

The Need for Flexible Generation in the Bulk Power System

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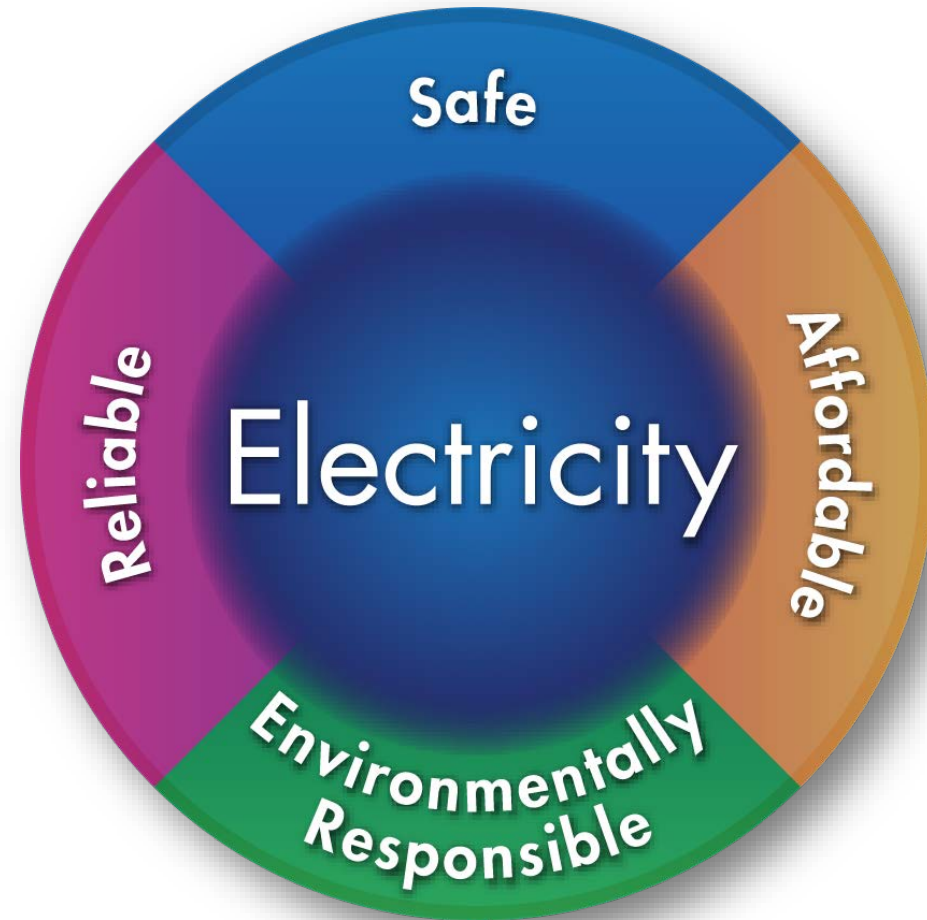
Electric Power Research Institute

EPRI Mission

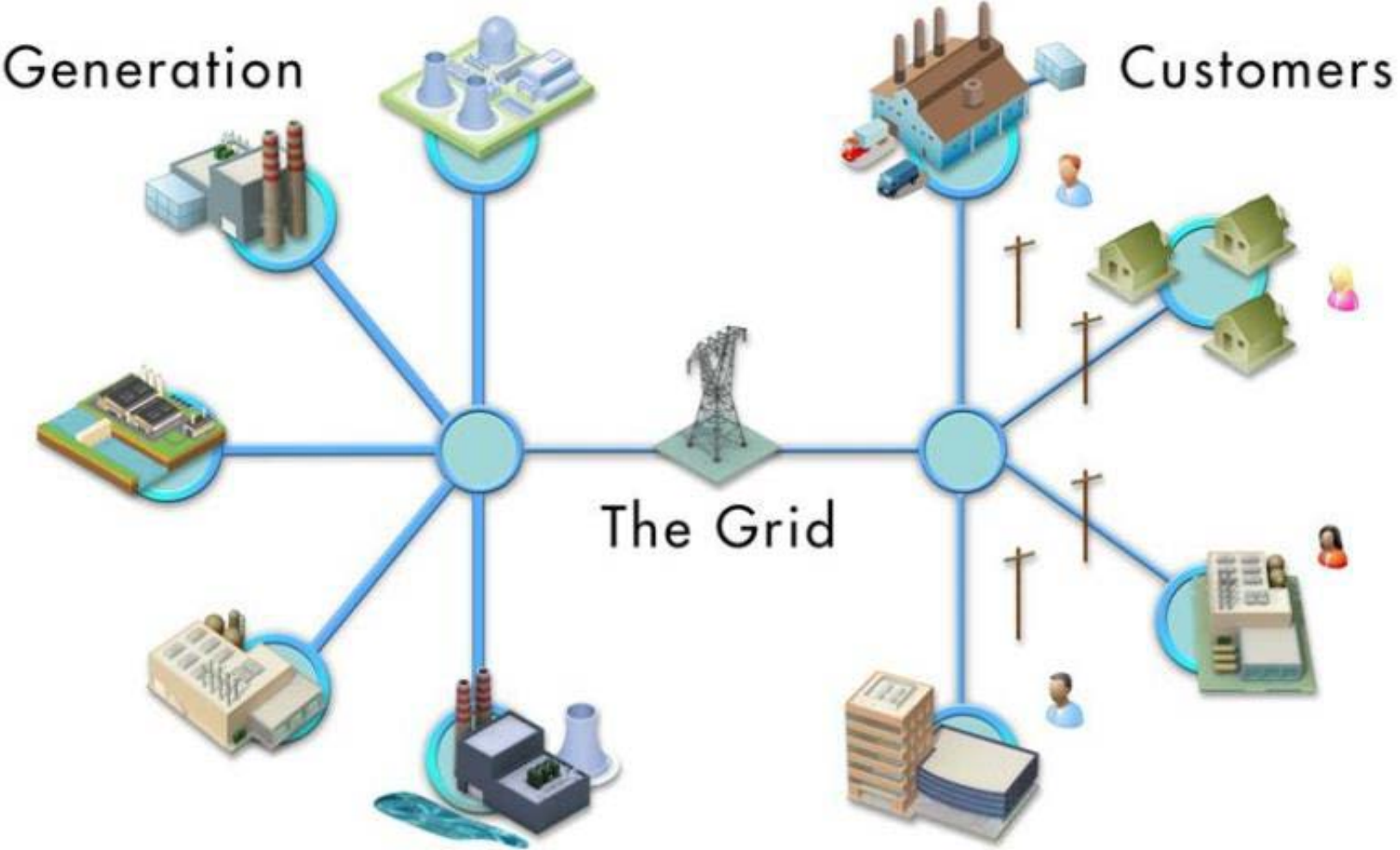
Advancing **safe, reliable, affordable** and **environmentally responsible** electricity for society through global collaboration, thought leadership and science & technology innovation

