Response to Grid Variability, or Flexible Operations for NPPs

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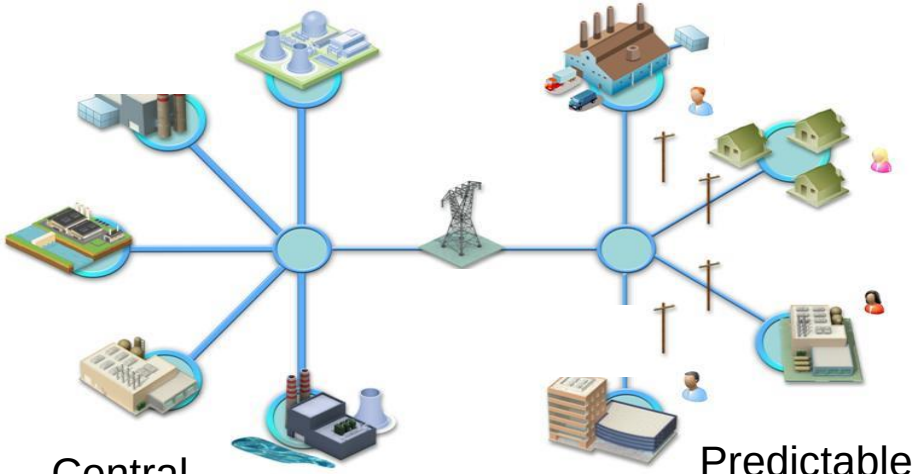
The Power Grid is Changing!

Traditional Grid:



Central Generation

Predictable Load

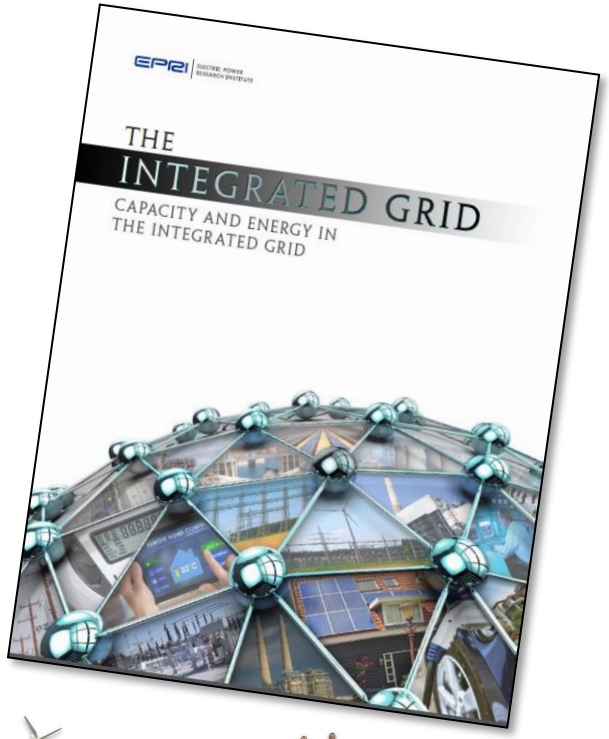
Looking Forward:

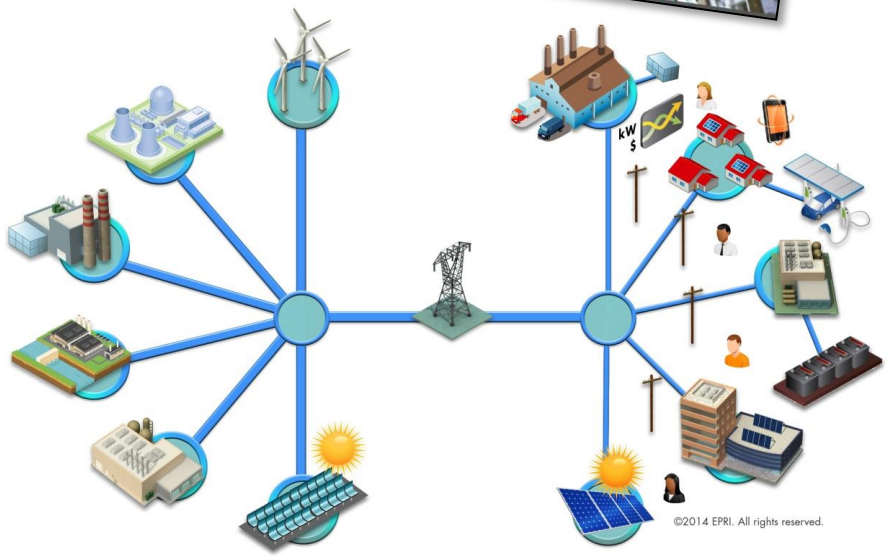
Renewables – wind & solar farms

Distributed generation – roof top solar

Changing consumer – electric cars

A More Dynamic End-to-End Power System





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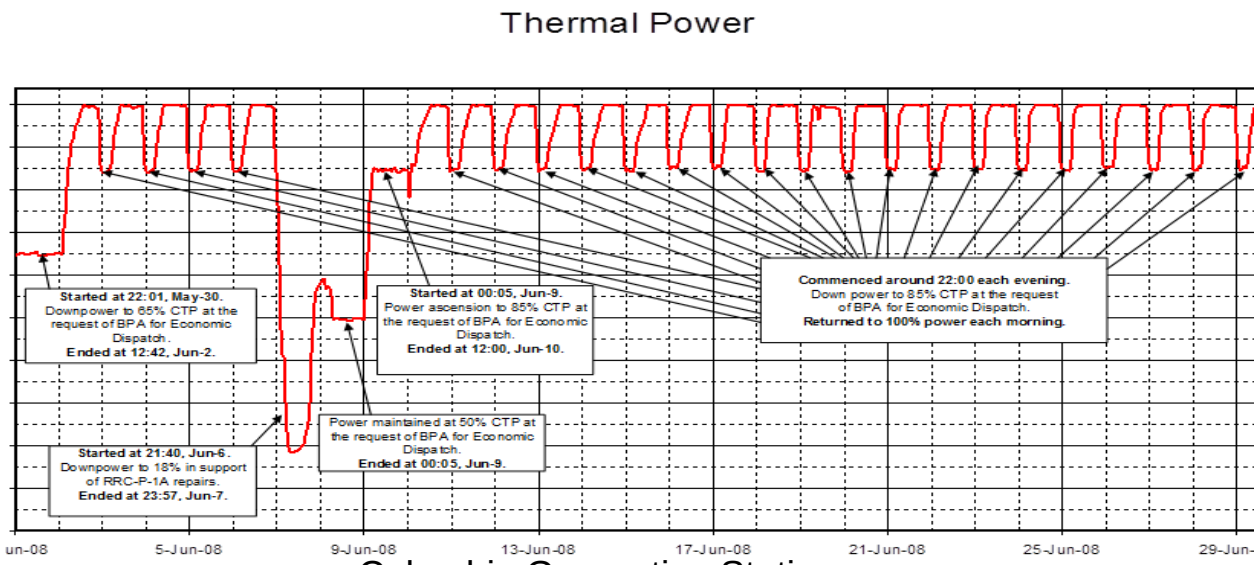
EPRI NPP Flexible Operations Program

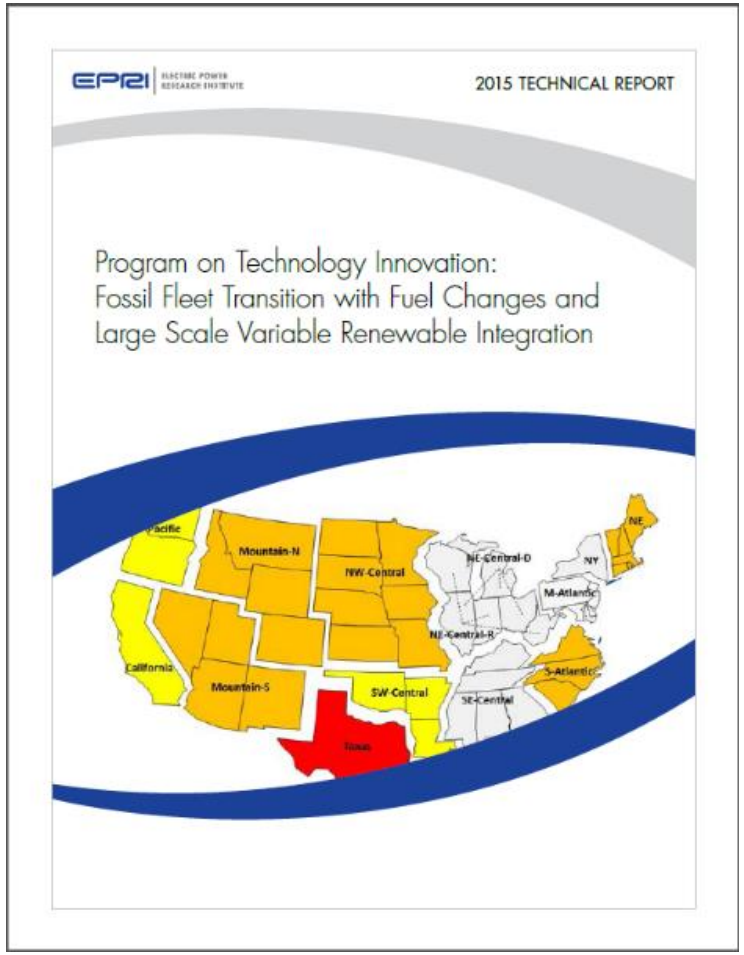
Purpose:

- Proactively identify, research and define management strategies to mitigate potential impacts of plant flexible operations
- Actively engage all key stakeholders
- Share Operating Experience

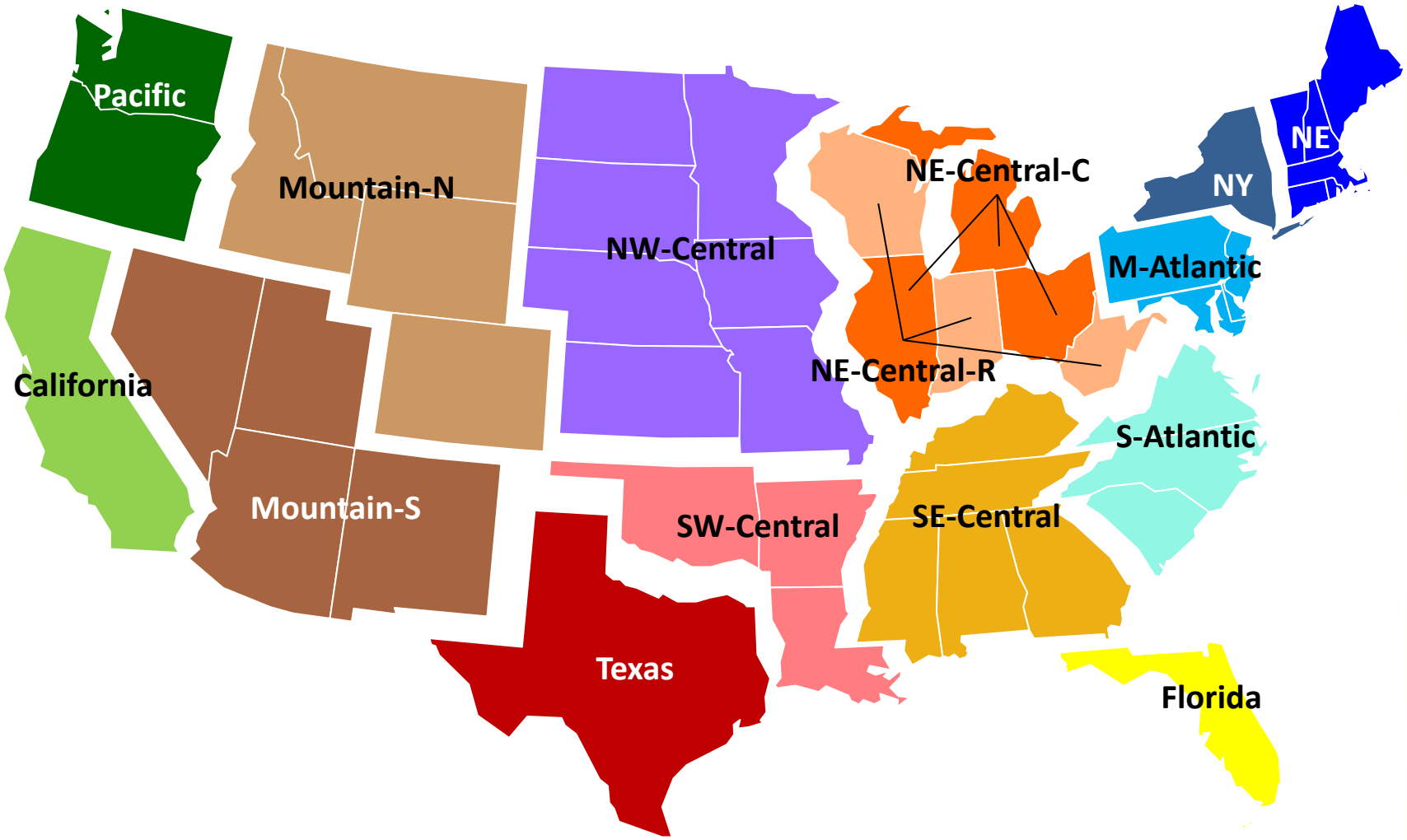


Columbia Generating Station

Economic Dispatch June 2008



Assessment Tools – Modeling Approach



Projection of Generation Fleet Capacity and Generation Mix to 2050 for 4 Scenarios:

- Reference
- Low future natural gas price trajectory
- High future natural gas price trajectory
- High future NG price trajectory without new transmission expansion

(Dynamic US-REGEN)

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Analysis of Hourly Dispatch by Region for 2025, 2050
(Unit Commitment US-REGEN, by scenario)

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Derivation of Flexibility Metrics from Hourly Dispatch Data
