# EUEC 2012 Conference
# Case Studies on Impacts of High Penetrations on Distribution Systems

DNV-BEW T&D Department
Ron Davis, Director of T&D
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EUEC 2012
Energy, Utility & Environment Conference

BEW ENGINEERING

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# Overall Objectives of Distribution Feeder and System Studies

- Sacramento Municipal Utility District (SMUD) and the Hawaiian Island Utilities (HECO, MECO and HELCO) are jointly studying the impacts of high penetrations of distributed PV
  - Assess potential system wide PV penetration on the distribution system
  - Feeder and Substation penetration limits
    - PV penetrations per individual feeders will vary
    - Summation of feeder PV not equals system total
  - Study of individual feeder impacts provide insight to the potential barriers and issues, restricting high penetrations
    - Provide analysis framework on both a feeder and system wide scale
    - Proactive approach to solving potential barriers before these occur

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# Distributed PV Study Conditions

- Steady State Minimum and Maximum Loads
  - Voltage, Line Loading, LTC operation, Reverse Power Flow, Protection, Time Sequential Modeling,etc.
- Contingency/Switching Routines
  - Outage of critical elements under varying renewable generation and switching routines during maintenance
- Transient and Dynamic
  - Frequency, Fault Current, Flicker, Harmonics, etc.
- Nodal PV Energy Estimating

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# Approach and Methodology

**Monitoring**
- Engage field personnel
- Gather & gain insight

**Modeling**
- Simulate response
- ID impact & sensitivities

**Validation**
- Pilot & iterate
- Communicate results

**Integration**
- Implement & re-evaluate for Ops & Planning

- Identification of high penetration feeder circuits
- Evaluation of load characteristics over a period of time capturing high and low load conditions
- Characterize circuit based on loading profile and generalize for modeling purposes
- Gather field data for validation
- Conduct detailed circuit level analysis using models
- Aggregate single phase unbalance circuit model to 3-phase equivalent
- Feed distribution impacts into system level models
- Continue monitoring and model validation as part of planning process
- Develop visualization tool and decision aids for operations & planning

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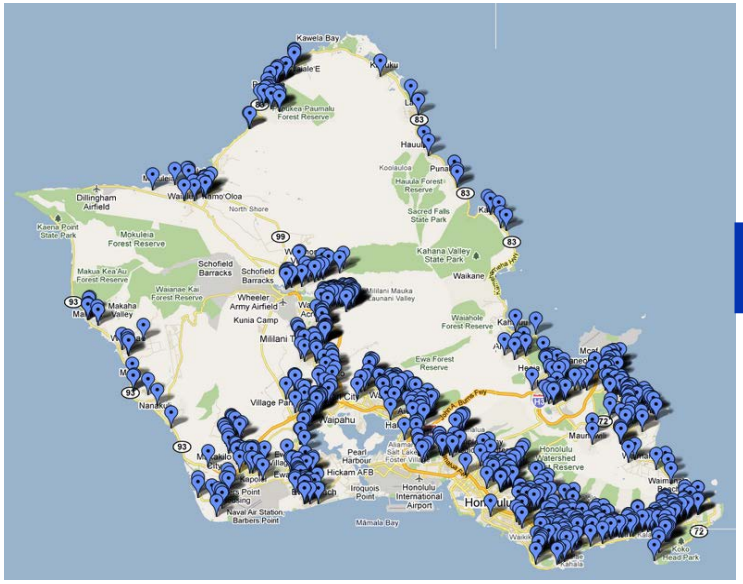
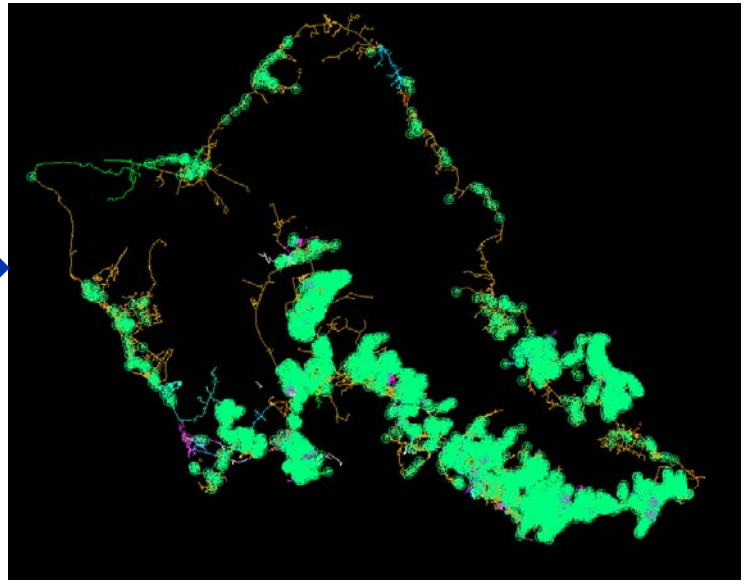
# Model Development: Adding Existing PV to Model





