

Overview of BNL's Solar Energy Research Plans

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BROOKHAVEN
NATIONAL LABORATORY

a passion for discovery



Why Solar Energy Research at BNL?



**BNL's capabilities
can advance solar energy
In the Northeast**



**World class
facilities**

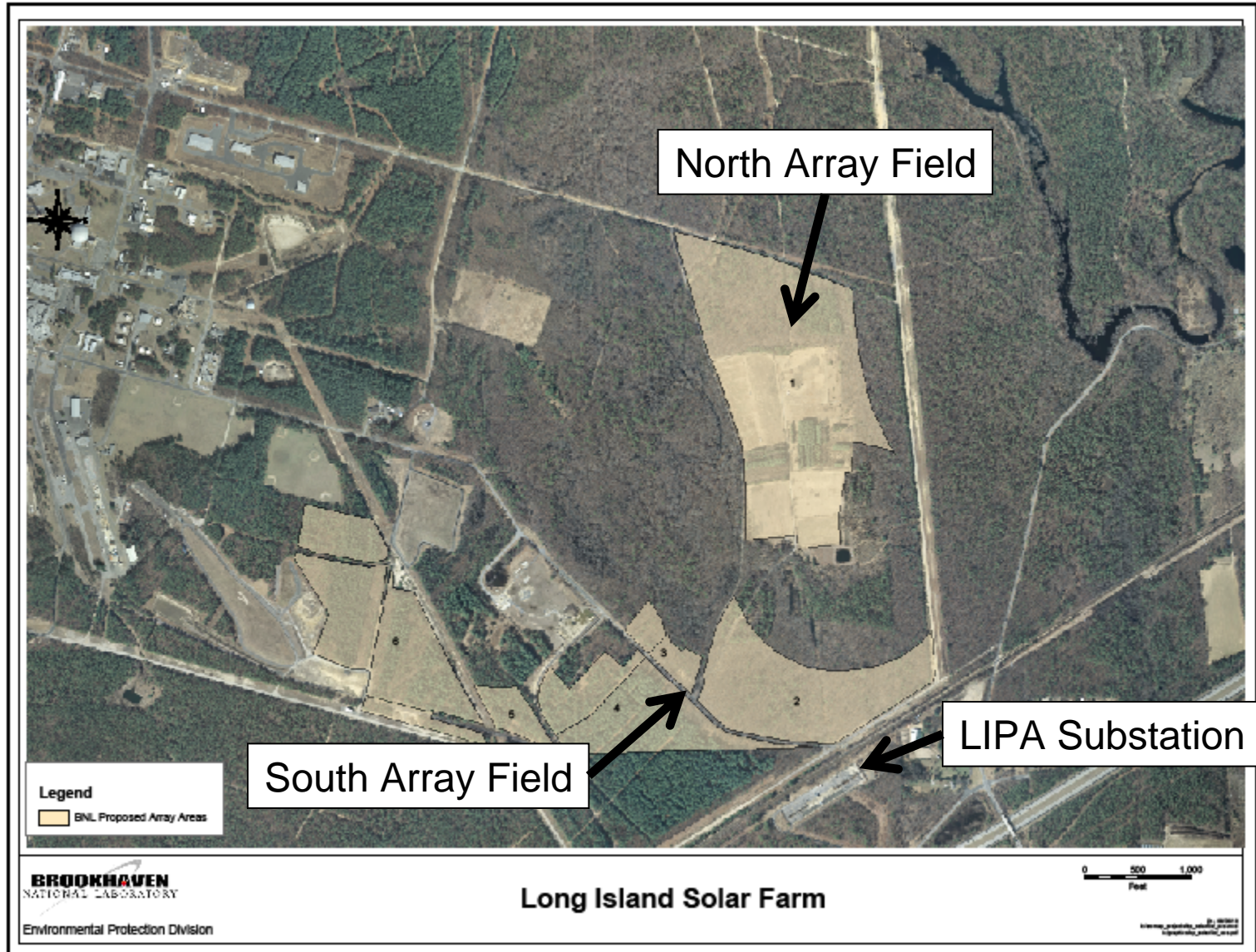


**History of
successful research**



**Renewable energy research
is part of BNL's mission**





Long Island Solar Farm

- BNL research will focus on several of the key issues facing deployment and grid integration of utility-scale, distributed PV systems.

