Distributed PV and HELCO Operations

Impacts and Actions

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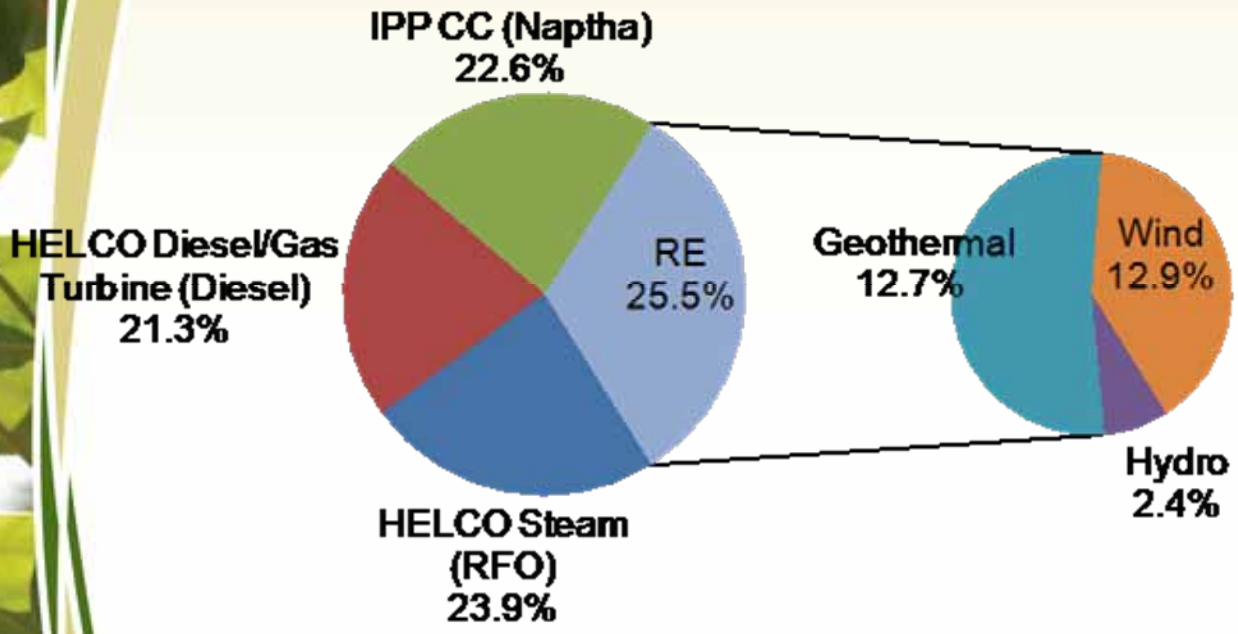
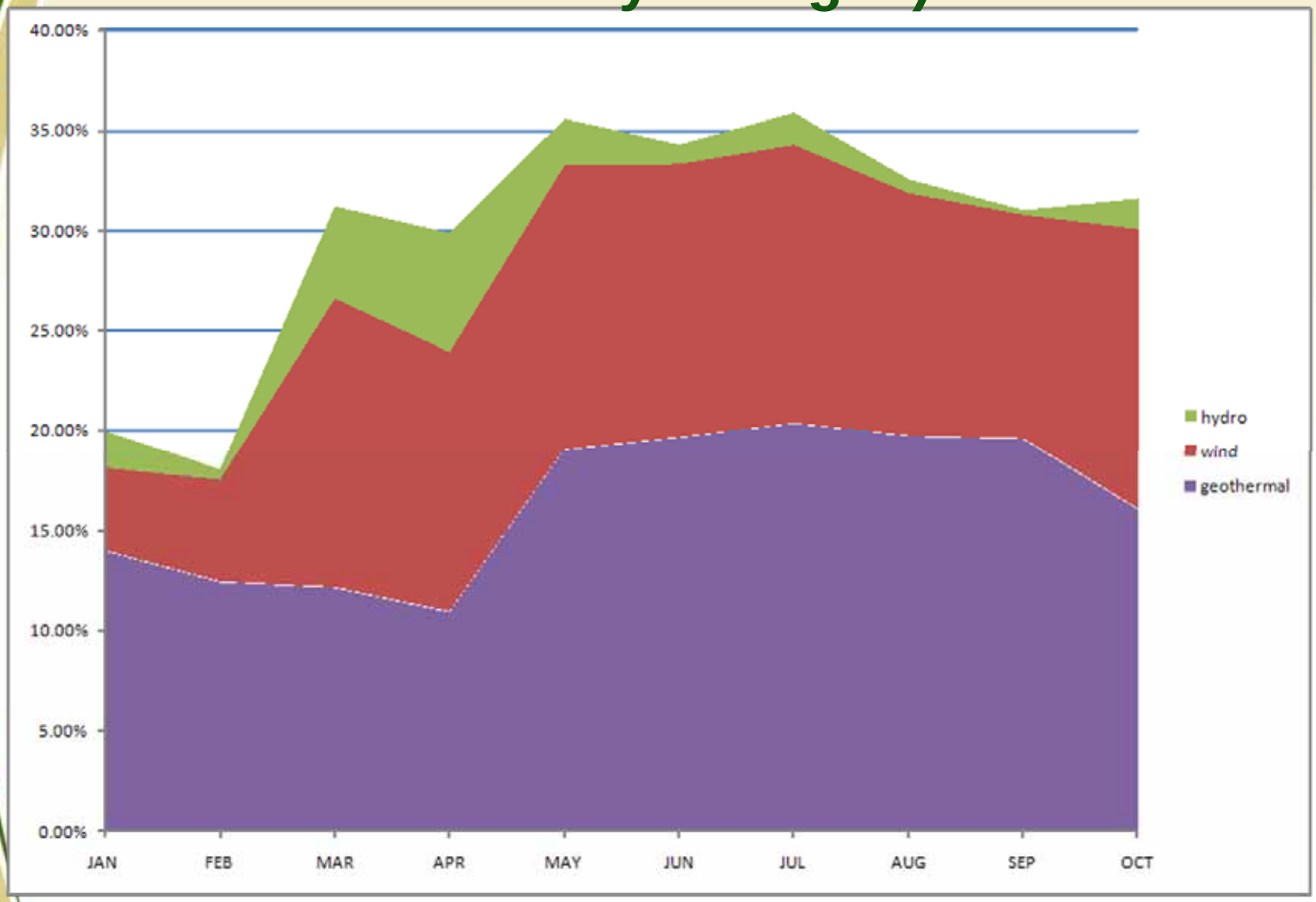
Overview of HELCO System