EPRI Strategic Direction

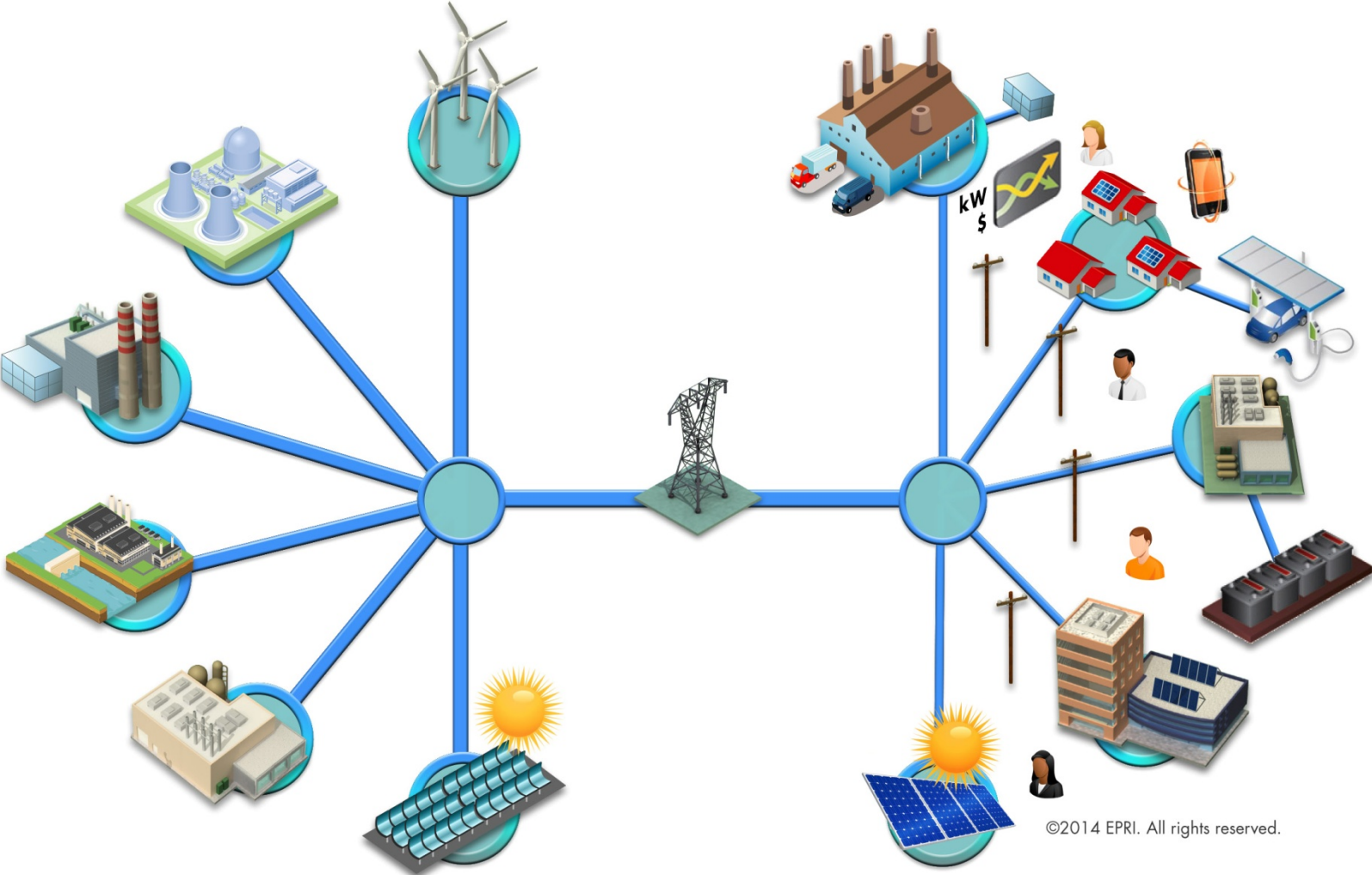
Innovative solutions that enable the transformation to more **flexible, resilient** and **connected** power systems