- Excel & Access
- Input from utility
  - Address
  - Rated kW Capacity
  - Feeder
  - Phasing at point of interconnection
- For each existing PV unit
  - Convert address to geographical coordinates (X,Y)
  - Match to nearest node with same feeder & phasing

- Aggregate existing PV units as necessary
  - Single phase to three phase balanced model
  - Aggregate to three phase only but include dynamic characteristics of single phase inverters

Source: HECO

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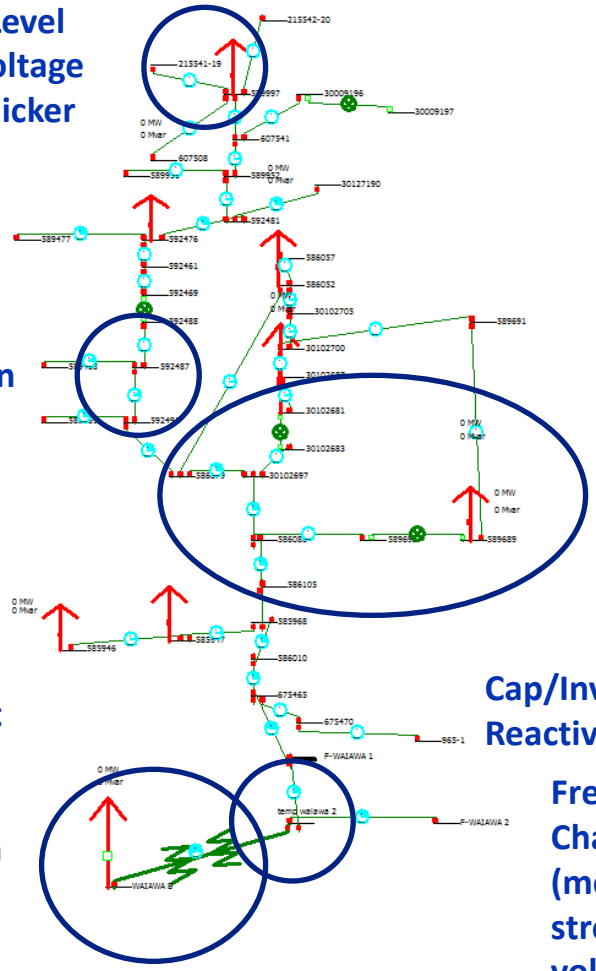
# Feeder and Substation Issues – Example of Definition Levels

