

# Introduction to Brookhaven National Laboratory

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Global and Regional Solutions Directorate (GARS)

STEAB Meeting  
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**BROOKHAVEN**  
NATIONAL LABORATORY

*a passion for discovery*

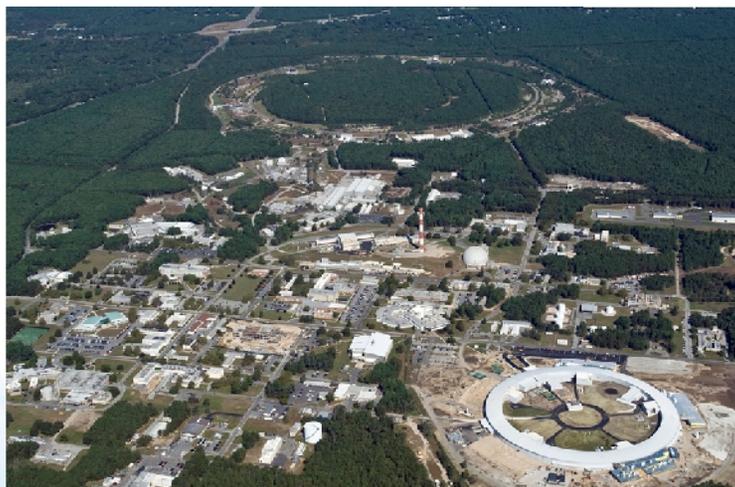


# Introduction to BNL

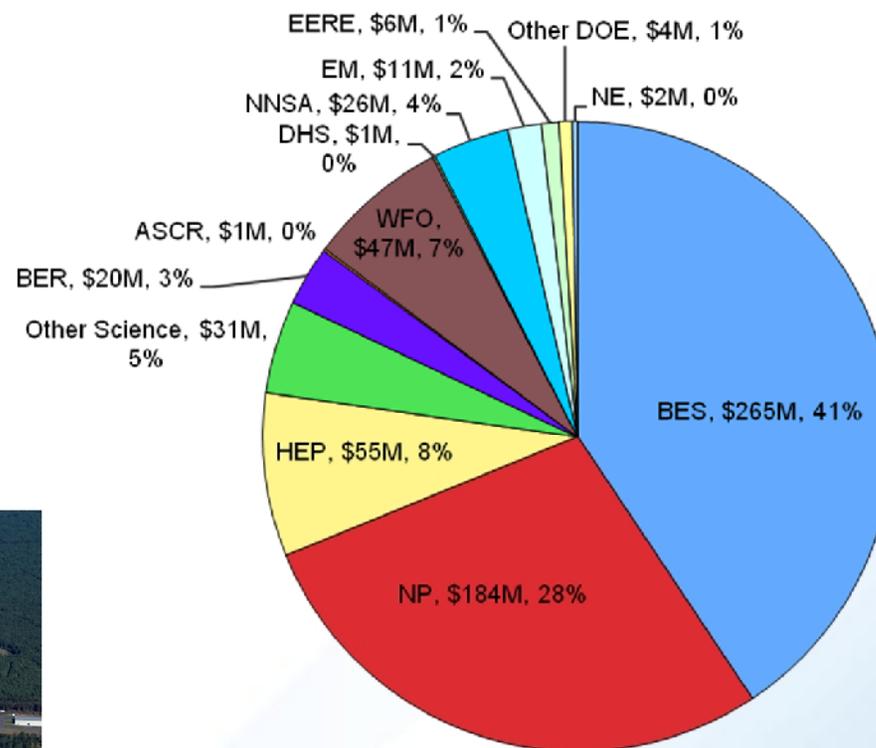
- Facts, figures, facilities overview
- BNL energy strategy
  - Building Discovery to Deployment pipelines
  - Tools for a Smarter Grid
  - Distributed Generation and Renewables Integration
- Meeting sustainability goals through research
- Discussion

