

# ARPA-E Town Hall



**Don DePaolo**

**Associate Laboratory  
Director for Energy &  
Environmental Sciences**

**Tuesday, March 13, 2012**

# Strategic Initiatives for Berkeley Lab Today



**RICHMOND CAMPUS AND HILL CAMPUS**



**COMPUTATION & NETWORKING**



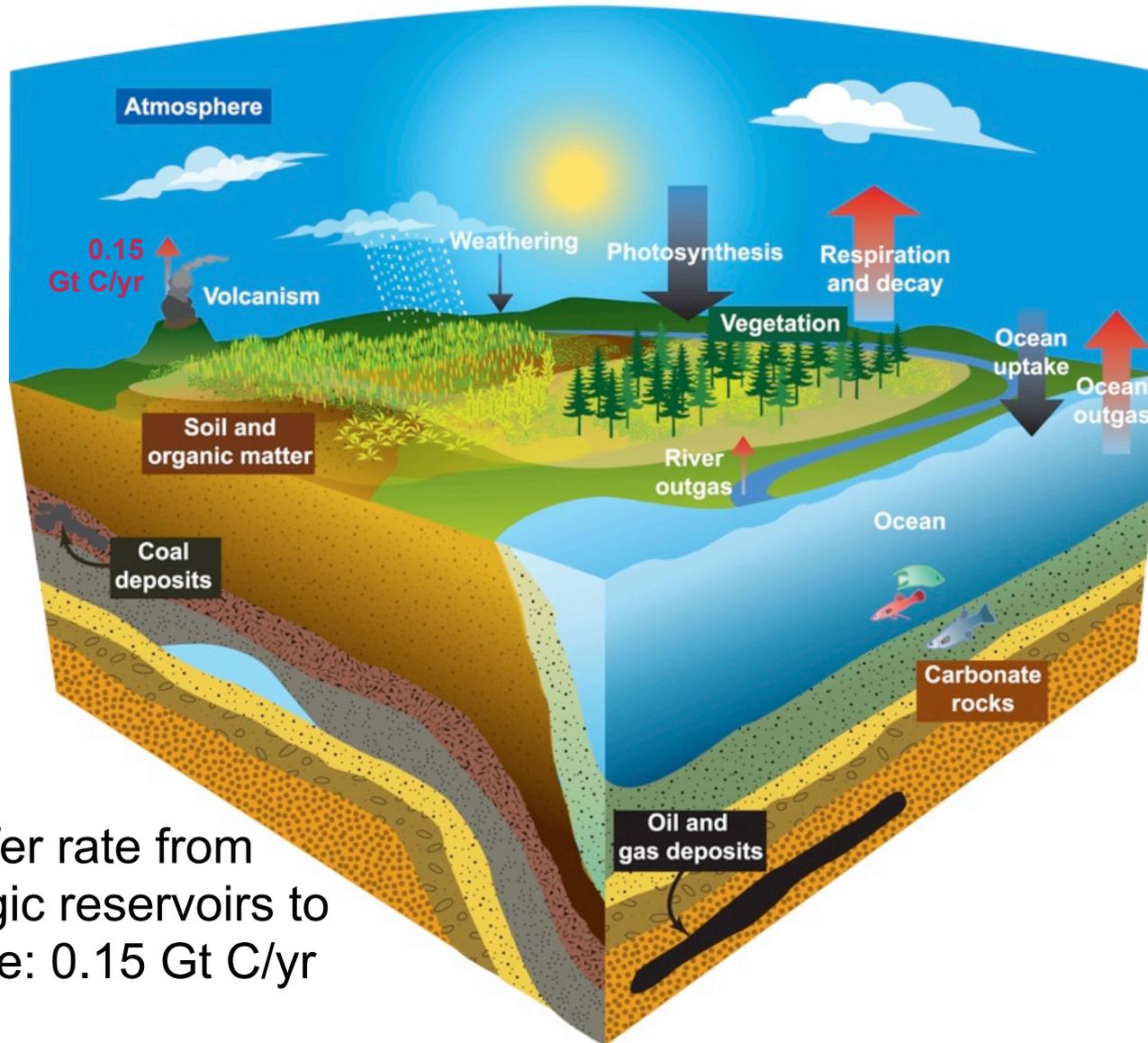
**COMMUNITY RELATIONS**



**SAFE AND EFFICIENT LAB**

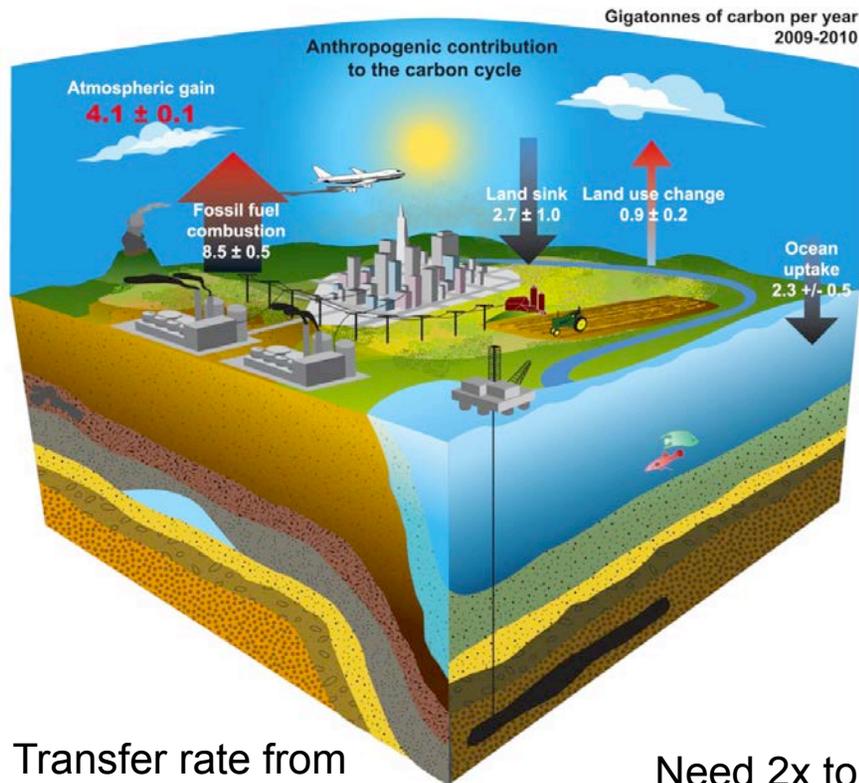


# Carbon Cycle 1.0: Natural Carbon Cycle



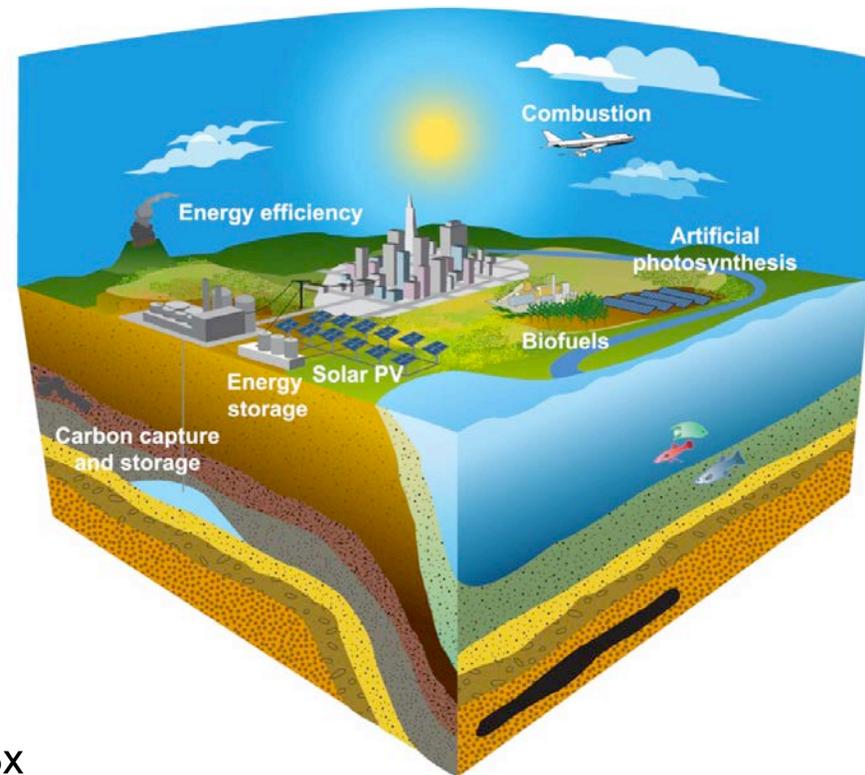
Transfer rate from  
geologic reservoirs to  
surface: 0.15 Gt C/yr

