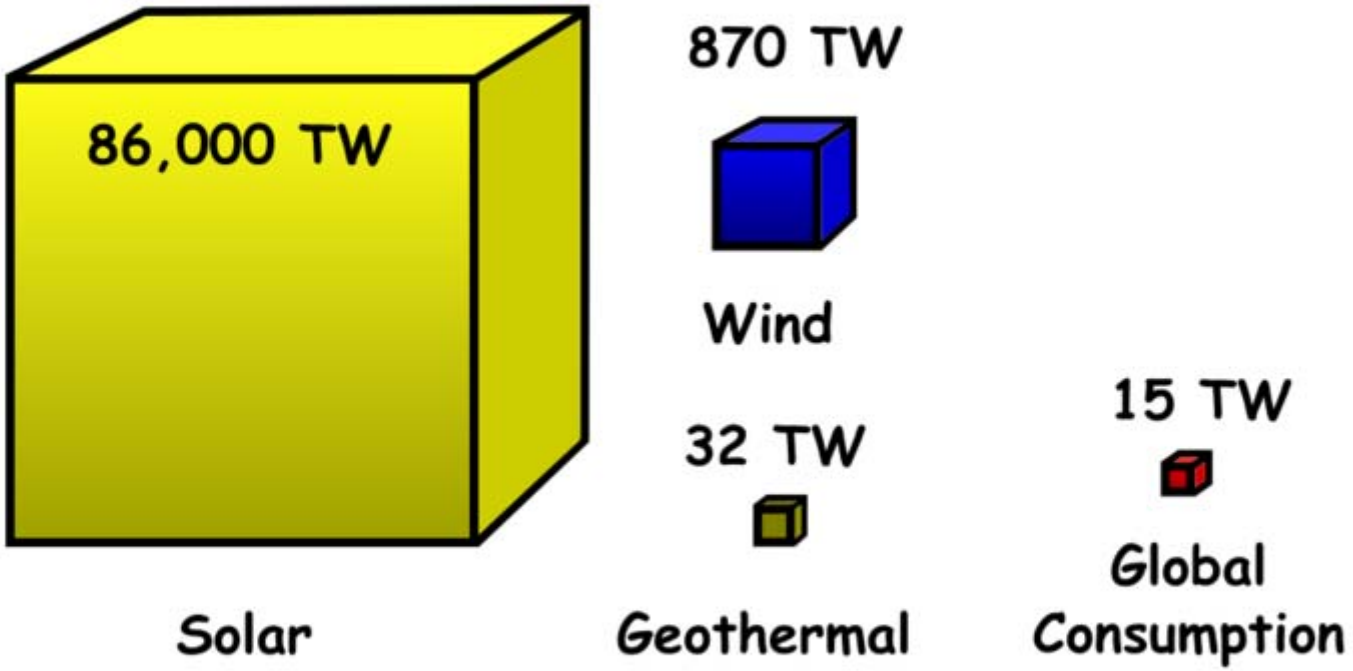
Customer Division
National Grid
Planning & Optimization Dept.

חברת החשמל

Integration of Renewable Energies into the Grid

January 2013

Power Levels on Earth



Renewable Energies in Israel

In June 2008, PUA published a decision regarding distributed energy generation by *small* photo voltaic systems, for *self* consumption and for passing the *extras* to the grid.

Domestic customers may connect PV systems up to 15 kW.

Non Domestic customers may connect PV systems up to 50 kW.

District	Installed Cap. (kW)	No. of Systems
North	75.256	2,945
South	97,884	3,495
Haifa	14,176	482
Dan	4,685	144
Jerusalem	26,941	1,162
Total	218,942	8,228

As reported on 21/11/2012 by IEC

Renewable Energies in Israel - 2

At the end of 2009, PUA published a second decision regarding energy generation using photo voltaics, which regulates the connection of *medium* size systems (above 50 kW) to the grid.