# Brookhaven at a Glance: FY 2011

- Physical Assets
  - 5320 acres
  - 306 SC buildings
- Human Capital
  - 2990 FTEs (3110 heads)
  - Direct/indirect: 0.61/0.39
  - 419 undergrad/grad students
  - 4253 facility users
  - 1570 visiting scientists



## FY 2011 Funding by Source



FY 2011 Total Lab Operating Costs: \$652

FY 2011 Total WFO (Non-DOE/Non-DHS) Funding: \$46.9

FY 2011 Total WFO as % Total Lab Operating Budget: 7.2%

# Brookhaven National Laboratory

RHIC

New York Blue  
Supercomputer

Interdisciplinary Energy  
Science Building

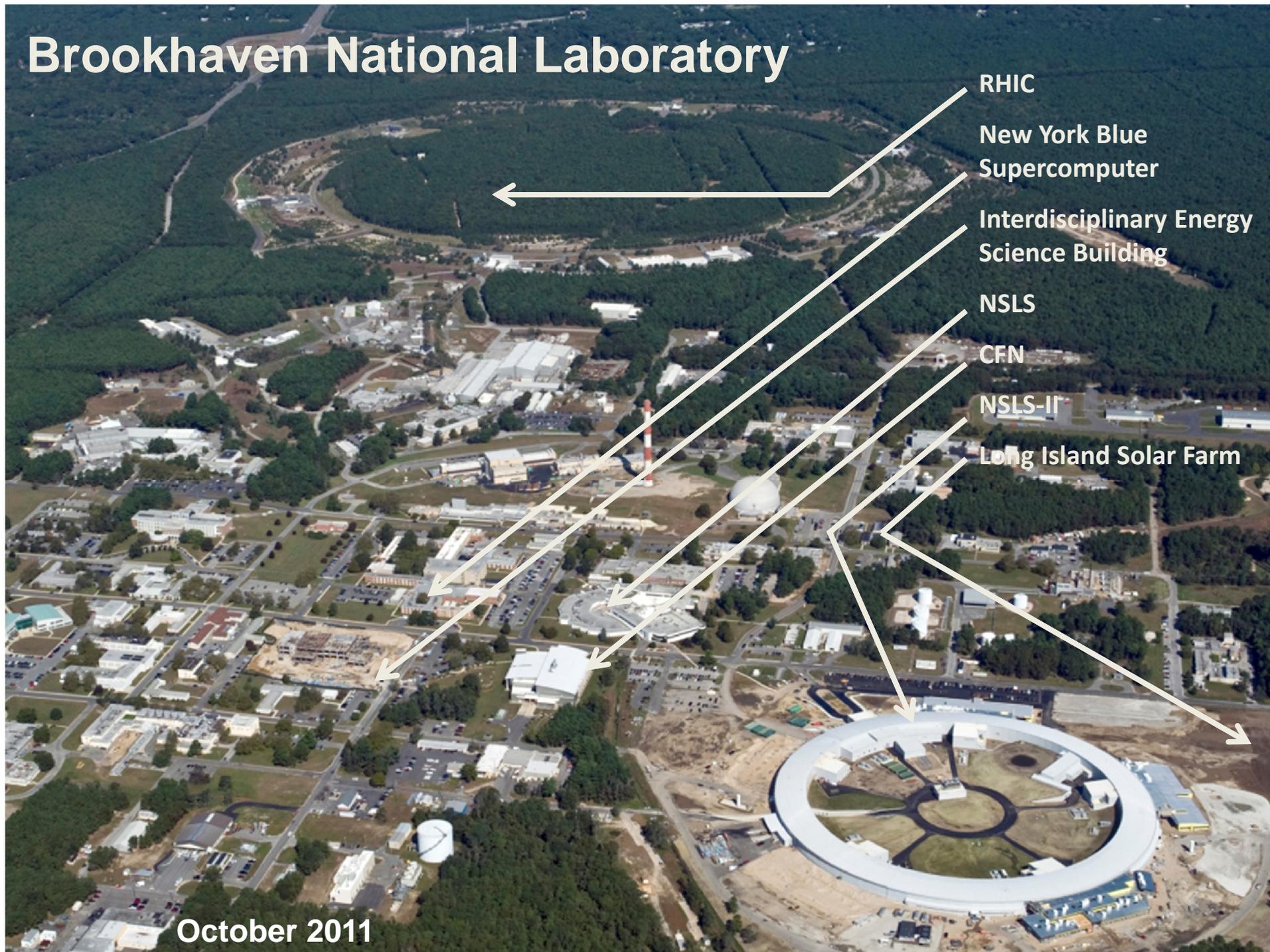
NSLS

CFN

NSLS-II

Long Island Solar Farm

October 2011



# Major Research Facilities



**National Synchrotron Light Source**

## **National Synchrotron Light Source**

- Industrial and academic users
- Researching battery storage, Alzheimer's disease, breast cancer, HIV/AIDS, environmental cleanup technology, and more



**National Synchrotron Light Source II**

## **National Synchrotron Light Source II**

- Soon to be world's most advanced x-ray source
- \$960 million project - hundreds of local jobs
- Will deliver research advancements in energy, nanotechnology, medicine and other fields



**Center for Functional Nanomaterials**

## **Center for Functional Nanomaterials**

- Exploring energy science at the nanoscale
- Building new materials atom-by-atom to achieve desired properties and functions

# Major Research Facilities



**Relativistic Heavy Ion Collider (RHIC)**

## **RHIC**

- 2.4 mile circumference
- Studying the origins of the universe through particle collisions revealing make up of matter
- Discovery of the 'perfect liquid'



**New York Blue Supercomputer**

## **New York Center for Computational Science**

- Partnership between BNL & Stony Brook University
- Two IBM supercomputers
- Supports broad range of research