## Current open-ended C cycle Carbon Cycle 1.x (2010 AD)



Transfer rate from  
geologic reservoirs  
= 9 Gt C/yr in 2010

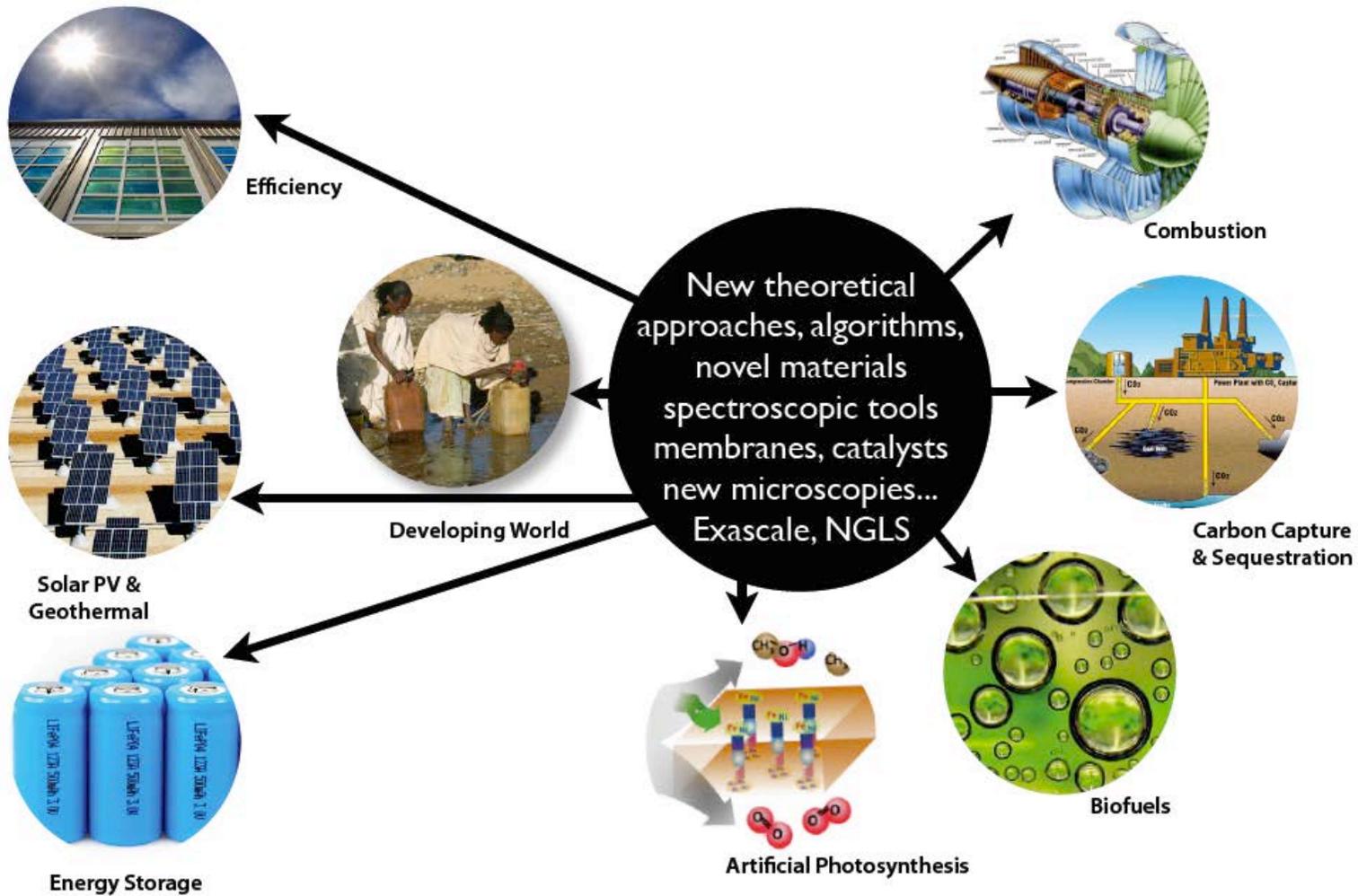
## Future balanced C cycle Carbon Cycle 2.0 (2100 AD?)



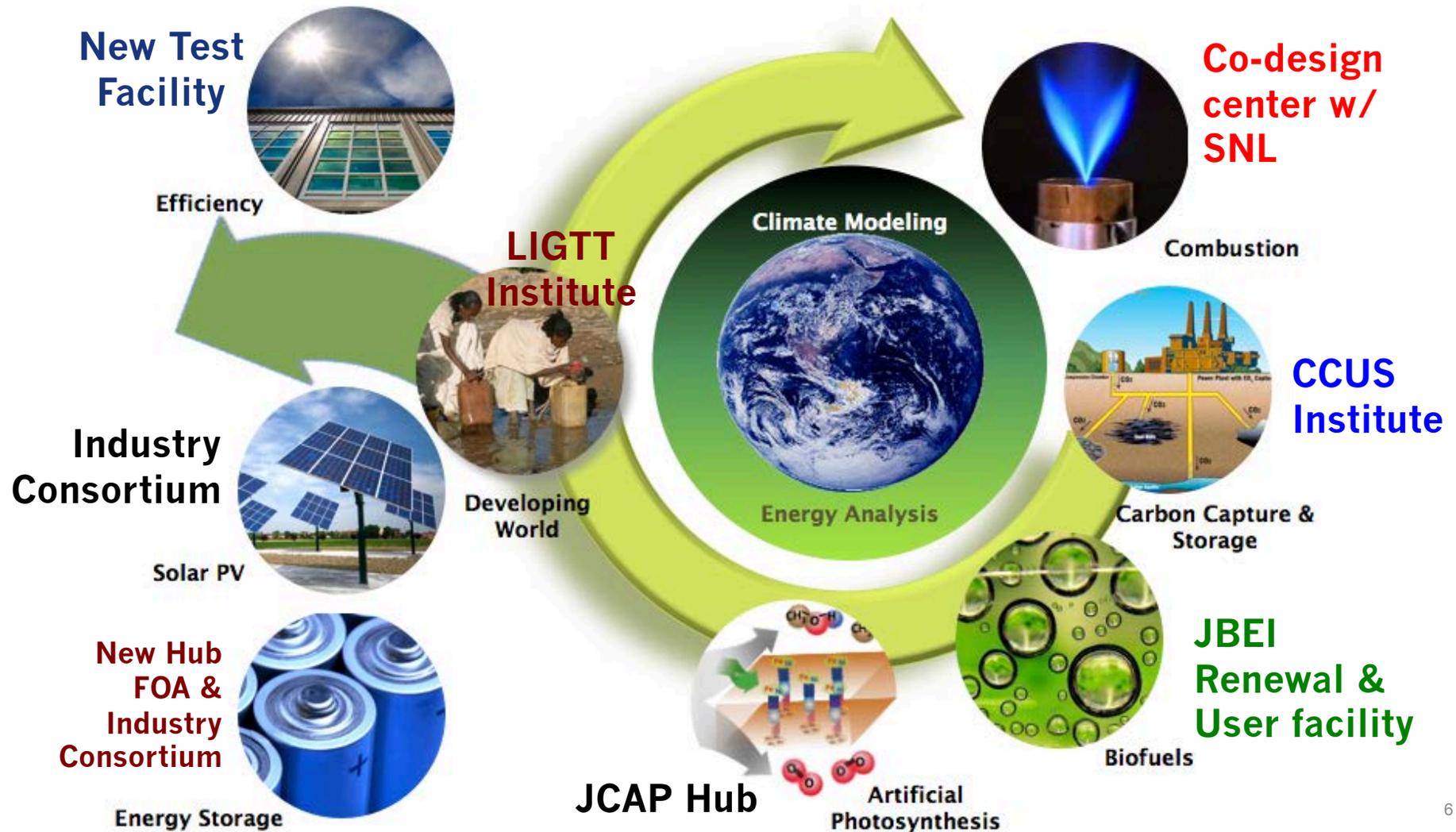
Need 2x to 3x  
more energy  
production with  
<0.3 of 2010 C  
emissions