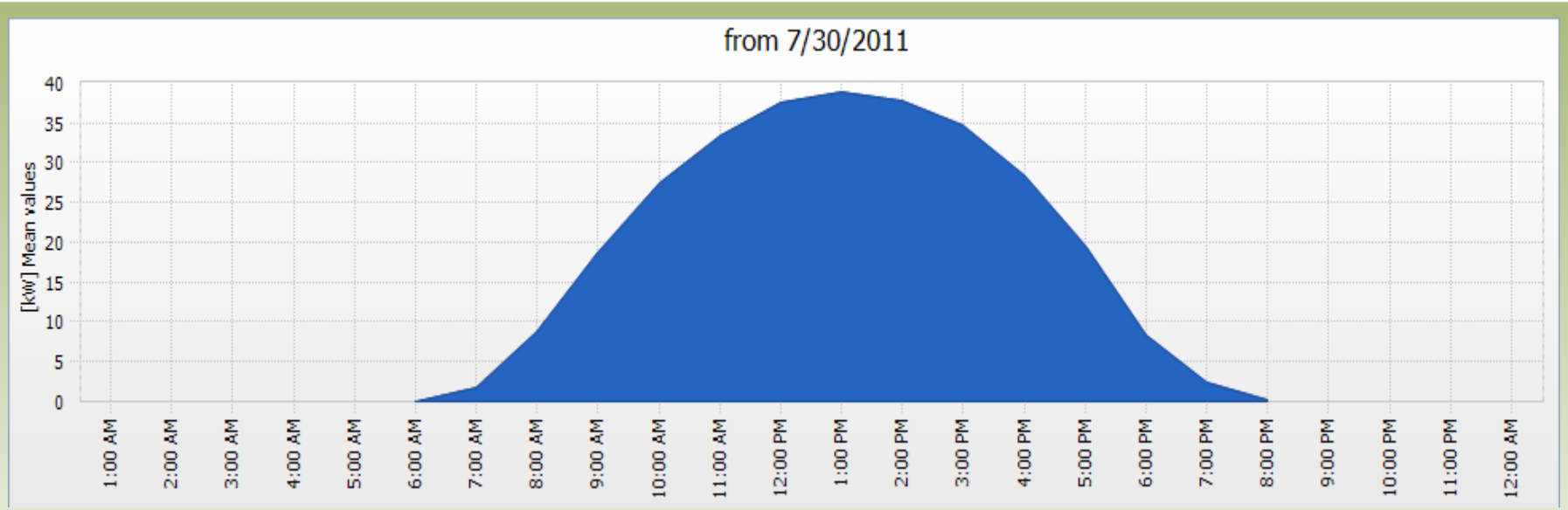
Systems up to 630 kW will be connected to low voltage grid