- Small autonomous system (no interconnections)
  - daily minimum 85-95 MW
  - day peak 155-165 MW
  - eve peak 180-195 MW (evening peaking)
- High costs
- Close to limits of stable operation
- High penetration of variable generation
- High penetration of distributed generation
- Large amount of renewable energy from wind, geothermal, and solar
- Demand is decreasing (negative load growth)

NET-TO-SYSTEM GENERATION THROUGH OCT 2010
(EXCLUSIVE OF UNMONITORED DISTRIBUTED GENERATION)



YTD HELCO Transmission-connected RE (as a % of net-to-system gen)



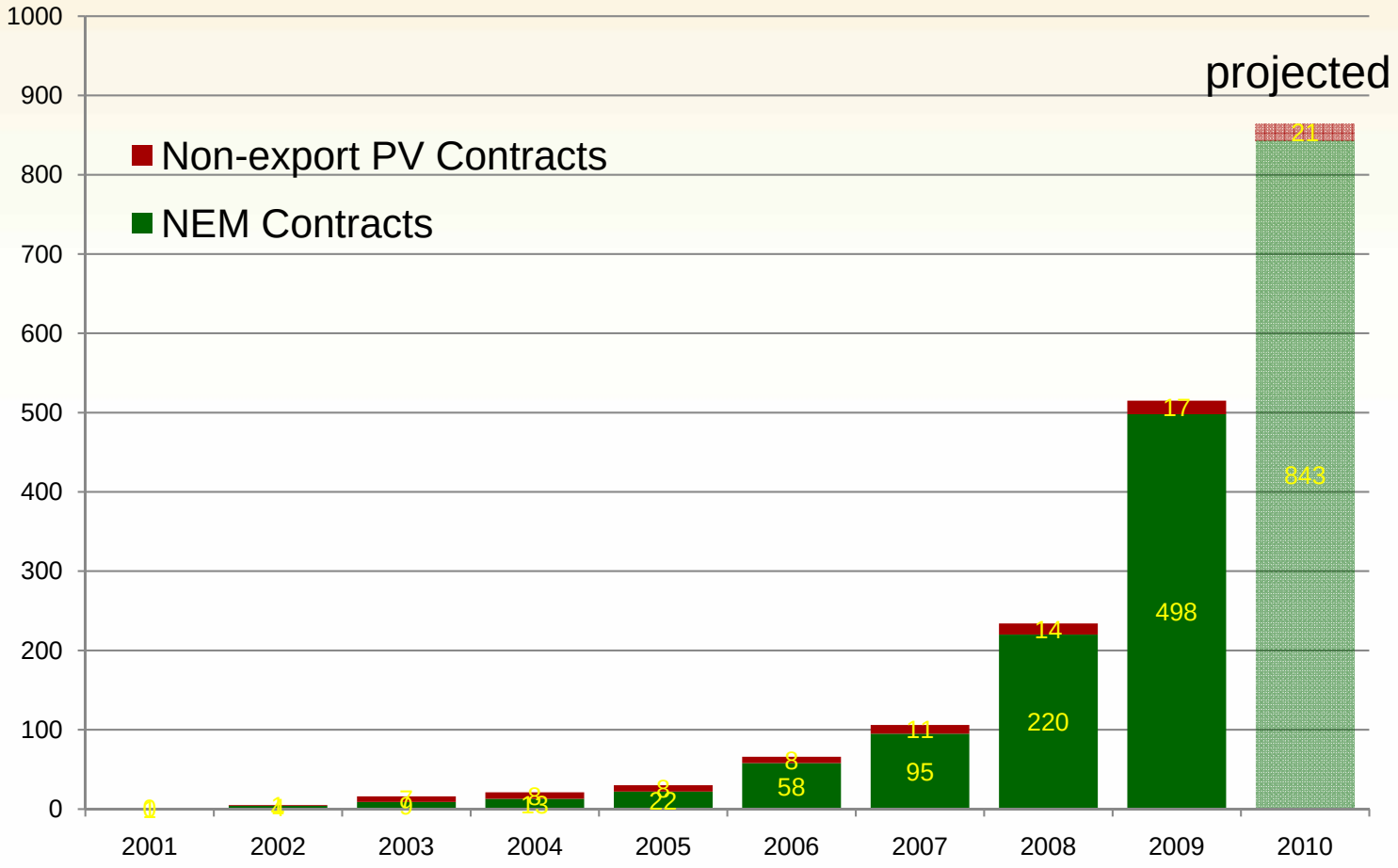
Reserve Policy

- Regulating reserves maintained for intra-hour frequency control.
- Contingency reserve includes offline capacity (fuel saving measure)
- Reserve down is minimal during excess energy conditions
- Reserve up may be very small during stable wind conditions (3-5 MW)
- Loss of generation events typically result in underfrequency load-shed