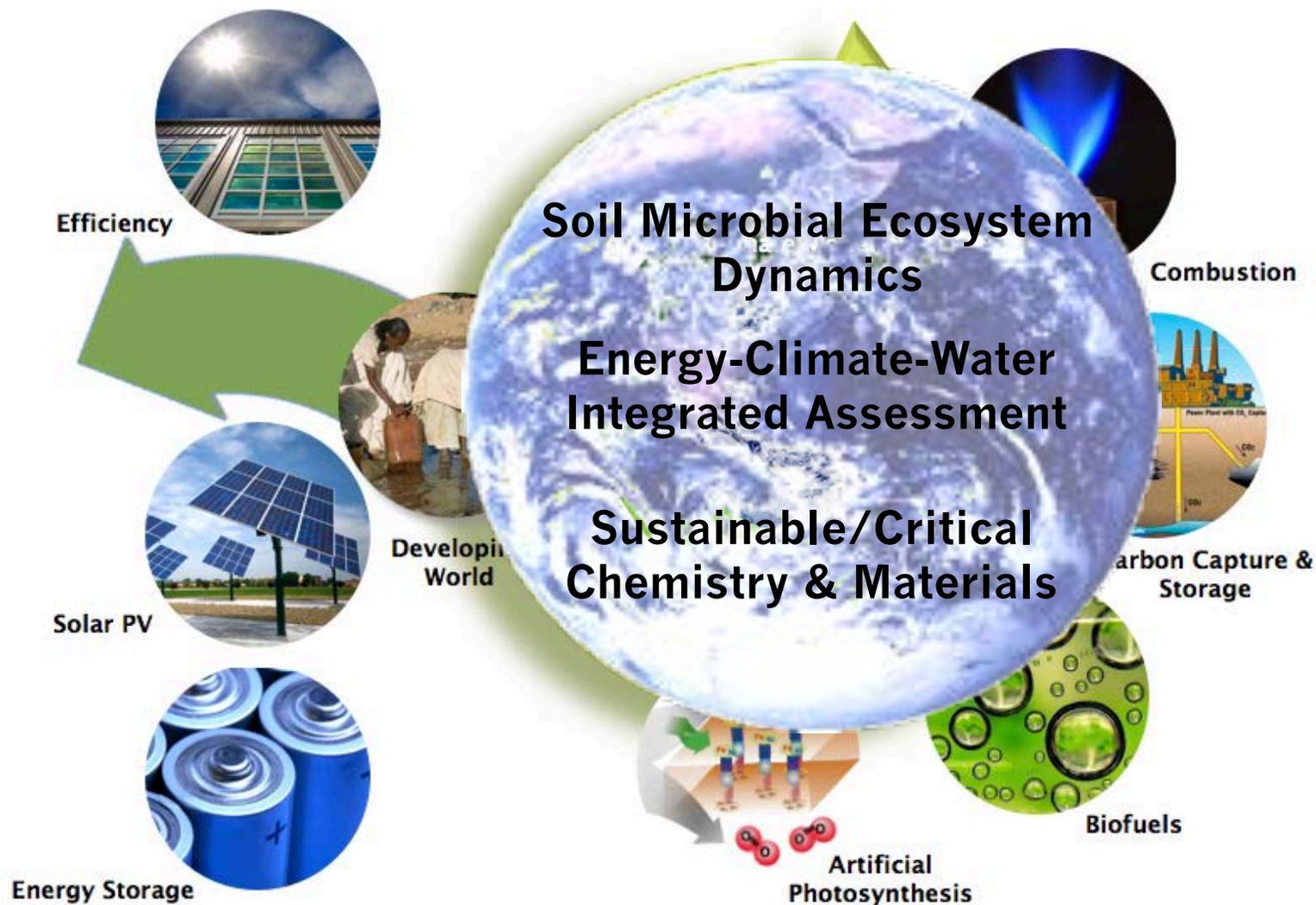
# Basic Science Discoveries Key To CC2.0 Effort



# Carbon Cycle 2.0 Initiative organized to deliver science-based solutions to societal problems



# Carbon Cycle 2.0 Initiative organized to deliver science-based solutions to societal problems





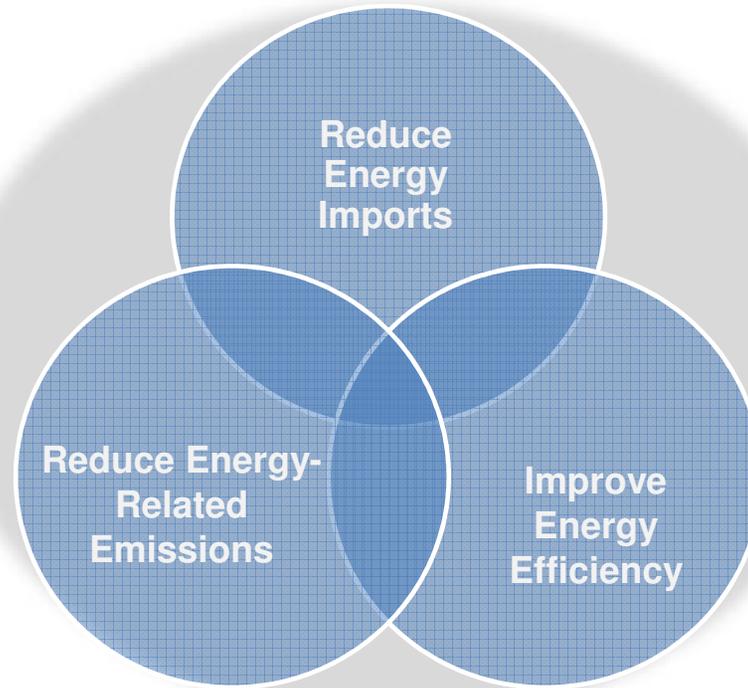
## CC2 and technology development

- An implicit goal of our Carbon Cycle 2.0 initiative is to turn our fundamental science into scalable technologies that will have a major impact on the relationship between energy production and carbon emissions
- There are few programs within the DOE funding structure that provide support for this transformation of science into technology
- ARPA-e is one such program
- Consequently, it is imperative that we use ARPA-e funding as effectively as possible to make CC2 a success

# ARPA-e Mission



- To enhance the economic and energy security of the U.S.
- To ensure U.S. technological lead in developing and deploying advanced energy technologies



# What makes an ARPA-e project?



## 1. Impact

- High impact on ARPA-E mission areas
- Credible path to market
- Large commercial application

## 2. Transform

- Challenges what is possible
- Disrupts existing learning curves
- Leaps beyond today's technologies

## 3. Bridge

- Between basic science and applied technology
- Not researched or funded elsewhere
- Catalyzes new interest and investment