Power System Transformation

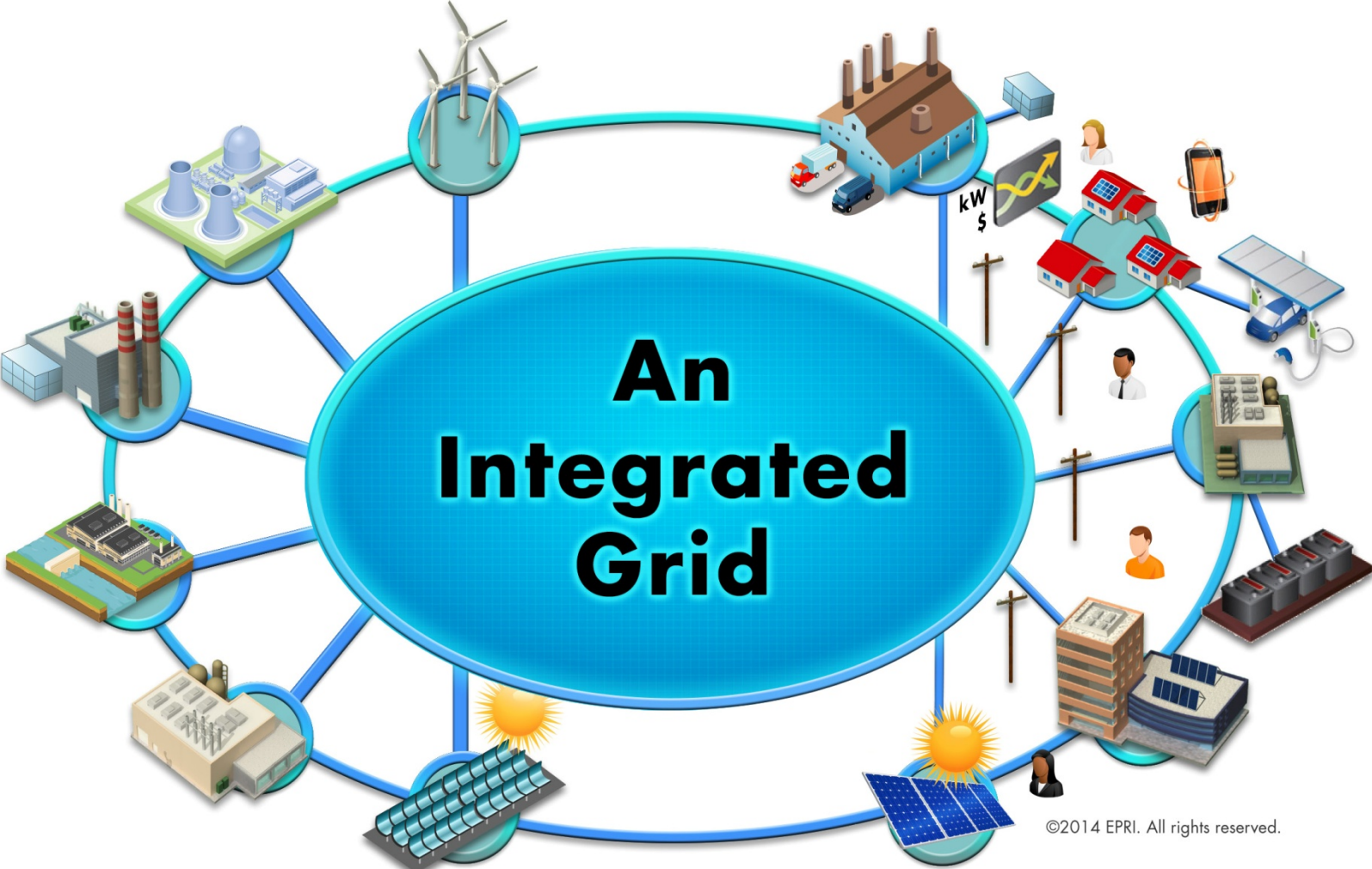


Power System Transformation



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Power System Transformation



Power System Transformation

CHALLENGES

FLEXIBILITY CHALLENGES

- Variable generation
- Fuel price uncertainty
- Customer adoption of efficiency, variable generation, PHEV, demand response

CONNECTIVITY CHALLENGES

- Large volume of data
- Need for enhanced cyber security
- Inconsistent lifecycle timescales
- Rapid pace of technology evolution
- Need for effective integration

RESILIENCY CHALLENGES

- Severe weather
- Physical attacks
- Cyber attack
- Natural gas dependence
- Other high-impact, low-frequency events

BENEFITS

ENHANCED FLEXIBILITY

- Enhanced reliability
- Minimized equipment damage
- Longer equipment life
- Reduced environment impact
- More cost-effective system

ENHANCED CONNECTIVITY

- Customer empowerment
- Enhanced power system operation, maintenance, control, security
- Improved utility worker productivity
- Enhanced distributed resource integration
- Faster recovery

ENHANCED RESILIENCY

- Minimized power system damage
- Faster system recovery
- Survivability
- Minimized financial impact
- Minimized societal impact
- Enhanced customer trust

Flexibility Requirements of the Fossil Fleet

- What are the operational requirements and engineering challenges facing the fossil generation fleet in response to the need for greater flexibility in power plant operations?
- Will the transitioning generation fleet evolve such that fleet operational flexibility capabilities will be adequate to support increasing variability in generation and demand?

Increased flexibility of the conventional generation fleet is one of many solutions that EPRI is researching for enhanced flexibility in the transformed power system.

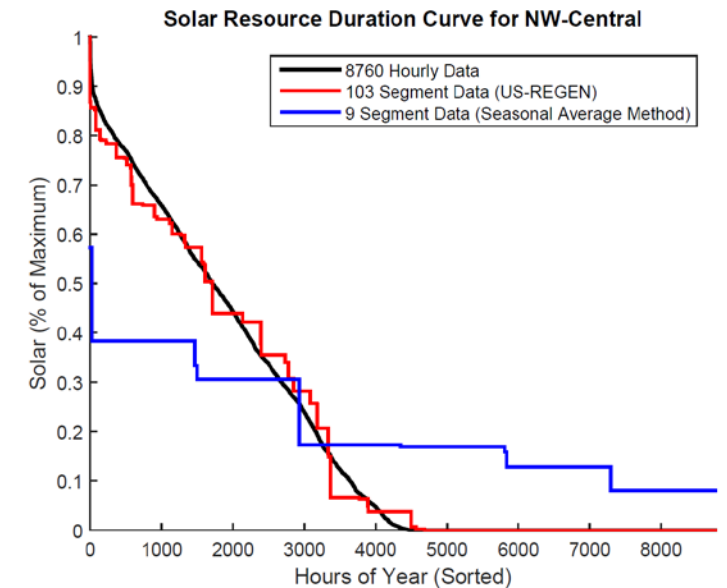
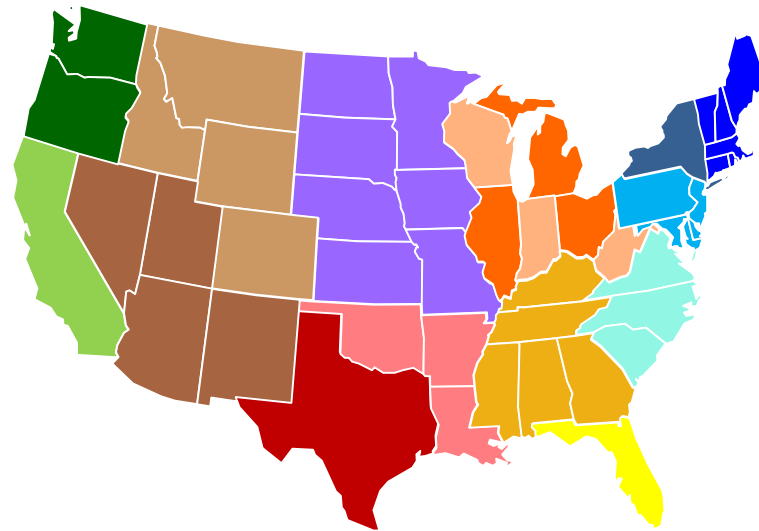
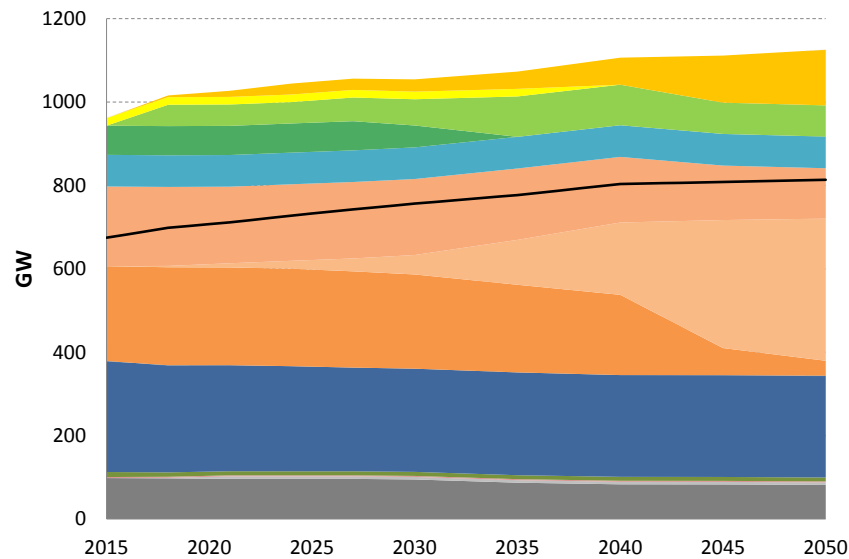