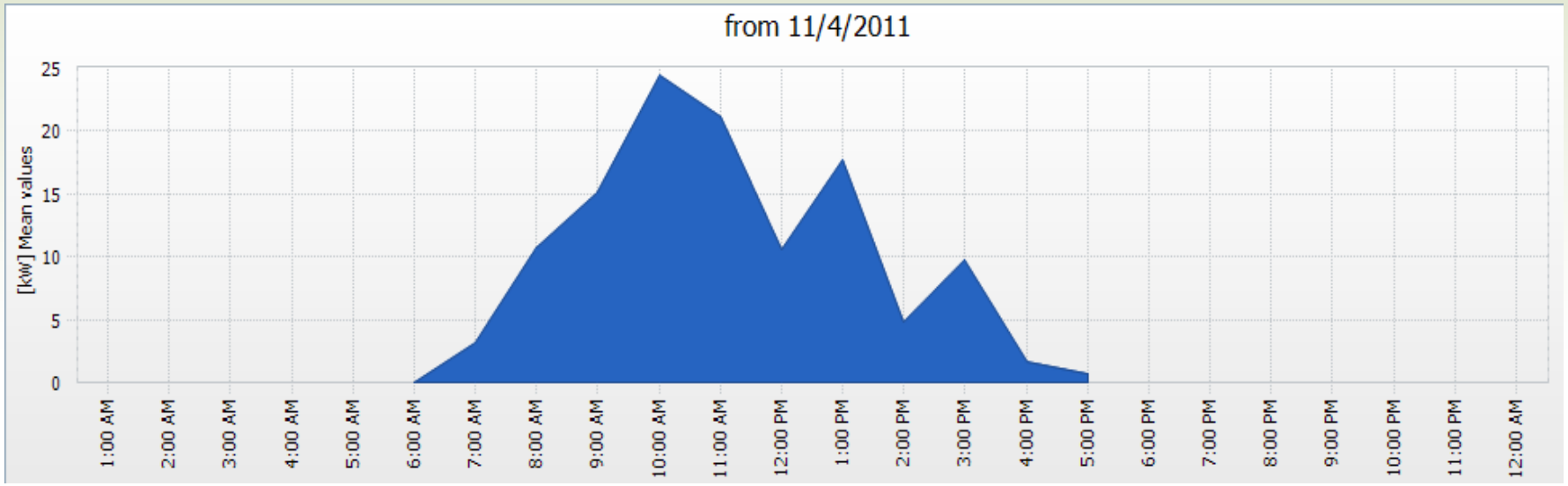
Systems above 630 kW will be connected to medium voltage grid.

Medium size PV systems are defined as producers, i.e. all the generated energy is injected into the grid.

By the end of 2012, PUE authorized the building of 152 medium size PV systems with overall power capacity of 270 MW.

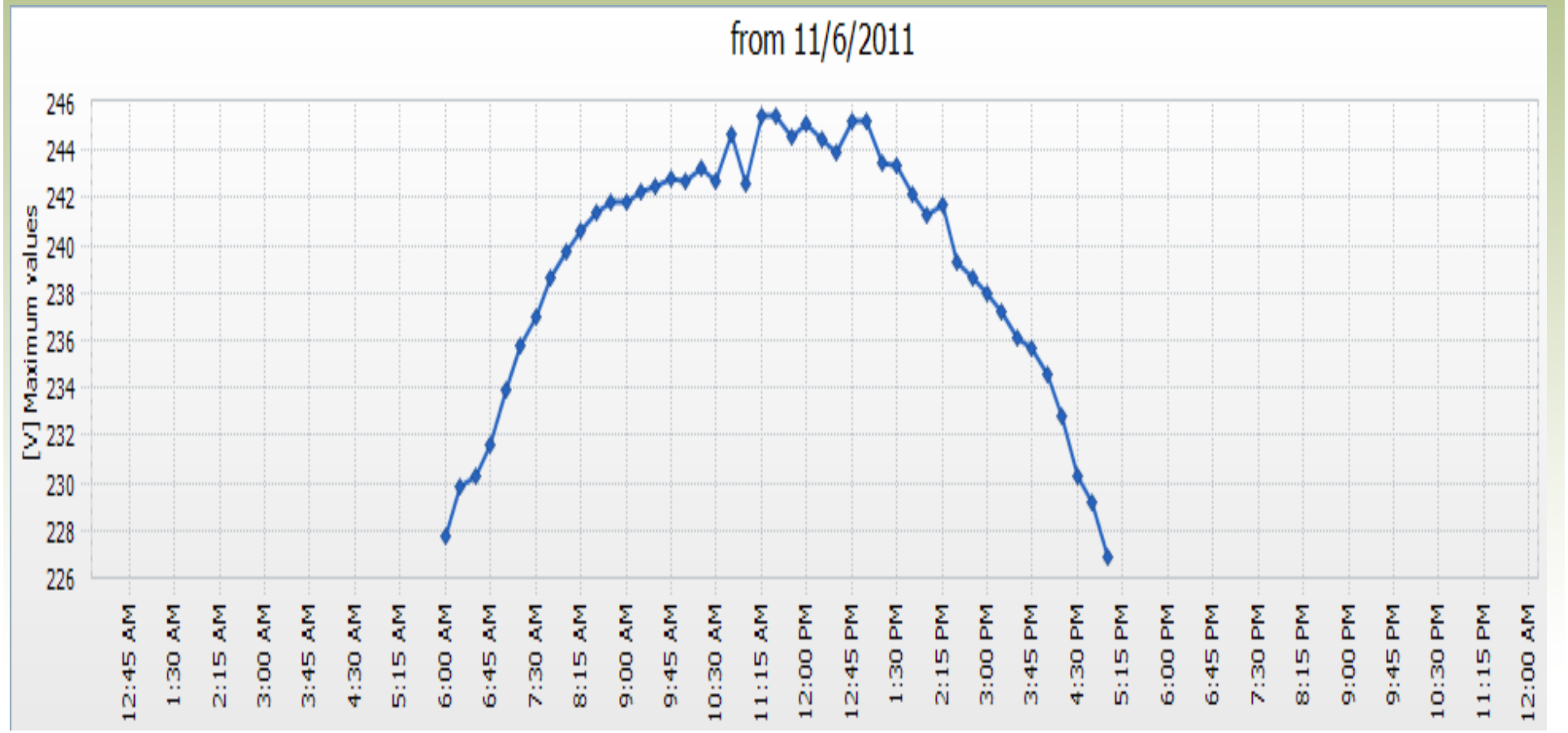
Power Characteristics in Summer and Winter