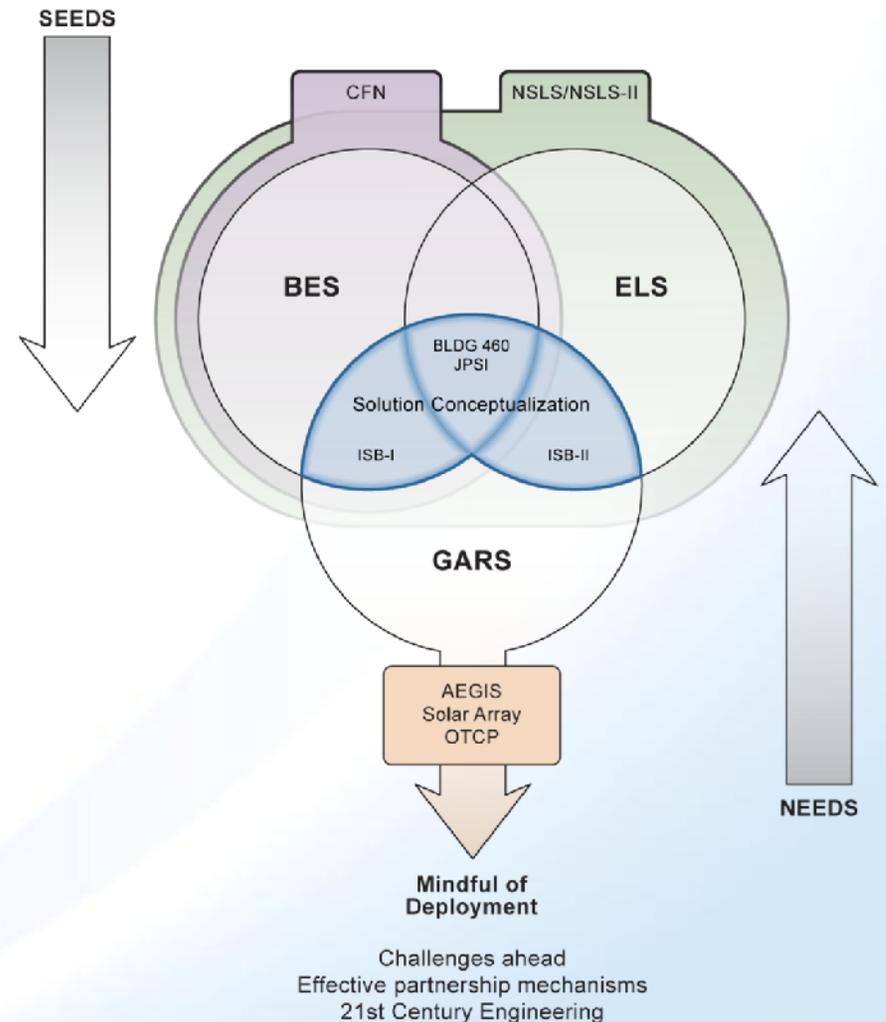
**Long Island Solar Farm**

## **Long Island Solar Farm**

- Partnership between BNL, LIPA and BPSolar
- 32MW Peak to power 4500 L.I. homes
- Unique opportunity to study renewables in the Northeast and test new Grid technologies

# Strategy for increasing BNL impact

- **Maintain** preeminence in basic research
- **Grow** applied programs, leveraging BNL core capabilities
- **Focus** on energy, national security, bio & life sciences
- **Expand** impact through
  - Commercialization
  - Partnerships in NYS, NE



# Energy R&D : A Collaborative Approach



+ BNL  
Research



Collaborators/Joint Appointments

**ENERGY CHALLENGES**  
New York  
Northeast  
Nation

