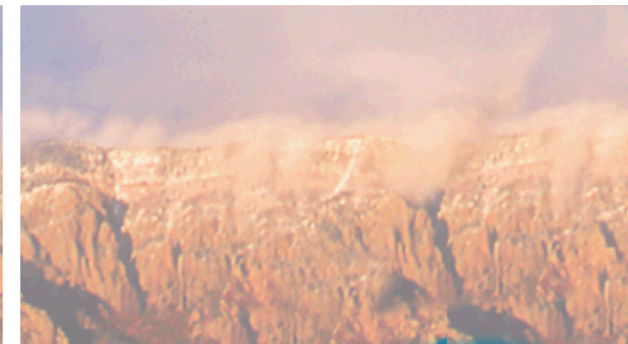


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Analysis of 2 MW of Residential PV Feeder in Ota City, Japan

November 7 Project Briefing

Joshua Stein, Matthew Lave, Abraham Ellis and Cliff Hansen



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Background

There is great interest in understanding the effects of high penetration PV on distribution circuits

Ota City, Japan is a unique test bed for high penetration PV research

Sandia conducted analysis of variability with assistance from Kandenko, summarized here

Purpose of analysis is to understand how PV variability scales with size and density (number of houses) and their configuration in a residential feeder scale

- **Geographic diversity**
- **Distributed generation vs. central plant designs**

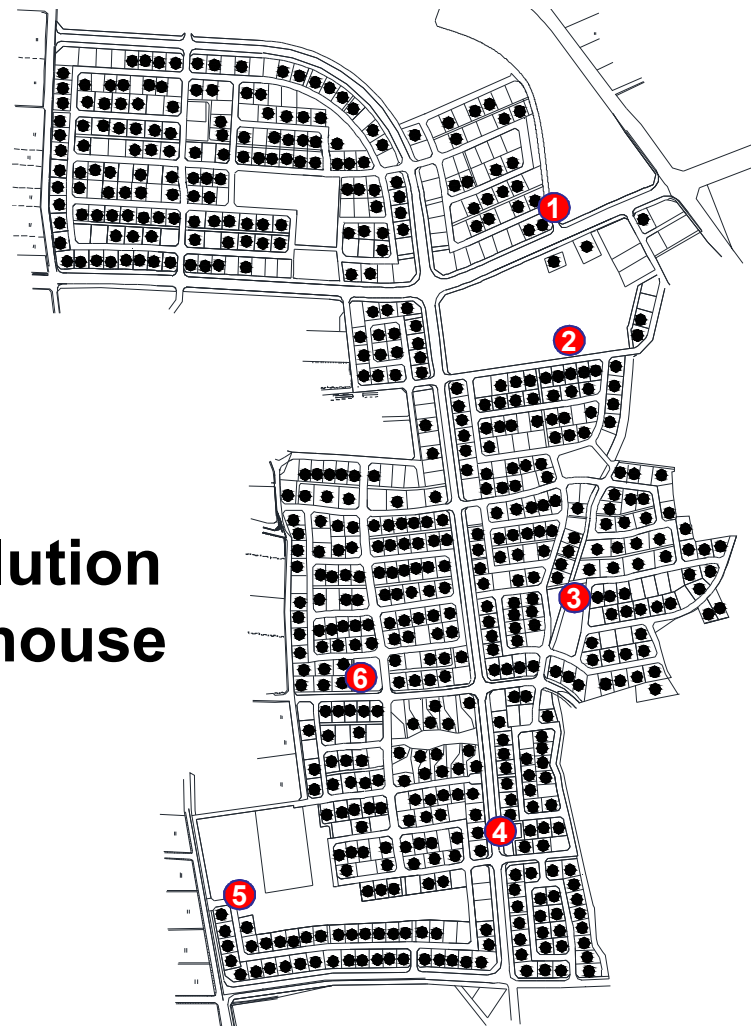
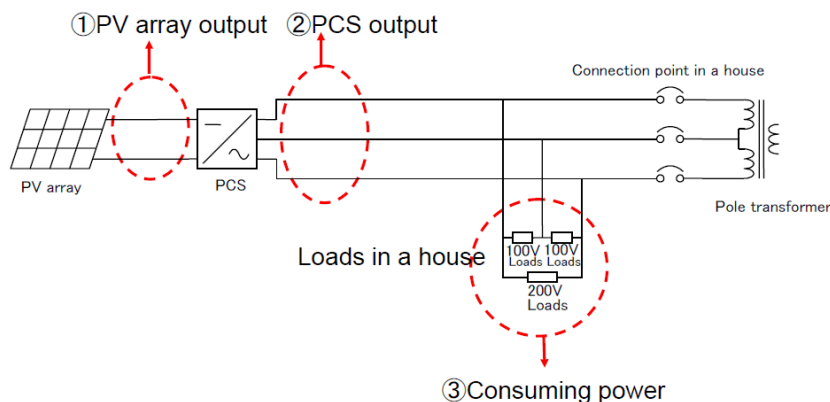
Ota City Data Set