US-REGEN: EPRI's In-House Electric Sector Model

Capacity Expansion Economic Model, Long Horizon to 2050

State Level Resolution for Policy and Regulation Analysis

Innovative Algorithm to Capture Wind, Solar, & Load Correlations in a Long-Horizon Model



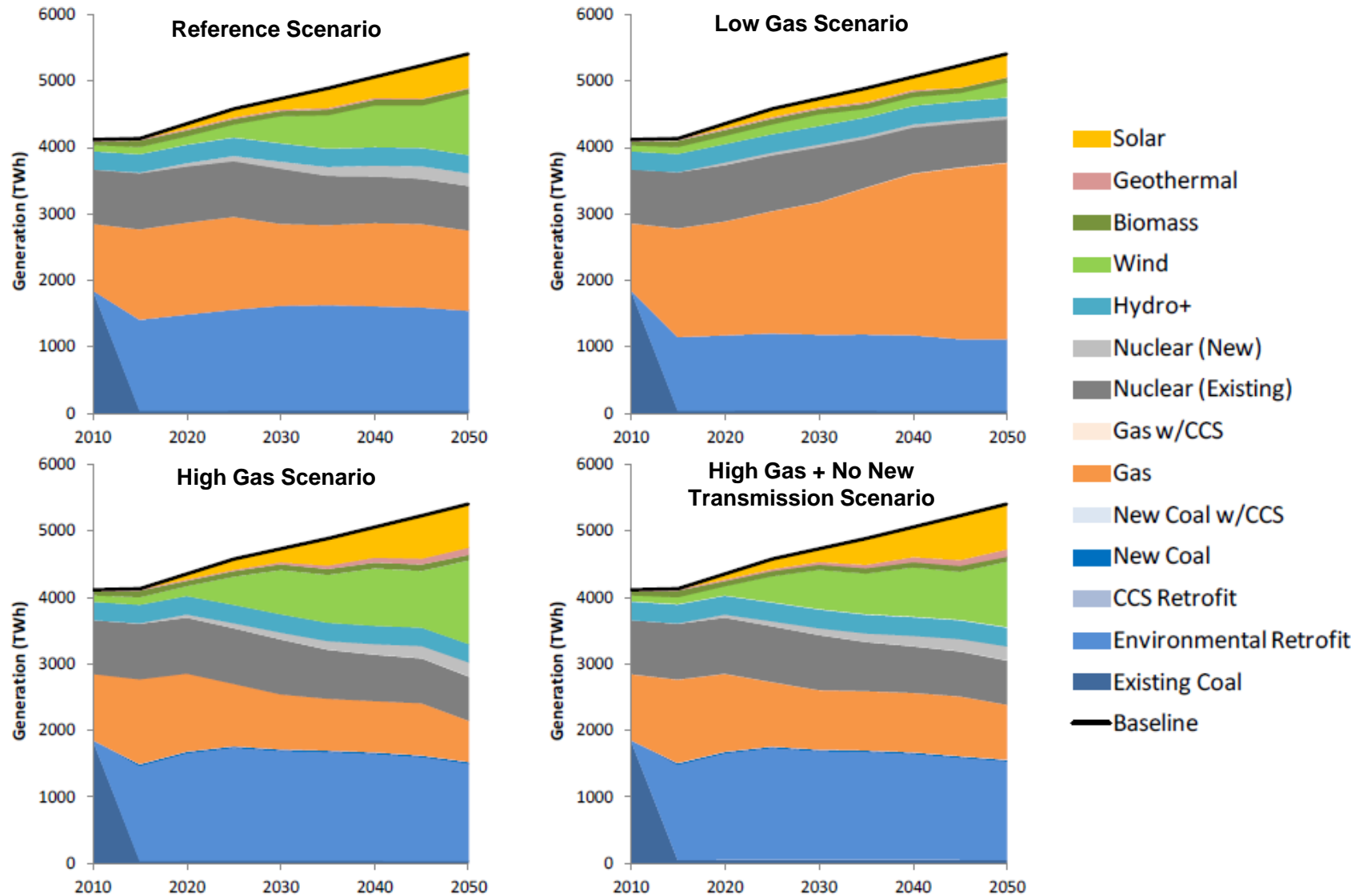
US-REGEN Reference Case

- Baseline reference: EIA Annual Energy Outlook (AEO) 2014
 - Projected level of energy demand
 - Reference energy prices
- Electric sector policies
 - Renewables
 - Existing state RPS requirements
 - Production and investment tax credits not included
 - Environmental
 - Environmental controls required on existing coal units (MATS, cooling water, coal ash)
 - Clean Air Act: New Source Performance Standards included; Clean Power Plan not included

U.S. Electricity Generation Mix 2010-2050

U.S. generation mix varies depending on scenario assumptions about natural gas price and transmission expansion capability

Generation by non-hydro renewables in 2050 ranges from 11% in the low gas scenario to 41% in the high gas scenario

