Enabling High Penetration Solar with Integrated Energy Storage, Demand Management, and Forecasting

Matt Kromer

InterSolar San Francisco

July 11, 2018

SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA

Building tomorrow's energy future today:

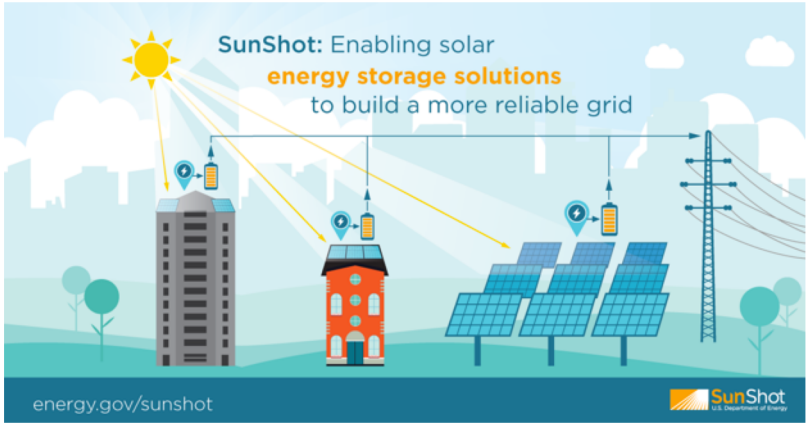
The Fraunhofer Center for Sustainable Energy Systems CSE accelerates the adoption of sustainable energy technologies through scientific research and engineering innovation.

- Non-profit, applied R&D laboratory
- Located in Boston (MA), additional laboratories in Revere (MA) and Albuquerque (NM)
- Founded in April 2008
- ~ 35 employees
- Key R&D Areas
  - PV module and system technologies
  - Energy efficient building enclosures
  - Building energy management
  - Grid integration of renewables
  - Distributed electrical energy systems

SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA

SunDial - Project Overview



nationalgrid

IPKeys

MASSACHUSETTS CLEAN ENERGY CENTER

Powered by SunShot U.S. Department of Energy

Funding provided under the Department of Energy's "SHINES" Program

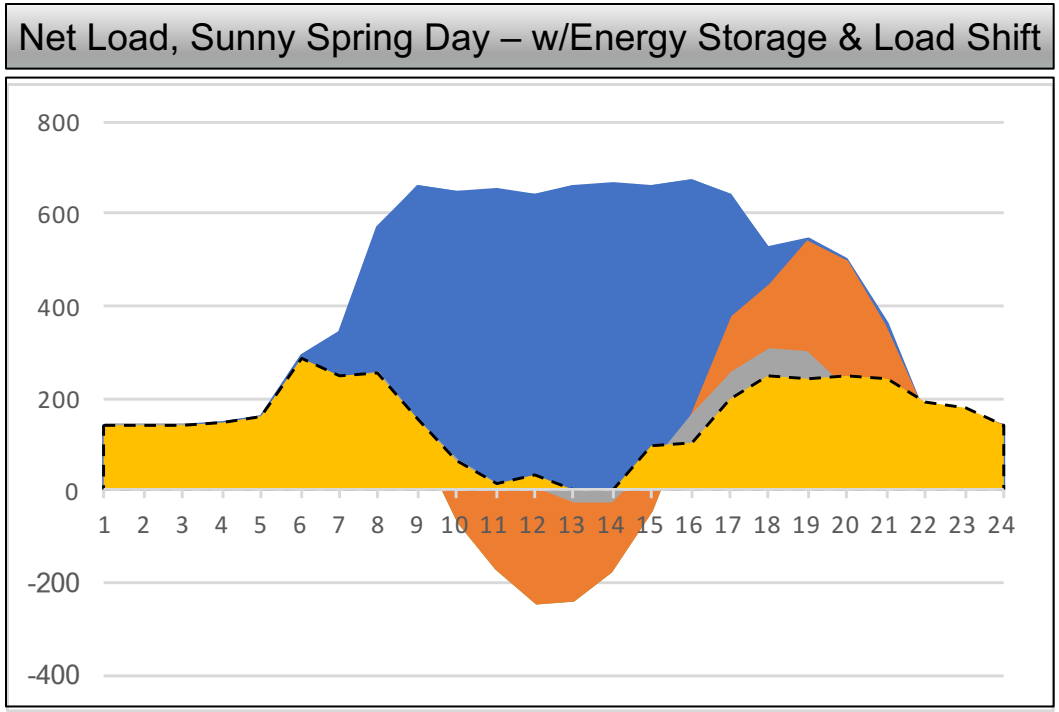
- "Sustainable and Holistic Integration of Energy Storage and Solar PV"
- Six projects awarded, each with substantial utility involvement
- Additional funding support from MassCEC