NY State Consortia/Resources

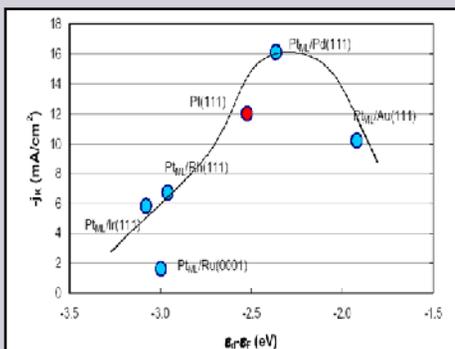


Basic Research, Applied Research, and  
Industry Working Together

# Discovery to Deployment Cycle

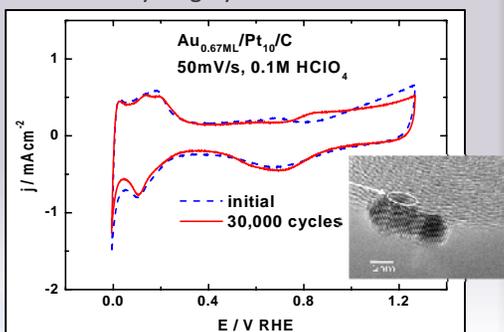
## DOE – BES Research advances

Pt Monolayer catalysis – high activity with ultralow Pt mass



Angewandte Chemie **44**, 2132 (2005)

Pt stabilized against corrosion in voltage cycling by Au clusters

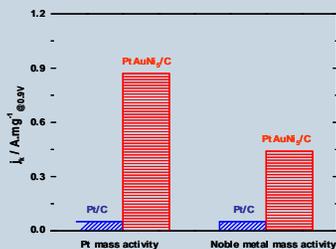
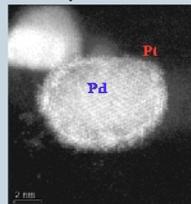
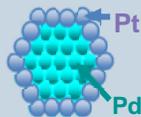


Science **315**, 220 (2007)

## DOE (BES & EERE) Core-Shell Nanocatalysts

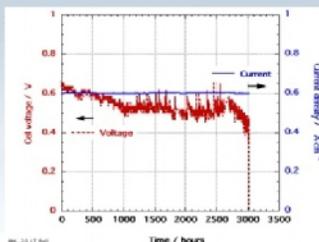
Active Pt ML shell – metal/alloy core  
Core tunes activity & durability of shell

