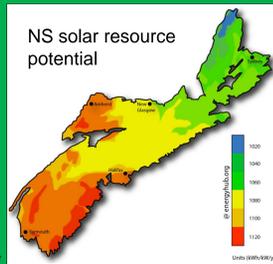


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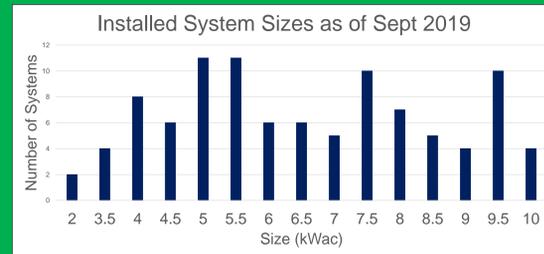
Overview

- Increased awareness about climate change coupled with decreased equipment costs is leading to rapid growth in solar photovoltaic electricity generation worldwide
- The nature of PV generation combined with favorable economic conditions permits commercial and residential building owners to participate in the energy market
- As the amount of PV systems continues to grow grid stability needs to be examined due to the variability of PV output
- Addition of energy storage can help to increase PV penetration and improve grid stability
- Need to evaluate generation characteristics of NS to accurately evaluate storage potential



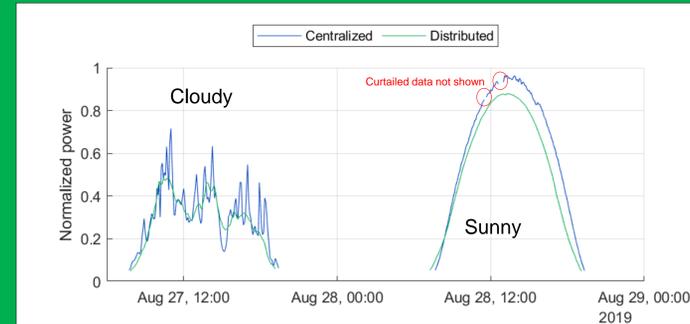
SOLAR CITY 2

- HRM provides preferred financing for solar projects including solar hot air, hot water, and PV systems.
- The systems report data to the city's public data portal
- Currently only systems using a microinverter architecture are reporting data (645 kWac, 99 systems, 2552 panels)
- Systems with over a year of data were used to create an aggregate system (265 kWac, 42 systems, 1093 panels)



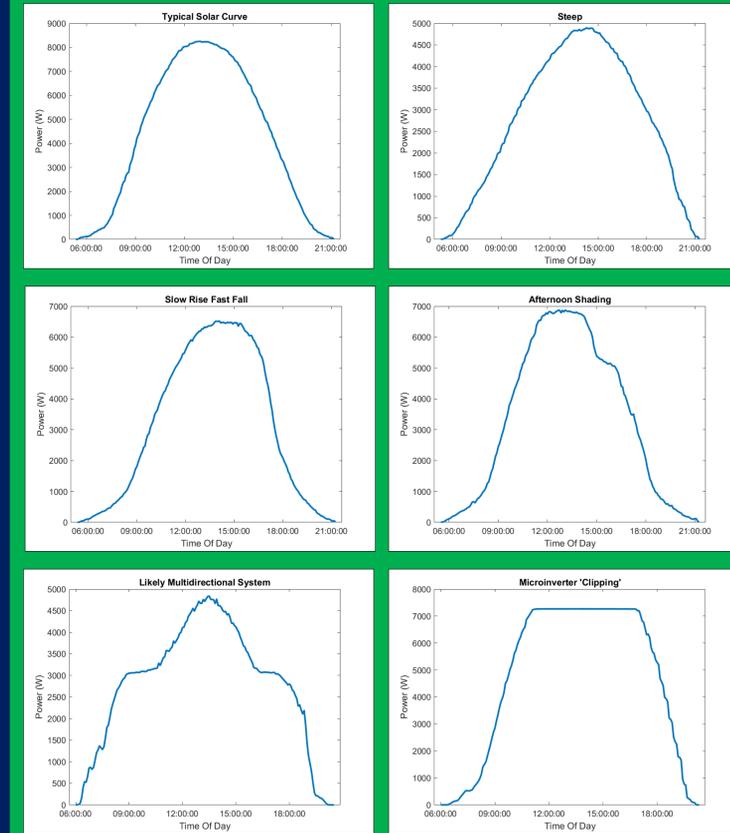
System Profiles

- Cloudy vs Sunny days show how PV output varies
- Centralized system generation more dynamic than distributed



Value of production data

- Modeled solar irradiance or pyranometer data may not capture unique aspects of installed systems. Examples of solar energy profiles from dataset are shown below and illustrate some interesting features of systems.