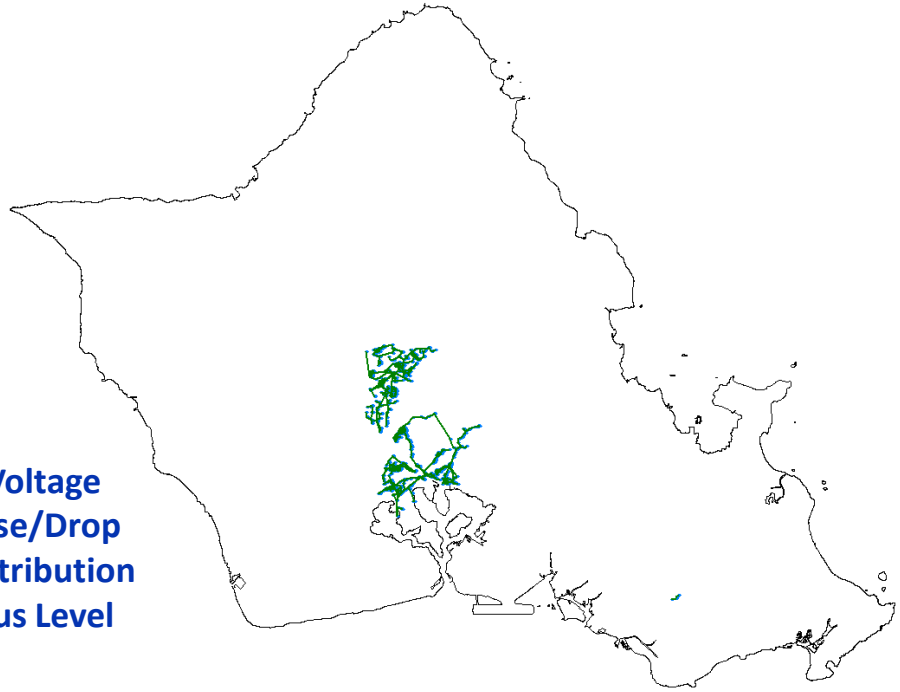
**Customer Level Voltage Flicker**

**Thermal Overload Limitations on Distribution Lines**

**Fault Current and Protection Coordination**



**Voltage Rise/Drop Distribution Bus Level**



**Cap/Inverter interaction Reactive power impacts**

**Frequent Tap Changer Operations (mechanical stresses, unwanted voltage changes)**

- Unbalanced PV penetration on a transformer
  - For example if W1 had 50% and W2 had 0%, would the tap changer lower the voltage too far for the non loaded transformer

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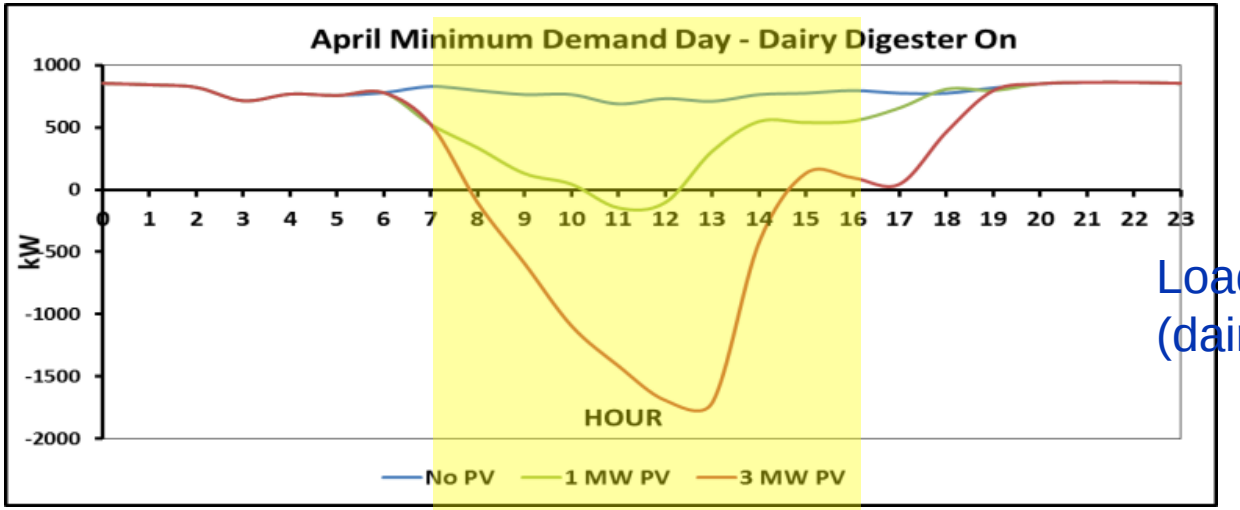
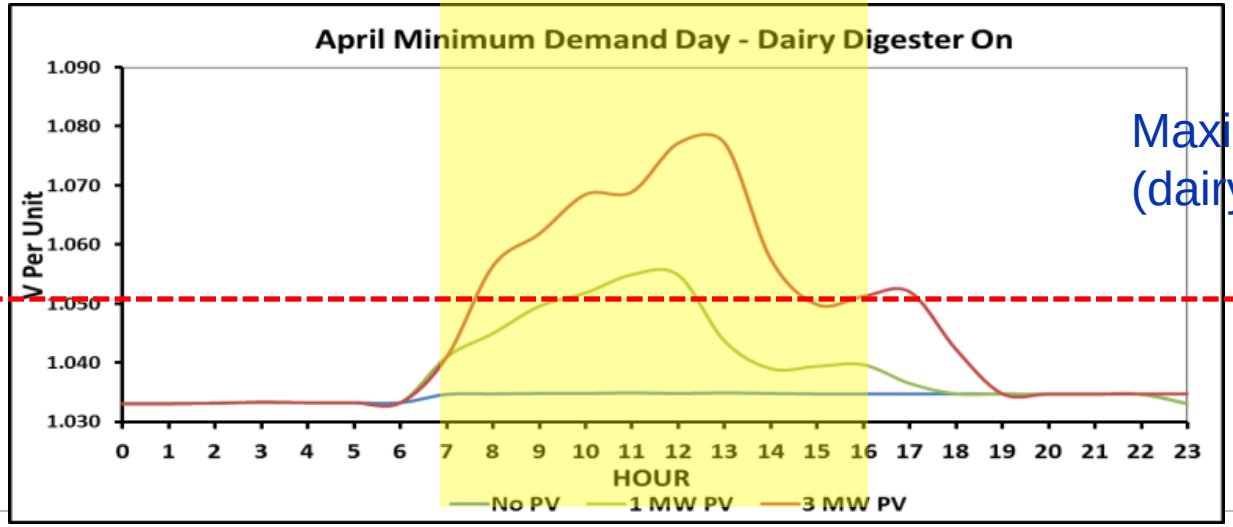
# SMUD Circuit at 3 MW




