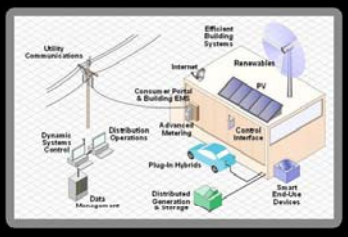
Alex McEachern, Power Standards Lab
http://Alex.McEachern.com
alex@powerstandards.com



Alex McEACHERN – Power Standards Lab – Alameda, California, USA

# Simple Ways that Smart Grids make Power Quality Worse

EPRI Power Quality and Smart Distribution 2012 Conference

Alex@PowerStandards.com

1

## What is the "Smart Grid" ? (1)

- Match the load to the generation, not the other way around

2

Alex McEachern, Power Standards Lab
http://Alex.McEachern.com
alex@powerstandards.com

## What is the "Smart Grid" ? (2)

- Integrate distributed generation (DG) into grid

3

## What is the "Smart Grid" ? (3)

- Allow grid to reconfigure itself for maximum reliability, efficiency

4

Alex McEachern, Power Standards Lab
http://Alex.McEachern.com
alex@powerstandards.com

## What is the "Smart Grid" ? (4)

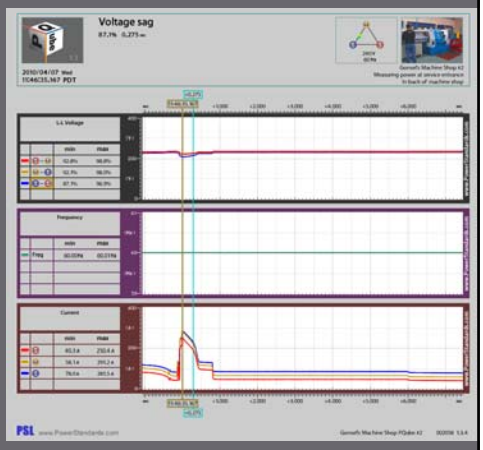
- Improved power quality?

Probably not.


5

## PQ effects – match load to generation

- More loads switching on and off
- More voltage sags from motor starts
- More impulses from inductive loads

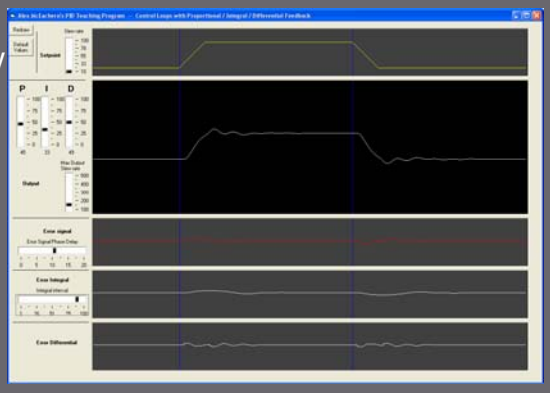



6

Alex McEachern, Power Standards Lab
http://Alex.McEachern.com
alex@powerstandards.com

## PQ effects – integrate DG

- Delays in control loops means less stability, voltage and power flow oscillation
- more likely



7

## PQ effects – integrate DG

- Distributed generation is higher impedance
- Distributed generation has less angular momentum
- In fact, inverter manufacturers take great pride in their lack of angular momentum!


8

Alex McEachern, Power Standards Lab
http://Alex.McEachern.com
alex@powerstandards.com

## PQ effects – integrate DG

- Distribution protection rules of thumb don't work.
- Power quality will get worse.

9

## PQ effects – integrate DG

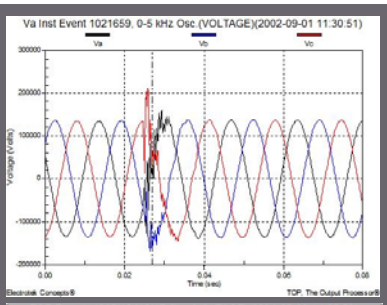
- The storage issue
  - Is storage available?
  - Conversion and stability
- Flicker and wind turbines
- Power quality will get worse.