## 4. Team

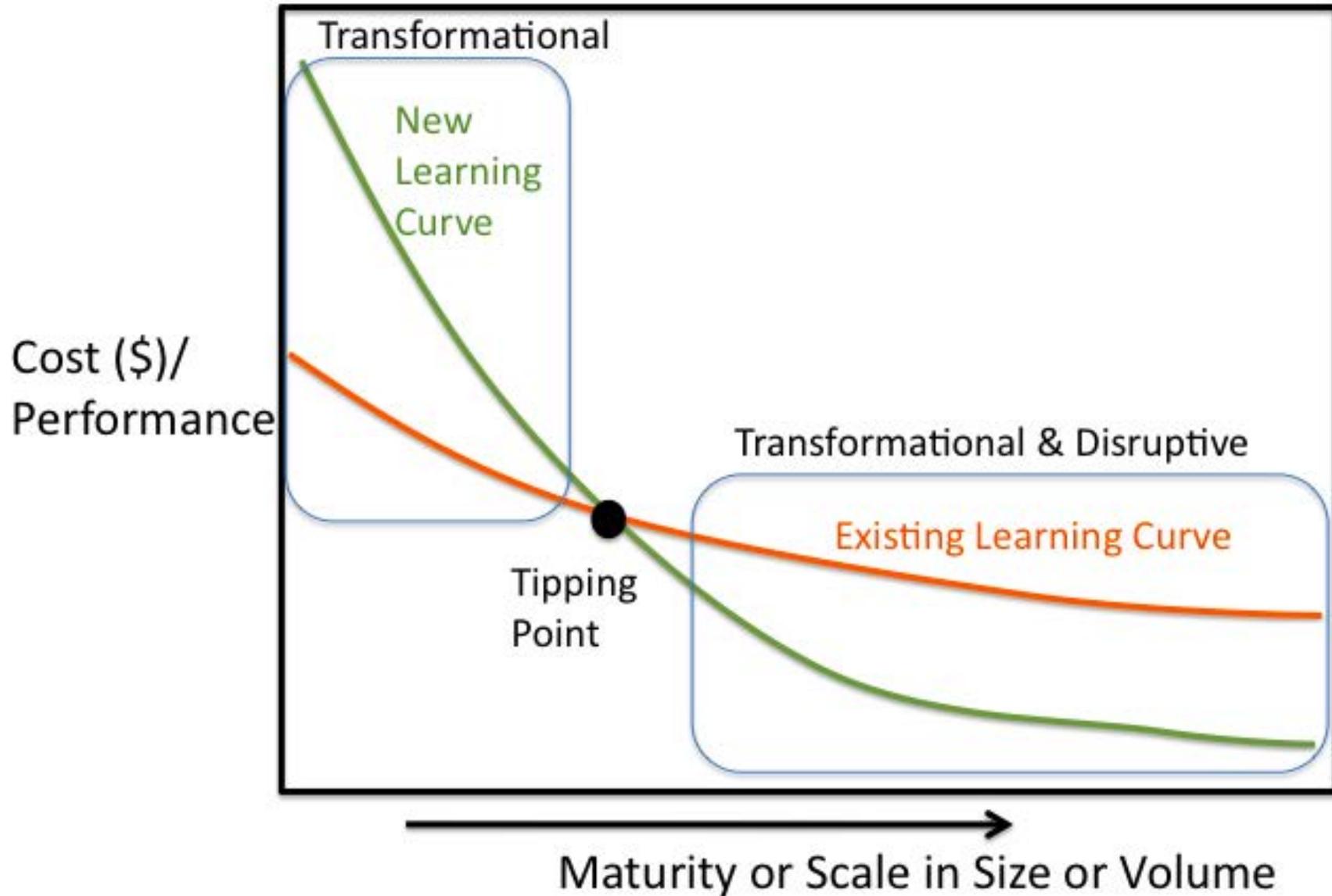
- Best-in-class people
- Cross-disciplinary skill sets
- Translation oriented

# Overview: What does ARPA-E fund?



- ARPA-E funds **applied research and development**
- ARPA-E exists to support **transformational, rather than incremental**, research
- ARPA-E funded technology has the **potential to be disruptive in the marketplace\*\***
- ARPA-E **will NOT support basic research** aimed at discovery and fundamental knowledge generation, **NOR** will it undertake **large-scale demonstration projects** of existing technologies
- Projects under this FOA must be aimed at *more than progress toward identified goals*; the **project must be aimed at actual delivery of project goals**

# \*\*Disruptive Technologies



# Overview: What does ARPA-E fund?



But.....

If you are uncertain about whether your project idea is appropriate for ARPA-e, it may be best to submit the concept paper and let them decide!

Sometimes their interpretation of what is “disruptive” and “transformational” may be different from what you think it is.

*(Funding application is a multi-stage process)*

# ARPA-E Application Process Overview



## Application Process:

- Applicants must submit **Notice of Intent**, required to obtain a Control Number
- Applicants **must submit a Concept Paper**
- ARPA-E will **encourage a subset to submit Full Applications**
- Following review, applicants will have opportunity to reply to review comments
- ARPA-E will **down-select**, which may include discussions and/or site visits, to choose those to proceed to **award negotiations**
- Selected applicants are required to participate in a **webinar** approximately one week after selection announcement
- **Notices of Intent, Concept Papers, Full Applications, and Replies to Reviewer Comments must be submitted through ARPA-E eXCHANGE**  
<https://arpa-e-foa.energy.gov/login.aspx>

# Technical Categories and Subcategories of Interest



- Proposals to address ARPA-E's Mission Areas; may span multiple disciplinary boundaries
- Each Notice of Intent, Concept Paper, and Full Application must identify relevant Technical Subcategory or Subcategories
- **Categories:**
  1. Renewable power (non-bio)
  2. Bioenergy
  3. Transportation
  4. Conventional generation (non-renewable)
  5. Grid
  6. Building efficiency
  7. Other
  8. None of the Above

**See FOA for subcategories**

# Applications that will be deemed nonresponsive and will NOT be considered



- **Applications & proposed technologies will NOT be considered if:**
  - Not within “Technical Areas of Interest”
  - **Already submitted to**, or are not scientifically distinct from applications already submitted to, **pending ARPA-E FOAs**
  - **Basic research aimed at discovery/fundamental knowledge**
  - **Large-scale demonstration projects** of existing technologies
  - **Incremental improvements** to existing technologies
  - **Not based on sound scientific principles** (e.g., violates a law of thermodynamics).
  - **Do not address at least one of ARPA-E’s Mission Areas**
  - **Not transformational**
  - **Do not have the potential to be disruptive/scalable.**

# ARPA-E Open FOA: Award Overview



- **Total Amount to be Awarded:** Approximately \$150 million
- **Anticipated Awards:** ARPA-E may issue one, multiple, or no awards under this FOA. Awards may vary between \$250,000 - \$10 million.
- **Types of Funding Agreements:** Cooperative Agreements, Technology Investment Agreements, Work Authorizations, and Interagency Agreements
- **Period of Performance:** Expected up to 36 months
- **Number of Applications:** Applicants may submit more than one application to this FOA, provided that each application is scientifically distinct.
- **Two project types:**
  - **Proof-of-Concept Seedling Project:** \$250 - \$999K. Early-stage, proof-of-concept level. ARPA-E may issue approximately 20-30 awards in this category, average award of \$500,000.
  - **Technology Development Project:** \$1 - \$10 million. Early-stage prototypes of technology concepts for which initial proof-of-concept demonstration exists. ARPA-E may issue approximately 40-50 awards in this category, average award of \$3 million.

