Capturing technological disruptions and behavioral change in long-term energy scenarios

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Breadth of technologies

Primary energy supply relative ranges for pathways limiting warming to 1.5°C with no or limited overshoot

Source: IPCC SR15 report.
Net Zero by 2050 - A Roadmap for the Global Energy Sector

Key clean technologies ramp up by 2030 in the net zero pathway

- **Capacity additions (GW):**
  - Wind: 4x increase from 2020 to 2030
  - Solar PV: Increase from 2020 to 2030

- **Electric car sales (millions):**
  - Double from 2020 to 2030

- **Energy intensity of GDP (MJ per USD ppp):**
  - Decrease by 4% per year from 2020 to 2030

Note: MJ = megajoules; GDP = gross domestic product in purchasing power parity.
REMAP Scenario Example

US Scenarios: Power Sector

Forward-looking scenarios of the U.S. power sector updated annually to support and inform energy analysis.
LA100: Los Angeles 100% Renewable Energy Study

NREL is uncovering analytic insights at unprecedented scale

• Infrastructure level insights to realize ambitious goals
• Critical roles of biofuels, or RE-fueled (e.g., RNG or H2) support seasonal storage & reliability
Each Scenario Evaluated Under Different Customer Demand Projections (different levels of energy efficiency, electrification, and demand response)

**SB100**
Evaluated under Moderate, High, and Stress Load Electrification
- 100% clean energy by 2045
- Only scenario with a target based on retail sales, not generation
- Only scenario that allows up to 10% of the target to be natural gas offset by renewable electricity credits
- Allows existing nuclear and upgrades to transmission

**Early & No Biofuels**
Evaluated under Moderate and High Load Electrification
- 100% clean energy by 2035, 10 years sooner than other scenarios
- No natural gas generation or biofuels
- Allows existing nuclear and upgrades to transmission

**Transmission Focus**
Evaluated under Moderate and High Load Electrification
- 100% clean energy by 2045
- Only scenario that builds new transmission corridors
- No natural gas or nuclear generation

**Limited New Transmission**
Evaluated under Moderate and High Load Electrification
- 100% clean energy by 2045
- Only scenario that does not allow upgrades to transmission beyond currently planned projects
- No natural gas or nuclear generation
Meeting the last 10% on the road to 100% renewables

Producing hydrogen (rather than buying commercially available RE fuels) adds ~20% to cumulative costs

Capacity Mix in 2045 — High Load Scenarios, Compared to 2020
## Implications for technology change

- Understanding commercial and near commercial technologies
- Characterizing precommercial technologies
- Understanding implications for behavior, institutional, policy and regulatory change
- Addressing Unknown Unknowns...

## Future casting....
- Electrification
- Multiday demand response
- Storage, esp beyond batteries
- H2
- Renewable Natural Gas
- P2X
- ???
Evolving practices

- Ensemble approaches
- Robust Decision making
- Improved characterizations and incorporation into LTES models
- Transparency