PV Grid Integration – System Management Issues and Collaboration Aspects

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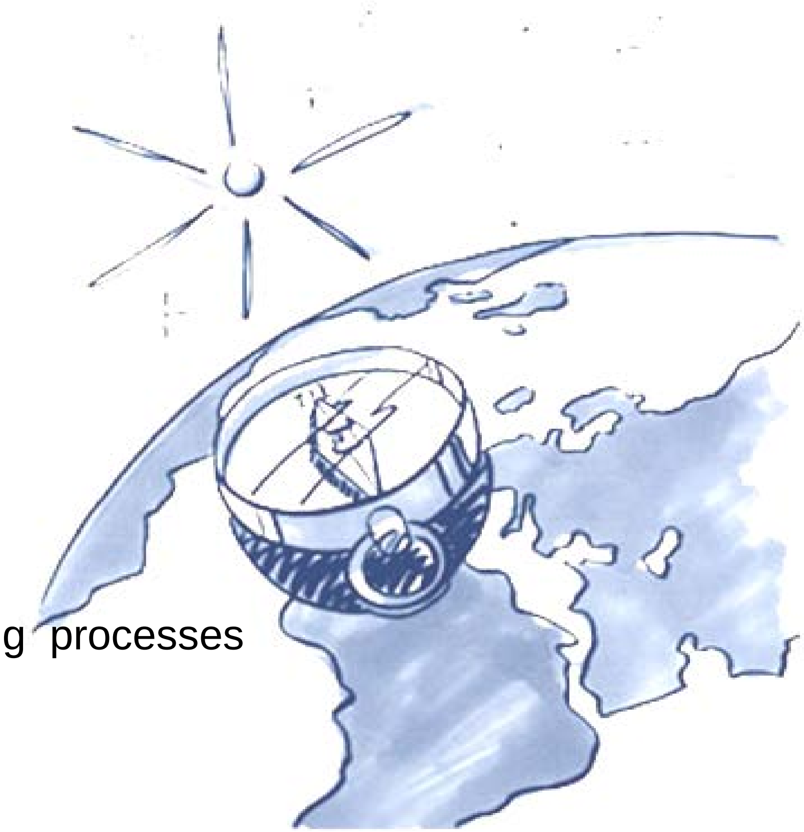
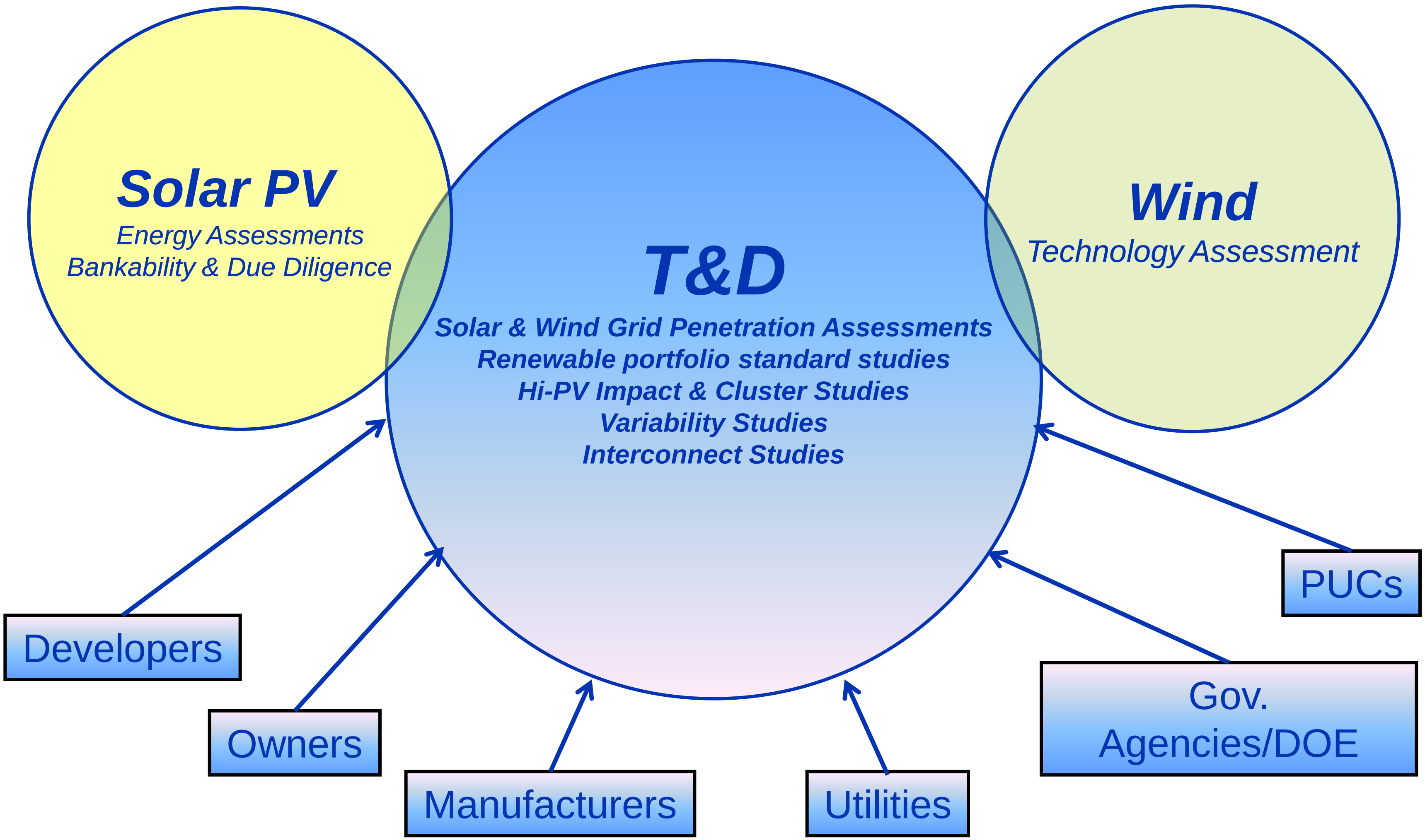
Highlights