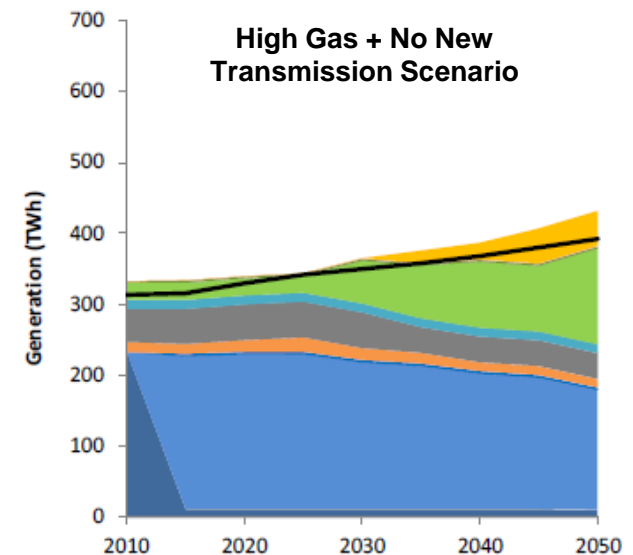
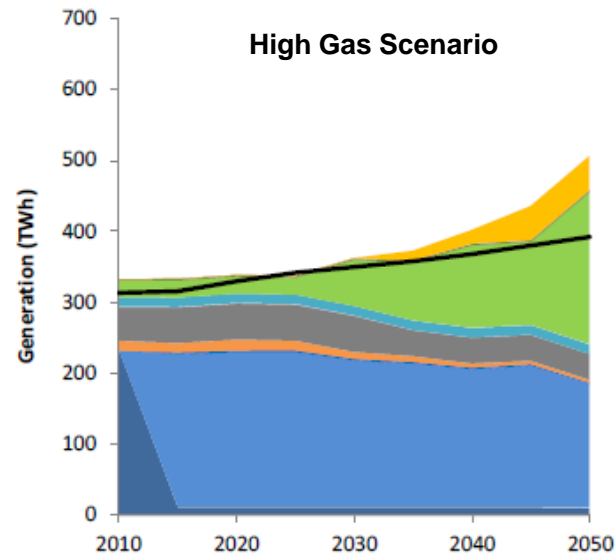
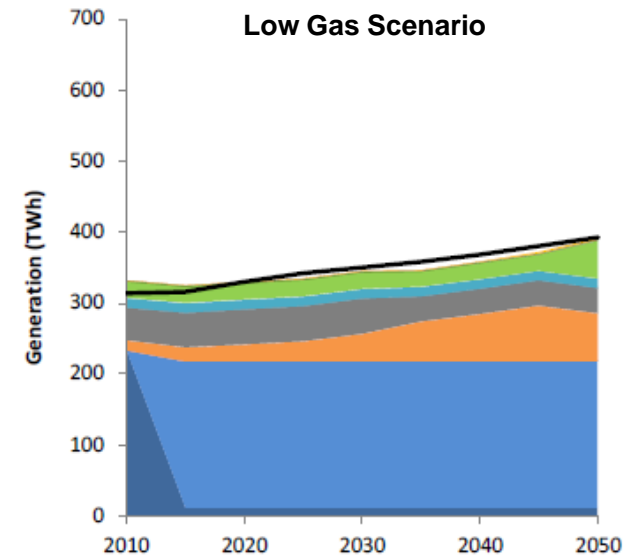
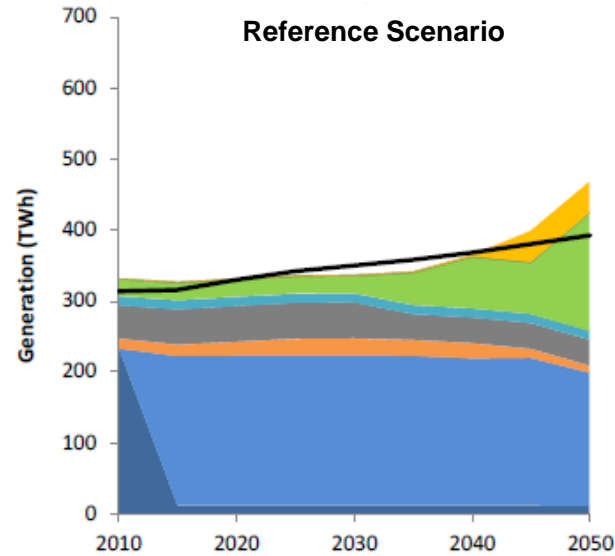


Generation Mix: NW-Central Region 2010-2050

NW-Central region has large wind resources and expected wind capacity deployment

Low gas price scenario erodes wind's generation share more than coal generation

In 2050, grid mixes illustrate systems with large percentage of renewables and/or exports



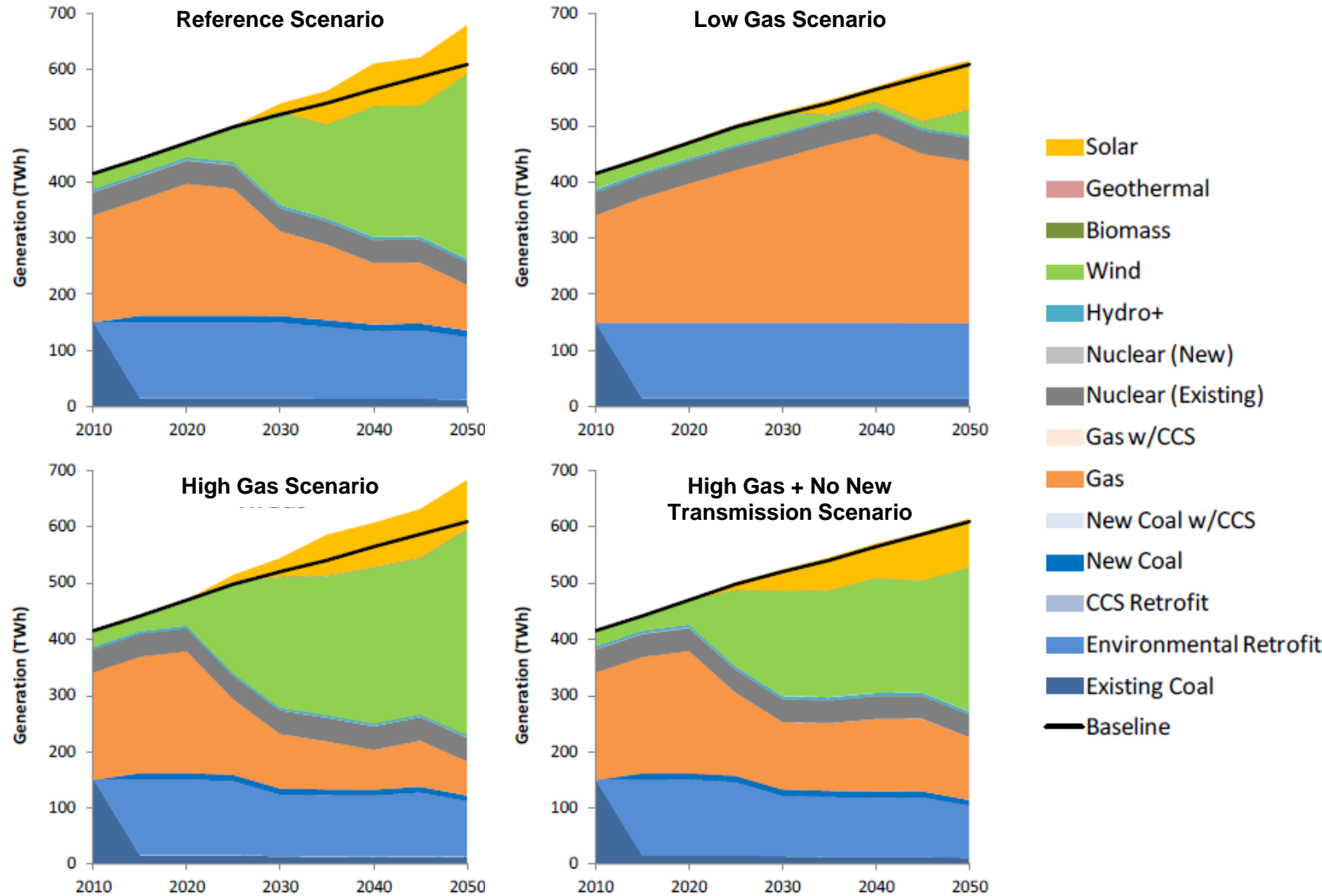
- Solar
- Geothermal
- Biomass
- Wind
- Hydro+
- Nuclear (New)
- Nuclear (Existing)
- Gas w/CCS
- Gas
- New Coal w/CCS
- New Coal
- CCS Retrofit
- Environmental Retrofit
- Existing Coal
- Baseline