IKEA Solar Array

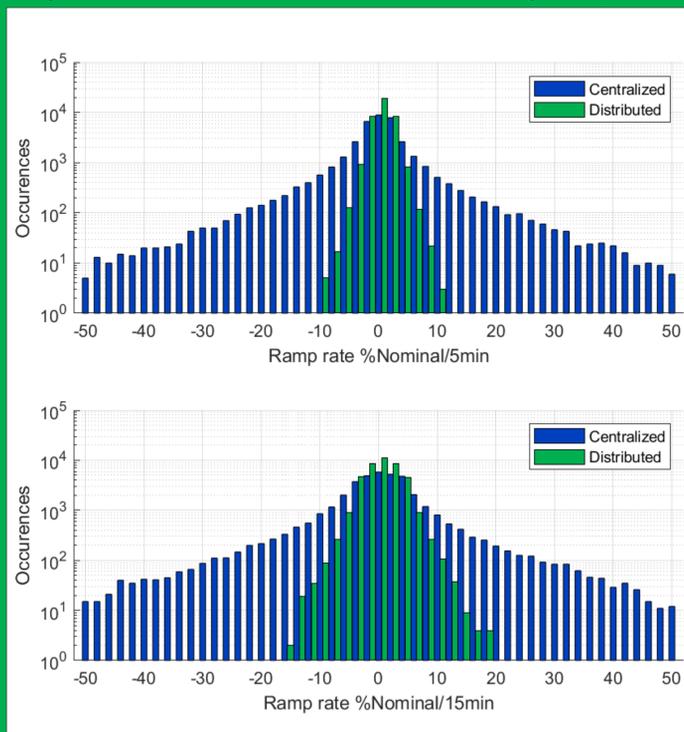
- Located in Dartmouth Crossing
- 28 strings of PV with a nominal size of 850 kWdc (actual output reduced due to low slope and some clipping)
- Provides an ideal centralized system for comparison due to location within HRM and its large nominal capacity
- Curtailed during periods of low building load (or high PV generation) due to backfeed restrictions



Example of system curtailment. PV generation closely follows load during peak generation hours.

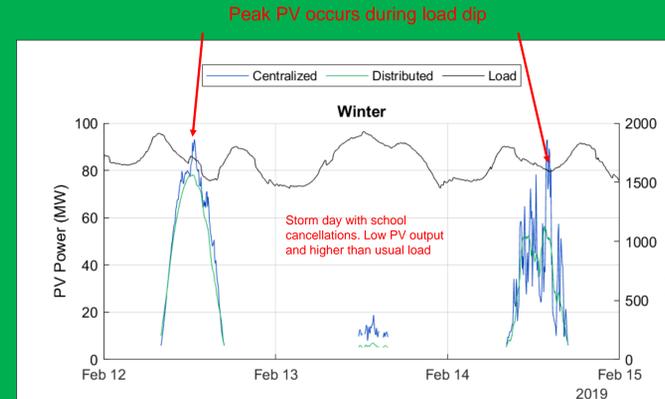
Production Ramp rates

- Large changes in PV output can occur rapidly and put stress on local grid
- The change in the power output of the system over time is referred to as ramp rate
- Centralized PV generation has a wider ramp rate distribution for both 5-minute and 15-minute timestep resolution series
- 23/119 occurrences of ramp rates above 50% for 5/15-minute timesteps of the centralized system
- Timestep resolution important to distinguish more severe ramp rates (greater impact of 50% ramp over 5 minutes than 15)
- Log scale used to emphasize importance of large ramp rates

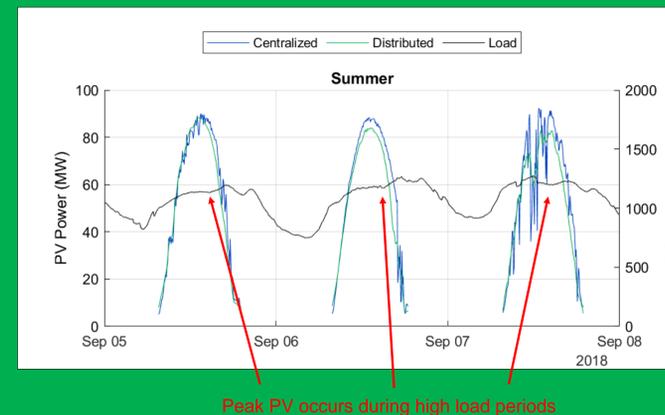


Load integration

- Load alignment of PV generation impacts total system ramp rate
- Load alignment during the winter is poor due to increased heating requirements during the evening. System impacts larger since load requirement grows while generation falls



- Much better load alignment during late summer consistent with increased space cooling demand as opposed to heating



Future Work

- SolarCity 2 dataset is a subset of installed residential PV systems installed in HRM. Addition of more systems may show different trends due to increased influence of physical parameters (predominant azimuth/slope, clipping)
- New PV installations through the Solar Energy for Community Buildings (SECB) program are scheduled to come online this year. Opportunity to investigate distributed generation across the province.
- Use of production data to evaluate energy storage benefits under different market policies

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