Influence to the Grid

Voltage Rise on Connection Point



Influence to the Grid

Voltage Rise on Connection Point

Low Voltage Grid

The maximum permissible voltage rise was set to 6%.

The power flow check is done for worst case, when there are no loads and the generation is at maximum rate.

Medium Voltage Grid

The maximum permissible voltage change was set to 3%.

A feasibility survey is done for different loading conditions.

Influence to the Grid

Voltage Rise on Connection Point

Solutions:

Visualization

1. Changing the tap of the transformer

STATIC:

Cheap, but affects all the feeders connected to the transformer.

In winter evenings, when the loads are high and there is no PV generation, the customers may encounter voltages under the permissible value.

Influence to the Grid

Voltage Rise on Connection Point

Solutions:

DINAMIC:

- Lowering the feeders' voltages based on measurements on weakest points (points of connection and distant loads)
- Changing the topology of the grid according to the loads and sources

Challenges:

- a reliable communication network between all the players
- smart algorithms and Real Time implementations

Influence to the Grid

Voltage Rise on Connection Point

2. Reactive Power Control

STATIC:

Constant Power Factor:

cheaper inverters, no need for communication

DINAMIC:

The distributor sets the power factor accordingly to the voltages measured in different points on the grid.

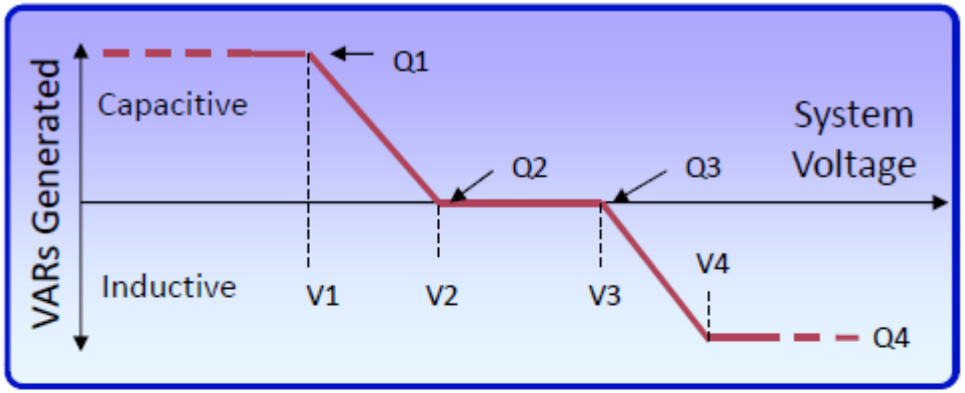
Israel Electric demands variable power factor between 0.90 capacitive to 0.90 inductive and remote access to control.