Generation Mix: Texas Region 2010-2050

Texas region has considerable renewable generation in the reference case with both wind and solar deployment

Non-renewable generation fleet is dominated by natural gas and nuclear

Given the region's relative isolation at present, the alternate transmission scenarios provide insights as to the role and importance of transmission

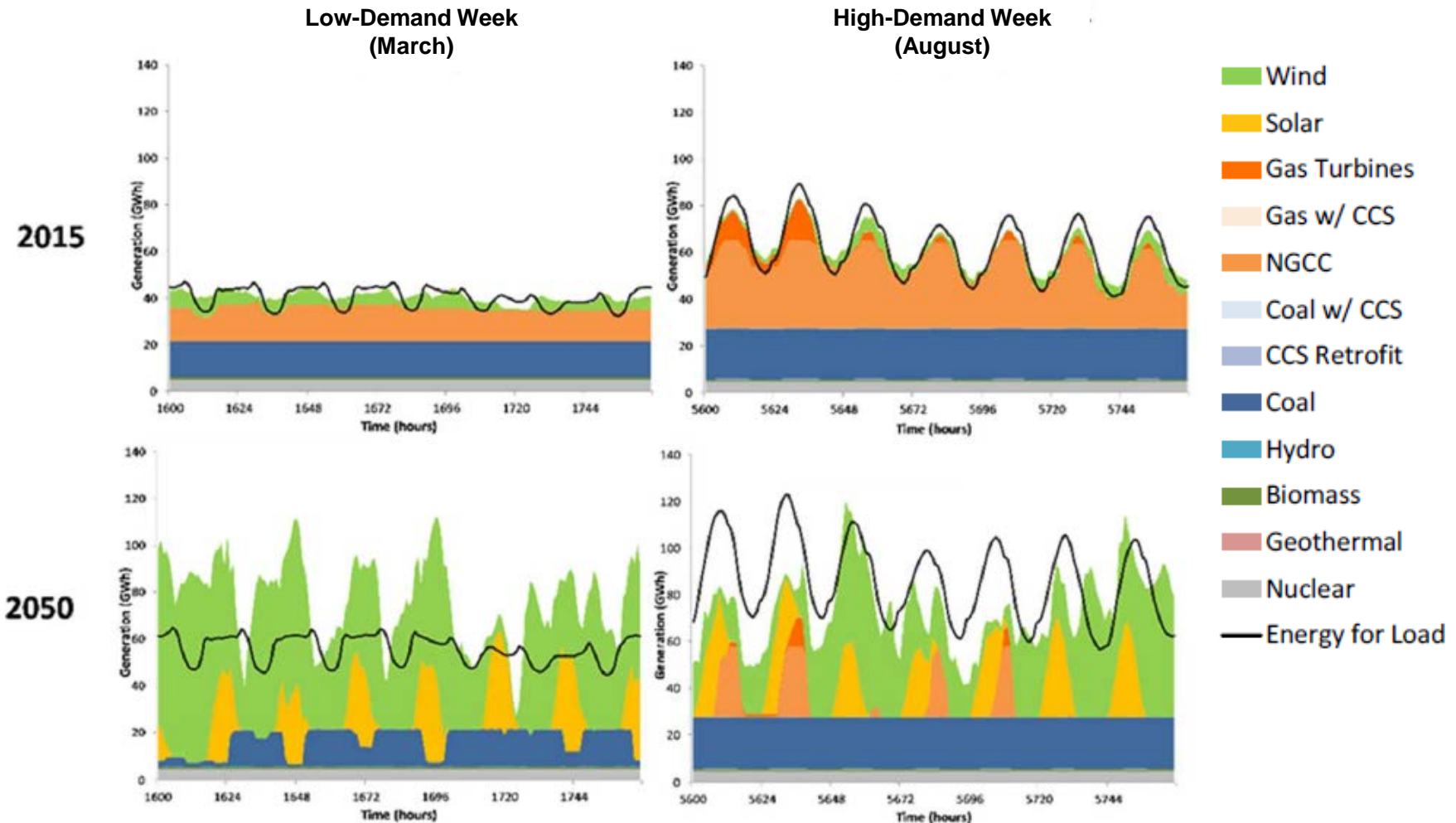


Month Comparison: Texas Region

March (low-demand month) and August (high-demand month)

Increased levels of renewable generation in future years lead to need for flexibility in coal and natural gas combined cycle operations

Demand for inter-regional transfers could increase as a result of over- or under-generation in the region