# ARPA-E Agreement Types



- Funding to LBNL comes through DOE Field Work Proposal (FWP) system
- Where LBNL is lead; ARPA-E will fund LBNL through FWP and issue a single **Cooperative Agreement** to provide financial and other support to other recipients. The Lab is still the lead organization and responsible for the entire team.
  - **Under Cooperative Agreements, the Government and Prime Recipients share responsibility for the direction of projects**
  - Prime Recipients should view the model Cooperative Agreement prior to award negotiations: <http://arpa-e.energy.gov/FundingAgreements/Overview/Award.aspx#CooperativeAgreements>
- Where LBNL is member of Project Team, ARPA-E will fund LBNL through the FWP process and issue a single Cooperative Agreement with the rest of the team. Prime Recipient will be the lead for the entire project, including work performed at LBNL.
- An alternative agreement type is a **Technology Investment Agreement** which may be favorable **for for-profit led Projects** desiring different Intellectual Property and Accounting provisions in the contract terms
  - Technology Investment Agreements require **≥50% cost-share**

# ARPA-E Substantial Project Involvement



- **ARPA-E is substantially involved in the direction of projects (regardless of the type of funding agreement) from inception to completion**
  - ARPA-E shares responsibility with Prime Recipients for the direction of projects.
  - ARPA-E may intervene at any time to address the conduct or performance of project activities
  - Prime Recipients are required to submit detailed quarterly technical and financial reports on the project
  - ARPA-E Program Directors share responsibility with Prime Recipients for the direction of projects
  - ARPA-E Program Directors visit each Prime Recipient at least twice per year, and hold periodic meetings, conference calls, and webinars with Project Teams
  - **ARPA-E Program Directors may modify or terminate projects that fail to achieve predetermined technical milestones and deliverables**

# Relevant Dates



- **Letter of Intent Submission Deadline: 3/30/2012 5:00 PM ET**
- **Concept Paper Submission Deadline: 4/12/2012 5:00 PM ET**
- **Full Application Submission Deadline: TBD**
  
- Applicants are responsible for meeting each submission deadline
- **Don't wait till the last minute**
  - ARPA-E will not extend the submission deadline for Applicants that fail to submit required information and documents due to server/connection congestion
- **ARPA-E will not review or consider noncompliant applications** including incomplete applications and applications submitted after the deadline

# MANDATORY Notice of Intent



**Each Applicant must enter the following information into ARPA-E eXCHANGE by the stated deadline of 5 PM ET March 30, 2012:**

- Project Title
- Lead Organization
- Organization Type (i.e. Federally Funded Research and Development Center (FFRDC))
- Whether the application was previously submitted to DOE
- % of effort contributed by the Lead Organization
- Principal Investigator, Team Members, and Key Participants
- Technical Subcategory or Subcategories
- Abstract – The abstract provided should be 200 words in length, and should provide a truncated explanation of the proposed project

# MANDATORY Concept Paper



**Each Applicant must submit a Concept Paper in Adobe PDF format by the stated deadline of 5 PM ET APRIL 12, 2012.**

**The Concept Paper must include the following:**

- Technology Description (2 pages max.)
- Addendum (1 page max.)

**Concept Paper Template provided at:**

- <https://arpa-e-foa.energy.gov/>

**Concept Paper must be submitted through ARPA-E eXCHANGE**

# Considerations for LBNL ARPA-e applicants



- **Eligibility: LBNL employees/organizations are eligible to lead and/or participate in Project Teams** (national labs are generally eligible; see FOA for exceptions & eligibility requirements for other lead organizations)
- **Cost share requirements:**
  - **≥5% for Project Teams comprised exclusively of domestic educational institutions, domestic nonprofits, and/or FFRDCs\***
  - **≥10% for Project Teams where domestic educational institutions, domestic nonprofits, and/or FFRDCs perform ≥ 80% but less than 100% of the work, as measured by Total Project Cost**
  - **≥20% for “All other projects” and ≥50% for Technology Investment Agreement** (non-Cooperative Agreement; IP option for industry-led project)
  - **LBNL will provide 5% cost share**
- **Prospective applicants are encouraged to contact their Division’s program development POC to inform them of your proposed project**
- **Current LBNL ARPA-e recipients may be available to review and make recommendations**

\*FFRDC = Federally-funded research & development center; e.g., LBNL

# More Information



- **ARPA-e website:** [arpa-e.energy.gov](https://arpa-e.energy.gov)
- **LBNL internal ARPA-e website:** [www.lbl.gov/dir/arpa-e/](https://www.lbl.gov/dir/arpa-e/)
- **Division POCs**
  - Please contact your division’s program development POC if you intend to submit a project
- [ARPA-E-CO@hq.doe.gov](mailto:ARPA-E-CO@hq.doe.gov)  
**For questions regarding Funding Opportunity Announcements**
  - Every Friday, ARPA-E will post responses to any questions that were received by Wednesday at 12 PM ET. Responses are posted to "Frequently Asked Questions" <http://arpa-e.energy.gov/About/FAQs.aspx>
  - ARPA-E will cease to accept questions 96 hours in advance of the applicable deadline.
- [ExchangeHelp@hq.doe.gov](mailto:ExchangeHelp@hq.doe.gov)  
**For questions regarding ARPA-E eXCHANGE**

# Berkeley Lab ARPA-E Awardees



- **Berkeley Lab-led Awards**

- **Jeff Long, PI:** High-Throughput Discovery of Robust Metal-Organic Frameworks for CO<sub>2</sub> Capture
- **Steven Singer, PI:** Microbial-Electrocatalytic Biofuel Production
- **Venkat Srinivasan, PI; Adam Weber, Vince Battaglia, co-PIs:** Hydrogen Bromine Flow Batteries for Grid Scale Energy Storage
- **Christer Jansson, PI:** FOLIUM – Installation of Hydrocarbon Accumulating Pathways in Tobacco Leaves

- **Awards with Berkeley Lab as partner/affiliate:**

- **David Watson & Mary Ann Piette:** Demand Response Optimization & Management System for Real-Time Integration of Renewable Generation, Project Lead: AutoGrid (startup company)
- **Gao Liu & Vince Battaglia:** Advanced Li-ion battery manufacturing: Novel high energy density cell designs & innovative manufacturing process modules Project Lead: Applied Materials (company)



# High-Throughput Discovery of Robust Metal-Organic Frameworks for CO<sub>2</sub> Capture

**Jeff Long, Principal Investigator**  
Materials Sciences Division  
Department of Chemistry, UC Berkeley  
[jrlong@berkeley.edu](mailto:jrlong@berkeley.edu)

## High-Throughput Synthesis

Highly-parallel, automated discovery of new MOFs



Automated Solid and Liquid Dosing



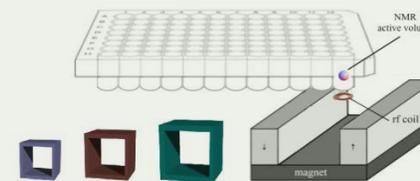
New Structure Types

## High-Throughput Characterization

Rapid identification of new porous materials



Powder X-ray Diffraction

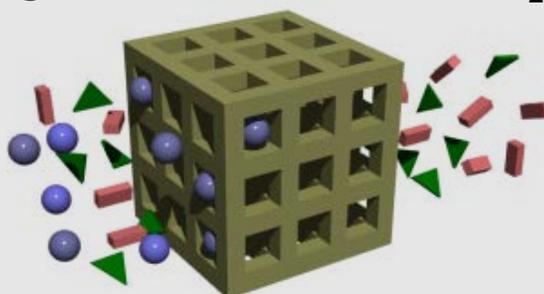


NMR Porosity Screening



Jeffrey R. Long  
Berend Smit  
Jeffrey A. Reimer  
Maciej Haranczyk  
Eric R. Masanet

