Towards the Energy System of Tomorrow

EESI Panel

Juan Torres
Associate Laboratory Director
Energy Systems Integration
The US Energy Supply is Shifting

U.S. electricity generation by major energy source, 1950-2019

- Coal
- Nat Gas
- Nuclear
- 17% Renewables

Note: Electricity generation from utility-scale facilities.
The US Energy Supply is Shifting

Renewable Energy

In 2019, 17% of annual electricity was from renewable sources.

• 7% Wind
• 7% Hydro
• 2% Solar
• 1% Biomass
• 0.5% Geothermal

Largest increase is in wind and solar
Vehicle electrification dominates incremental growth in **annual** consumption

2050 U.S. electricity consumption increases
- **Medium** +932 TWh (20%)
- **High** +1,782 TWh (38%)

https://www.nrel.gov/analysis/electrification-futures.html
The Grid of the Past

- Generation
- Transmission
- Distribution
- Load
The Grid is Changing
Power Electronics-Based Energy System

- Operating with Less Inertia

**Generation**
- Solar PV, wind, microturbines, fuel cells use power electronics (PE) interfaces to connect to the grid
- Over 50% PE generation by 2050
- Other bulk source work synergistically

**Storage**
- Batteries use PE interfaces to connect to the grid
- Pumped hydro can add PE to increase controllability and provide grid services

**Building Loads**
- Over 60% of major home appliances expected to be PE-based by 2021
- Lighting switching to LEDs
- Variable speed drives for motors

**Mobility**
- EVs – 7 million by 2025
- MD/HD – Electrifying

---

- Operating Complete Systems
- Part of a Larger System
Advancements in AI and Autonomous Energy Systems (AES)

NREL’s AES Research developed advanced controls for integrating hundreds of million controllable grid assets
- Scalable, distributed-hierarchical control
- Fast and accurate real-time optimization
- Network-cognizant making best use of available data

Enabling large-scale deployment of distributed energy resources (EVs, Buildings, Generation) through advancements in optimization, control, data analytics, and complex system simulation

- Campuses
- Communities
- Cities
- Regions
Detailed, ultrahigh resolution analysis evaluating a range of future scenarios to equip LA decisionmakers to understand:

- 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 is the **impact on the environment**?
- How might the **economy** and **rates** respond to such a change?
Sources of Energy System Disruption

Natural Disasters
Space Weather
Physical Threats
Electromagnetic Pulse
Cyber Threats

Natural Hazards
Human Threats
Thank You

www.nrel.gov