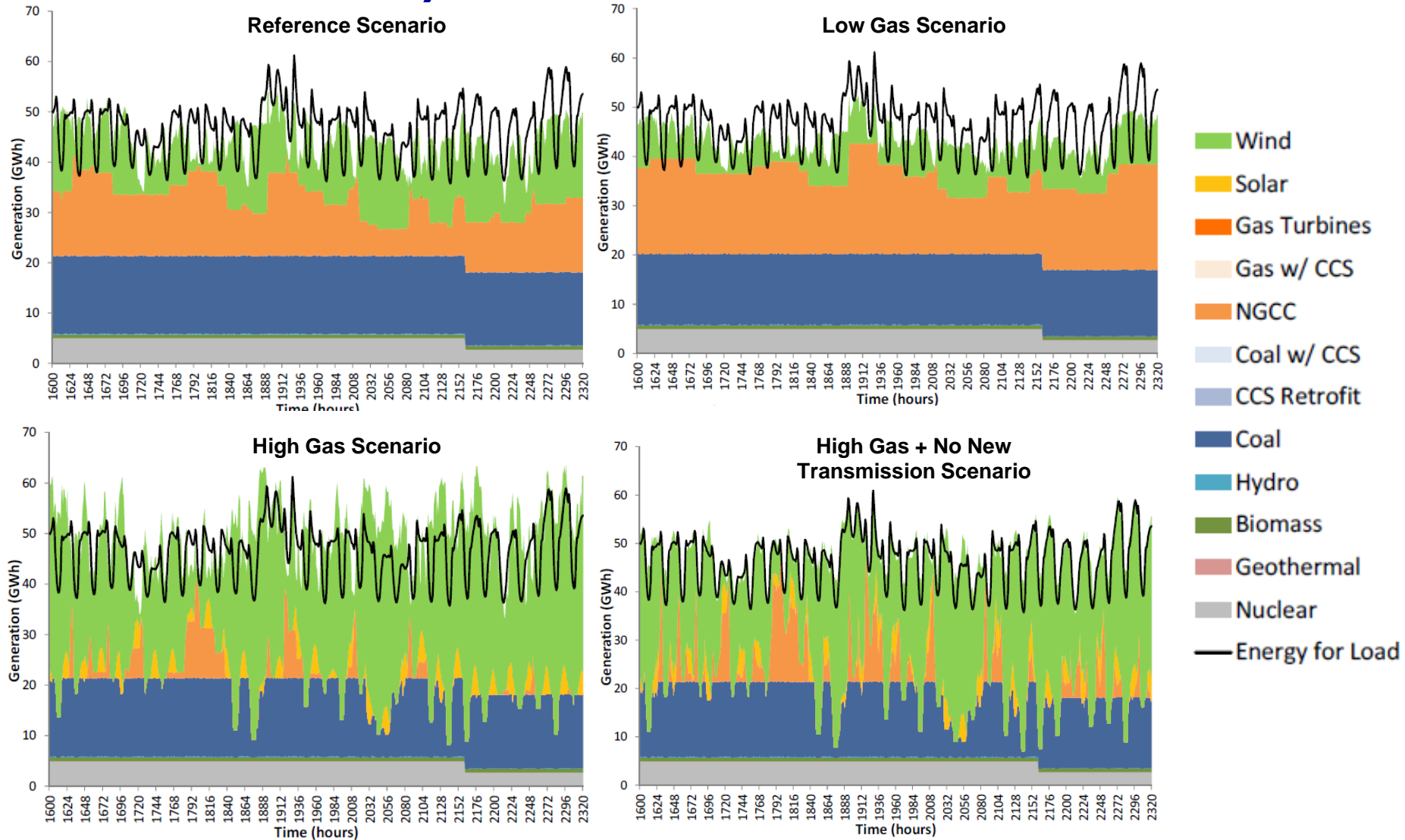
Scenario Comparison: Texas Region

March 2025 (low-demand month)

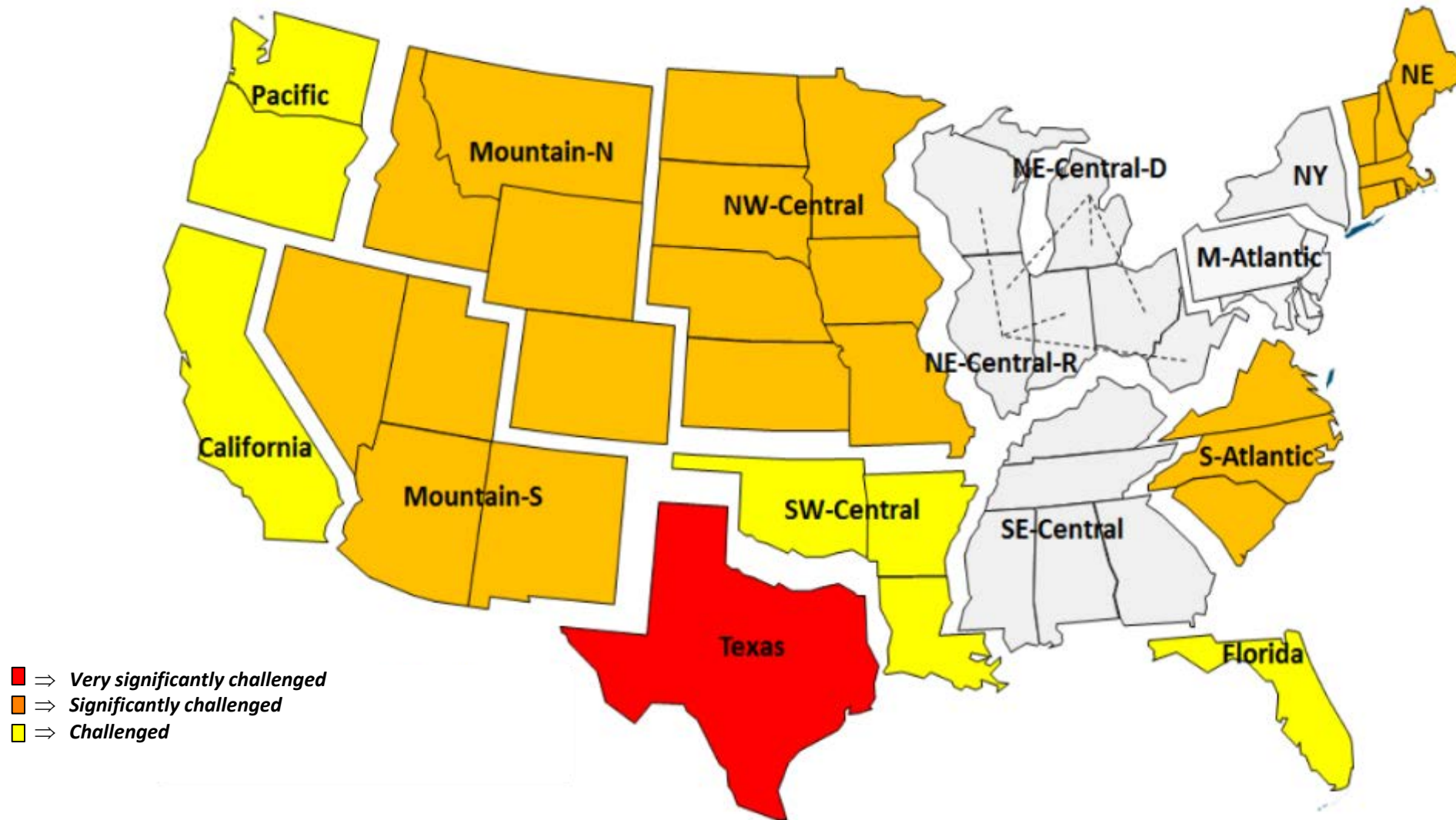
Gas generally absorbs majority of flexibility in support of renewables

High gas prices and no transmission expansion assumptions affect coal operations

Constraints on inter-regional transfer will affect flexibility demand from regional generation