Distributed PV

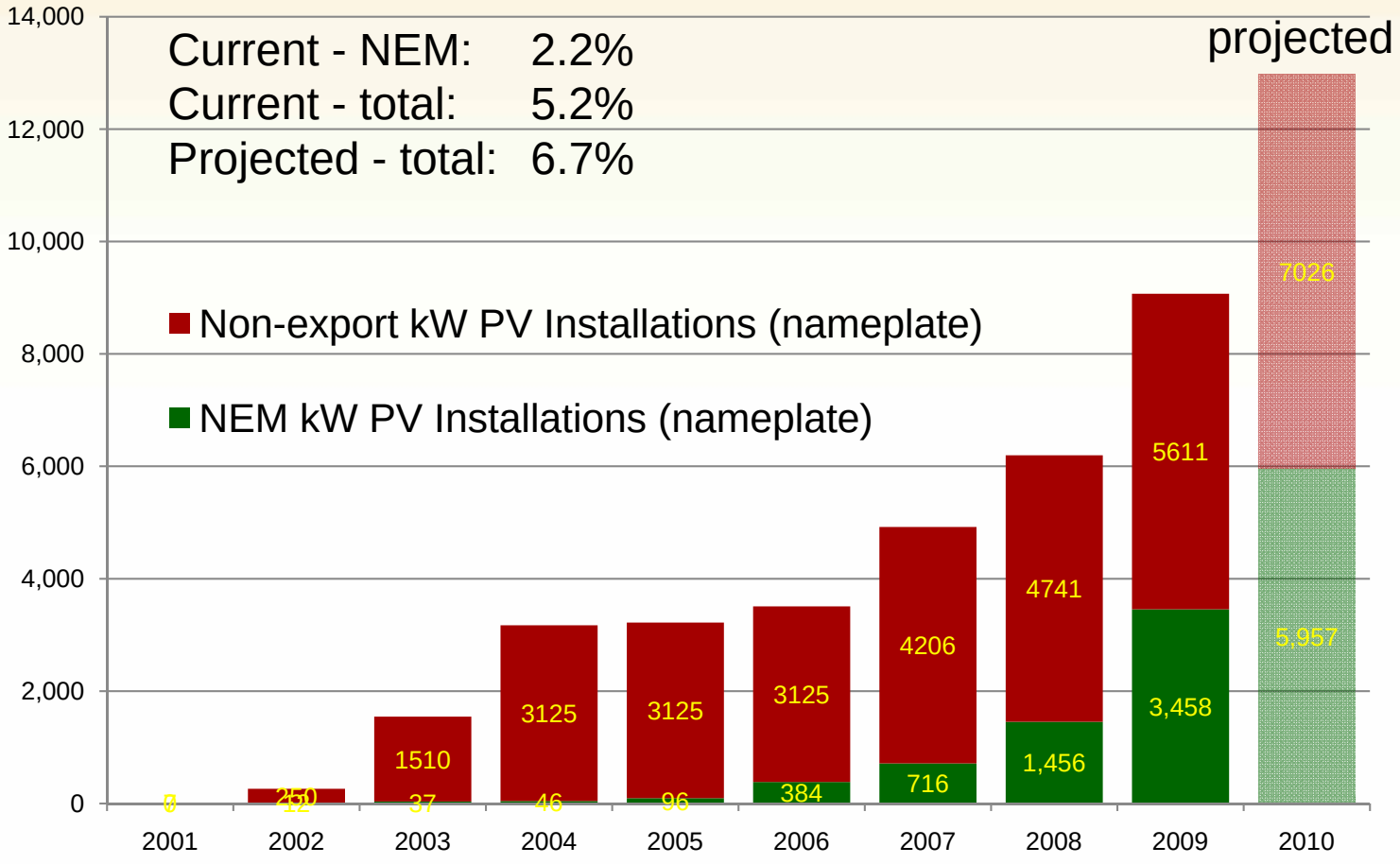
- HELCO has had a large increase in distributed solar in the last two years
  - NEM
  - Load-offsetting PV
  - FIT (coming very soon)
- Monitoring, control, and forecasting are not available
- Impact on intra-hour variability is not known
- Apparent load (demand – distributed PV) difficult to predict