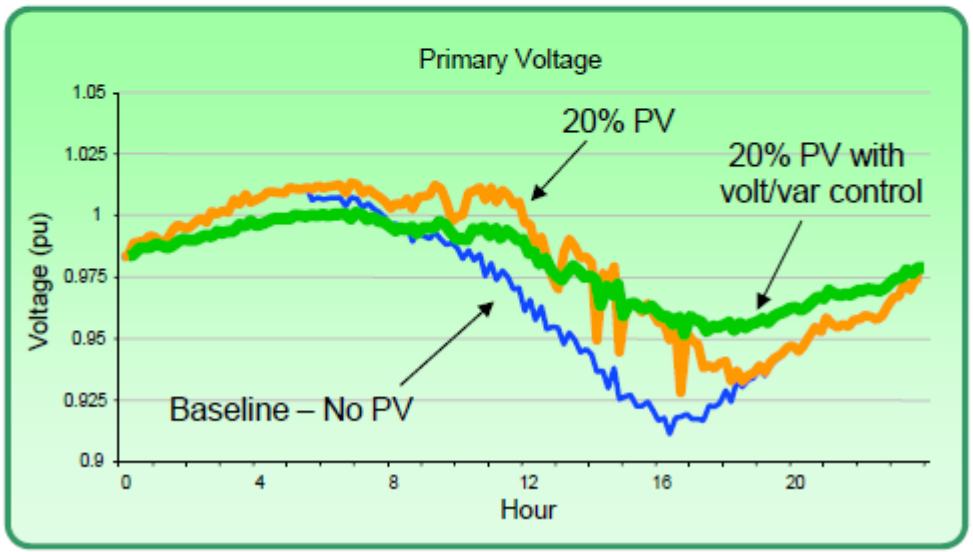
Challenges:

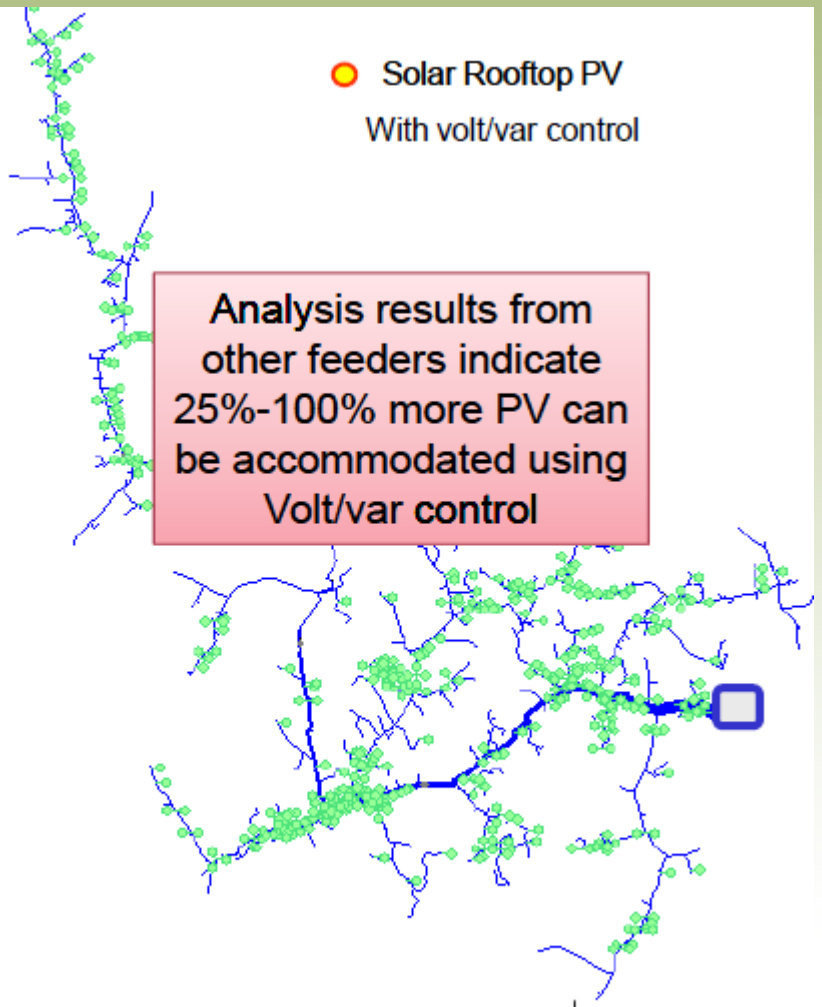
- Communication between producers, consumers and distributors
- Real Time Optimal Power Flow Analysis
- Smart billing software that relies on big databases (energy traffic)