Key Issues

■ Variability and Non-Dispatchability

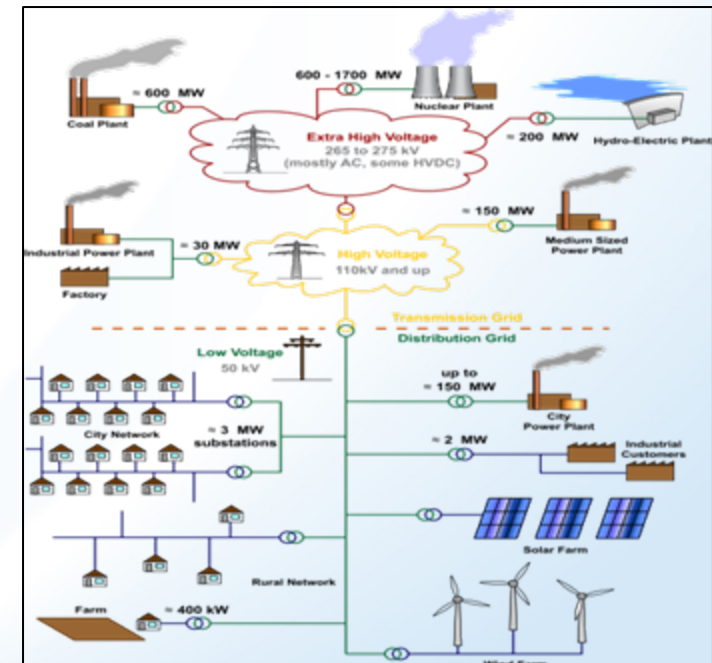
- Solar energy varies
- Solar generation cannot be dispatched when needed

■ Grid Integration

- Grid is not designed for two-way power flow
- Distributed generation can adversely impact grid control

■ Environmental Impacts

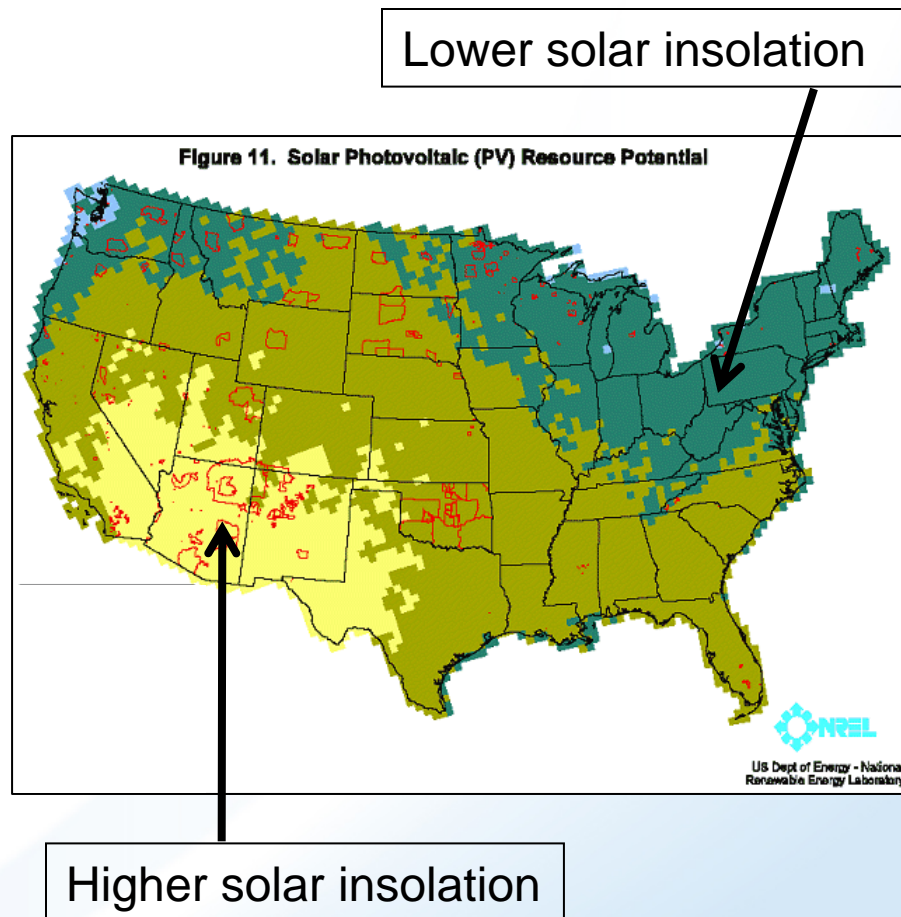
- Utility-scale solar PV plants can have impacts on local environment and ecology