Load Flow Results
(dairy digester on)




Maximum Voltage Results
(dairy digester on)

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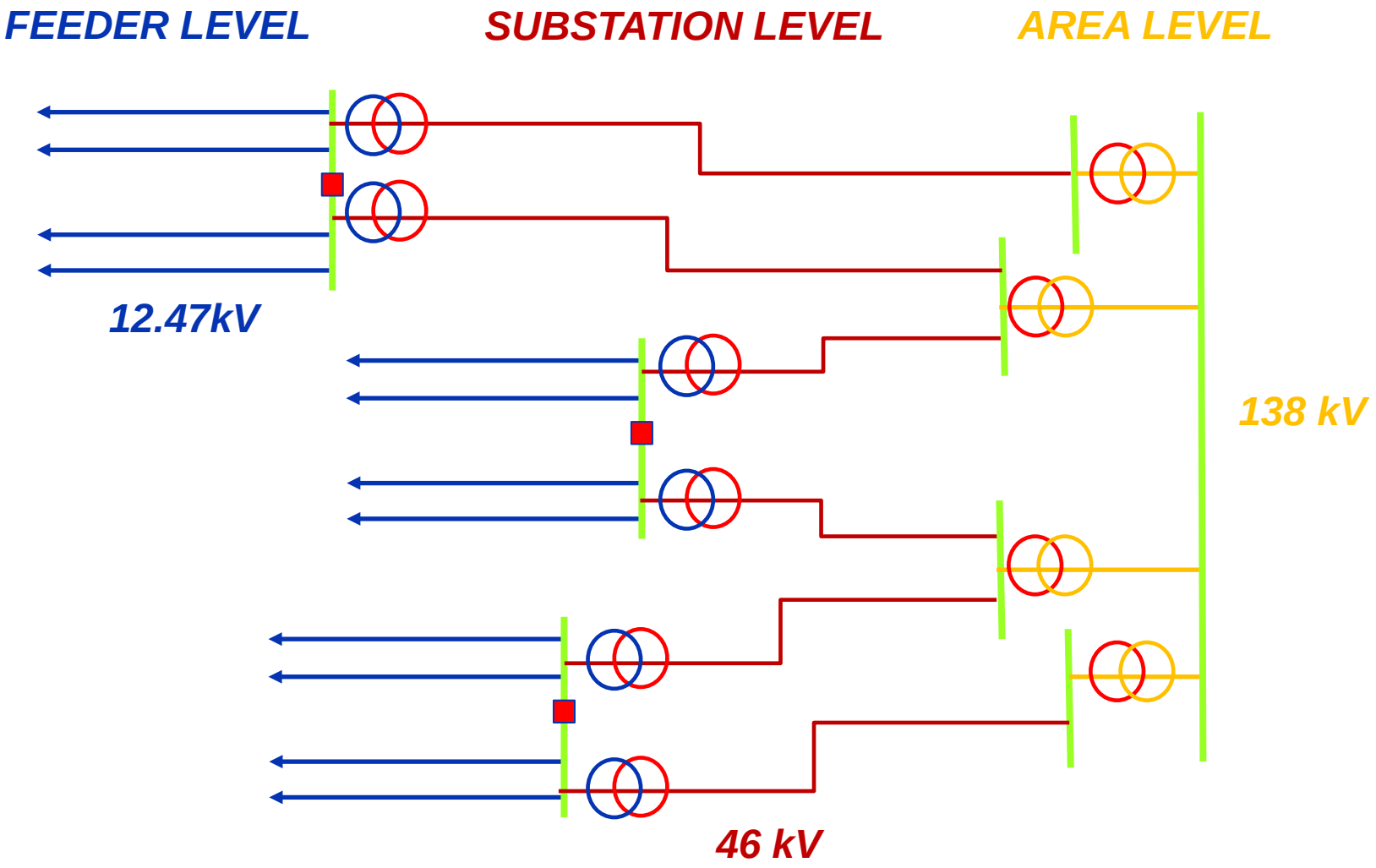
# Defining Analysis Groups

