

# Otimizando redes elétricas através de **tecnologias habilitadas digitalmente**

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# Connected Intelligence, from Edge to Cloud

## EDGE



### Growing observability:

- 300,000+ GE critical infrastructure assets connected to remote M&D
- 10,000+ PMUs deployed globally

### Computing power accelerating:

- Wind turbine control >15X in '07-'17
- Substation controller 30X in '07-'17

## UTILITY OPERATIONS



### Growing number of controlled assets:

- Up to 3X assets in control by EMS, '07-'17
- 20+% CAGR in DERMS/Microgrids market
- MMS – Retail electricity markets coming

### Computing power accelerating:

- 3X EMS computation burden '07-'17
- 2X Phasor Data Concentrators '07-'17

## CLOUD



### Asset RM&D becoming mainstream

- 10X data volume (MB/day), '07-'17

### Ideal for heavy computation

- Dynamic contingency analysis
- Fleet-based analytics
- Asset Digital Twins

### Emerging platform for future SCADA

**Powerful outcomes** possible by leveraging intelligence across levels



# Digitally-Enabled Outcomes

BETTER GRID UTILIZATION



MORE RENEWABLE ENERGY



BETTER RELIABILITY

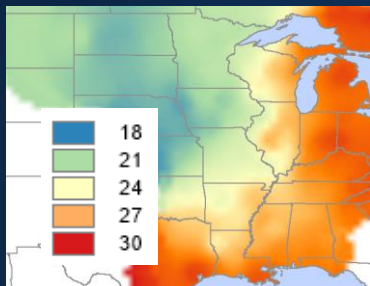




# Outcome: Better Grid Utilization via Dynamic Tools

## REAL VALUE TRAPPED

### CONGESTION



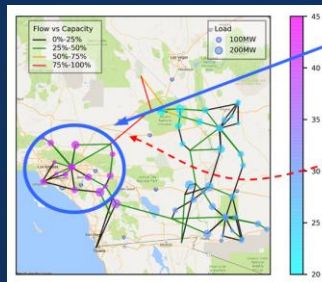
**NYISO**  
\$1.2B '13-'16

**PJM**  
\$1.4B in '15

**MISO**  
\$5.3B '13-15

## THE OPPORTUNITY

### EXAMPLE: PRICE VARIATION (CONGESTION)



Region with high  
LMP when a major  
corridor **hits limits**

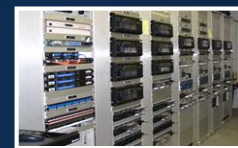
## DIGITAL & NON-WIRES TOOLBOX

### REDUCE UNCERTAINTY (SENSORS, DIGITAL TWIN)



- PMU - real-time limits
- °F & Dig Twin - dyn rating

### REDUCE CONSERVATISM (REMEDIAL ACTION SCHEMES)



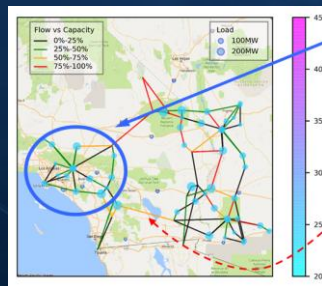
- Reclaim capacity from N-1 path de-ratings

## RENEWABLES CURTAILMENT



**15.5% renewables curtailment in WECC at 50% renewables penetration without transmission reinforcement\***

## MITIGATION: POWER RE-ROUTING W/ FACTS (Instead of building new lines)



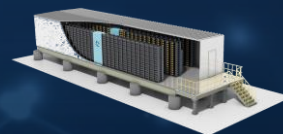
LMP evens out -  
**FACTS enabled transmission rerouting**

## RESHAPE LIMITS (FACTS)



- Move stability limits
- Adjust impedance topology

## RESHAPE LOAD (STORAGE, DSM)



- Peak load reduction
- Curtailment relief

IMAGINE **30+% HIGHER UTILIZATION** OF CONSTRAINED ASSETS

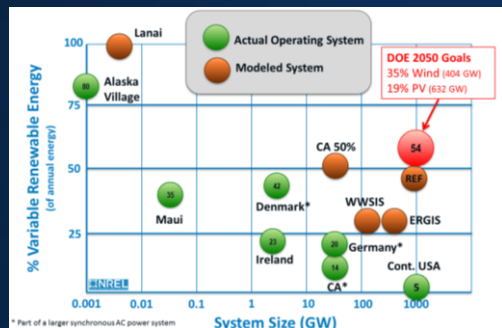
\* NREL - <http://www.nrel.gov/docs/fy17osti/67240.pdf>



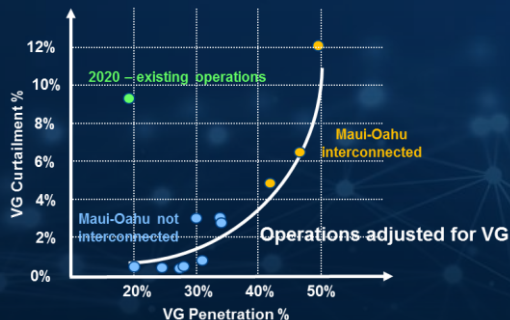
# Outcome: More As-Available Renewable Energy

