U.S. Department of Energy

WORKSHOP ON VALUATION OF BENEFITS AND COSTS OF DISTRIBUTED GENERATION

Session Title

"Costs and Benefits of Providing Ancillary Services Using Distributed Energy Technologies"

Abe Ellis, Bobby Jeffers, Ross Guttromson
Sandia National Laboratories

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Why Ancillary Services?

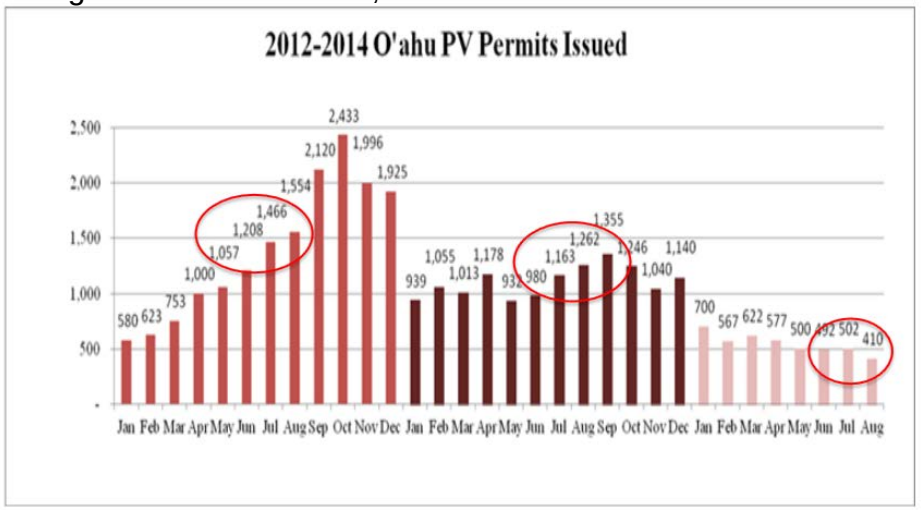
Growth in Distributed Energy Technologies can be limited by need for ancillary services

- See: Hawaii, Germany

Explore benefits that DET can provide to the bulk grid:

- **Technology**
  - Smarter inverters
  - Monitoring and control
  - Aggregation and virtual plants
- **Understanding and Analysis**
  - Modeling integration of DET
  - Forecasting availability of resources
  - Planning for growth in new markets
- **Markets and Policy**
  - Value the services that are being provided