PV installations



As of 5/6/2010

PV installations as % of Annual High Peak

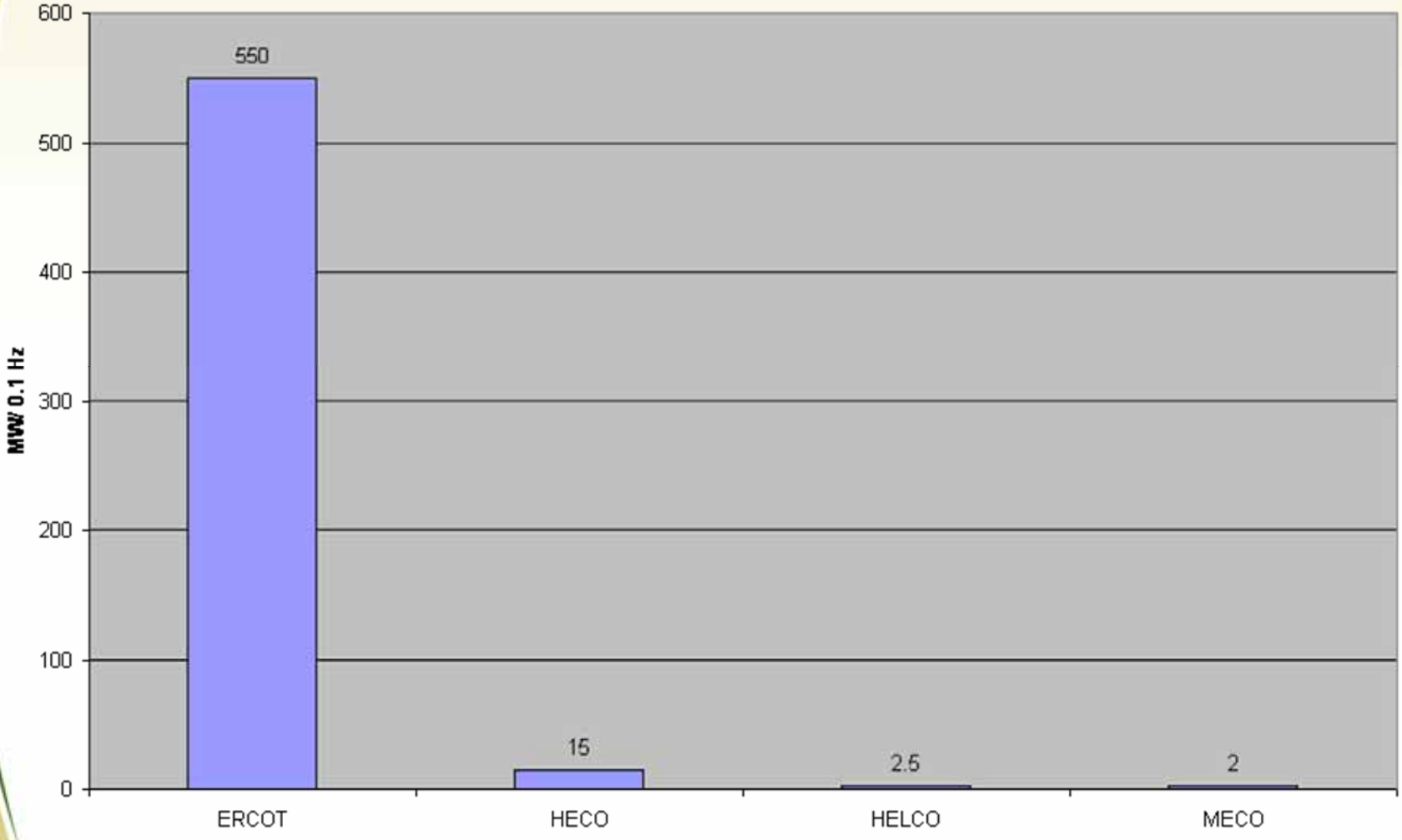


As of 5/6/2010

Significant DG Issues for HELCO Operations

- Displacement of generation performing critical grid services
- Adding to existing system balancing and frequency control challenges (variability)
- Adds to excess energy from non-dispatchable resources
- Lack of visibility and control
- Aggregate loss of distributed PV during faults and contingencies - nuisance trips