(by scenario, generation asset type, region for 2025, 2050)

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Identification of Regions, Weeks with Demanding Levels of Flexible Operations
(by scenario, generation asset type, region for 2025, 2050)

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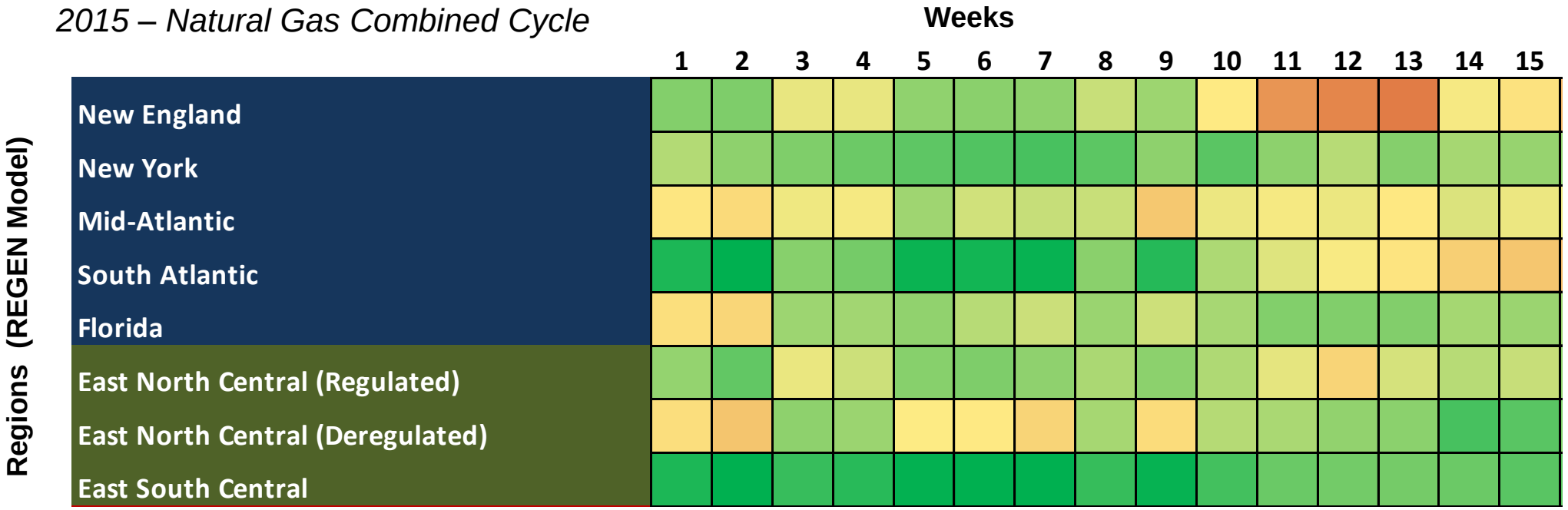
Identification of Technical Implications of Results
(Engineering Subject Matter Experts)

Metrics and Visual for “Flexibility Demand”

2015 – Natural Gas Combined Cycle



Reference: 3002006517 *Program on Technology: Fossil Fleet Transition with Fuel Changes and Large Scale Variable Renewable Integration*

Each cell is color coded based on the average hourly change in generation relative to the maximum in that region at that time.