Image Credit: Mark Duda, HI PV Coalition



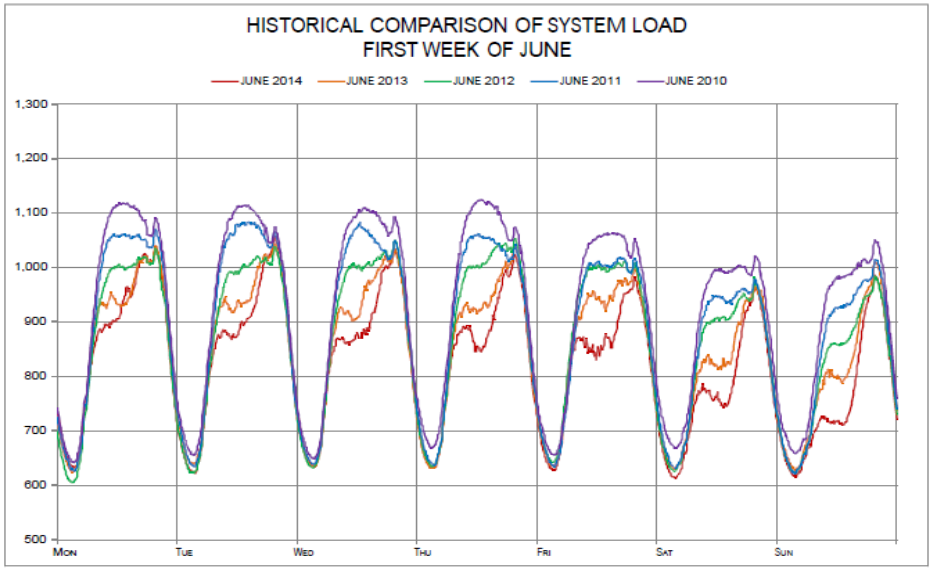


Image Credit: HECO

Contingency Reserves

- **Value from DET:**
  - Can provide reserves
  - Decrease size of largest contingency
  - Frees central generators up to do what they do best – generate energy
  - May lessen impact of contingency through intelligent islanding
- **Cost/benefit analysis methods:**
  - Production Cost Modeling
  - Transient modeling
- **Challenges/opportunities:**
  - Balance between speed and inertia
  - Duration issues
    - regulatory limitations
  - Ride through events
  - Market signals
  - Frequency regulation reserves respond during a contingency, too

Distributed Tech	Impact to contingency reserves
Non-dispatchable Generation	May decrease system inertia, can decrease size of largest contingency, could be curtailed to provide reserves
Dispatchable Generation	Can increase inertia, decrease size of largest contingency, and provides all forms of reserves
Storage	Can provide reserves without the need to be providing energy
Demand Response	In aggregate, very fast response to need for reserves

Frequency Regulation

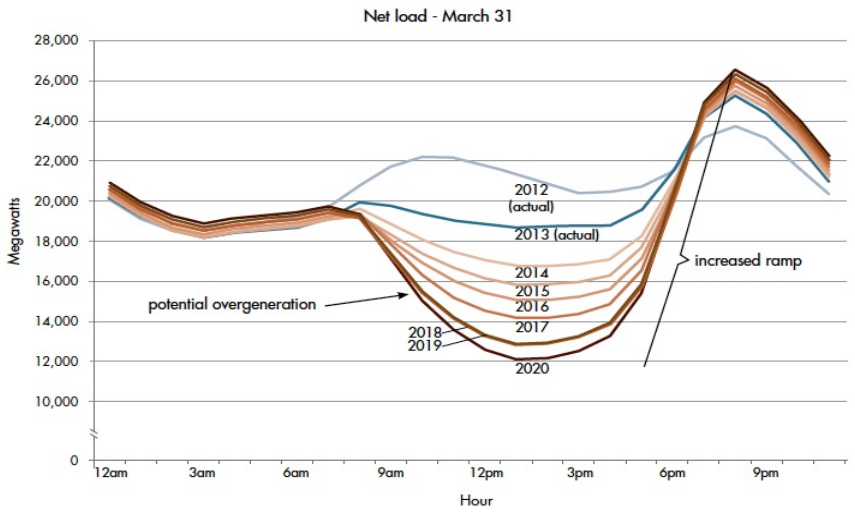
- **Value from DET:**
  - Can provide regulation
  - Depends on what generation it's displacing (opportunity cost)
  - Changes net load variability
  - Can more closely and quickly follow the AGC signal
- **Methods:**
  - Production cost modeling
  - Weather and Climate forecasting
  - Dynamic stability modeling
- **Challenges/opportunities:**
  - How much regulation is available from DET, how much is needed?
  - Aggregation of DR, Storage
  - Integration of DET with SCADA/EMS
  - No market signal for speed of response

Distributed Tech	Impact to frequency regulation
Non-dispatchable Generation	May decrease system inertia, can lead to higher short-term variability
Dispatchable Generation	Can increase inertia, follow AGC signal better than large generators
Storage	Net-zero energy resource fits well with net-zero energy service
Demand Response	Requires aggregation to provide regulation service