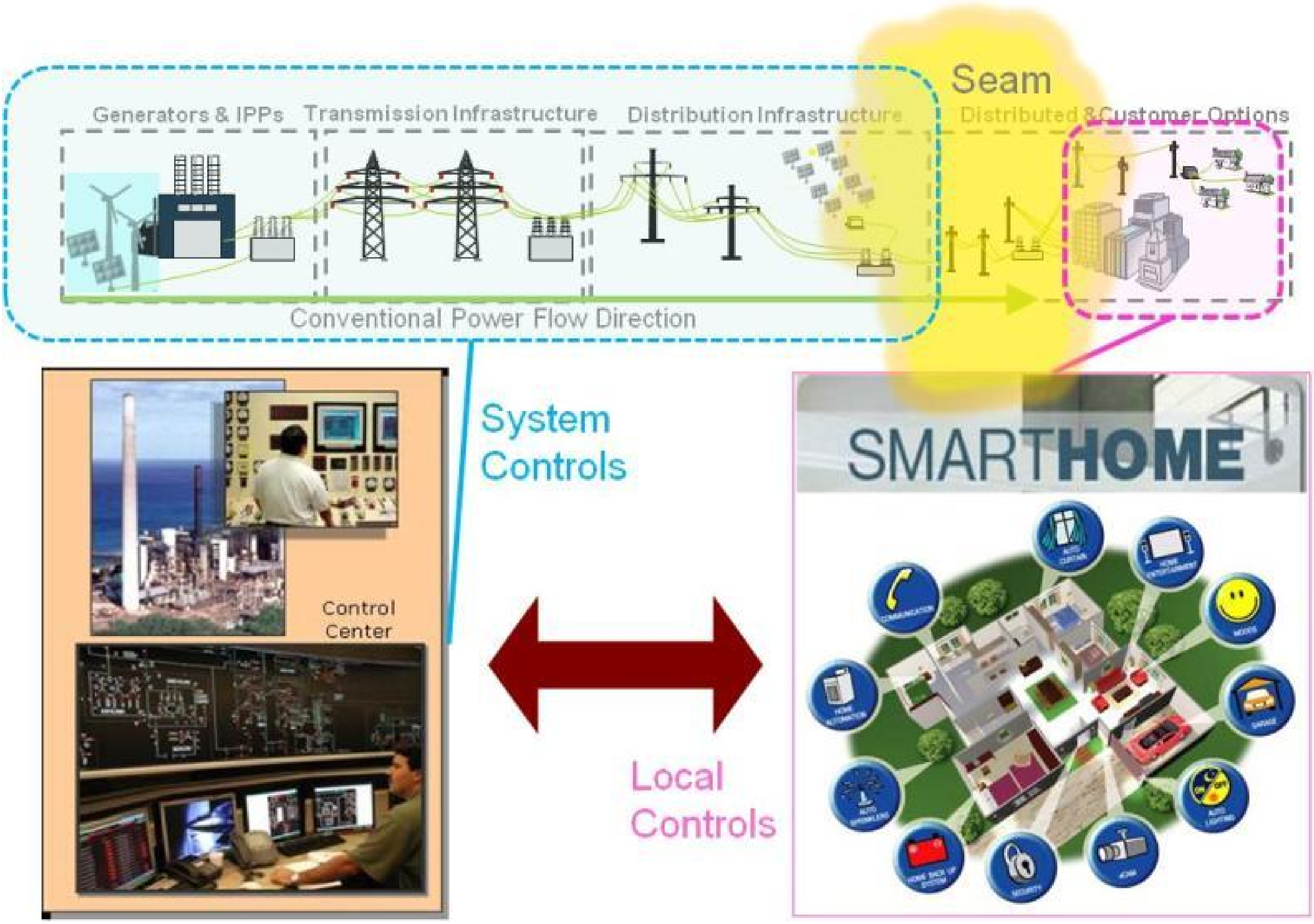
- **DNV/BEW Perspective**
- **Some Industry Concerns of Renewable Integration**
  - Inherent variability of solar
  - Lack of appropriate and standard models
  - Lack of performance data for validation
  - Non-standard distribution systems across the nation
- **How to prepare for the integration of high penetration of PV**
- **Options/Solutions**
  - Adapting codes and standards
  - Updating models
  - Validating new technologies
  - Utility collaborations to understand impacts to existing processes
- **Q&A**