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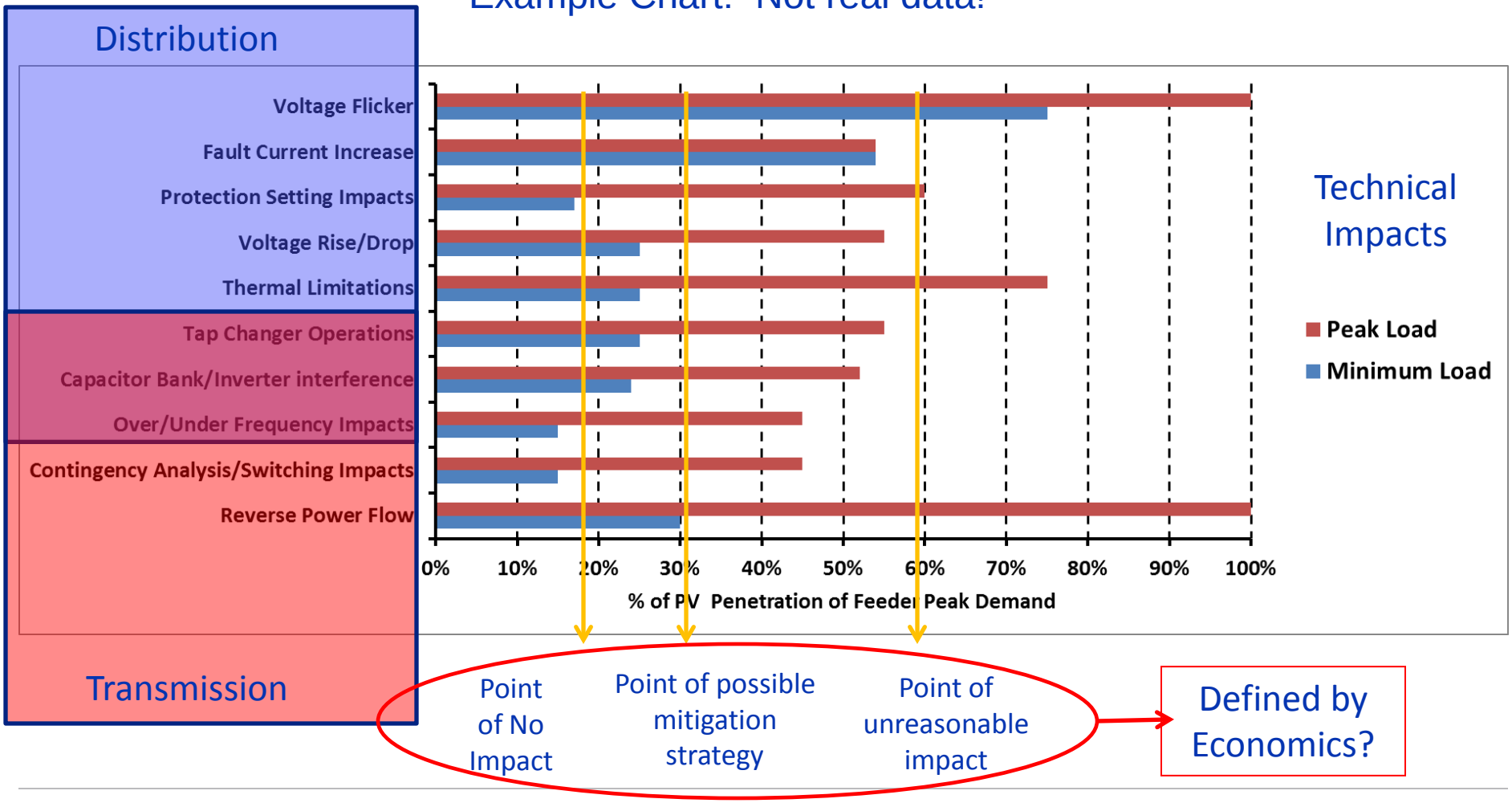
# Goal of Steady State Analysis Studies

Example Chart: Not real data!

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# HECO and SMUD Lessons Learned

- 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 **(PROACTIVE PLANNING)**
- Utilities must pre-plan for upgrades and operational changes ahead of time
- Commissions, regulatory agencies, developers, manufacturers need to work together on understanding on potential impacts to utility performance
- All stakeholders must find common ground for continued sustainable development

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