Yellow to red => greater average hourly change.

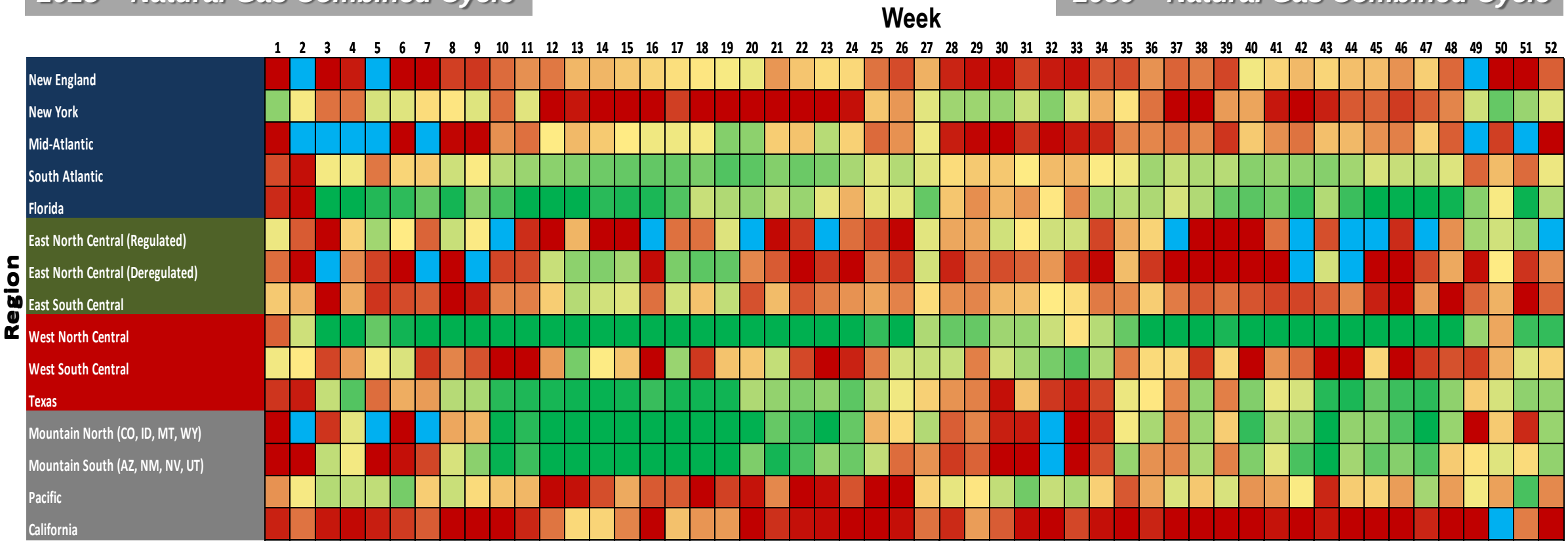
Regions/weeks where average hourly generation is particularly significant highlighted in blue.

Metrics were generated for each generation technology in each region, scenario, timeframe.

Grid Variability: The Trend Is *Increasing…*

2025 – Natural Gas Combined Cycle

2050 – Natural Gas Combined Cycle



Why

- Early retirement of fossil plants
- In 2025 to 2030 renewable portfolio standards met
- Modest growth in demand
- Continued lowering cost of renewables as technology improves