Ota City PV System

- 553 homes with PV
- Single feeder

Data available to Sandia

- 2/1/06 to 12/31/07, 1-sec resolution
- PV output and load for each house
- Irradiance at 6 locations



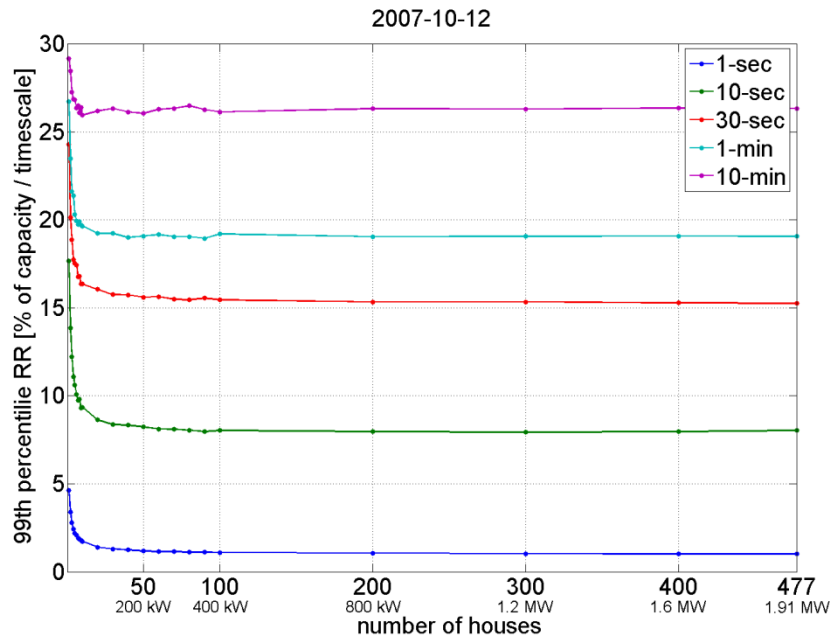
Pictures courtesy of Kandenko

Overview of Analysis

Showed the reduction in variability through 2 different methods:

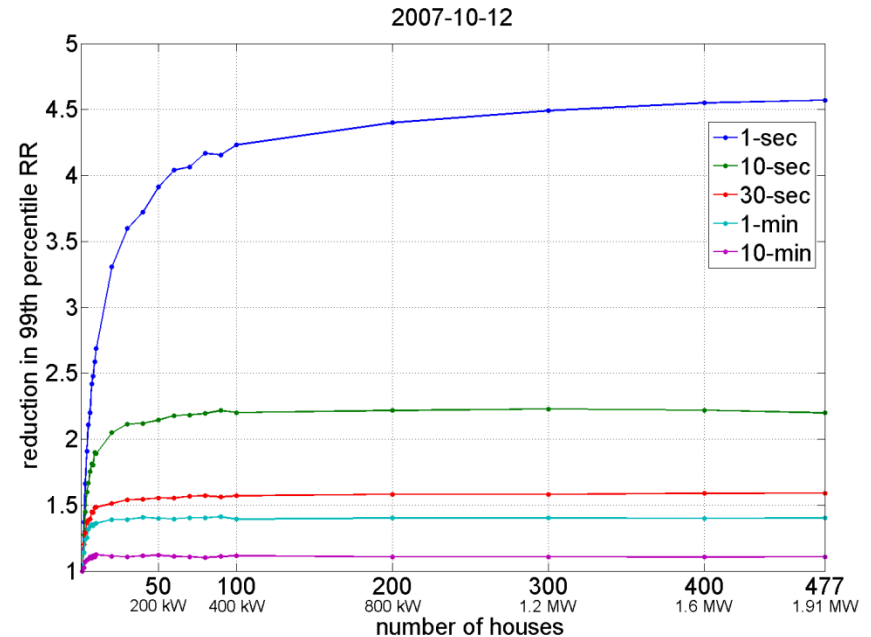
- **Compared Ramp rates (RRs) at timescales of 1-sec to 10-min**
- **Wavelet decomposition to show reduction in variability at various timescales**
 - **Separates fluctuations by time scale**

Ramp Rates Method



RRs decrease with increasing number of houses.