Source: <http://www.soldata.dk/pyr-80spc.htm>

The LISF will also help characterize solar PV system performance in the Northeast..

- Solar generation tends to concentrate in the south and southwest
 - Highest solar insolation
- Performance data sets for utility-scale solar PV plants in the Northeast are not readily available
 - LISF data will help system designers



Research using LISF data

Key Issue 1: Solar Variability and Non-dispatchability

- Develop database with time-resolved solar resource and meteorological data for BNL (Northeast U.S.) and solar plant electrical performance
- Examine statistical relationship between solar radiation input and solar plant output
- Study the impacts of weather variations and cloud transients on large-scale PV system performance
- Characterize the variability of PV generation as a function of cloud and meteorological conditions
- Develop models for real-time forecasting (“now-casting”) of available solar irradiation and impact on power production

Research using LISF data

Key Issue 2: Grid Integration

- Establish the performance characteristics of large-scale solar PV plants located in the Northeast and factors affecting capacity credit
- Evaluate the impacts of large-scale solar PV plants on electrical distribution system power quality
- Study the impacts of large-scale high penetration solar PV arrays on the reliability and stability of the grid and local distribution systems
- Characterize the response of various system elements (e.g., inverter recovery) following rapid changes in solar insolation due to cloud transients and how it impacts array output
- Develop models to predict the response of the solar plant and individual components (e.g., inverters) to fault conditions
- Evaluate the impact of surface soiling on solar plant performance
- Study the impact of aging degradation on solar plant performance
- Develop an integrated performance model to forecast generation and study grid impacts due to high-penetration variable solar power and how control schemes can be used to mitigate these impacts

Research using LISF data

Key Issue 3: Environmental Impacts

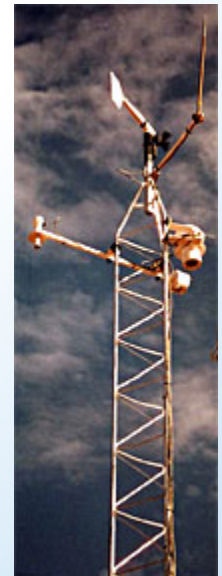
- Continue current programs on recycling of solar panels
- Perform life-cycle assessments of large-scale solar PV plants and energy policy options
- Verify our understanding of the impacts of large-scale solar array to the local environment, including microclimate, meteorology, and hydrology, and the associated impacts to the habitats for local plants and animals
- Collect data useful for evaluating the impacts of large-scale solar plants to regional and global climate, including greenhouse gas emissions

A suite of advanced research instruments will be installed in the LISF plant...