Frequency Bias

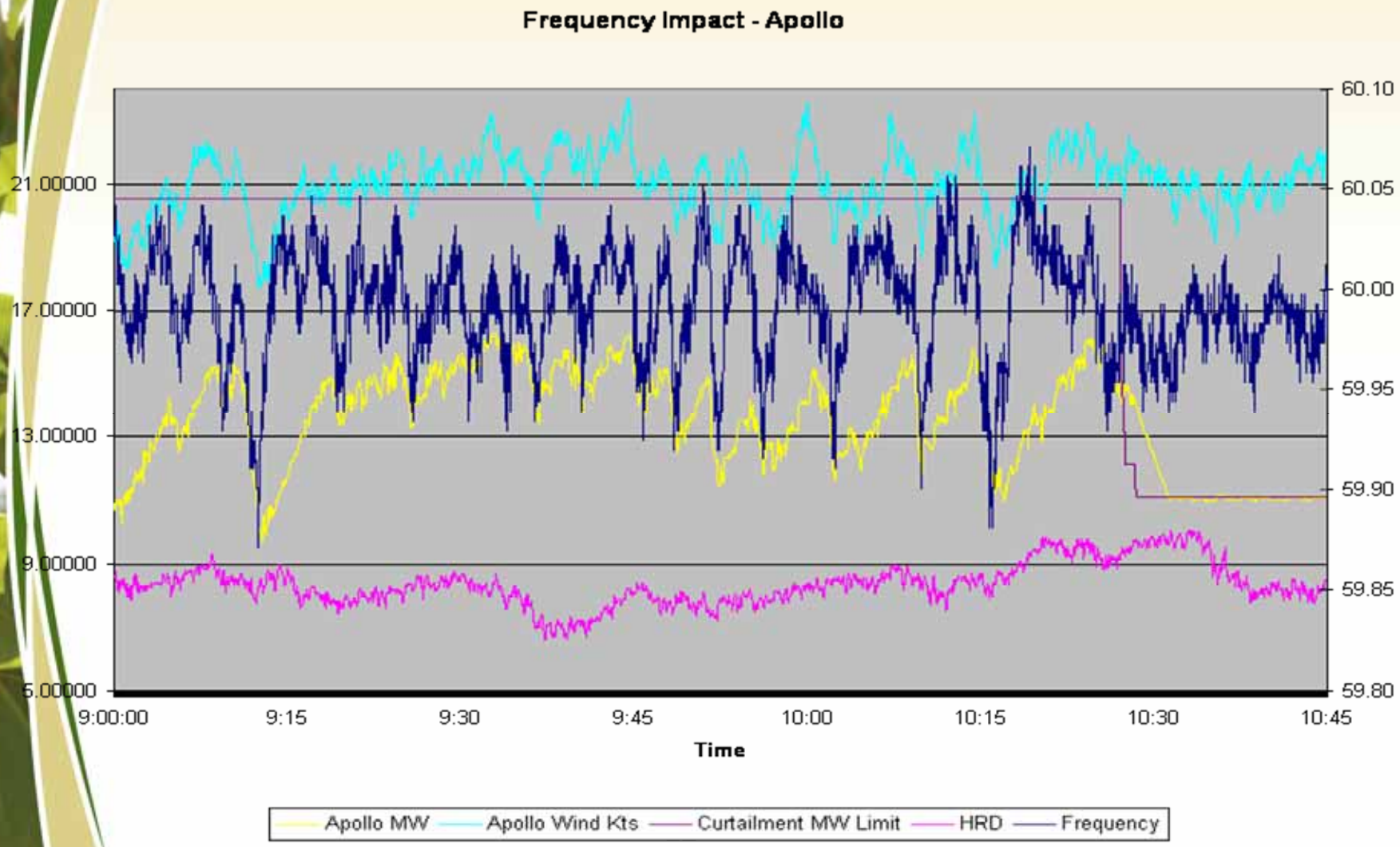


HELCO System Frequency

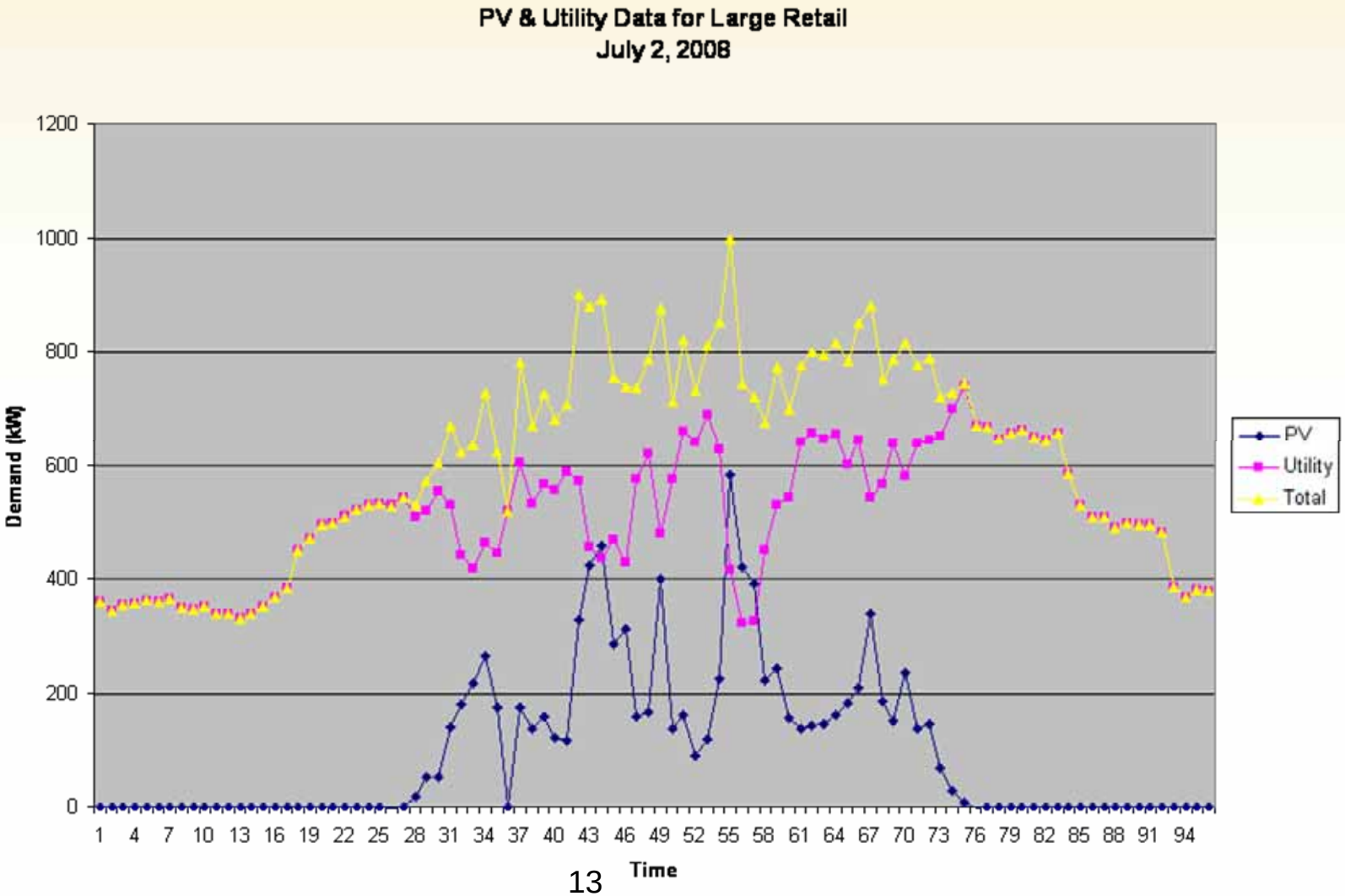
HELCO System Frequency Targets and Action Levels

59.95 – 60.05 Hz	Targeted Frequency Control Range
59.85 - 60.15 Hz	Disturbance level: System Operator to identify cause and take corrective action
59.80 – 60.20 Hz	System Alarm Level: Operator to take immediate corrective action
59.5 Hz	Emergency Action Level: Mandatory manual load shed by the System Operator required if not corrected within 15 minutes
59.3 Hz	Block 5 Automatic load shed if frequency remains at this level for approximately 20 seconds
58.8 Hz	Block 1 instantaneous automatic load shed
58.5 Hz	Block 2 instantaneous automatic load shed
58.0 Hz	Block 3 instantaneous automatic load shed
57.7 Hz	Block 4 instantaneous automatic load shed