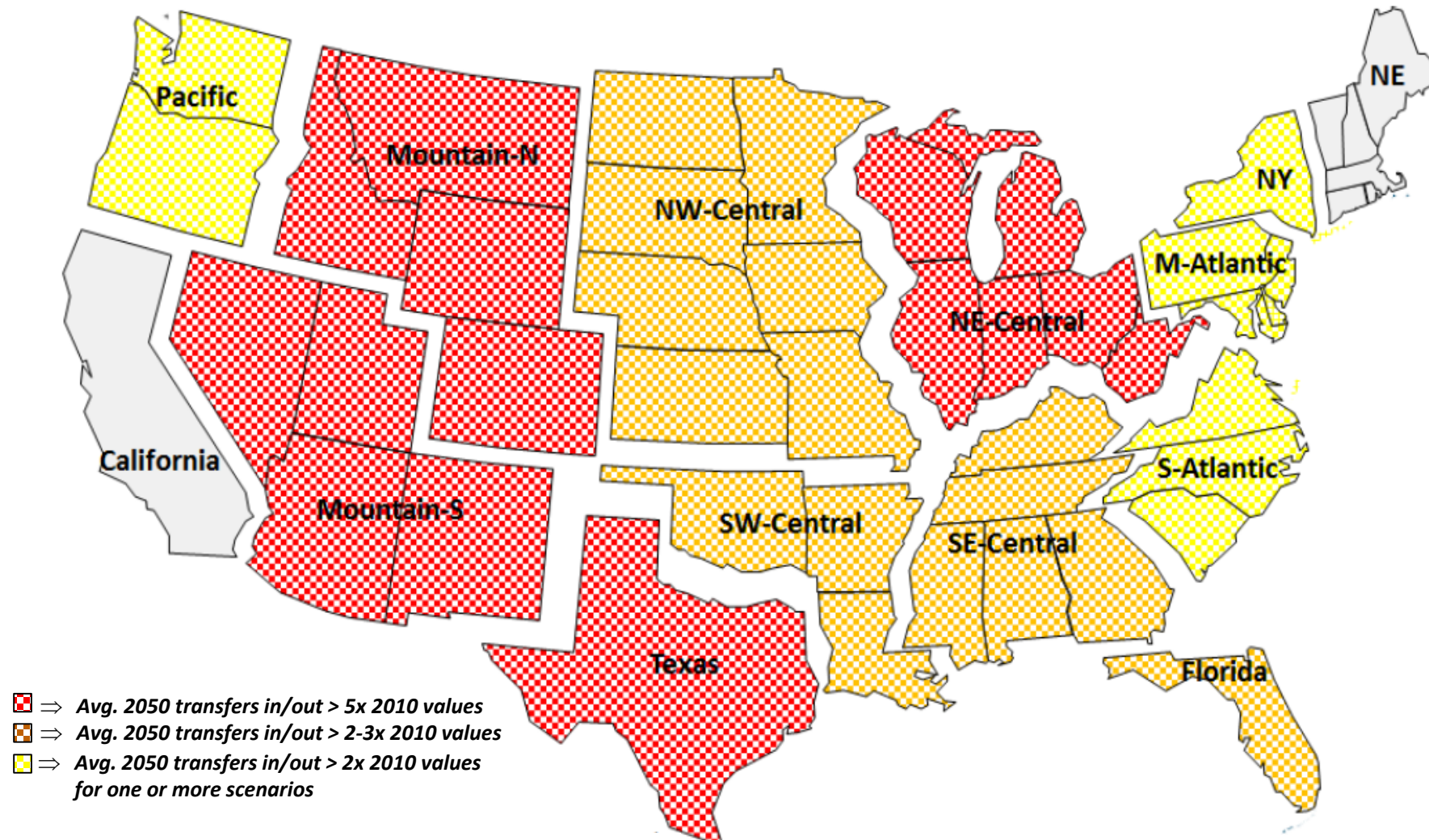


Trends in Increased Levels of Flexible Operations 2050 - *Significantly Increased Flexible Operations*



Trends in Inter-Regional Energy Import/Export

2050 - Reliance on Import/Export Increases Significantly



Technical and Operational Challenges Associated with Increased Fossil Asset Flexible Operations

- High levels of operational flexibility is uncertain without:
 - additional technical capabilities enabling increased flexible operations,
 - expanded inter-regional transmission capacity, and
 - economic drivers causing asset owners to invest in creating increased unit flexibility
- Late-life capital investments in coal assets will likely be necessary to maintain availability and efficiency under increased flexible operations
- Availability of units to operate at low capacity factors or between periods of prolonged layup may be limited if asset owners opt to retire rather than operate
- Actual combustion turbine combined cycle (CTCC) unit lifetimes are uncertain given limited current experience with heat recovery steam generators (HRSGs) and the impact of sustained operations at higher capacity factors
- Water availability and gas pipeline access may prove to be additional externalities that limit new asset deployment and/or reduce operational flexibility

Ongoing EPRI Research on Flexibility Solutions

- **Viable Cycling of Conventional Generation** – coal, natural gas, nuclear, hydro
- **Polygeneration** – cycle between output products
- **Renewables as a Solution** – concentrating solar with thermal storage, wind for active power control, geothermal for load following
- **Electricity Energy Storage** – buffer for bulk energy, ancillary services, T&D infrastructure, customer energy management
- **Clean Flexibility** – fast ramping natural gas turbines, distributed energy resources (DER) for emissions reduction by switching fuels, wind/solar forecasting
- **Transmission** – power electronics devices, high voltage DC, dynamic ratings
- **Distribution** – enhanced reconfigurability via distribution management system, smart inverters
- **Power System Balancing and Operation** – situational awareness, operating practices, new power market products, inter-area coordination
- **Power System Planning** – renewable integration planning, flexibility metrics, advanced assessment tools and models
- **Customer Behavior and Adoption** – energy efficiency, fast-reacting loads, distributed storage, dispatchable DER, communications for connectivity

EPRI References

- *Program on Technology Innovation: Fossil Fleet Transition with Fuel Changes and Large Scale Variable Renewable Integration.* ([3002006517](#))
- *The Integrated Grid: Realizing the Full Value of Central and Distributed Energy Resources.* ([3002002733](#))
- *Power System Transformation: Flexibility, Connectivity, Resiliency.* ([3002007377](#))
- *Electric Power System Flexibility: Challenges and Opportunities.* ([3002007374](#))
- *Electric Power System Connectivity: Challenges and Opportunities.* ([3002007375](#))
- *Electric Power System Resiliency: Challenges and Opportunities.* ([3002007376](#))
- *Contributions of Supply and Demand Resources to Required Power System Reliability Services.* ([3002006400](#))



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