## High-Throughput Discovery of Robust Metal-Organic Frameworks for CO<sub>2</sub> Capture



Steven S. Kaye



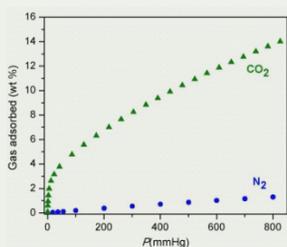
Abhoyjit S. Bhowm

## CO<sub>2</sub> Adsorption Screening

Rapid screening of CO<sub>2</sub> capture performance



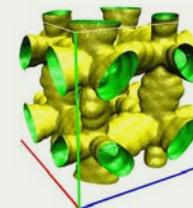
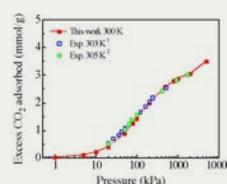
High-throughput Instrumentation



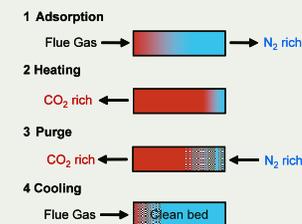
Adsorption Data

## Computational Analysis

Data analysis, life cycle and sorbent performance analysis



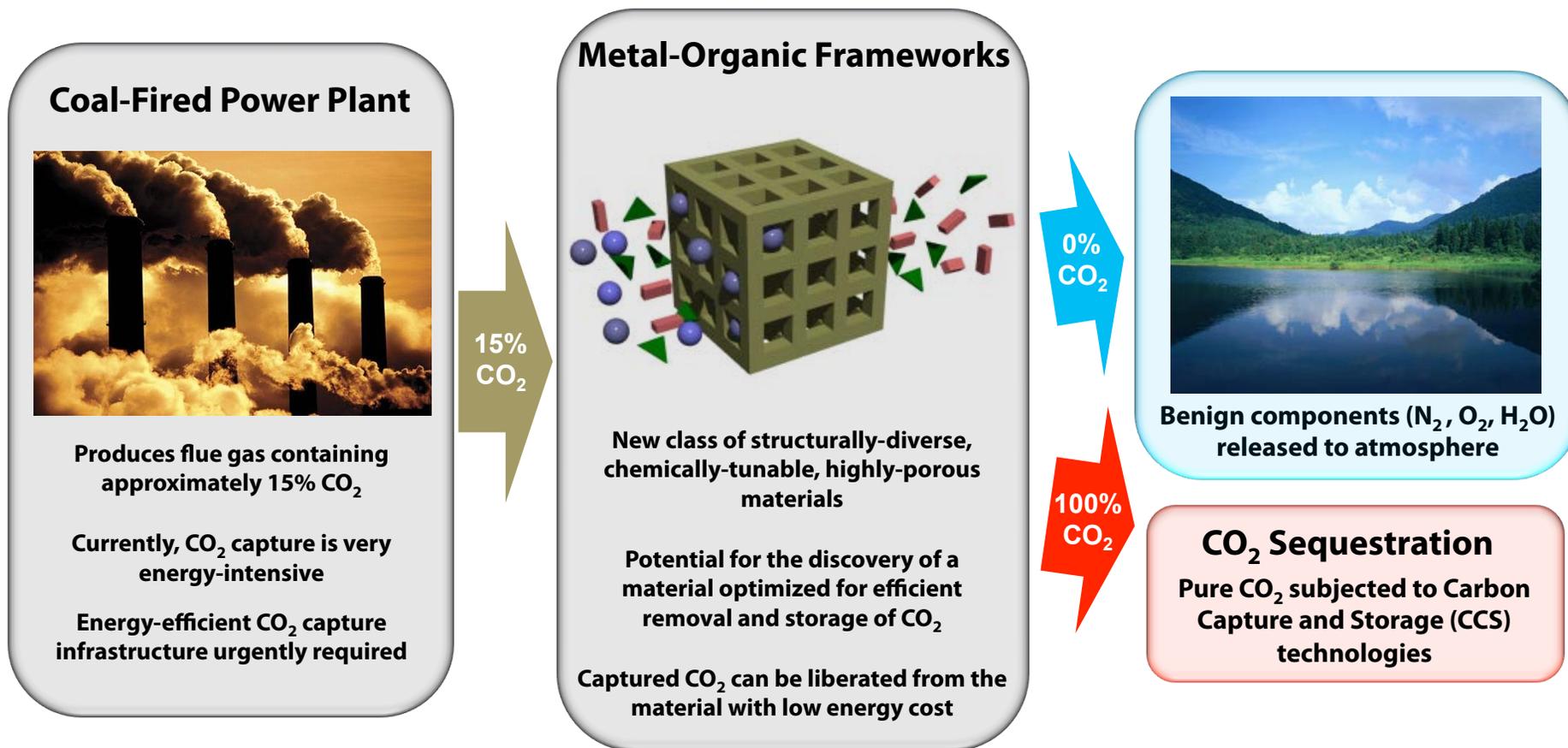
Simulations



Sorbent Performance

# High-Throughput Discovery of Robust Metal-Organic Frameworks for CO<sub>2</sub> Capture

Jeffrey R. Long, Berend Smit, Steven S. Kaye, Jeffrey A. Reimer, Maciej Haranczyk, Eric R. Masanet, and Abhoyjit S. Bhowm



*Our project will use high-throughput technologies and cutting-edge computational techniques to design and synthesize metal-organic frameworks optimized for CO<sub>2</sub> capture applications*





**Microbial Electrocatalytic Biofuel Production:  
Combining synthetic biology and chemistry to  
produce biofuels using an autotrophic bacterium  
(*Ralstonia eutropha*)**

**Steve Singer, Principal Investigator**

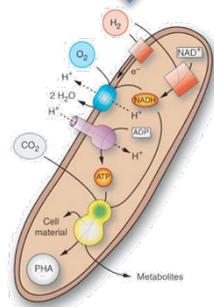
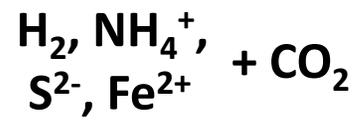
Earth Sciences Division

[swsinger@lbl.gov](mailto:swsinger@lbl.gov)

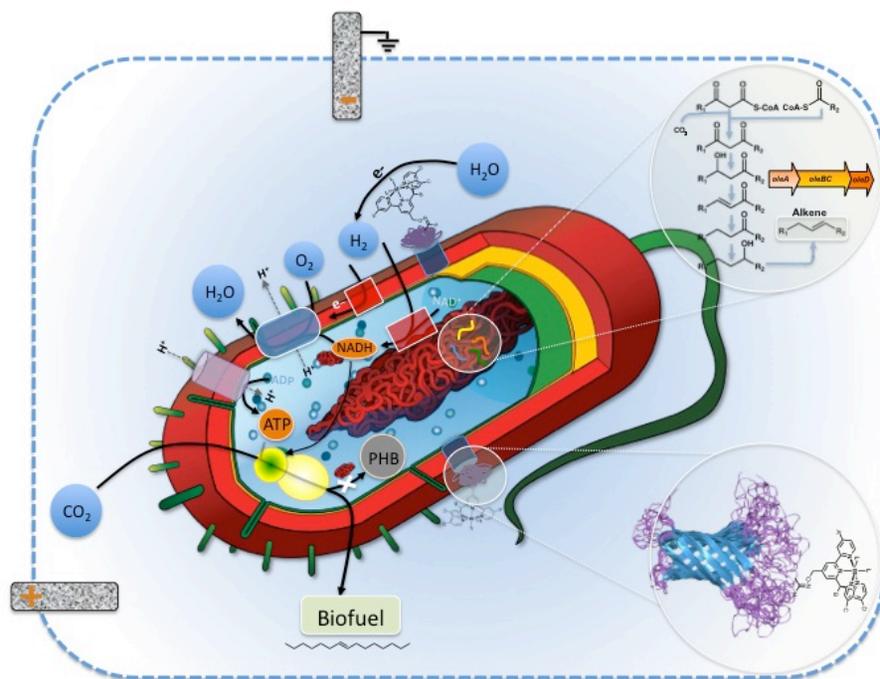
# Electrofuels: Transforming electricity and CO<sub>2</sub> to advanced biofuels