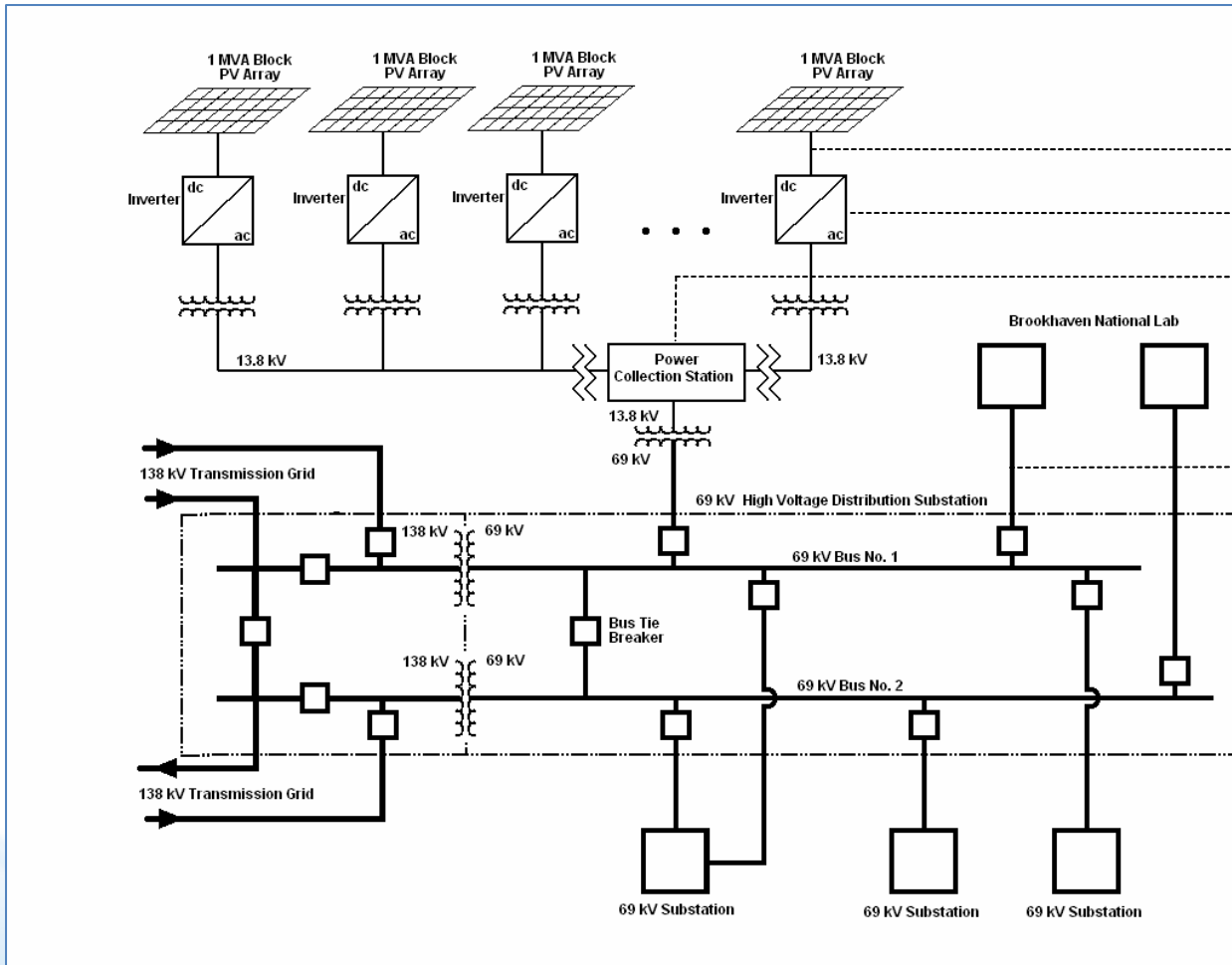
- BNL is working with LISF/BP Solar to incorporate instrumentation into the array
- Data will be obtained at high sample rates for research purposes
 - Solar Resource Data: sample rates up to 1 per second
 - Meteorological Data: sample rates up to 1 per second
 - Power Quality Data: sample rates up to 512 per cycle
- All data will be time synchronized
- Plans to participate in the NREL PV Variability Database

Solar irradiance and meteorological data will be collected...

- Instruments to measure solar insolation (pyranometers) covering the entire array
- Base station with precision instruments to measure solar insolation at high accuracy
- Meteorological measurements:
 - *Temperature (air and panel)*
 - *Relative Humidity*
 - *Barometric Pressure*
 - *Wind speed and direction*
 - *Rain gauge*
- Total Sky Imagers
 - Capture images of clouds as they move over the array



Power quality data will be collected for research purposes...



