GE Energy

Flexible Generation & Renewable Energy

Natural Gas / Renewable Energy Dialogue on Grid Integration Issues

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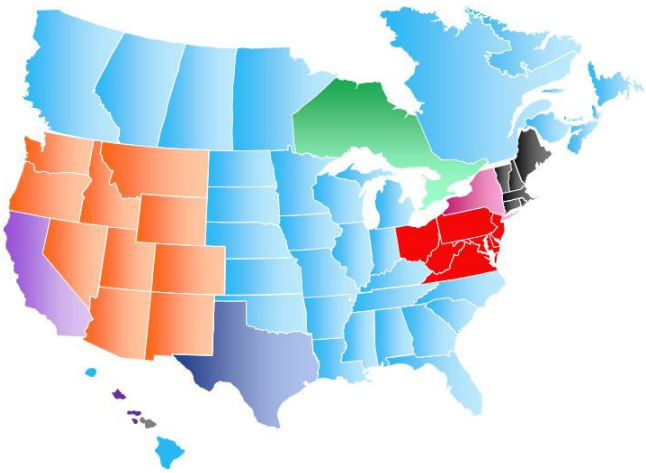
the power of Flexibility

imagination at work

GE's Integration of Renewables Experience

Studies commissioned by utilities, commissions, ISOs…
- **Examine feasibility of 100+ GW of new renewables**
- **Consider operability, costs, emissions, transmission**



- 2008 Maui
  70 MW Wind
  39% Peak Load
  25% Energy
- 2010 Oahu
  500 MW Wind
  100 MW Solar
  55% Peak Load
  25% Energy
- PJM Study (underway)
  96GW Wind
  22GW Solar
  30% Energy
- 2004 New York
  3 GW Wind
  10% Peak Load
  4% Energy
- 2005 Ontario
  15 GW Wind
  50% Peak Load
  30% Energy
- 2006 California
  13 GW Wind
  3 GW Solar
  26% Peak Load
  15% Energy
- 2007 Texas
  15 GW Wind
  25% Peak Load
  17% Energy
- 2009 Western U.S.
  72 GW Wind
  15 GW Solar
  50% Peak Load
  27% Energy
- 2010 New England
  12 GW Wind
  39% Peak Load
  24% Energy

Need for fleet flexibility, new operating strategies and markets, transmission reinforcement, grid friendly renewables

Lessons Learned …

Impediments

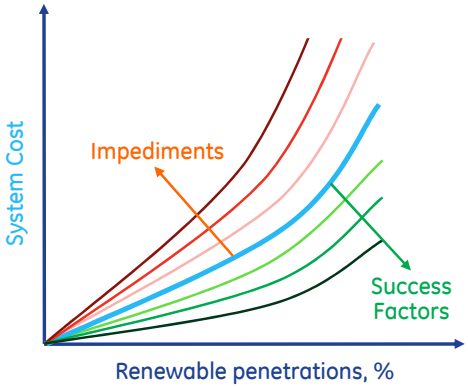
- Lack of transmission
- Lack of control area cooperation
- Inflexibility due to market rules and contracts
- Unobservable DGs – behind the fence
- Inflexible operation strategies during light load & high risk periods

Success factors

- Forecasting
- Thermal fleet flexibility
  - Higher quick starts
  - Deeper turn-down
  - Faster ramps
- More spatial diversity
- Renewable + DG + Demand A/S
- Grid-friendly renewables

System cost

- Unserved Energy
- RPS miss
- Higher Cost of Energy
- Higher Emissions
- Higher O&M



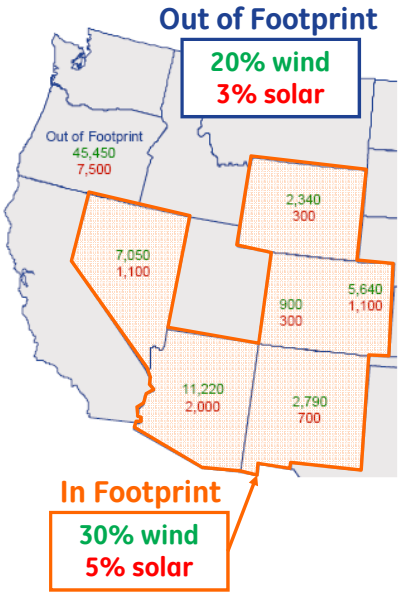
• All grids can accommodate substantial amounts of wind and solar
• There is NEVER a hard "upper limit"
• Policy and power market structures … key to success

Western Wind & Solar Study

Can 35% wind and solar, by energy be integrated into the western United States?

Goal: Assess the operating impacts and economics of wind and solar

- How do local resources compare to remote, higher quality resources delivered by long distance transmission?
- Can balancing area cooperation help manage variability?
- Do we need more reserves?
- Do we need more storage?
- How does geographic diversity help?
- What is the value of forecasting?