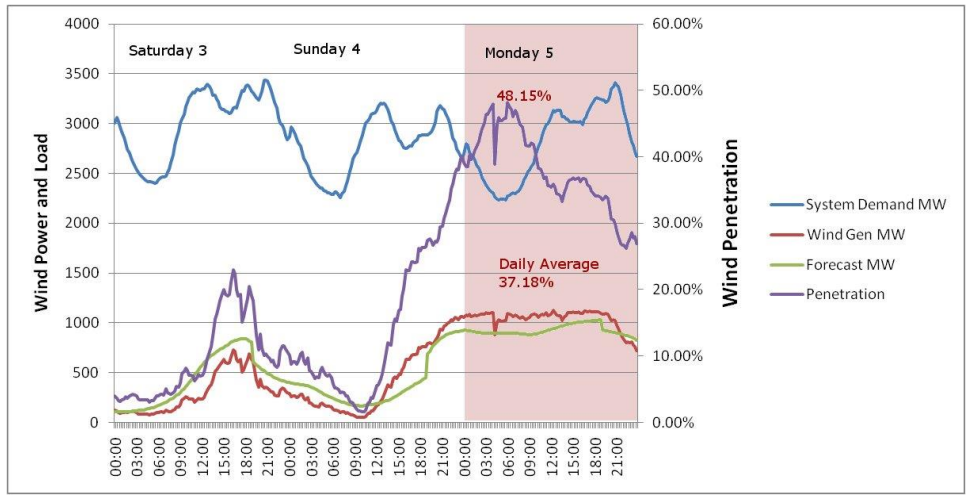
Completed Activities

- ✓Gap Matrix
- ✓Transition Guidelines published
- ✓Secondary-side vulnerability assessment published
- ✓Supplemental program funded for 2015-2017
- ✓EPRI Project Team formed
- ✓Prioritized list of projects for 2015-2017

What We Learned …. *Flexible Operations is Possible*

"Approach to Transition NPPs to Flexible Plant Operations" (January 2014)

- Need to establish protocol with the ISO/TSO
- Plant modifications maybe needed
- Challenges at end-of-cycle
  - ➢Xe transients
  - ➢Li-control band
- Volume of waste water generated
- Protection of secondary components
- Accident and transient analysis
- Changes are needed to operating procedures, and maintenance programs
- Training needs to be a part of the plan



Flexible Operations is possible … but what are the impacts?

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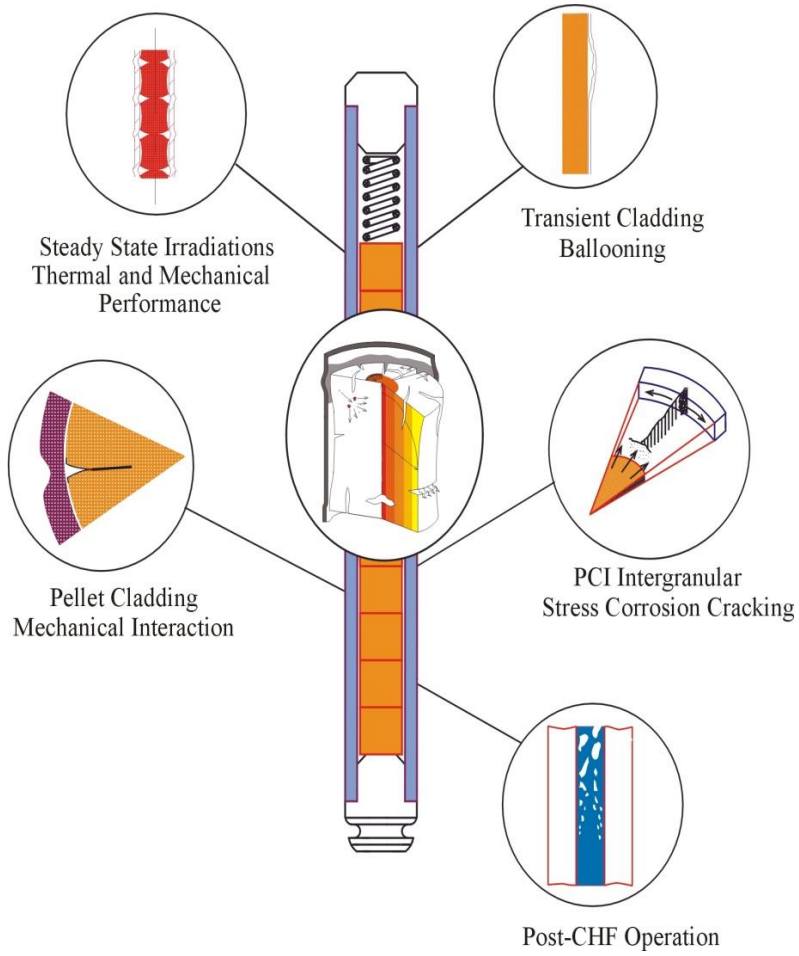
Research Priorities For 2015 – 2017

- Fuel integrity guidance
- Chemistry, Low Level Waste and Radiation Management
- Impacts on balance of plant and recommendations for preventative strategies
- Fatigue and impacts assessment on primary side
- Support for ‘site readiness reviews’
- Bounding cases for NPP Flexible Operations Studies:

High renewable integration
Be available on a routine basis for a pre-planned 100-80-100 power cycle

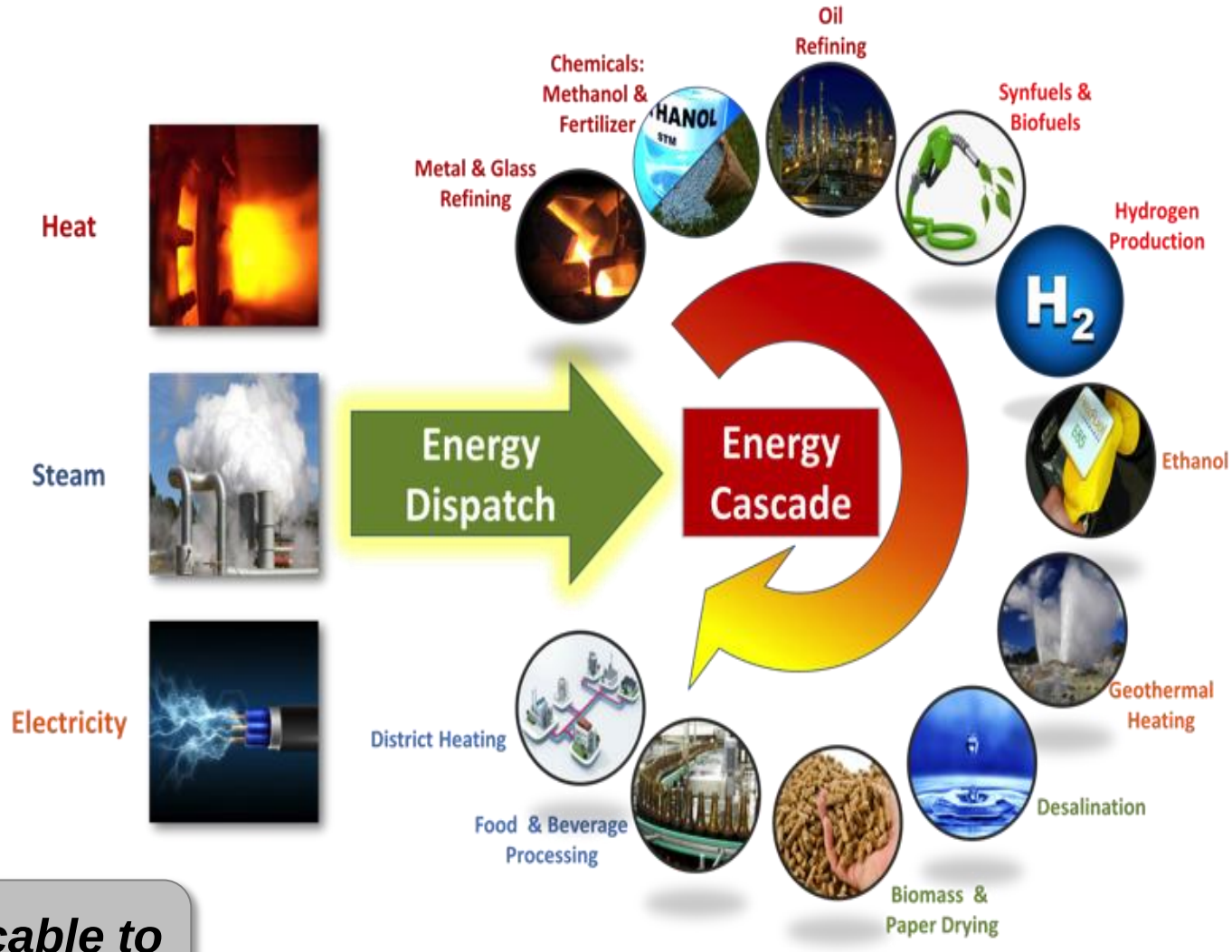
Extended low power operations
Pre-planned extended operations at ~50% power with scheduled maintenance activities

Response to grid transients
Up to 5%/minute power change 100-30-100 due to grid conditions



Future Work Scope

- Feasibility study for a hybrid integrated energy system with an existing NPP
- Collaboration with Idaho National Labs (DOE funded) and NREL (National Renewable Energy Lab)
- Use electrical power during periods to low demand for desalination or hydrogen generation



Flexible operations research is applicable to existing and new plants

Together…Shaping the Future of Electricity