Data Acquisition System - Power Quality

Power Quality Data

- String level
- Inverters
- Array Substation
- LIPA Feeders to BNL

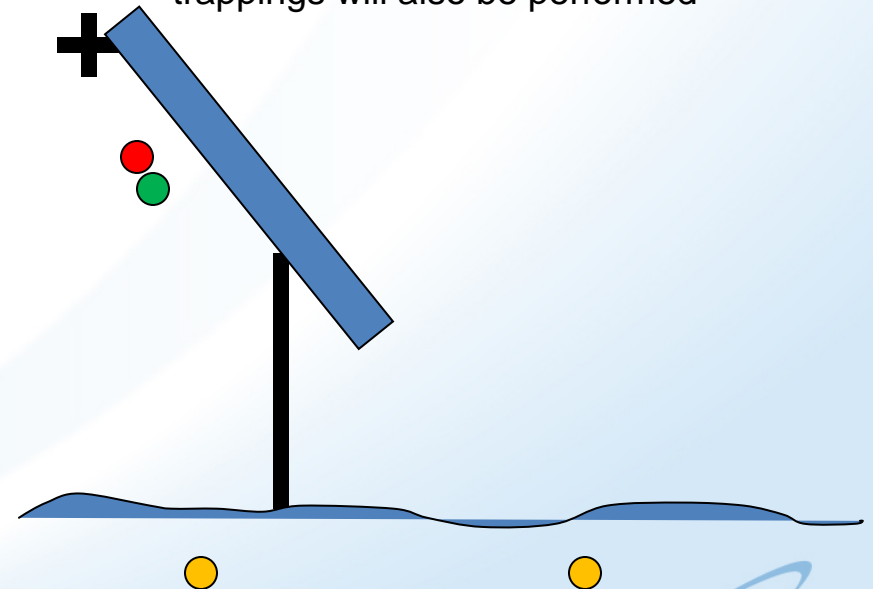
Environmental monitoring instruments for research purposes...

North array only



- Relative Humidity (at 10 locations in north array)
- Soil Temperature (2 at 10 locations in north array)
- Air Temperature below panel (at 10 locations in north array)

* Data from the BNL Met instruments, along with mobile instruments and animal trappings will also be performed



Planned Partnerships

- Other National Laboratories
 - National Renewable Energy Laboratory
 - Sandia National Laboratory
- Universities
 - Stony Brook University
 - Columbia
- Solar Equipment Manufacturers
 - BP Solar
 - American Superconductor
- Local Government and Utility Organizations
 - Long Island Power Authority
 - New York Power Authority
 - New York State Energy Research and Development Authority

BNL is planning to develop a Northeast Solar Energy Research Center (NSERC)

- Supplement research using the LISF array
 - Dedicated research array for field testing
 - Laboratory space for standardized testing
- NSERC would enable research in various other areas of interest to the solar industry
 - Testing under actual northeast conditions
 - Technology development test bed
- Energy would be delivered directly into the BNL electrical system
 - Help with sustainability goals
- BNL held a technical workshop to obtain input from industry experts for the development of NSERC

Preliminary Research Agenda for NSERC

- **Smart Grid Integration Studies**
 - Research on strategies that improve communication and control
 - Techniques for integrating large numbers of systems into utility grids
- **Energy Storage Research**
 - Value propositions for integrated grid-level storage
 - Evaluation of storage and control alternatives
 - Reduce intermittency, resource extension
 - Frequency regulation capability
- **Field Testing of New Technologies**
 - Evaluation and testing of new design concepts, such as inverters with capability for voltage regulation and VAR control
 - Comparison of performance for components and systems using different technologies
- **Reliability and Degradation Studies**
 - Long-term reliability and degradation studies under Northeast conditions
 - Standardized test conditions to evaluate component degradation
 - Post mortem testing and failure analyses

For further information..

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