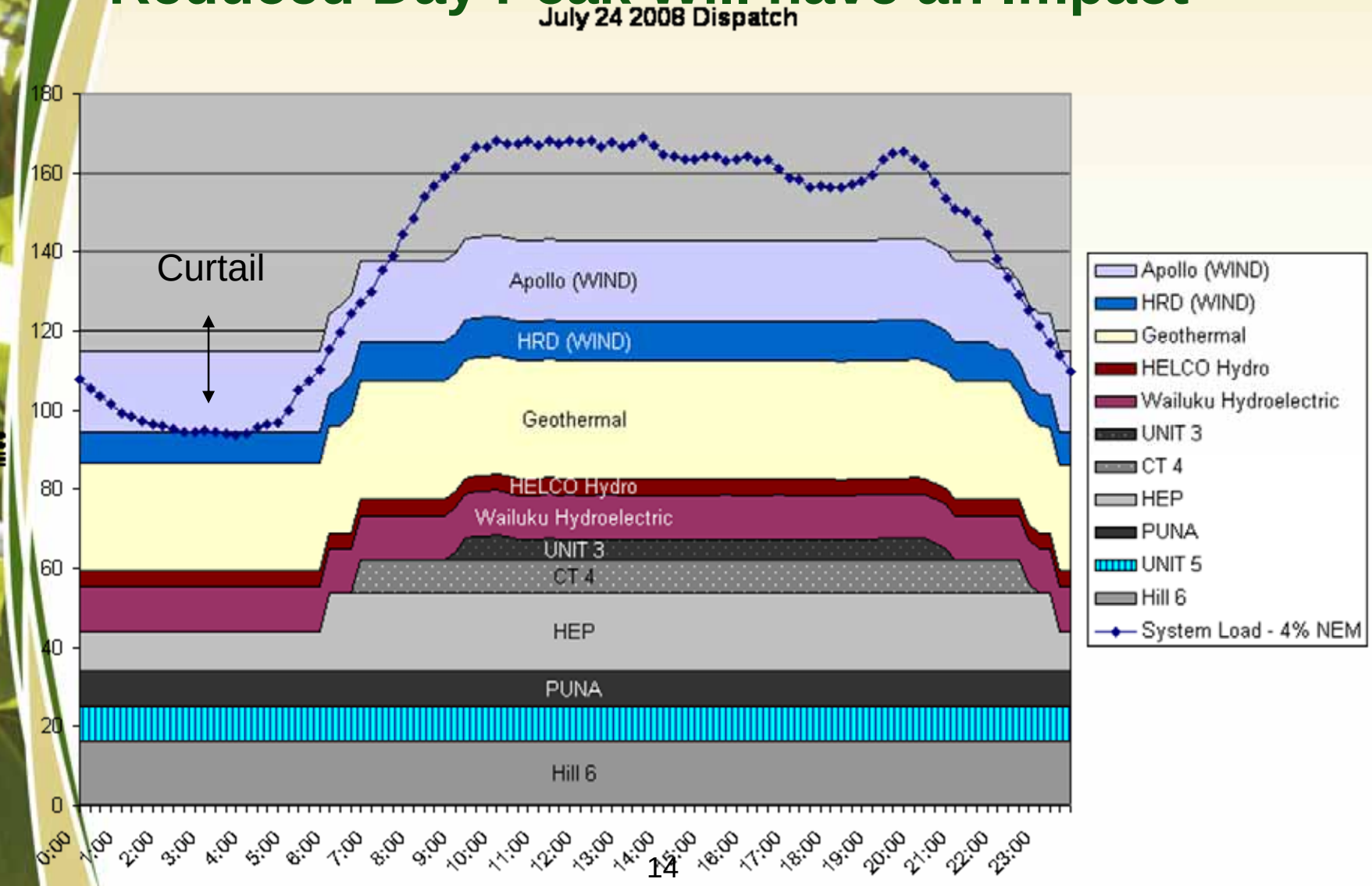
The balancing impact of wind power can be measured… and is significant…



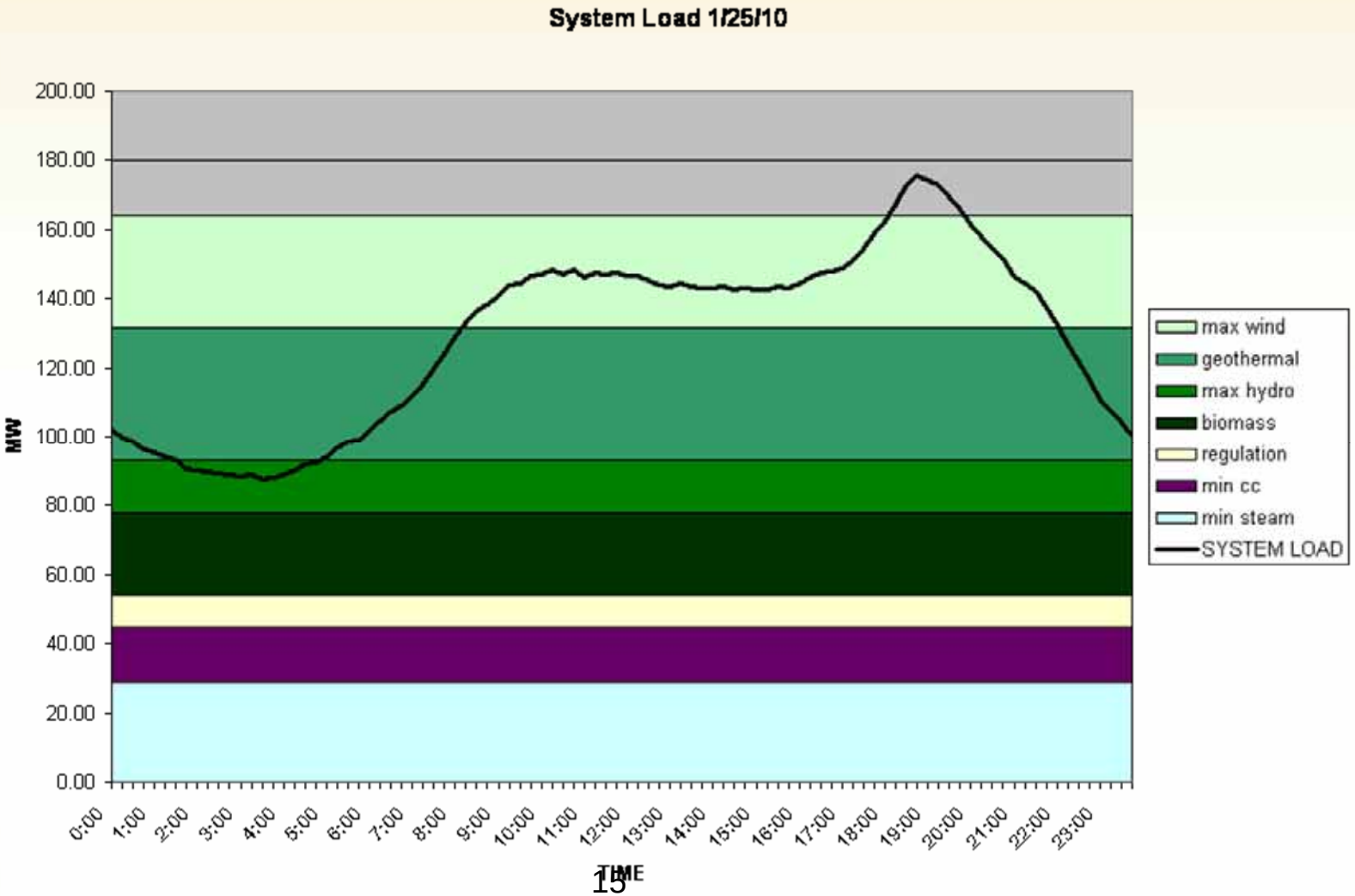
… the impact of distributed PV (in aggregate) is not monitored and thus unknown. We are working to gather data (discussion later).