Model and TEM image of a Pt monolayer on Pd nanoparticle



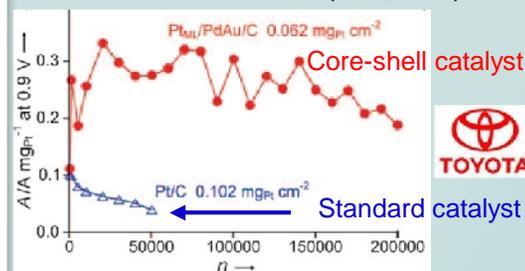
Pt-mass weighted activity enhanced 20x

3000 hr Fuel Cell Durability Performance

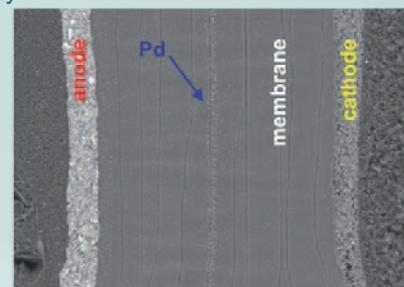


## BNL-Toyota CRADA Toward Deployment

Scale-up synthesis: Pt-ML/Pd<sub>9</sub>Au<sub>1</sub>/C  
Excellent fuel cell durability 200,000 cycles



Membrane electrode assembly >200K cycles  
Very small Pt diffusion & small Pd diffusion



Angewandte Chemie **49**, 8602 (2010)

Fuel Cell Catalyst readied for automotive application

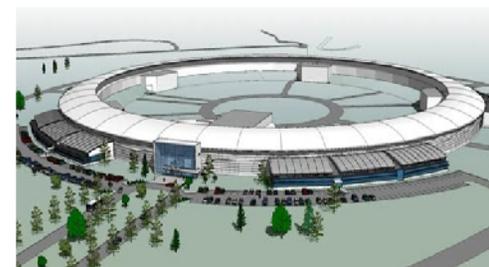
# Energy Storage: Lithium ion and Flow batteries

ISB I



**Electrochemistry (GARS)**  
**Electrode/Cell assembly & testing**

NSLS I & II



**Characterization: Synchrotron**  
**(GARS, NSLS, BES/Chem)**

**In situ & in operando studies**

CFN



**Synthesis (GARS & CFN)**  
**alternative cathodes**  
**nanoscale anodes**

**Characterization: Electron**  
**microscopy (GARS, BES/CMPMS, CFN)**  
**lithium mapping**  
**solid electrolyte interface**



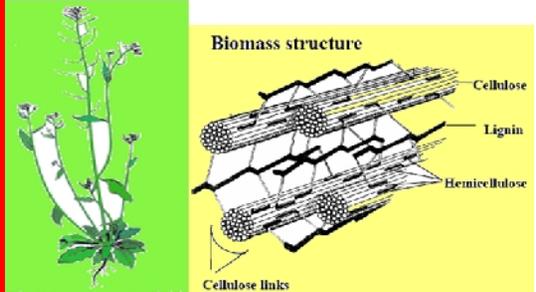
**Collaboration**



Brookhaven Science Associates



# Thermochemical Conversion of Biomass



**Biomass structure**

Cellulose  
Lignin  
Hemicellulose  
Cellulose links

Arabidopsis

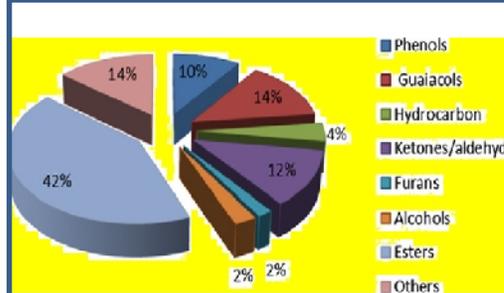
**Biomass Structure**  
**BIOLOGY**




High-pressure pyroprobe

**GC-MS**

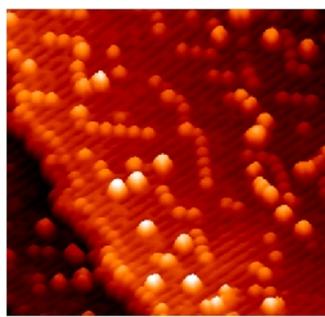
**SET**



42%  
14%  
10%  
14%  
4%  
2%  
2%

- Phenols
- Gualacols
- Hydrocarbon
- Ketones/aldehydes
- Furans
- Alcohols
- Esters
- Others