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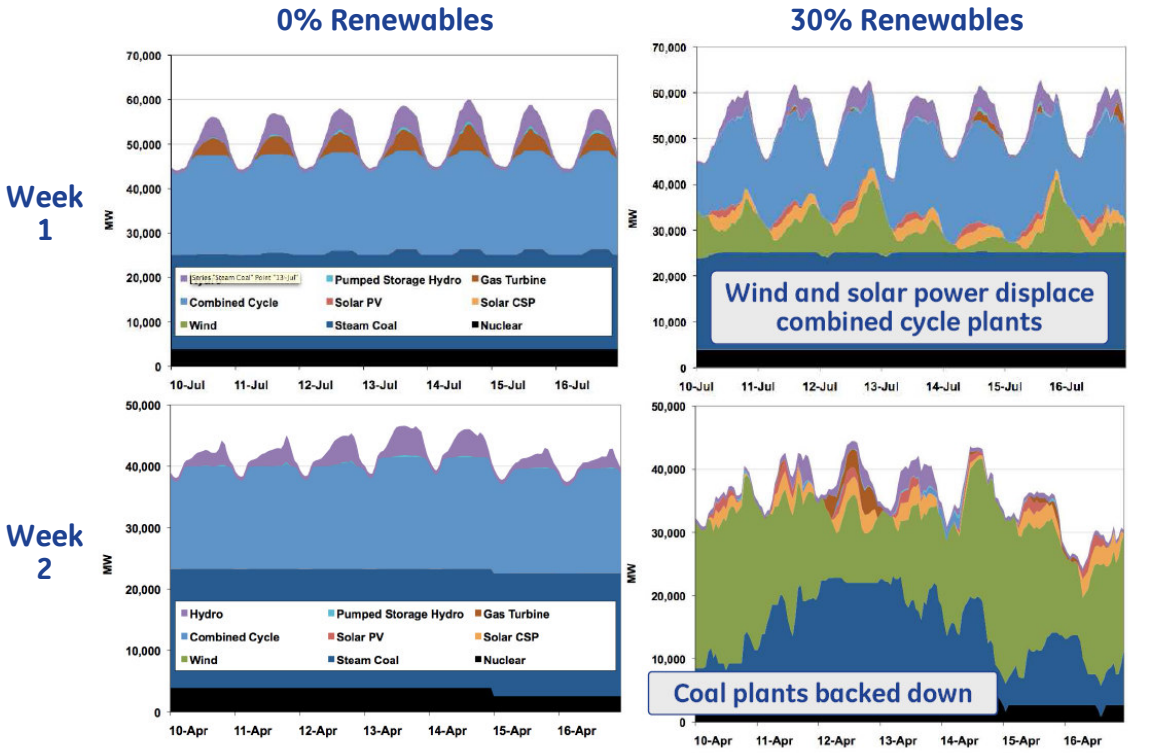
Source: NREL Western Wind & Solar Integration Study

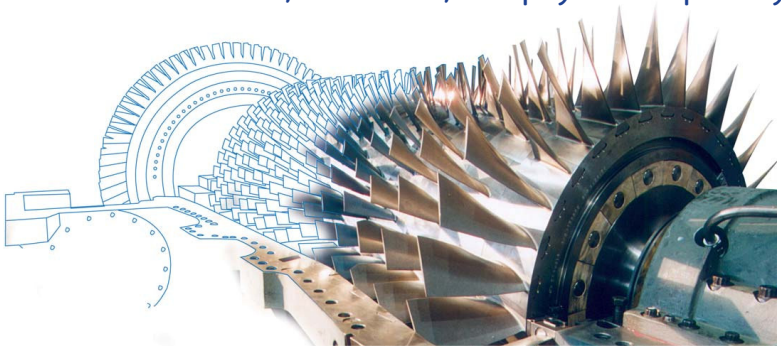
Operation During Two Different Weeks



Source: NREL Western Wind & Solar Integration Study

Impact on the Existing Generation Fleet?

- Lower capacity factors for base and mid-merit generation
- Use of "peakers" at "unusual" times
- Pressure to increase hydro maneuverability
- Increased combined cycle cycling (today and growing rapidly)
- Increased coal cycling (growing rapidly in some places)
  - Increased O&M, higher outage rates, environmental performance impacts
- Credible quantitative data is limited; sensitive
- Claims of costs, loss of life, and physical capability are variable



Severity of impacts and the allocation of costs is a topic of intense debate

Thermal generation … the throttle

Gas turbine and combined cycle plants must have capability to respond to the needs of a highly renewable-penetrated grid

- Faster starting capability
- Higher start reliability
- Faster ramping capability
- Transient emissions compliance
- Lower turndown
- Smaller block size
- Better hot-day performance and grid support

Need to prepare for the future grid:
Today's gas generation technology is substantially more flexible

imagination at work

Conclusions

- **Multiple studies have shown the feasibility of integrating 30% wind, by energy**
- **Flexible generation plays an important role … and has many aspects; each of which needs economic signals**
- **New market products hold promise:**
  - **Energy imbalance market**
  - **15min Energy; with negative price signals**
  - **10min Spin & Non-Spin; with demand response**
  - **5min Frequency Regulation; including mileage payment; asymmetric (separate) up/down**
  - **Capacity market for flexibility**
- **Flexibility of gas supply may be critical in some places**
- **New products , services and cooperative arrangements do not mean RTOs… there are many mechanisms to create economic signals**

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Thank you!

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