BEW Engineering and Consulting Service Areas



Electric Sector Paradigm Shift



Work needed to bridge the gaps - “Seams” Infrastructure and Control Interface with Utilities

Source: D. Nakafuji, HECO

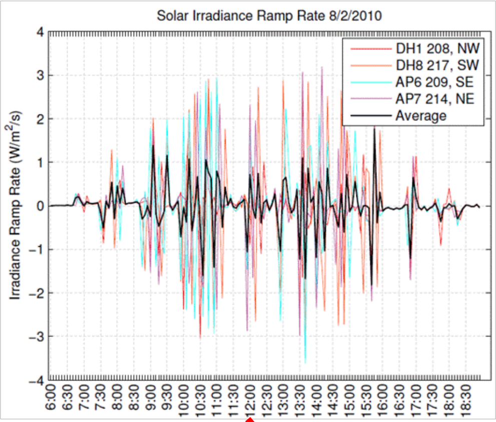
BEW/DNV Perspective

- Emerging levels of distributed generation "behind-the-meter" generation is increasing
- Levels are exceeding "rules-of-thumb" used in standard utility practices for planning
  - Installed levels of DG are a continually moving target
- Industry lacks capability (tools/data) to effectively plan for PV impacts on the grid
- Currently no cost-effective, commercially available capability exists to meet solar forecasting needs and industry standardization of monitoring equipment is lacking
- Integrating utility departments and software communications is essential for sustainable renewable deployments
- Developing a collaborative of utility staff, developers, regulatory agencies to develop a cooperative framework for a sustainable and cost effective renewable expansion plan
  - Combining utility optimal locational value of development strategies with public and private preference
  - Integration of energy efficiency, renewable development while reducing greenhouse emissions

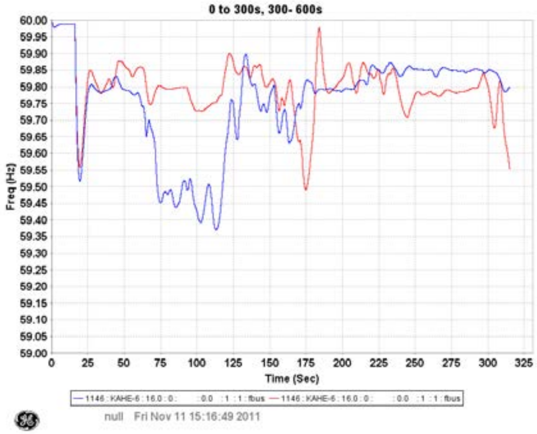
Real World Integration Issues

- Lack of recorded PV generation and customer load profile changes
  - Operational observability is limited in renewable fields
- Accurate distribution system modeling
  - Limited validation of models with recorded data
  - Accurate modeling of single phase and three phase PV inverters and generator characteristics
    - Quality is varied
- Integration of customer-owned generation with utility owned generation
- Maintaining performance, reliability and safety is the key for utilities
- Utility interconnections need to be considered in the mix

- Variability is often not quantified accurately due to lack of predicted/validated/measured data



Irradiance ramp rates translate to system frequency impacts through detailed simulation