3.5-year project to demonstrate a novel approach to deeply integrating solar PV, energy storage, and demand-side management at National Grid PV Site

SOLAR ENERGY TECHNOLOGIES OFFICE U.S. Department Of Energy

Fraunhofer USA

Project Objectives



Integrated Solar+ES+DSM: Use demand-side load shaping and energy storage to support high-penetration of solar

Support local + wholesale markets: Test technologies and business models that can facilitate exchange of load-shaping services within local distribution grids

"Real-World Experience": Field demonstration on the National Grid distribution system with a portfolio of C&I Customers, derive lessons learned through real-world deployment

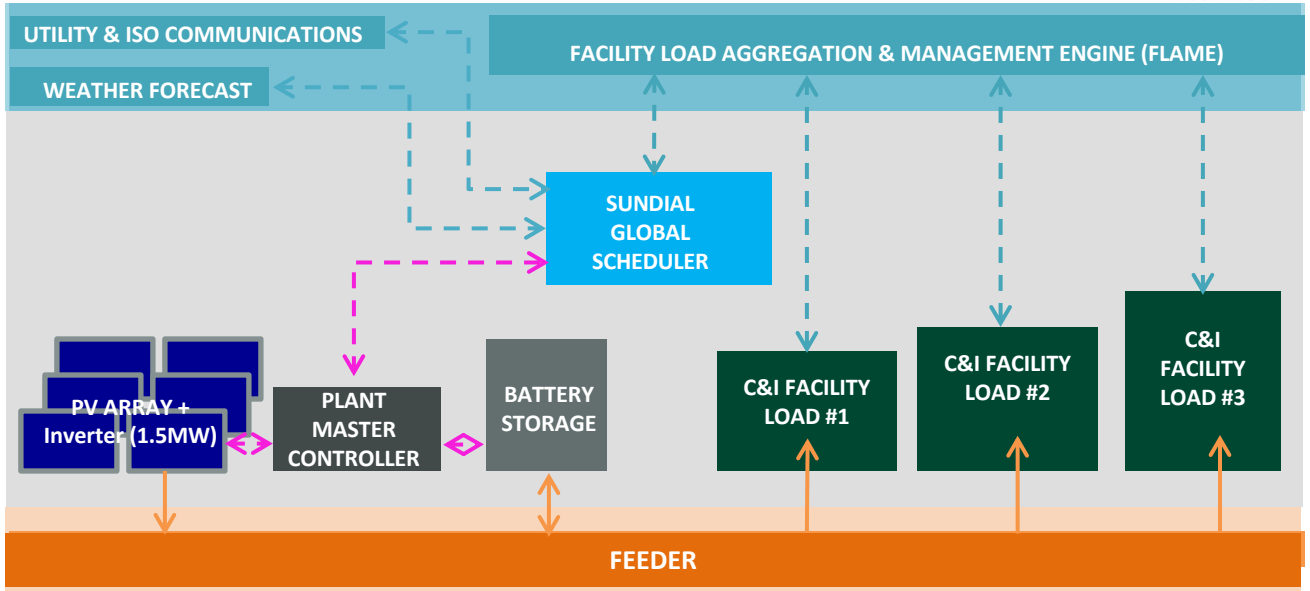
Target 10-20% reduction in ESS size using demand-side resources while controlling feeder-scale load shapes

SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA

The SunDial System Architecture

openADR ALLIANCE VOLTTRON™ python SUNSPEC ALLIANCE



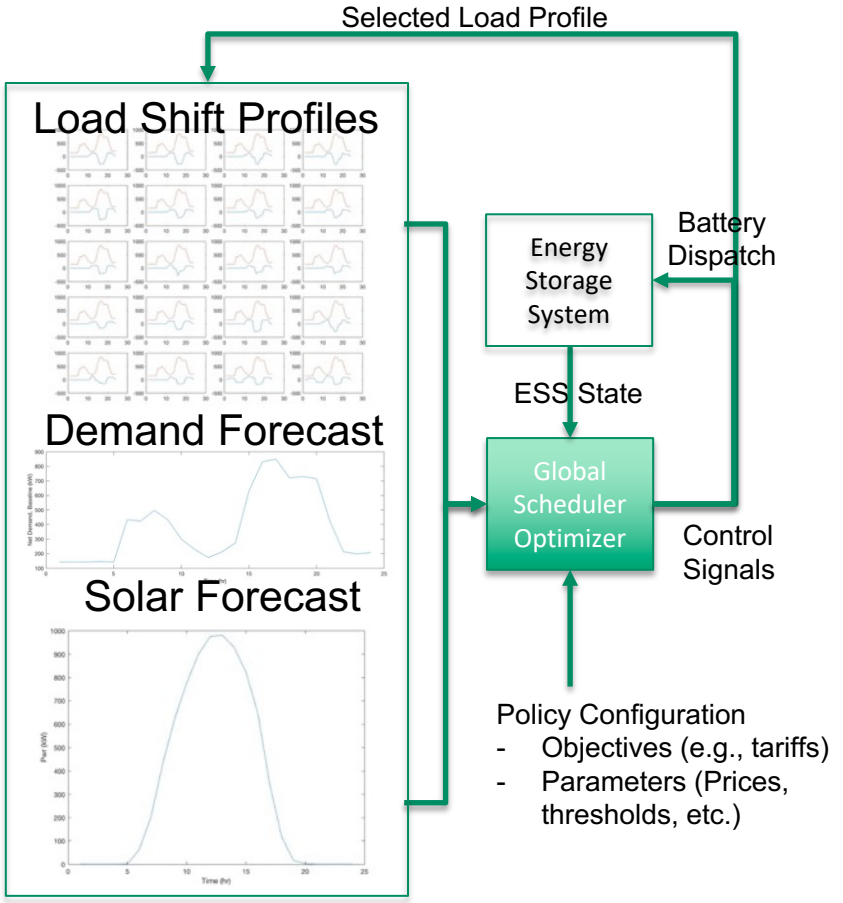
- Renewable Generation
- Energy Storage
- Demand-side resources
- Monitoring
- Forecasting and analytics

SOLAR ENERGY TECHNOLOGIES OFFICE U.S. Department Of Energy

Fraunhofer USA

Global Scheduler

- Vendor agnostic, open-source tool for the control of “Solar + X”
  - VOLTTRON, open-source platform developed by PNNL
  - Securely Aggregates Distributed DERs
  - Optimal real power dispatch
- Potential Use Cases / Value Streams
  - Demand Management
  - Peak Shaving
  - Energy Arbitrage
  - Short-term solar variability (ramp limiting, etc)
  - Volt-VAR / Power Factor Set Points
  - Battery Degradation Management
- Flexible configuration

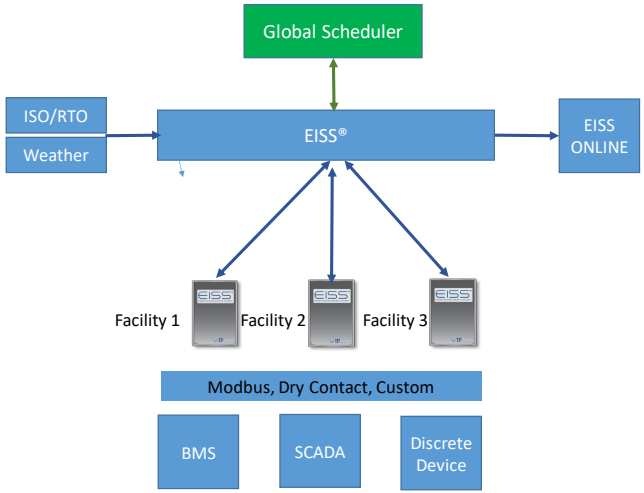


SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA

Facility Load Aggregation and Management Engine (FLAME)