**Characterization**  
**SET**

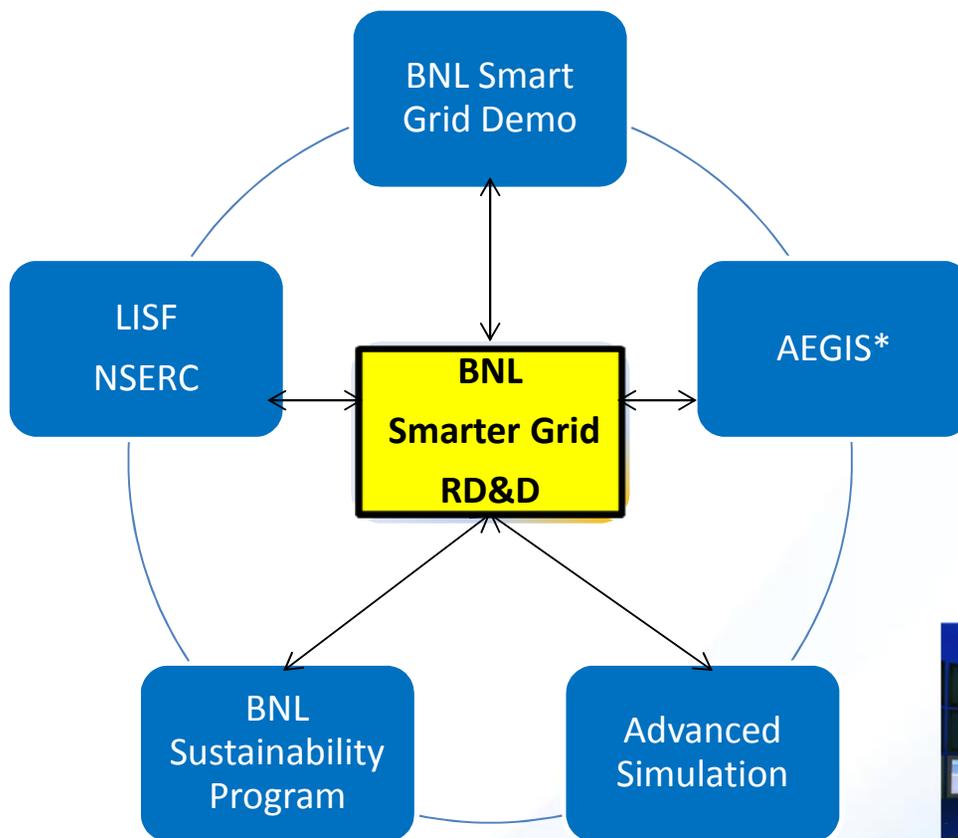
nano-catalysts

**CFN**  
**CHEMISTRY**




**Renewable Fuels**  
**Chemicals**  
**SET**

# BNL's inter-related Grid RD&D initiatives



**BNL/Stony Brook Univ. partnership received \$5million NYS grant to initiate development of SGRID<sup>3</sup> for which the Advanced Electric Grid Innovation and Support (AEGIS) Facility is the BNL component**

# Long Island Solar Farm



A Unique Partnership: DOE, BSA, BPSolar, LIPA

# LISF: Unique Research Opportunity

- Research Issues
  - Solar Variability & Impact
  - Grid Integration
  - Environmental Impacts
- Research Instrumentation integrated into plant
  - String Level Monitors
  - Power Quality monitors
  - Weather Stations
  - Total Sky Imagers