October 12, 2007 was a day with some of the most extreme ramp rates.



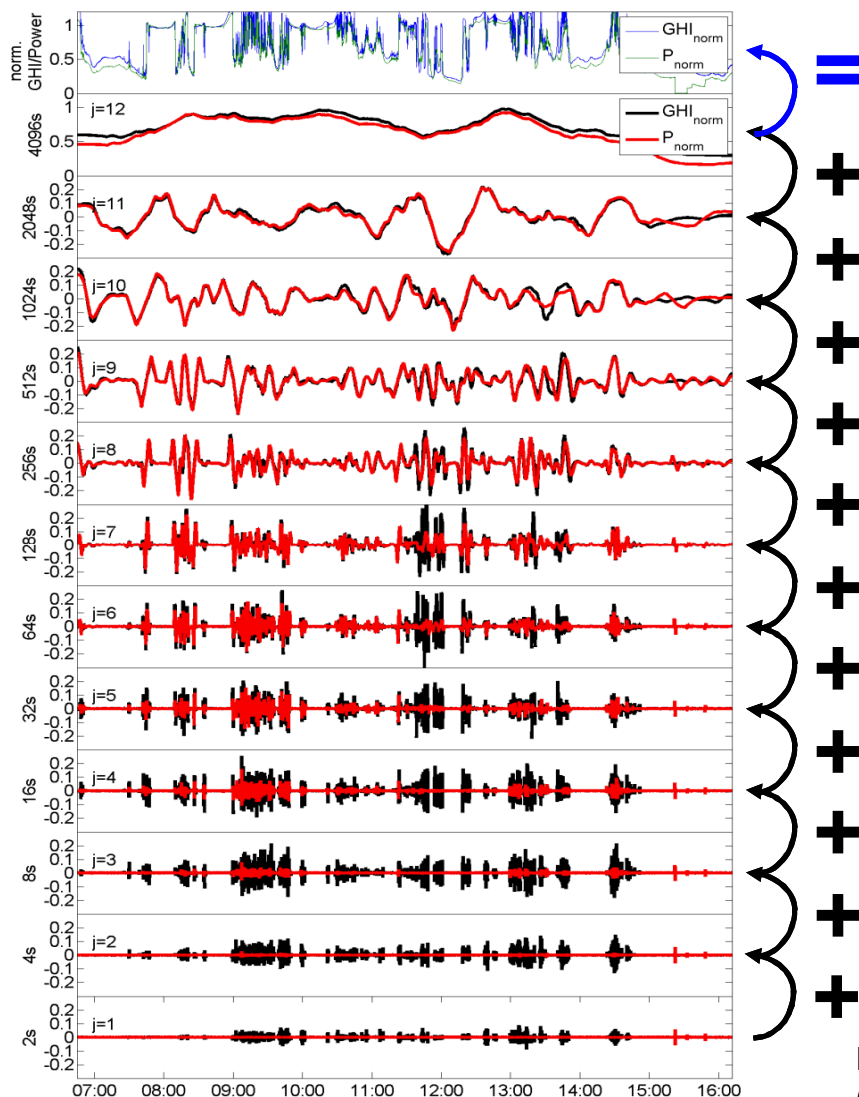
Reduction in RR = $RR(1 \text{ house}) / RR(\text{many houses})$
Large numbers mean large reductions in variability.

1-sec RRs are always reduced as more houses are added, but longer timescales reach a limit at ~50 houses.