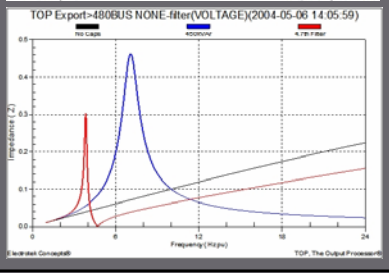
10

Alex McEachern, Power Standards Lab
http://Alex.McEachern.com
alex@powerstandards.com

# PQ effects – grid reconfiguration

- Improved reliability, but more switching events.
- Resonance in some configurations may (will?) make harmonic problems worse.
- Power quality will get worse.




11

# Second-order effects – always a surprise!

- FIDVR, as an example (Fault Induced Delayed Voltage Recovery)


map.PQube.com

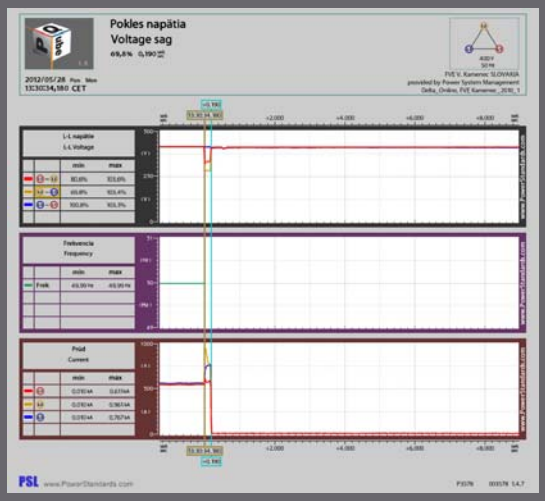
12

Alex McEachern, Power Standards Lab
http://Alex.McEachern.com
alex@powerstandards.com

## Second-order effects – always a surprise!

- Overcurrent trips of solar inverters during sags

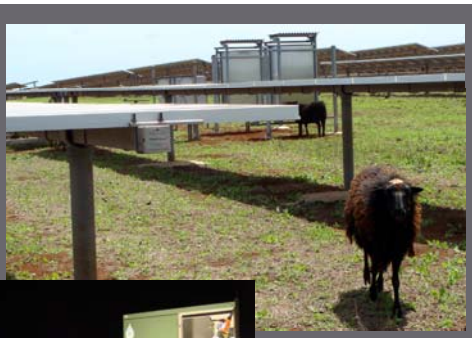
map.PQube.com




13

## Reduced(?) generator diversity

- We know about the importance of load diversity in time
- We don't know much about the importance of generator diversity in time



Also, interesting new work environments…

14

Alex McEachern, Power Standards Lab
http://Alex.McEachern.com
alex@powerstandards.com

## Specific Conclusions

1. Switching loads on and off will probably make power quality worse.

2. Distributed generation may (will?) reduce angular stability in large grids.

3. There is increased risk of harmonic resonance during grid reconfiguration.

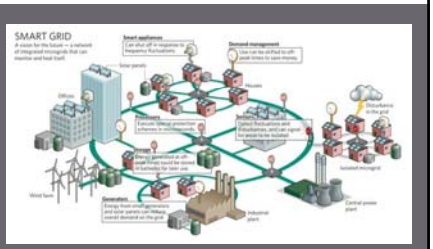
4. Many of the Smart Grid ideas that have great first-order effects, but we don't know their second-order effects.

5. We don't know the first-order effects of reducing or altering generator diversity.

15

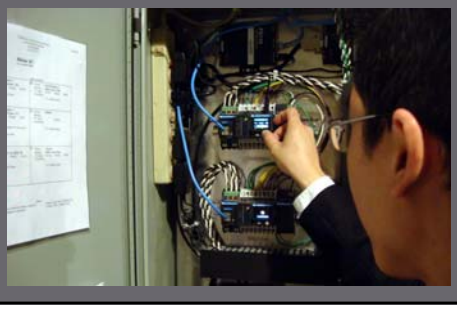
## General Conclusions

1. Smart Grid will make power quality worse, not better. But the benefits of Smart Grid are great, so we should move ahead.




2. But let's pay attention to possible problems!

3. Include complete power quality monitoring, e.g. PQubes, in every project.



16

Alex McEachern, Power Standards Lab
http://Alex.McEachern.com
alex@powerstandards.com