**Electricity**



# Microbial Electrocatalytic Biofuel Production: Combining synthetic biology and chemistry to produce biofuels using an autotrophic bacterium (*Ralstonia eutropha*)



*Steven Singer, PI - LBNL*

*Harry Beller, Co-PI - LBNL*

*Swapnil Chhabra, Co-PI - LBNL*

*Christopher Chang, Co-PI - UC Berkeley*

*Gregg Deluga, Co-PI – Logos Technologies*





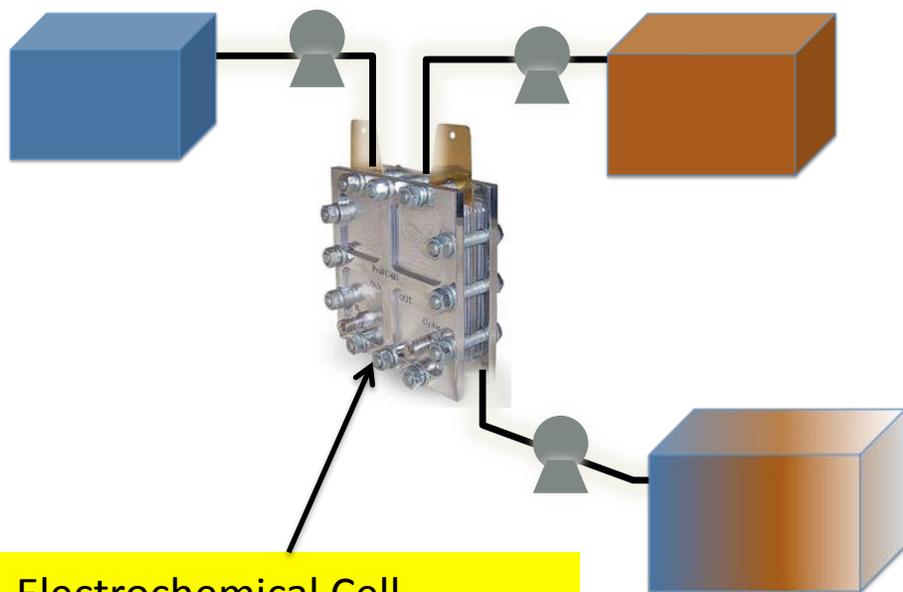
# Hydrogen Bromine Flow Batteries for Grid Scale Energy Storage

**Vince Battaglia, co-PI**

Environmental Energy Technologies Division

[vsbattaglia@lbl.gov](mailto:vsbattaglia@lbl.gov)

# Flow batteries for grid scale energy storage

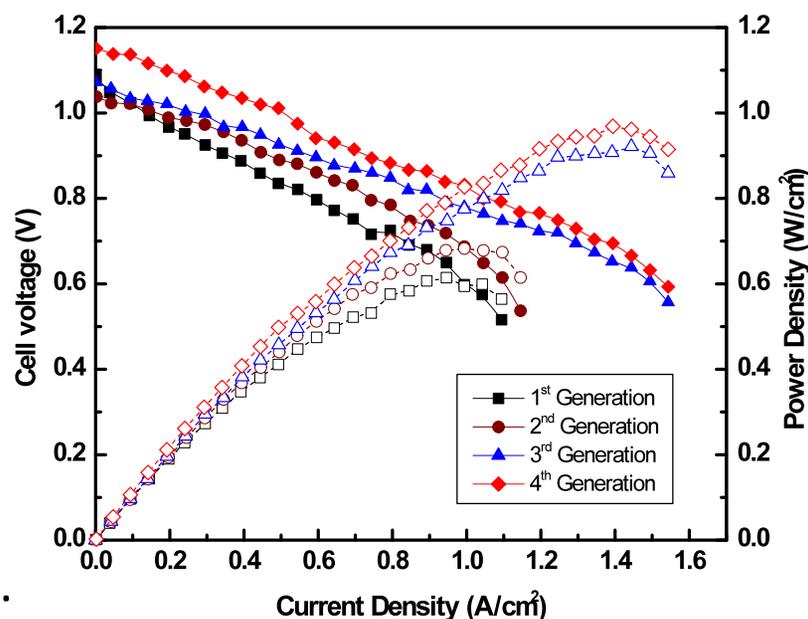


Electrochemical Cell  
(membranes, catalyst layers)

- Electrochemical cell is expensive in a flow battery
- LBNL proposed to minimize the cost by using chemicals that have fast reaction kinetics based on hydrogen and bromine.

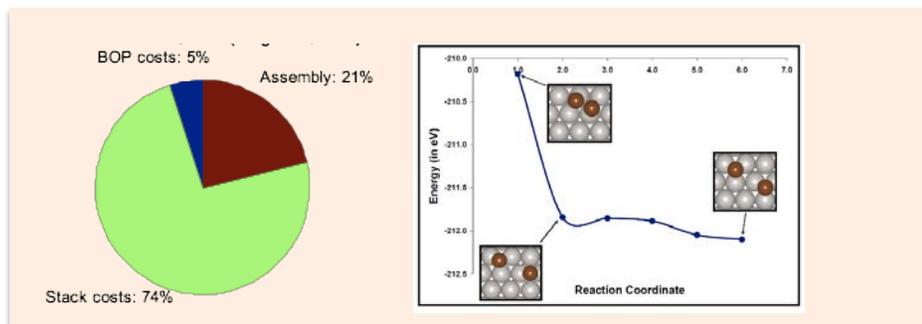
- Flow batteries allow separation of energy and power

- Energy dictated by size of tank
- Power depends on size of cell

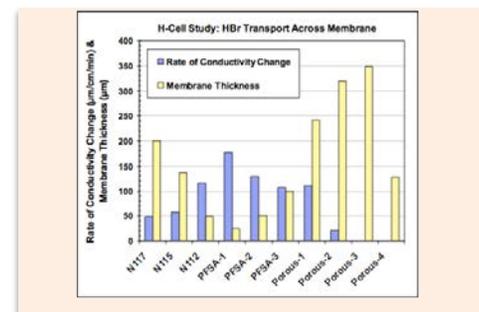


We have recently demonstrated the highest power flow battery at 80% round-trip energy efficiency

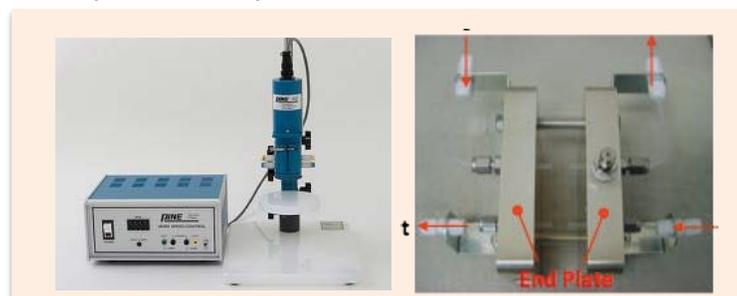
# LBNL has been working with industrial partners



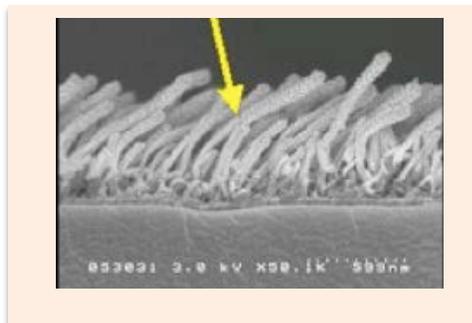
**Bosch:** Cost modeling, catalyst theory