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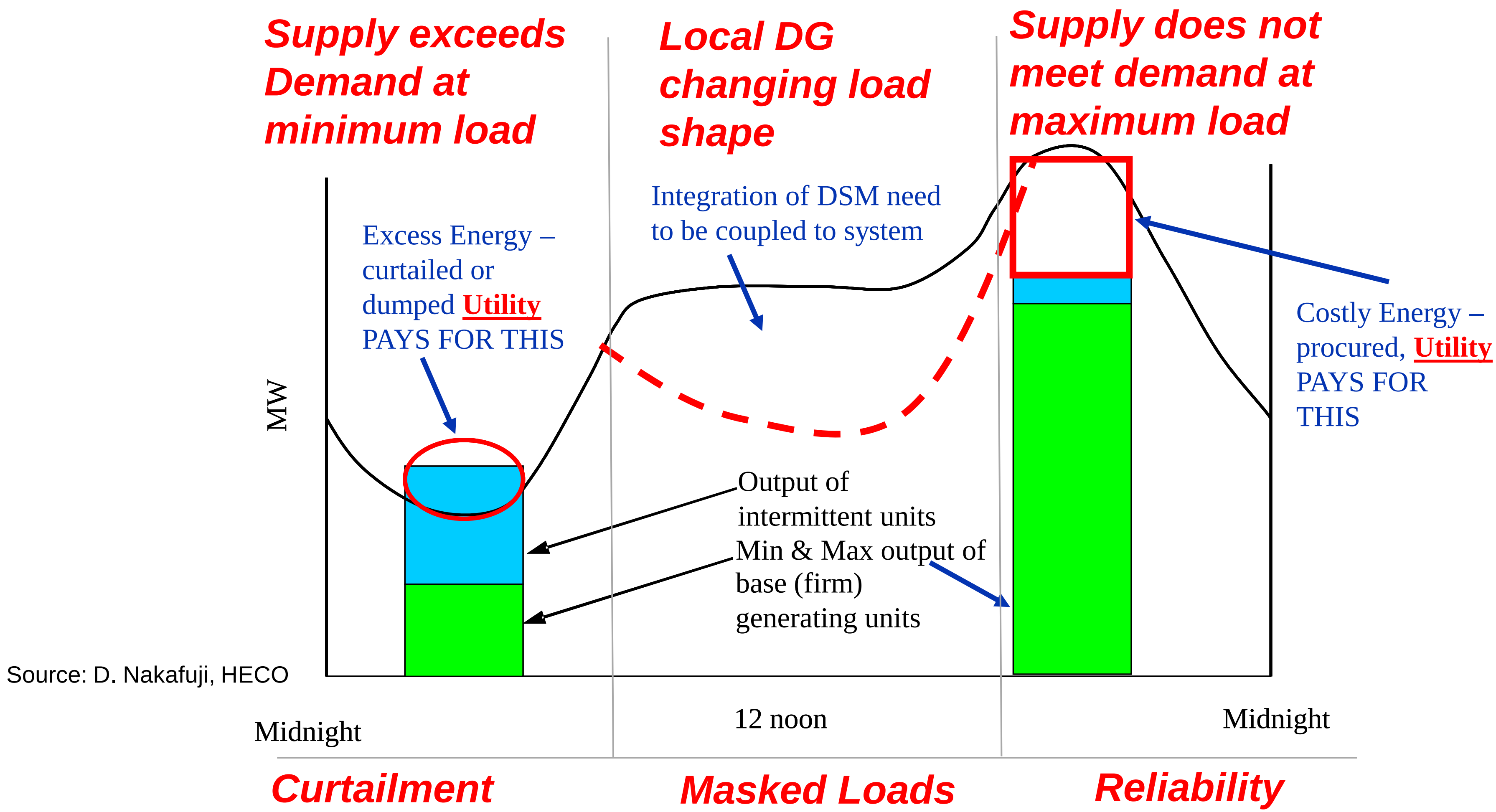
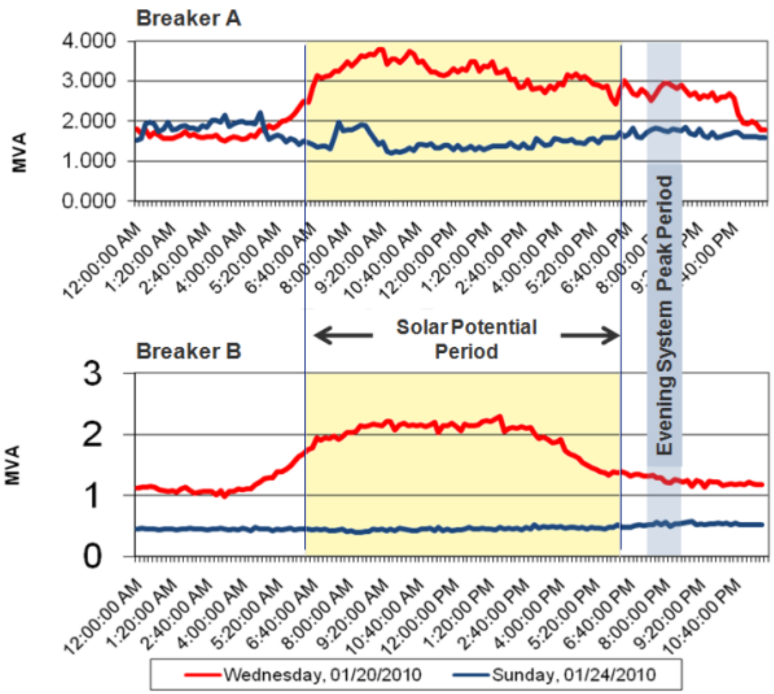
Issues Being Encountered as Penetration Increases