Influence to the Grid

Voltage Rise on Connection Point







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Influence to the Grid

Power Balance between Producers and Consumers

There is only very little flexibility in the nuclear power plants and the coal based plants. For them it is "more reasonable" to keep their fires burning, even if that means producing more electricity than is needed. So in this situation of imbalance they gave away the electricity for free or even paid you to take it.

Hans Schäfers, e-harbours project, Germany

Influence to the Grid

Power Balance between Producers and Consumers

Solutions:

Flexibility on both sides

Generation: building base load power plants that work intermittently with low extra costs

Loads: postpone the electricity demand to more convenient time (flattening the consumption)

Timing between producers and consumers

Demand Side Management - “Circuit Switching”

Energy Storage

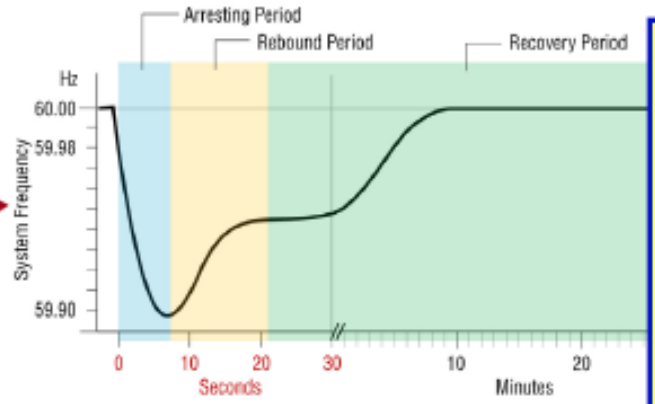
Flatten the generation and the consume

“Packet Switching”

Influence to the Grid

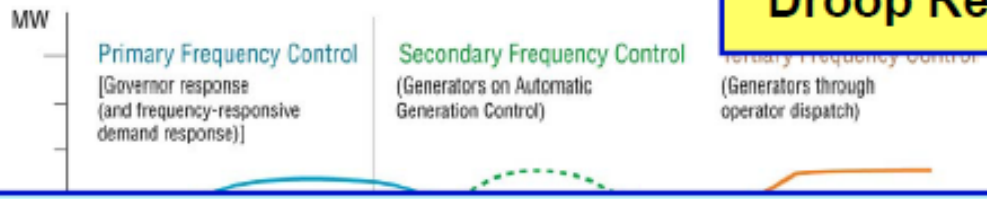
Frequency Stability

Sudden Loss of Generation



VG Freq Impacts

- Increase Regulating Reserve small
- Potentially Reduce System Inertia & Droop Response



Inverter-Based Wind & PV can be controlled to emulate Inertia & Governor Response → Determine system needs & validate at scale for actual system disturbances

Graphics Source: LBNL-4142E Use of Frequency Response Metrics to Assess the Planning and Operating Requirements for Reliable Integration of Variable Renewable Generation, Prepared for Office of Electric Reliability Federal Energy Regulatory Commission, Dec 2010

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Influence to the Grid

Protective Devices Settings and Coordination

Increased Short Circuit Currents

Safety Issues

חברת החשמל

Thank You !