Excess Energy occurs Routinely Today, Reduced Day Peak Will have an Impact



Excess Energy for Future Gen Mix – Distributed PV will Displace other RE



Distributed Solar and Excess Energy

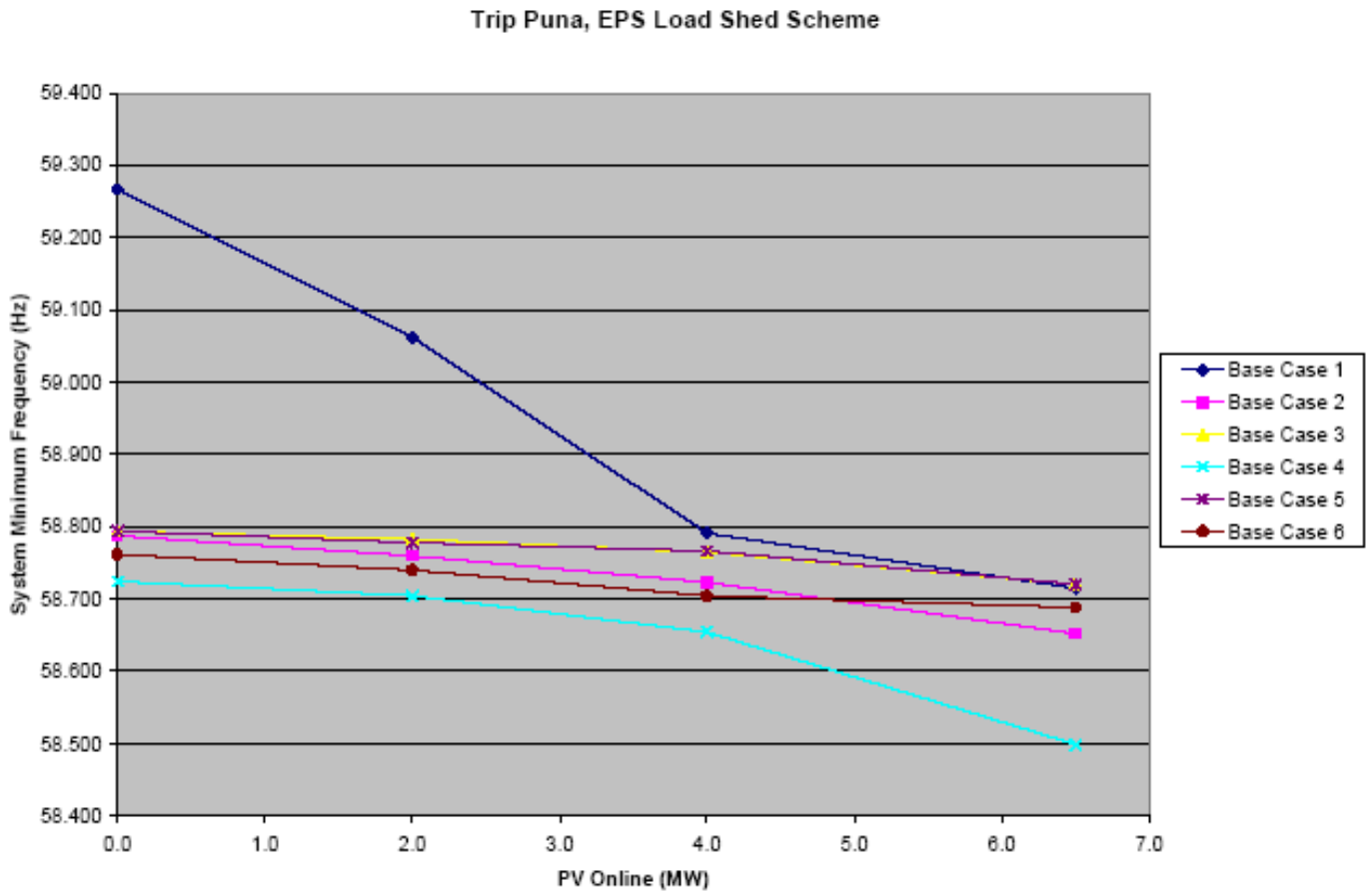
- Provide monitoring and curtailment capabilities on the renewable energy additions. Proposed for 250 kW and larger (Interconnection rule modification).
  - System Operator must be able to administer
  - Need clear rules
  - May be economically infeasible for small installations, such as residential PV for present methods (RTU)
- Storage may be technically feasible (centralized or distributed) but at present remains an uneconomic solution
- Distributed Solar will displace dispatchable RE to some extent

Aggregate Impact System Studies

- Studies are needed to evaluate the aggregate impact of distributed DG as it has become significant, similar to typical generator transmission interconnection study
  - Ensure generation mix provides system stability through faults and contingencies
  - Modifications to system protection including underfrequency and under voltage schemes
  - Interconnection requirements such as underfrequency and under voltage ride through
  - Operational changes necessary for secure operation (such as modification of reserves)
- Incorporate into interconnection requirements for DG (Rule 14H) - historically only considered individual project and distribution impacts