Feeder and System Load Impacts

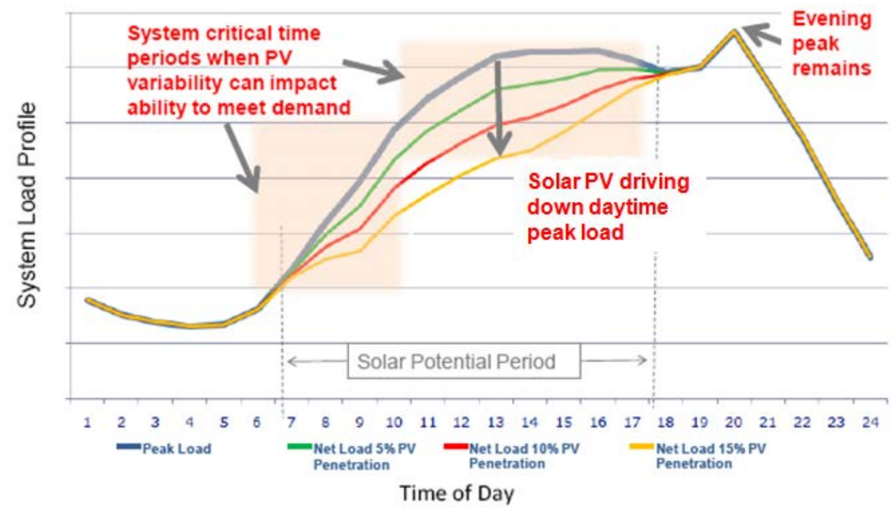
- Local Feeder Load Impacts



Concerns:

1. Need to assess the feeder loading not only at peak periods but also when the loads are lower (light load Sundays) – Rule 14H
2. Circuit peaks often not coincident with System peaks

- System Load Impacts

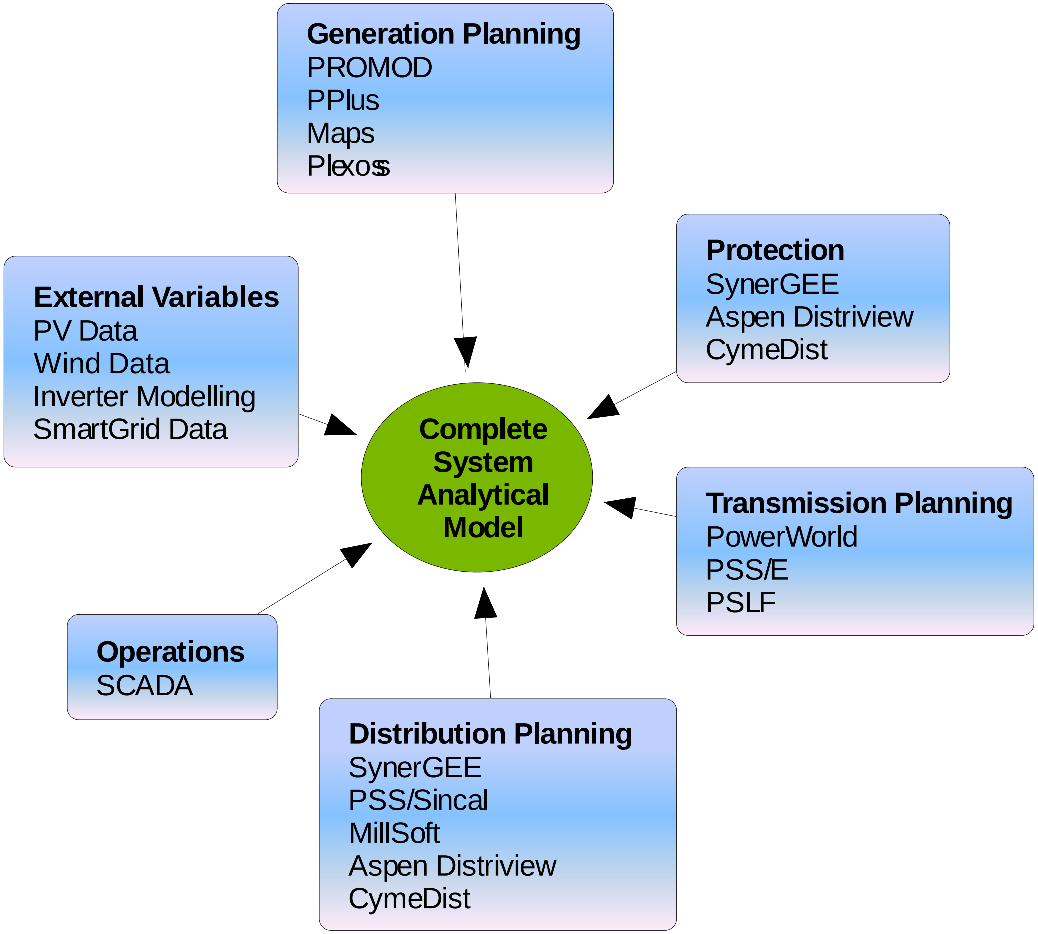


Concerns

1.PV provides energy (kWh) for day time load but misses the evening peak

2.Dispatchable resources need to be available to meet evening peak load

Graphical Flow of Model Interfaces – Bringing together Modeling, Data and Departments