# Northeast Solar Energy Research Center (NSERC)

- Supplement research using the LISF array
  - Dedicated research array for field testing (up to 1MW)
  - Laboratory space for standardized testing
- NSERC will enable research in various other areas of interest to the DOE and the solar industry
  - Field testing under actual northeast conditions
- Energy would be delivered directly into the BNL electrical system
  - Supports BNL sustainability goals

# Smarter Electric Grid Research, Innovation, Development, Demonstration, Deployment Center - SGRID<sup>3</sup>

## ■ Mission

- Lower the cost of electric power by 5-10%
- Improve the quality and reliability of electric power
- Ensure the security of the Smart Grid
- Develop capabilities to guide utility investments

## ■ Accomplished by

- Grid performance data collection & analysis
- Advanced modeling
- Testing and demonstration of new technologies
- Model technologies using grid performance data



BNL Advanced Electric Grid Innovation and Support Facility (AEGIS)



SBU Advanced Energy Research & Technology Center (AERTC)

# BNL Distribution System as a Microgrid

- ~ 30 MW Avg Load; sized for 70MW
- 13.8 kV primary distribution
- One (or more) circuits used for a micro-grid
  - High penetration DG (1 MW Solar)
  - Stationary generation
  - Integrated storage
  - Advanced, low-cost distribution sensors
  - Load demand management
- Advanced monitoring/simulation
  - ISM: fast, scalable, precise



# Simulation-Informed Grid Management

- Single Integrated Tool for:
  - Reliability
  - Transient analysis
  - System planning
  - Failure propagation
  - Outage Management



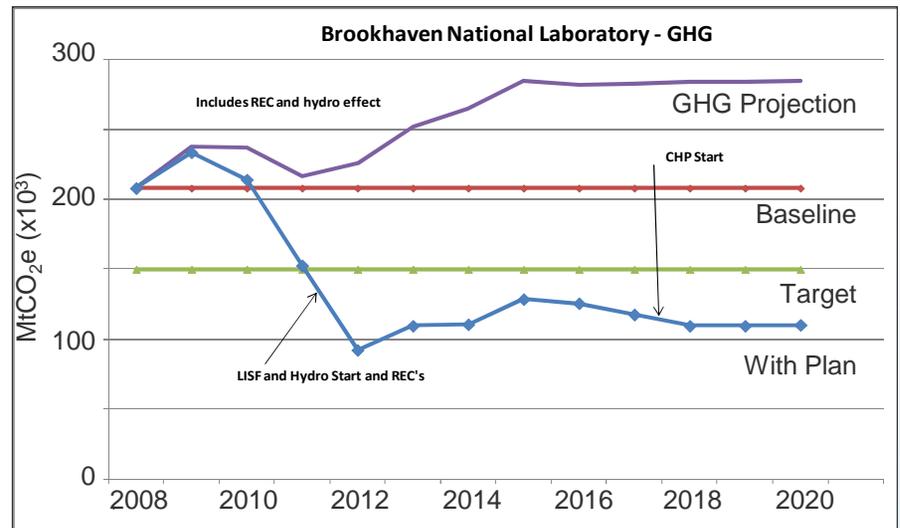
**Using exact models of as-installed distribution systems**

- Projects
  - ORU Collaboration on Load Growth Management
  - LIPA Collaboration on east-end feeder stability



# Laboratory Sustainability

- DOE Laboratories to meet Executive Order 13514
- GHG reduction target will be met
- Solar-array and hydropower reduce 50% of GHG footprint
- Hydro power: cost savings of ~\$3.6M/year
- All alternative fuel options in place as fleet renews
- Integration of research initiatives, demonstration projects, and operations to leverage capabilities



# Summary

- There is a new emphasis to our research portfolio
- BNL energy research focused on
  - Building Discovery to Deployment Pipelines
  - Regional emphasis: NY, NE, Nation
- Meeting our sustainability goals through research
- BNL are just getting started
- We look forward to welcoming STEAB to BNL