Example Completed PV Study – Impact of Aggregate Loss during Unit Trip

Figure 2 – Minimum Frequency vs. PV Penetration



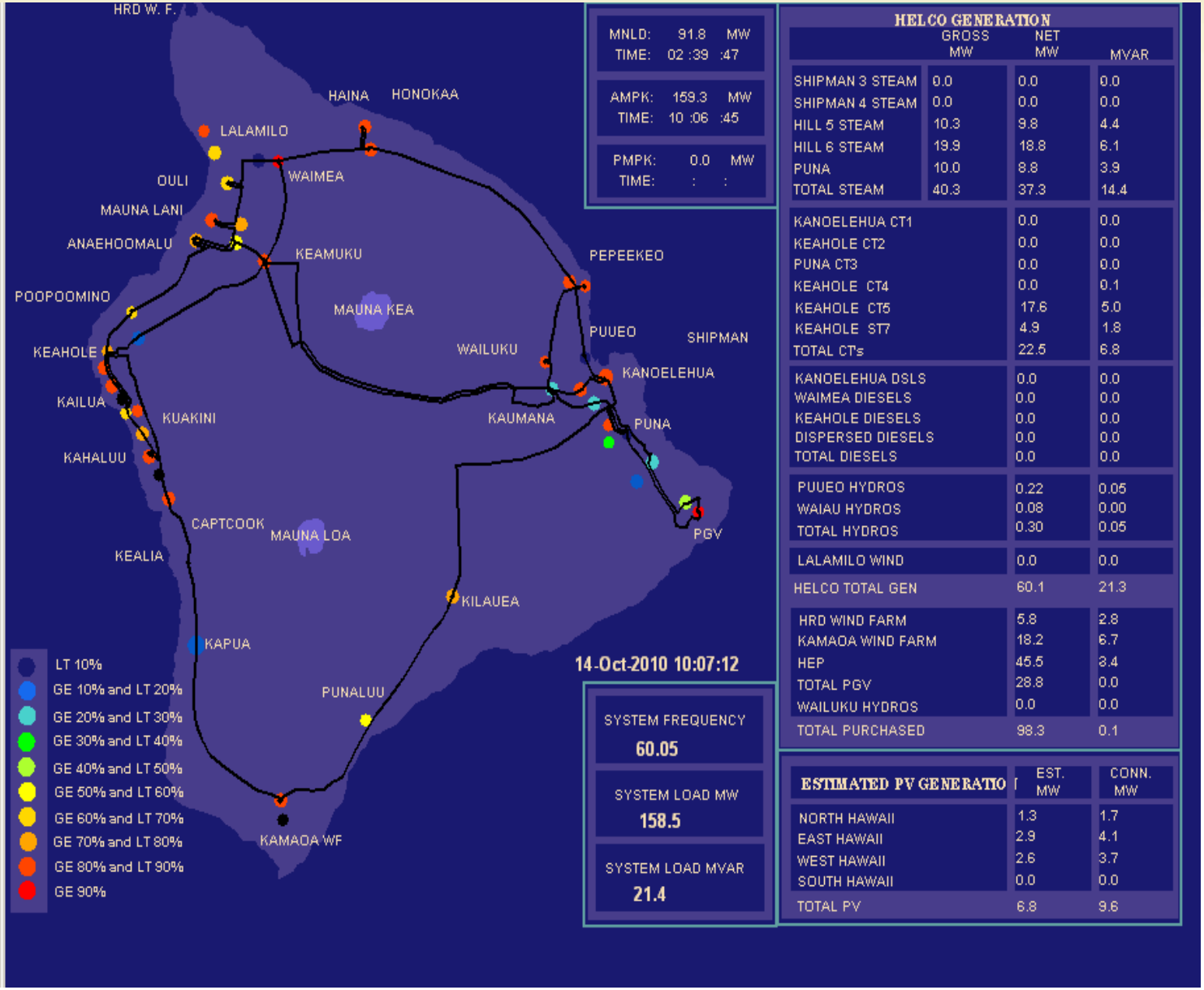
Proposed Changes to DG Interconnection (Rule 14H)

- Consideration of aggregate impacts on the power system in determining additional requirements or limits
- Remote monitoring and control through SCADA/EMS (250 kW and larger)
- Provide for adjustable voltage and frequency trip settings for *all* facilities (including less than 30 kW) to reduce nuisance trips and coordinate with the underfrequency load shed scheme.
- These changes are necessary because distributed generation provides a significant amount of system generation

Other Work…

- Real-time stability data captured through use of synchrophasor data (by end of the year)
  - Detect stability issues as they emerge in real-time
  - Validate stability models to improve simulation of dynamic response
- Investigating alternative communications/controls measures for low-cost monitoring and control of DG
- Incorporate lessons learned from other high penetration areas (Europe, other islands)
- Visualization and estimation of island PV production

Real-time Irradiance and Estimated PV



HELCO GENERATION

	GROSS MW	NET MW	MVAR
SHIPMAN 3 STEAM	0.0	0.0	0.0
SHIPMAN 4 STEAM	0.0	0.0	0.0
HILL 5 STEAM	10.3	9.8	4.4
HILL 6 STEAM	19.9	18.8	6.1
PUNA	10.0	8.8	3.9
TOTAL STEAM	40.3	37.3	14.4
KANOELEHUA CT1		0.0	0.0
KEAHOLE CT2		0.0	0.0
PUNA CT3		0.0	0.0
KEAHOLE CT4		0.0	0.1
KEAHOLE CT5		17.6	5.0
KEAHOLE ST7		4.9	1.8
TOTAL CTs		22.5	6.8
KANOELEHUA DSLS		0.0	0.0
WAIMEA DIESELS		0.0	0.0
KEAHOLE DIESELS		0.0	0.0
DISPERSED DIESELS		0.0	0.0
TOTAL DIESELS		0.0	0.0
PUUEO HYDROS		0.22	0.05
WAIAU HYDROS		0.08	0.00
TOTAL HYDROS		0.30	0.05
LALAMILO WIND		0.0	0.0
HELCO TOTAL GEN		60.1	21.3
HRD WIND FARM		5.8	2.8
KAMAOA WIND FARM		18.2	6.7
HEP		45.5	8.4
TOTAL PGV		28.8	0.0
WAILUKU HYDROS		0.0	0.0
TOTAL PURCHASED		98.3	0.1

ESTIMATED PV GENERATIO	EST. MW	CONN. MW
NORTH HAWAII	1.3	1.7
EAST HAWAII	2.9	4.1
WEST HAWAII	2.6	3.7
SOUTH HAWAII	0.0	0.0
TOTAL PV	6.8	9.6

Real-time Irradiance and Estimated PV

- The estimates are based on measured solar irradiance, converted to available per unit energy
- The per unit energy is used to estimate area PV production based on neighboring installed capacity
- Future work will be done to validate the estimates and/or suggest enhancements to algorithm (i.e.; smoothing or accumulating values)
- We will also work to evaluate effect on frequency control (assuming reasonableness of estimated data is verified).