Load Following

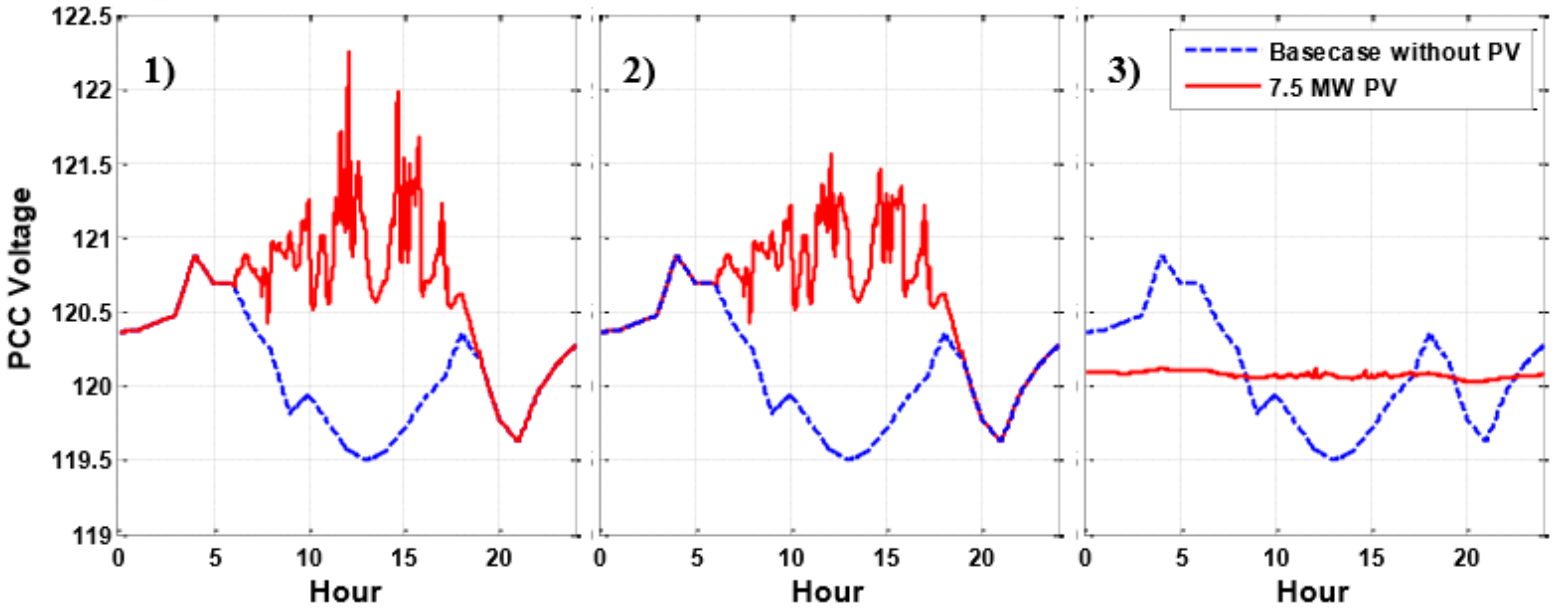
- **Value from DET:**
  - Some can follow load ramps
  - Could add to or subtract from intra-hour forecast error
  - Smaller generators often have faster ramp rates
  - Can displace expensive generation, thereby lowering cost/price of LF
- **Methods:**
  - Production cost modeling
  - Long-term dynamic modeling
  - Weather and climate forecasting
  - Load and generation forecasting
- **Challenges/opportunities:**
  - The duck/Nessie curve
  - Dispatch of DET
  - Better forecasting will decrease forecast error

Distributed Tech	Impact to load following
Non-dispatchable Generation	Can increase system ramps (esp. early evening)
Dispatchable Generation	High ramp rate can follow load ramps
Storage	Can provide if dispatchable
Demand Response	Can provide via aggregation, curtailment and load displacement