## HIGH AMBITIONS ARE REALISTIC

### HIGH RENEWABLES CONTENT GLOBALLY†



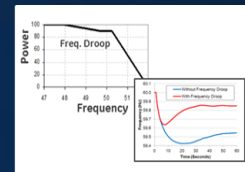
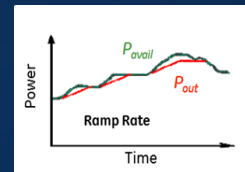
### ECONOMIC FEASIBILITY – MAUI/OAHU\*



## DIGITAL SOLUTIONS FOR ACHIEVING HIGH PENETRATION

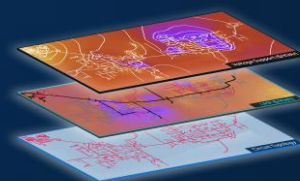
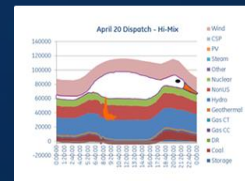
### EDGE: GRID-FRIENDLY RENEWABLES

- Fault ride-through
- Volt/VAR regulation
- Ramp-rate controls
- Curtailment
- Inertial response



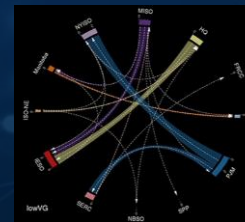
### UTILITY OPERATIONS: OPTIMIZE SYSTEM

- Production forecasting in dispatch
- Intelligent unit commitment
- Broader balancing areas
- Fast-start gen & bridging storage
- Supportive PV & loads – retail markets
- Microgrids & aggregation
- Distribution Volt/VAr control

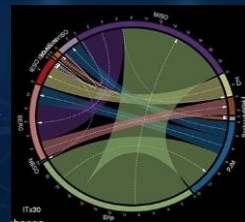


### HIGH PERFORMANCE COMPUTING & CLOUD

- Faster and broader inter-area balancing
- Dynamic contingency analysis
- Resource forecasting



Eastern Interconnection – 2010\*\*



30% Var Gen scenario - 2026\*\*

IMAGINE **50+% PENETRATION** OF AS-AVAILABLE RENEWABLES

† NREL – Courtesy of Ben Kroposki, Power Systems Engineering Research overview

\* Derived from HNEI – Hawaii Renewable Portfolio Standards Study

\*\* Taken from NREL – Eastern Renewable Generation Integration Study



# Outcome: Better Reliability

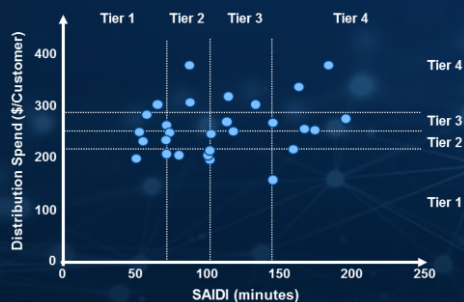
## A GROWING PROBLEM

US OUTAGES UP >50% SINCE 2008\*



- ~\$150B annual losses in the US alone
- 25% from equip faults & human error\*
- Mean outage duration 48 min\*

## REPUTATION A STRONG INFLUENCE †



## DIGITAL SOLUTIONS FOR ENHANCING RELIABILITY

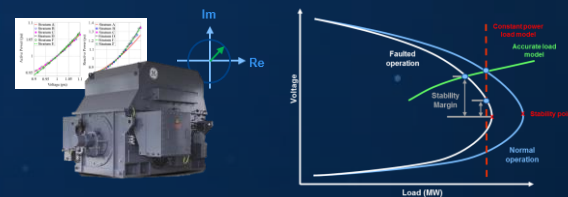
### SEE EQUIPMENT FAULTS BEFORE THEY HAPPEN

- Instrument and monitor critical assets
- Asset Digital Twin – predictive analytics:
  - Failure precursors
  - Remaining useful life (RUL)
  - Life extending operation



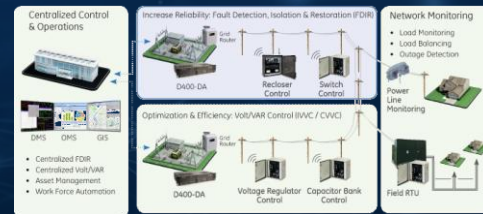
### UNDERSTAND TRUE SYSTEM MARGIN

- Load impedance modeling and characterization\*\*
- Accurate contingency analysis and more aggressive system operation



### RESTORE SERVICE QUICKLY

- Distribution automation in critical substations and feeders
- Fault Detection, Isolation and Restoration



IMAGINE A **50+% REDUCTION** IN OUTAGE HOURS



# Biggest challenges are not technical...





# Digitally-Enabled Outcomes

BETTER GRID UTILIZATION



IMAGINE **30+%**

HIGHER UTILIZATION OF CONSTRAINED ASSETS

MORE RENEWABLE ENERGY



IMAGINE **50+%**

PENETRATION OF VARIABLE RENEWABLES

BETTER RELIABILITY



IMAGINE **50+%**

FEWER OUTAGE HOURS