- The existing models are not designed to simulate the operation of large numbers of distributed resources
- Conversion of single phase and poly-phase PV inverter characteristics from an unbalanced distribution model to a balanced transmission model
- Highly variable PV systems must be analyzed in a detailed dynamic and steady state simulation
- As more detailed inverter control schemes become widely available to customers the impact must be justifiable and proven through simulation
- Availability of measured data is essential for validation and lacking in many cases

Source: R. Davis, E. Stewart; BEW; Solar Power International.

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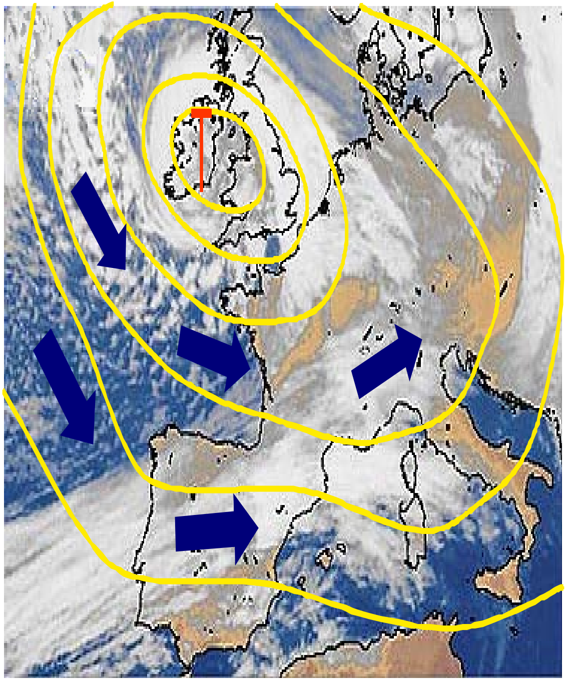
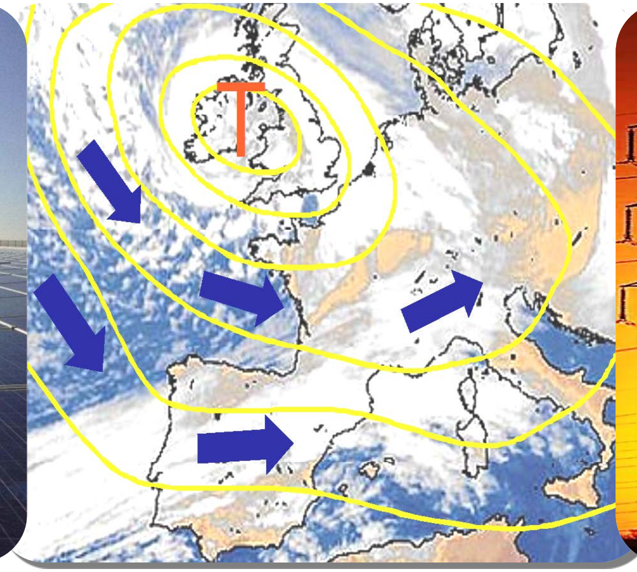
Many Different Disciplines… Must Understand Each Other



	Photovoltaic	Meteorology	Utility Network
Main topic	Financial Profitability	Weather of tomorrow	Load Balancing/ Integration of transmission and distribution
Heartbeat	1 Second	1 Hour	15s to 15 Minutes
Forecast	years	days	Tomorrow 8h00, 8h15,…

Options/Solutions: Energy Meteorology



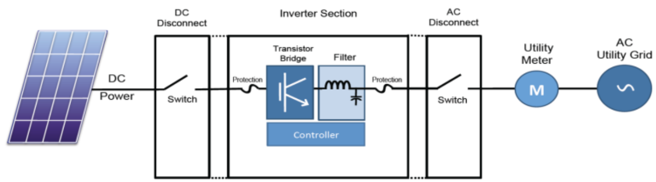
- Adapt PV systems to the energy economy and utility system management aspects
  - Real time data for observeability
  - Interaction
  - Grid assistance

- Develop forecast products to the needs of the variable renewable power
  - Higher time resolution
  - New forecast parameters (ramps)

- Invest into energy meteorology
- Adapt utility grid to variable distributed power input