- Cloud-based server interfaces directly to facility end-points and to the Global Scheduler
  - FLAME: Virtual Top Node (VTN) server,
  - Virtual End Node (VEN) client-side devices located at individual facilities.
- Generate Load prediction
  - Process, schedule, weather, seasonal and same-day adjustments
  - Future enhancements based on machine-learning
  - Load-shift potentials based on
- Generate Load-Shift Potentials
  - Minimize cost articulated by GS
  - Subject to constraints of connected loads
- Trigger actuation at end-point devices



SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA

Pilot Deployment

9MVA feeder, approx. 7MW PV installed or under construction

Controllable DERs:

- Solar: 1.5 MW, aggregated across two adjacent PV fields
- ESS: 0.5MW / 1.0MWh Tesla PowerPack
- ~300-500kW load shift potential

“Load Shaping” differs a lot from traditional DR

Attribute	Traditional DR	Load Shaping to support PV
Frequency of Calls	Order of 5-20 times/year	Majority of days/year
Key Goal	Load shedding	Load sinking and shedding to increase PV and load coincidence
Duration of LM	1 to 4 hours	Up to 16 hours/day
Most Needed	Usually summer or winter peak	Mid-/late-spring – largest surplus Summer – peak matching

Develop of new algorithms for load sinking over extended periods of time

Automated load management essential

Millions of potential load profiles due to temporal path dependence of load management – need techniques to simplify assessment

Existing standards (e.g., OpenADR) does not readily accommodate communication of potential load profiles

Load Management Portfolio

School:

Load management by adjusting zone temperature cooling setpoints for packaged rooftop units (RTUs) via building automation system

Food Processing:

Can shift multiple loads, with varying frequency and duration

Facility unwilling to fully automate control of core production processes, will be manually actuated by facility personnel

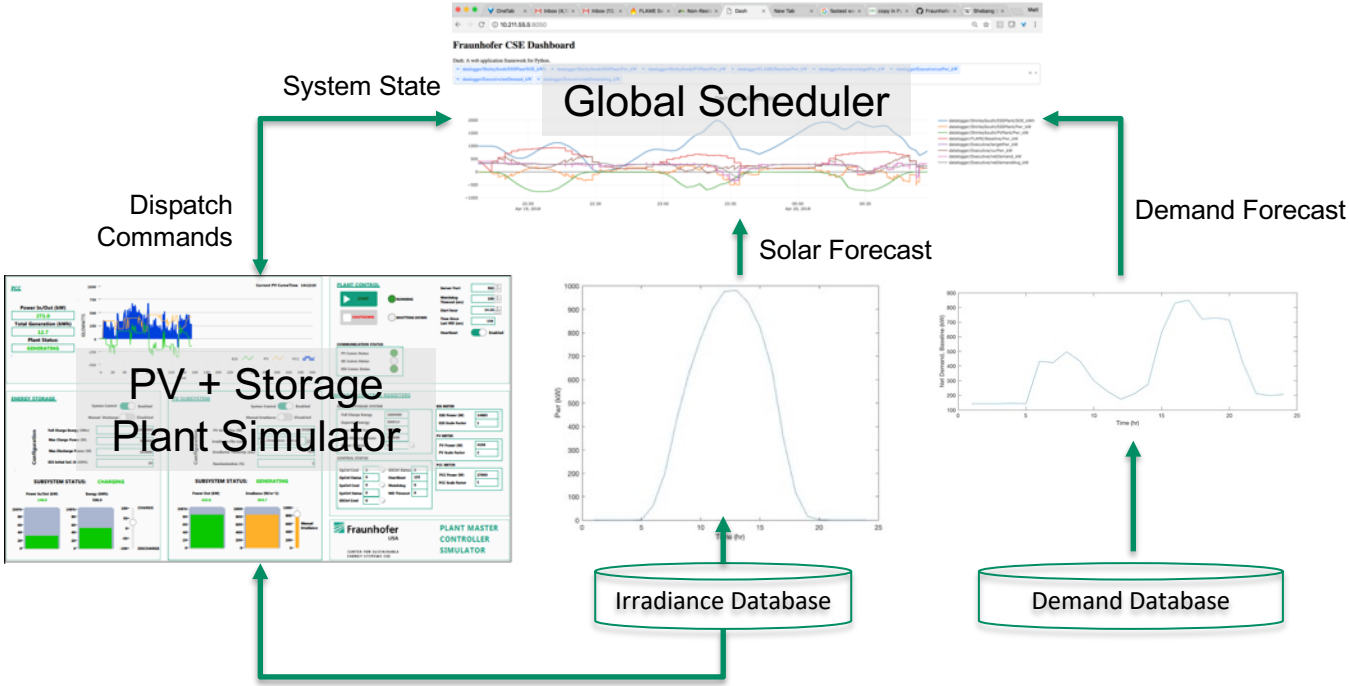
Will email ops manager daily with preferred times to run processes