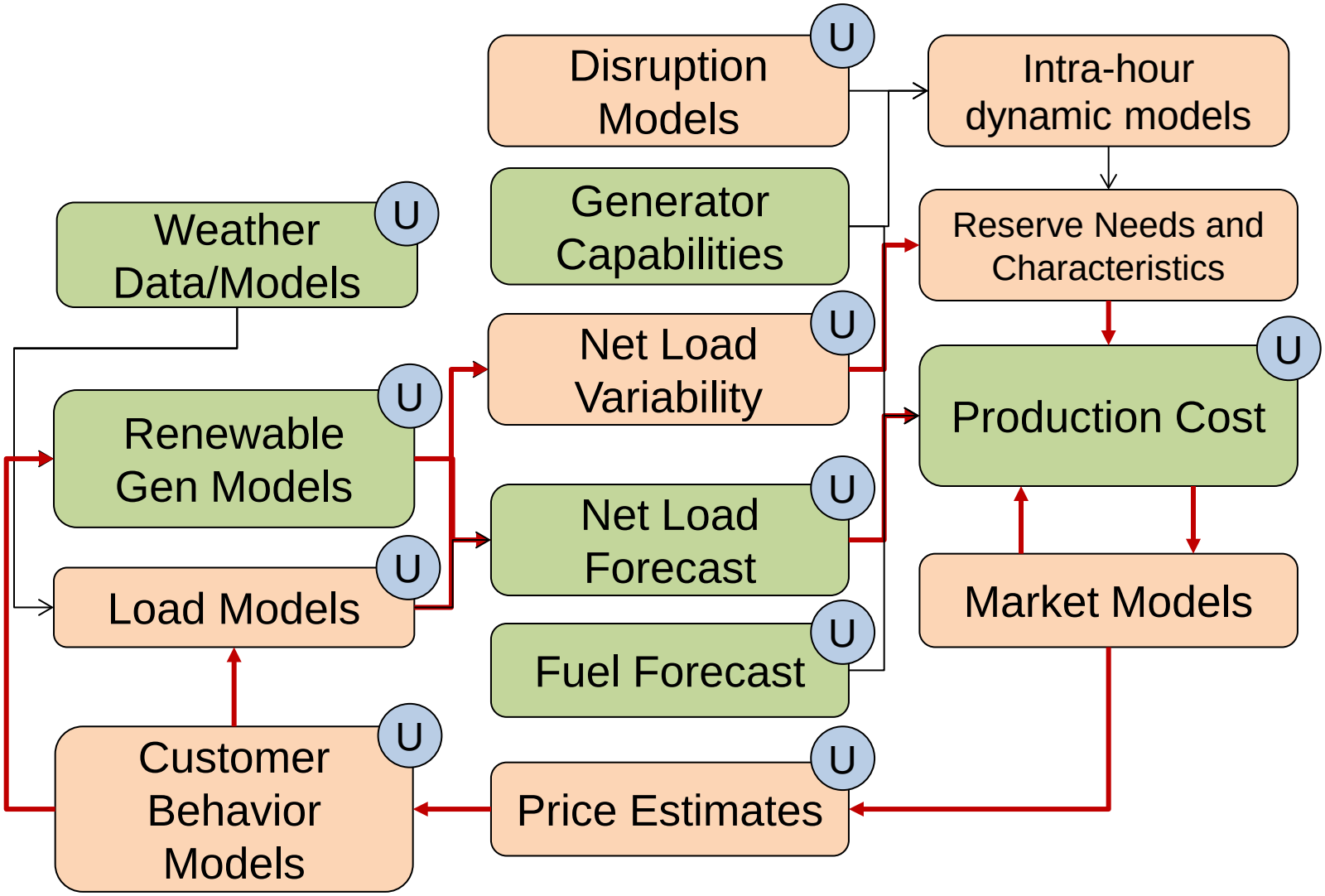


Voltage Regulation

- **Value from DET:**
  - Very difficult to provide value to bulk transmission system
    - Does help levelize feeder voltage profile
  - Can provide local voltage stability during transmission disturbances
- **Methods:**
  - Load Flow modeling
  - Dynamic modeling
- **Challenges/opportunities:**
  - VARs do not travel well
  - Will DET displace large generators?
    - A major supplier of system VARs



Methods/Models Working Together



The Potential for Statim Control

- **Alternative control methodologies**
  - Derivative-based control
  - Leverages inverter speed and distributed computation
  - Can greatly reduce initial frequency perturbation (virtual inertia)
  - Challenge is to decrease this system's time constant