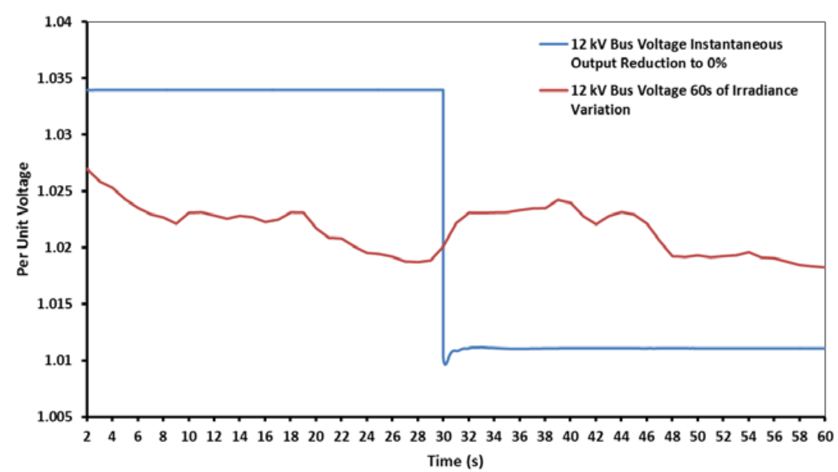
Present US DG Standards Status

- PV Inverter implements the interface to utility grid



- In US - designed to meet IEEE 1547
  - Based on low penetration installations from California Rule 21 which is 15%
- Listed to UL-1741 (harmonized with IEEE 1547)
  - Anti-Islanding
  - Tight over/under voltage and frequency trip settings
  - Unity Power Factor
- Purpose is to get out of the way in fault condition and let existing utility protection scheme operate
  - May contribute to cascading faults

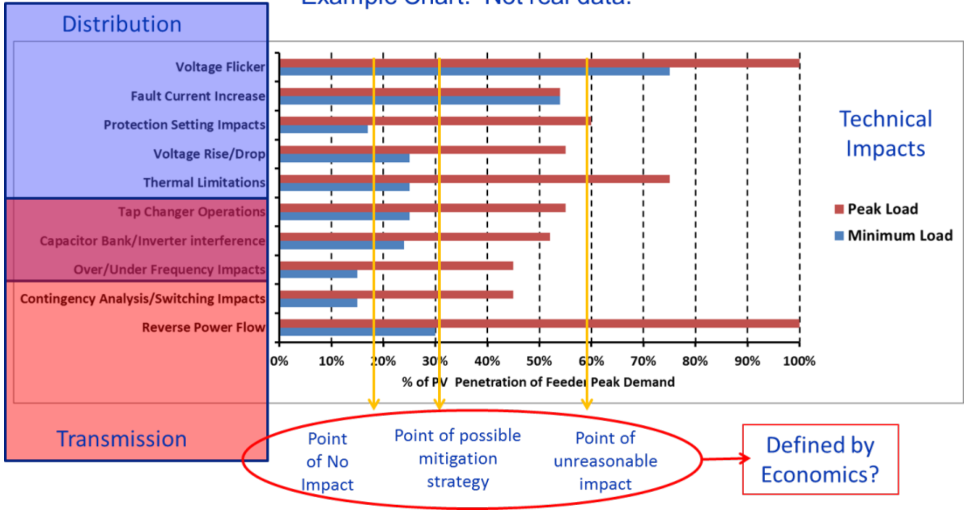
- Harmonics and Flicker Requirements
  - IEEE 519 - 1992
  - IEC Standard 61000-3-6
- Perception vs. Reality
  - Lack of measured data ties utilities/developers hands, and hinders interconnect process



Benefits of Collaborations

- No man is an island – utilities can work together – may not be interconnected physically but lessons can be learned throughout
  - Data can be shared and processes informed
  - Cost sharing
  - How much data needs to be collected? What can you learn from it?

Example Chart: Not real data!



- SMUD & HECO collaborating on Hi-PV studies
- Clusters of individual sites can be considered vs. a study on each individual generator
  - Limitations on interconnections can be better informed, costs shared
- Instead of connecting PV on every feeder in California and Hawaii up to 15% of Peak BEFORE considering detailed impacts
  - First one over 15% is the issue
  - Waste of resources/Time
- Analyze detailed impacts of clusters and inform where more or less can be added

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Lessons Learned (So Far!)

- Multiple criteria must be considered at both the steady state and dynamic level to assess feeder level and system wide penetration levels
- Availability of measured data is essential for validation and lacking in many cases
- Highly variable PV systems must be analyzed in a detailed dynamic and steady state simulation
- Feeders can be characterized in terms of load type, geo location, voltage, and PV penetration
- Commercially available tools must be integrated and used for different tasks
- As more detailed inverter control schemes become widely available to customers the impact must be justifiable and proven through simulation
- Availability of measured data is key to fully understanding impacts and sustainable development
  - Software integration is essential for maintaining growing portfolio
- Issues traditionally considered 'key bottlenecks' to increase in penetration are often wrongly perceived
- Utilities must prepare for high penetrations of variable resources and get ahead of the curve
  - Utilities must pre-plan for upgrades and operational changes ahead of time
- ***All stakeholders must find common ground for continued sustainable development***

Thank You!

