they have the potential to bolster the stability of the U.S. electric grid. Validating, testing, and documenting these deployments, however, will be critical to guarantee this stability without introducing new threat vectors.

The National Renewable Energy Laboratory's (NREL's) CloudZero project is evaluating the ability to reliably and securely manage complex energy systems from the cloud, identifying major technical and regulatory barriers to cloud adoption, suggesting new security controls and best practices for cloud applications, and empowering industry to embrace the cloud, where appropriate.

Using the Advanced Research on Integrated Energy Systems (ARIES) Cyber Range, NREL is rapidly instantiating realistic environments with legitimate cloud components to ensure the secure and stable usage of these next-generation technologies.

Advanced Research Capabilities in ARIES Cyber Range

The ARIES Cyber Range enables researchers to replicate scenarios as they would occur on real, complex energy systems. The cyber range brings together utility-scale hardware at NREL's Flatirons Campus with physical devices at NREL's Energy Systems Integration Facility in the emulated world of the cyber range, allowing for hardware-, controller-, and human-in-the-loop studies.

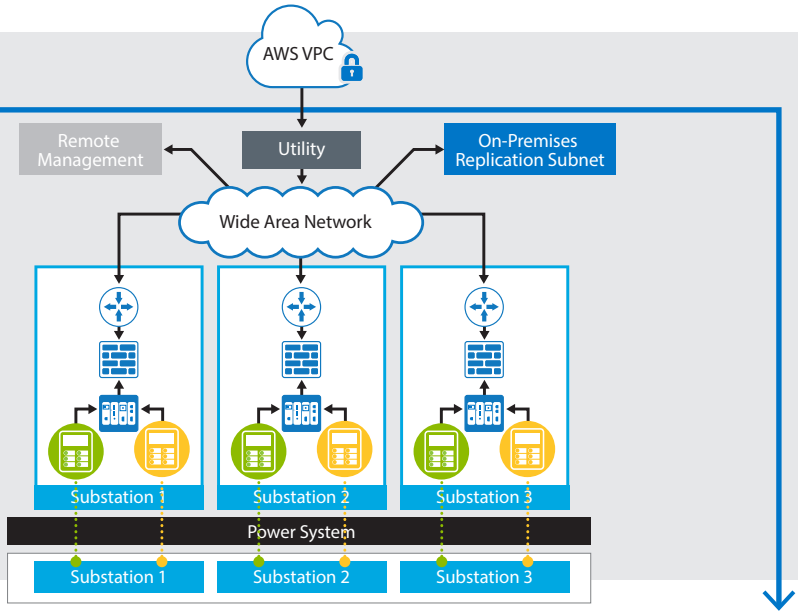


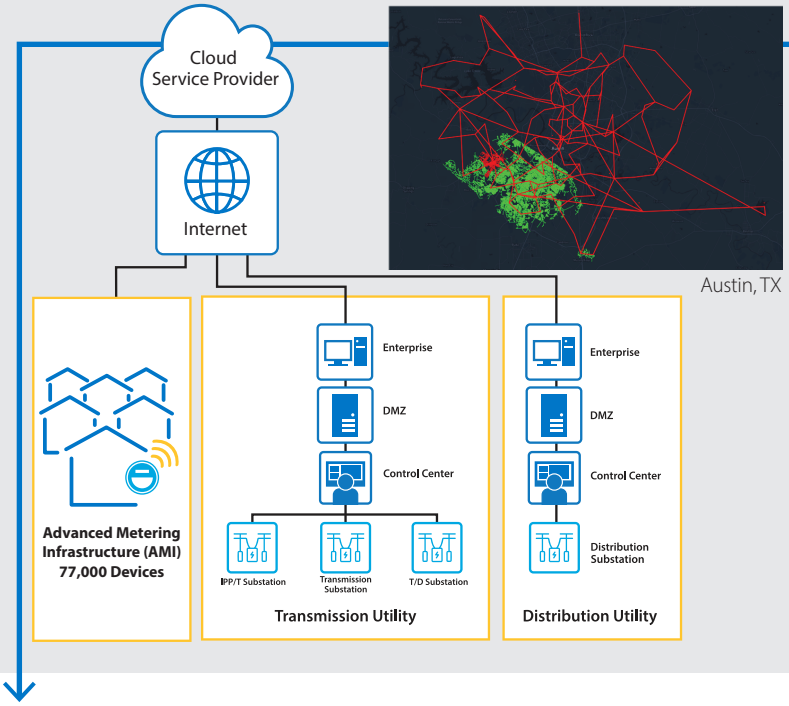
PHASE 1

GOALS: Conduct preliminary analysis of cloud suitability for operational technology (OT) and net-zero systems. Establish partnerships and infrastructure that lay the foundation for more complex phases of analysis.

TESTING ENVIRONMENT: Modeled a three-substation microgrid connected to an Amazon Web Services (AWS) virtual private cloud (VPC).

RESULTS: Confirmed reliable data transfer to the cloud. Established infrastructure for further evaluation of cloud-based solutions.





Austin, TX

PHASE 2

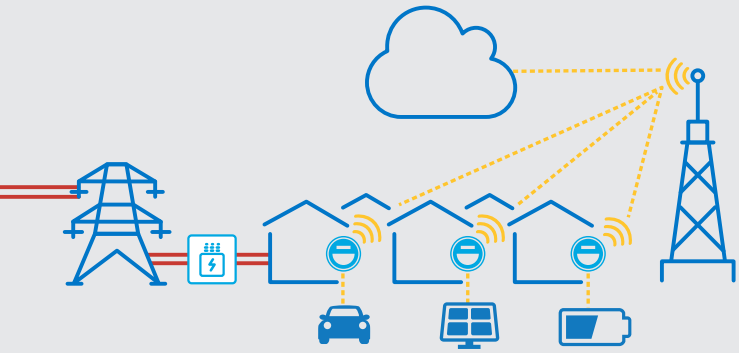
GOALS: Develop and explore three use cases:

- **High availability and scaling**—Investigate the ability of cloud systems to provide uninterrupted service, even when components fail.
- **High-fidelity load forecasting**—Increase the amount of power usage data and leverage artificial intelligence and machine learning to demonstrate how cloud services will improve load forecasting.
- **Bulk electric system reliability operations**—Extend OT systems to the cloud infrastructure to enable automatic generation control, voltage control, and situational awareness services.

TESTING ENVIRONMENT: Built a high-fidelity, transient transmission and distribution co-simulation of a major urban area of Austin, Texas. Modeled hardware and software infrastructure in addition to cloud connectivity.

PRELIMINARY RESULTS: Verified that certain cloud configurations and infrastructure deployments improved load forecasting. The experimental co-simulation used the cloud to test automatic generation control operations.

PHASE 3



GOALS: Validate cybersecurity and secure cloud integration approaches that enable the monitoring and control of aggregated distributed energy resources participating in grid reliability functions. Conduct validation testing in a high-fidelity hybrid environment consisting of virtual, emulated, and full-scale hardware-in-the-loop power system infrastructure.

Want to learn more?

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NREL/FS-5R00-88013 • November 2023