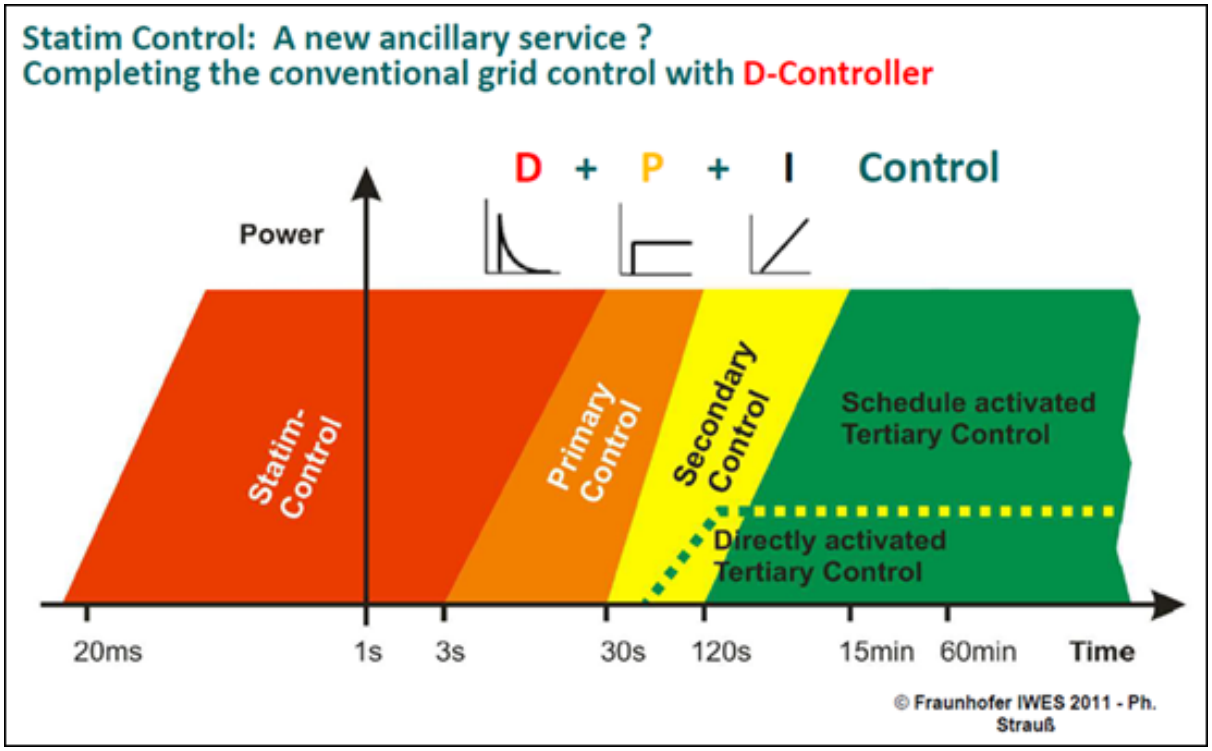
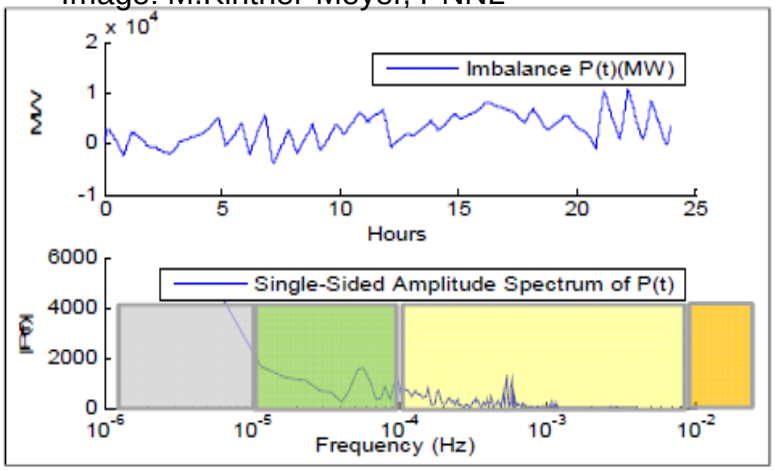