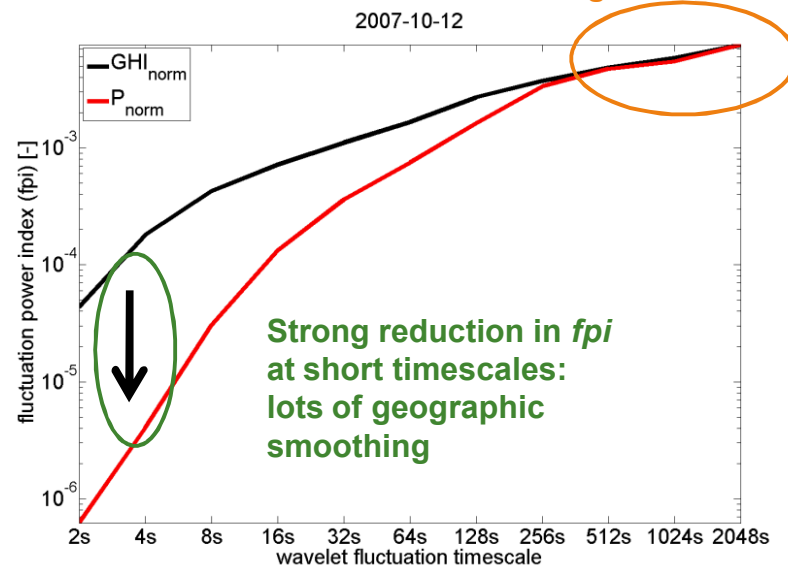
Wavelet Decomposition

GHI sensor = 1 house

2007-10-12



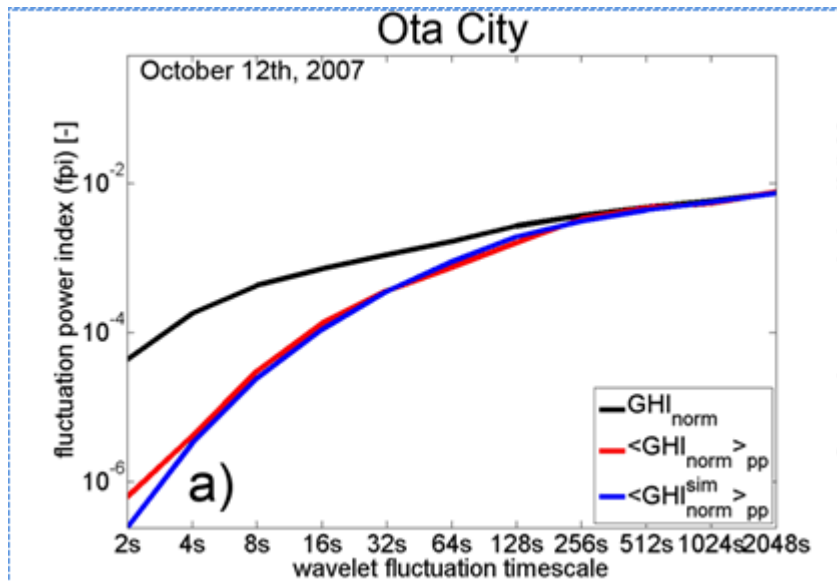
Little reduction in *fpi*
at long timescales:
little geographic
smoothing



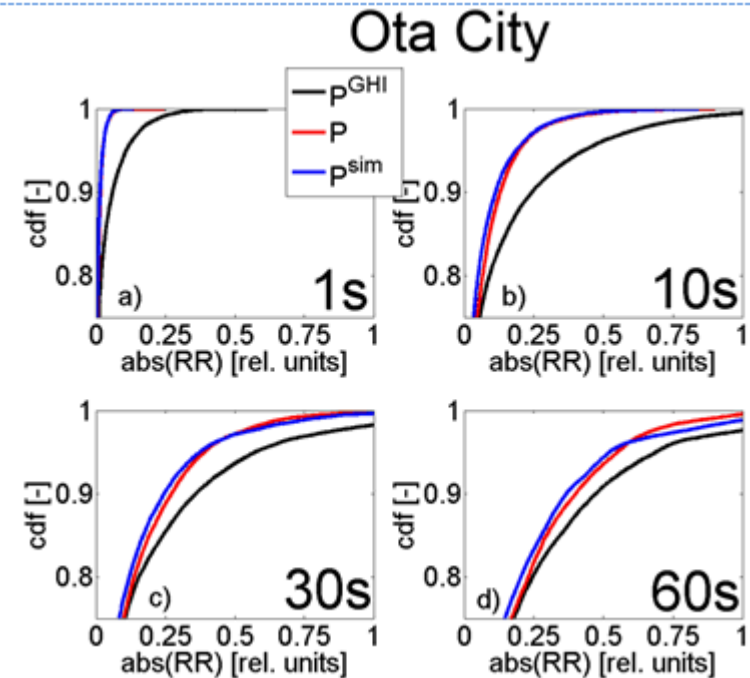
Fluctuation power index = average
magnitude of wavelet modes.

Reduction in wavelet modes of total power output
(red) over GHI sensor (black) at short timescales.

Validation of Variability Models



- Wavelet variability model matches variability



- Wavelet variability model matches ramp rates distributions

Going Forward

- Publish: Technical paper on Ota City data analysis:
 - As a Sandia Report first (in preparation)
 - Submit to Peer-Reviewed Journal
 - IEEE PES, IEEE Photovoltaics, or other

•Ota City: Lessons Learned from a 2MW Residential Rooftop PV System

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- Next, results to be included with other sites for validation in a technical paper describing a new wavelet variability model

Thank You