Food Production:

Controlling EV charging (forklift, rider pallet jacks) by automatically enable and disable EV charging on two circuits

Approximately 3.5MW, 10-20% shiftable

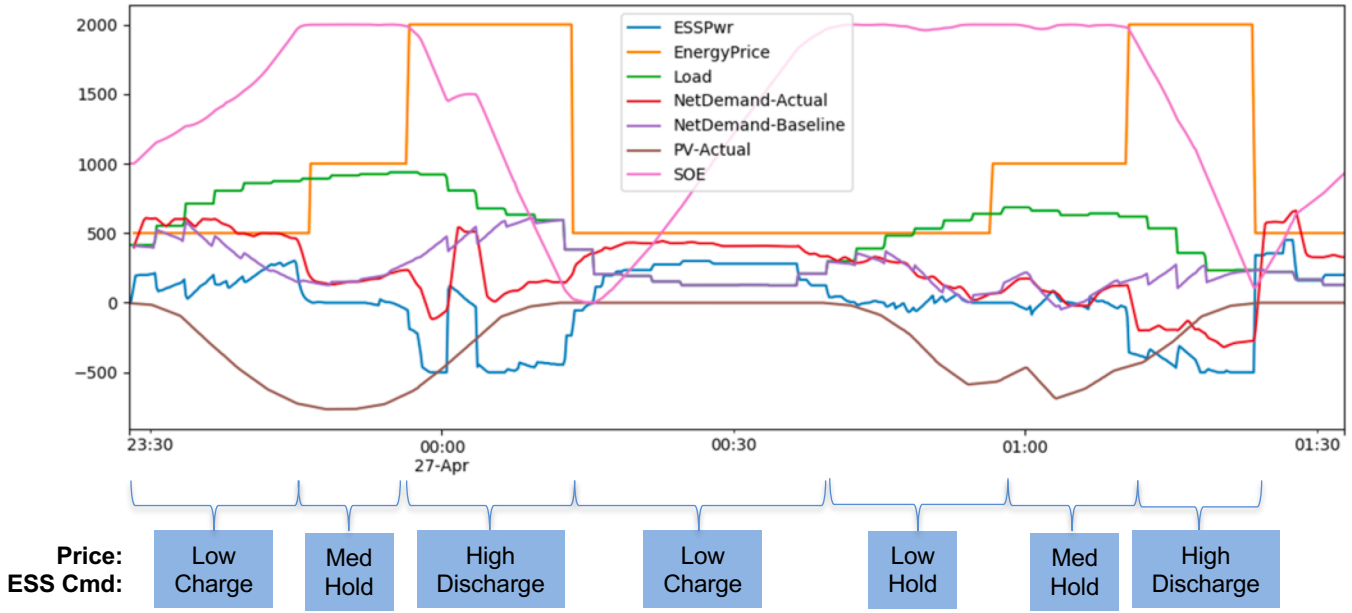
Virtual Test Environment



SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA

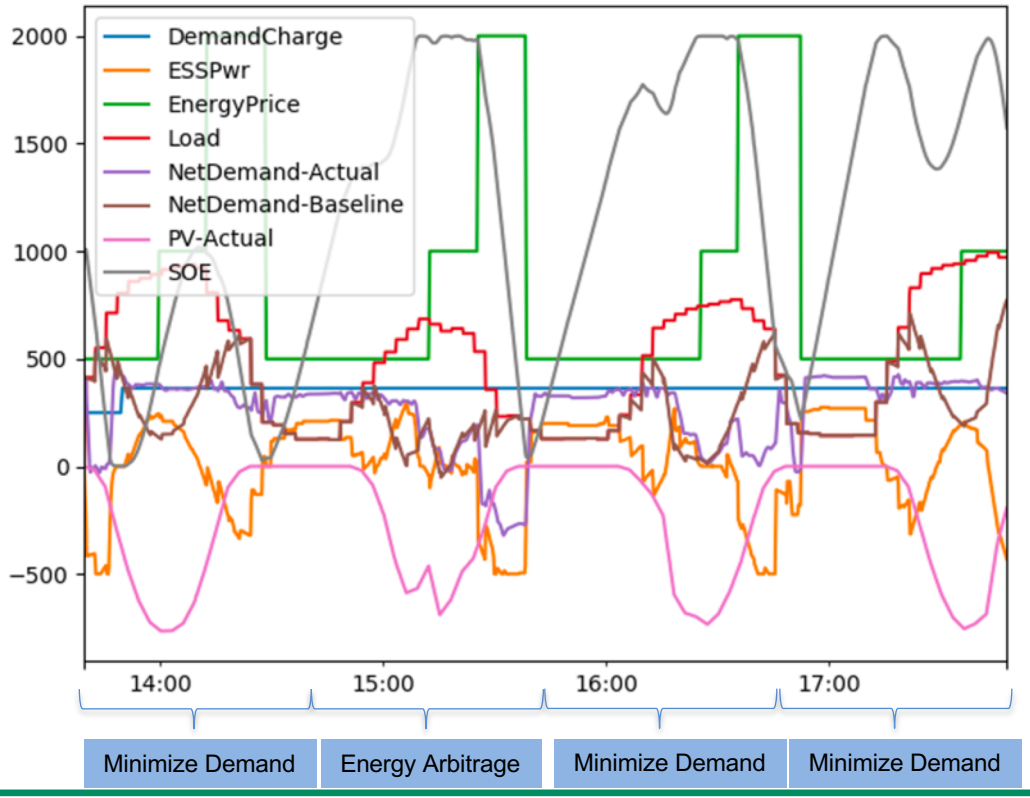
Energy Cost Minimization – TOU Energy Price



SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA

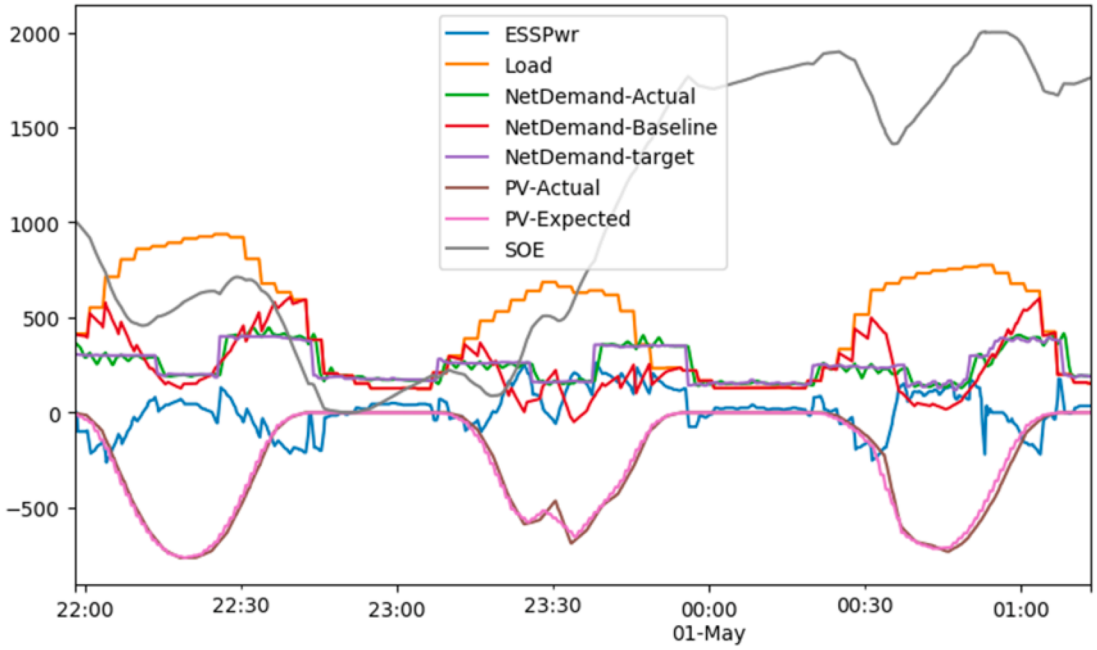
Energy Cost Minimization – Energy + Demand



SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA

Target Load Shape

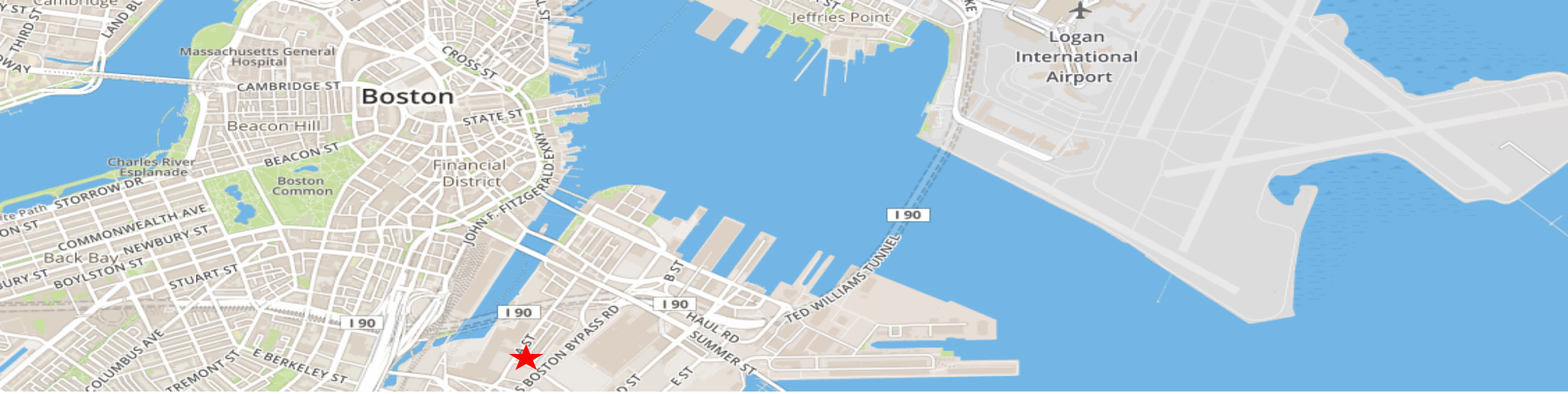


SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA

Future Work - Test Multiple Use Cases over 12-month pilot

- Final Acceptance Testing in process
- Energy Cost Management, based on National Grid fixed rate G-3 tariff, modified to…
  - Value power exports valued at a lower, but non-zero value
  - incorporate TOU pricing
- Peak Shaving + Energy Arbitrage for an ISO-NE wholesale market participant:
  - ISO-NE Day-ahead and real-time energy market
  - ISO NE capacity market
- “Virtual Peaker” Plant
  - Prioritize export to match system peaks / displace conventional peaking generation
- Follow a defined load shape
  - Firms power flow based on day-ahead target
  - Either: minimize error based on a set dispatch schedule -or- minimize demand peaks and reverse power flow on the distribution system
- Overlaid with high-resolution (1-min) forecast to improve ramp-rate performance



Contact

Matthew Kromer

Lead, Grid Integration

Fraunhofer CSE

e: mkromer@cse.fraunhofer.org

SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Fraunhofer USA