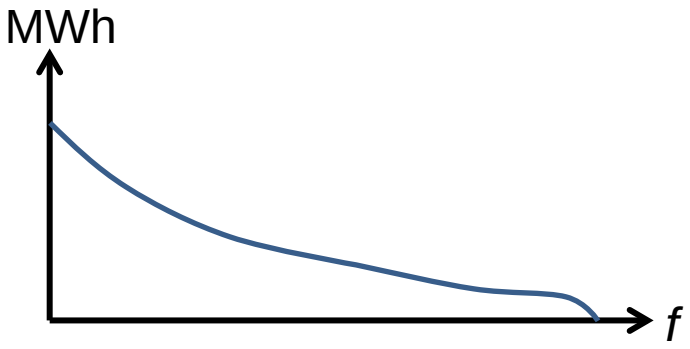
Image: Philip Strauss, Fraunhofer

Dispatching for Performance

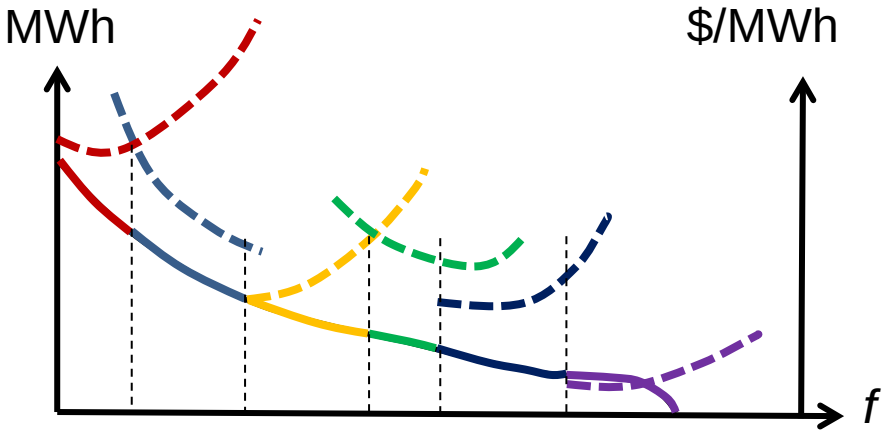
Image: M.Kintner-Meyer, PNNL



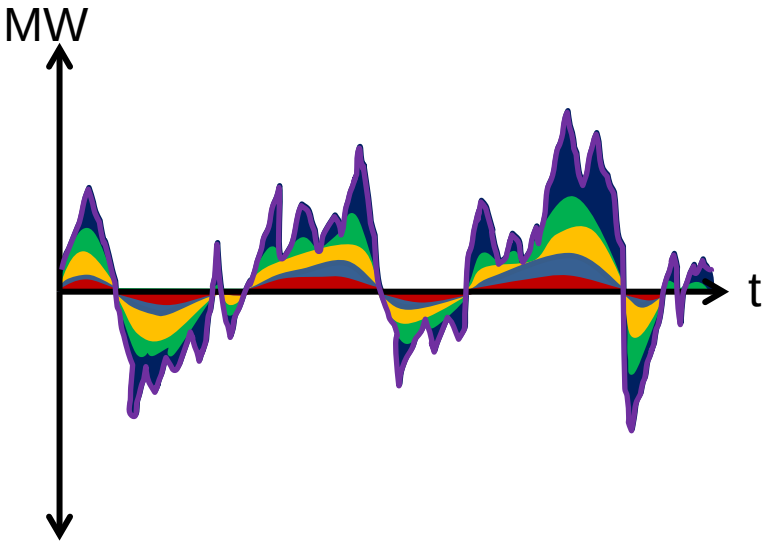
Demand



Supply

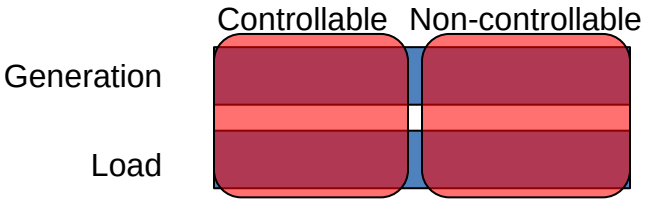


Performance-based Dispatch



Summary of Key Points

- **What is the net impact of increasing DET on the grid's overall cost of providing ancillary services?**
  - And how does it depend on the service and the DETs?
- **What are the most promising technologies that will derive the most net benefit w.r.t. providing ancillary services?**
  - DET aggregation
  - Inverter ride-through
  - DET communications
  - Automated P,Q response