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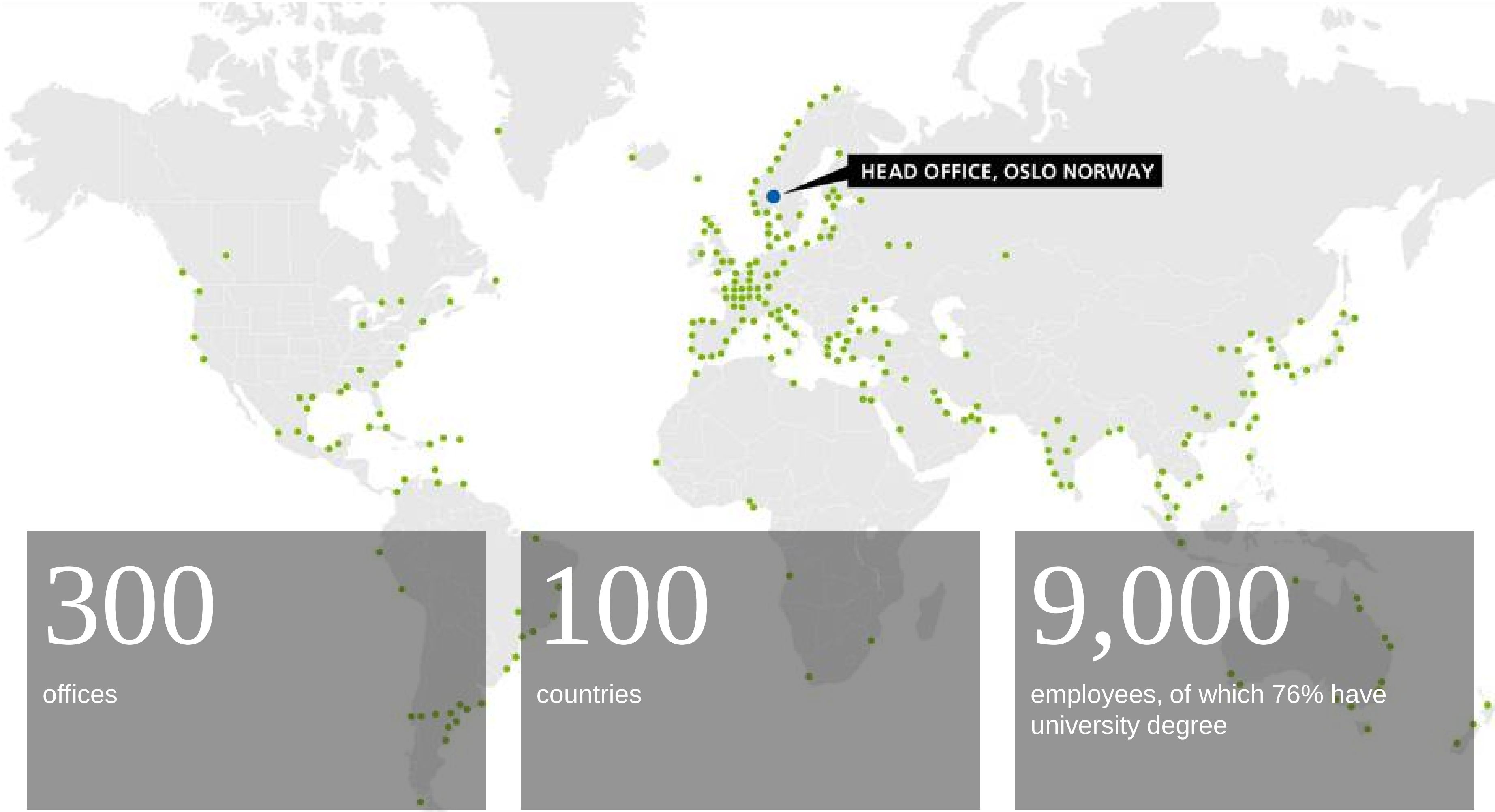

300

offices

100

countries

9,000

employees, of which 76% have university degree

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Preparing for the Integration of High Renewable Penetration

- Load Forecasting, PV locational maps

- Distribution feeder analysis
- Feeder-Substation-Area-Utility wide

- Transmission planning
- Impacts of DGPV and central PV plants.

- Generation planning
- Conventional resources needs, spinning, ramping, etc

- Protection, operations, finance

Two schools of thought for PV penetration impacts studies

Traditional Representation of PV from a transmission POV

Recommended Representation of PV for a Transmission Analysis