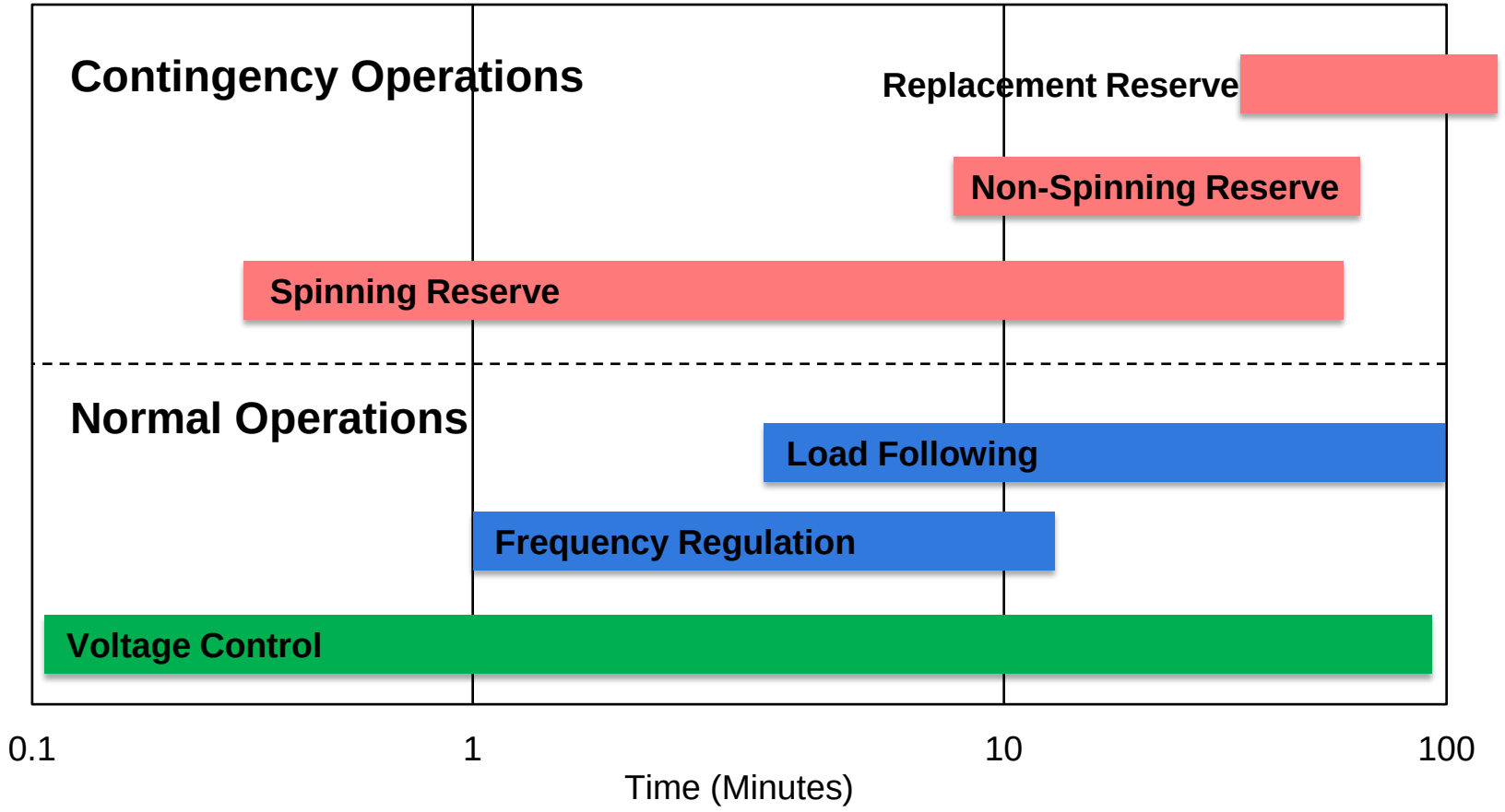


- **We are concerned with minimizing the holistic cost of providing ALL grid services**
  - Conventional generators change the cost of ancillary services, too
  - Let's be clear about the services that the grid provides customers

- **BACKUP**

Ancillary Services Under Consideration

- **Three broad categories for AS:**



Repurposed from B. Kirby (2007)