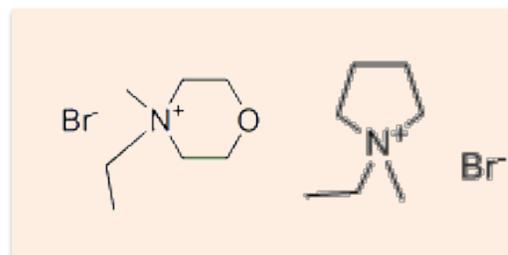
**Dupont:** Low-cost, stable, ion-exchange and microporous membranes



**LBNL:** Catalysis studies, high power designs, new couples, integration



**3M:** Novel catalyst structures for lower cost



**Israel Chemicals:** Bromine complexes for safety



**Proton Energy:** Electrochemical hydrogen compression



# **FOLIUM – Installation of Hydrocarbon Accumulating Pathways in Tobacco Leaves**

Christer Jansson, PI  
Earth Sciences Division  
[cgjansson@lbl.gov](mailto:cgjansson@lbl.gov)



# Folium

Tobacco as a Platform for Foliar Biosynthesis of Advanced Hydrocarbon Fuels

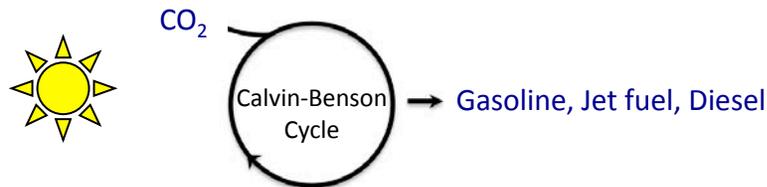
## Objectives

- Installation of microbial metabolic pathways in tobacco for biosynthesis and accumulation of hydrocarbon fuels in green biomass.
- Optimization of carbon flux toward hydrocarbon accumulation in tobacco.
- Enhancement of tobacco productivity by improved photosynthetic performance and agricultural practices.
- Establishment of tobacco as a platform for the production and extraction of high-density liquid hydrocarbon biofuels.



### Team

*Christer Jansson, PI* – LBNL  
*Tasios Melis, Co-PI* - UC Berkeley  
*Peggy Lemaux, Co-PI* - UC Berkeley  
*Kris Niyogi, Co-PI* - UC Berkeley  
*David Wemmer, Co-PI* - UC Berkeley  
*Cheryl Kerfeld, Co-PI* - UC Berkeley, LBNL  
*Orlando Chambers, Co-PI* – KTRDC  
*Ling Yuan, Co-PI* – KTRDC  
*Carol Valladao, Project PM* - LBNL

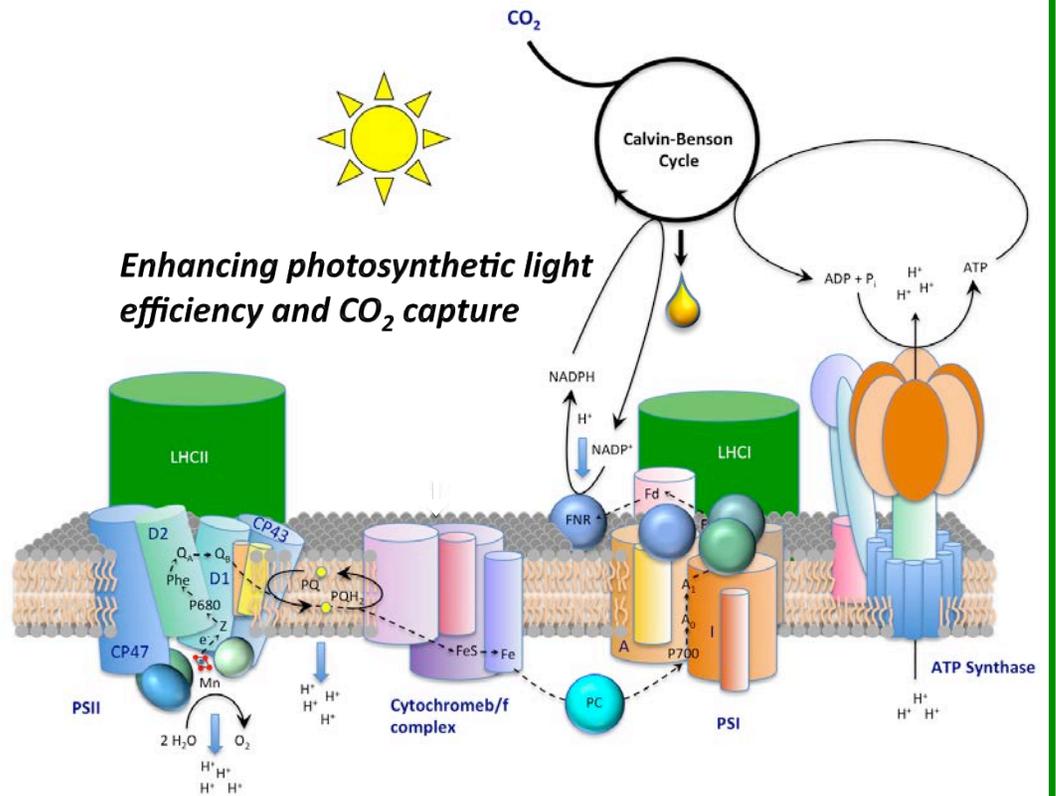
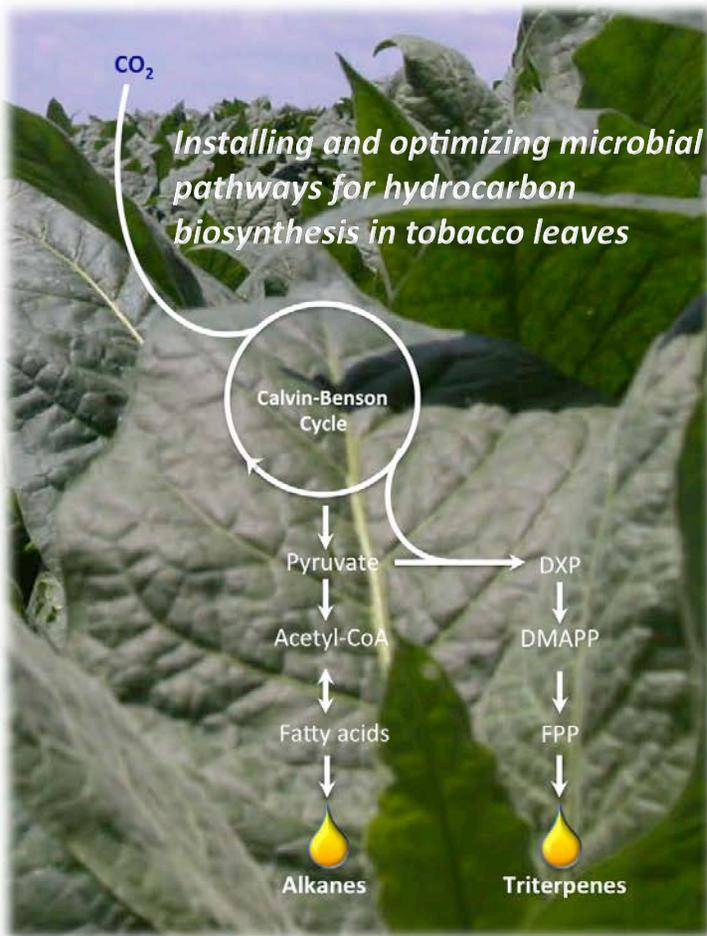




# Folium

Tobacco as a Platform for Foliar Biosynthesis of Advanced Hydrocarbon Fuels

## Technology





## **Demand Response Optimization & Management System for Real-Time Integration of Renewable Generation**

**Dave Watson, LBNL partner**  
Environmental Energy Technologies Division  
[dswatson@lbl.gov](mailto:dswatson@lbl.gov)



# Integration of Renewables via Demand Management

## Problem:

- High penetrations of wind and solar will make the electric grid unstable
- Must to be firmed up with reliable resources

## Solution:

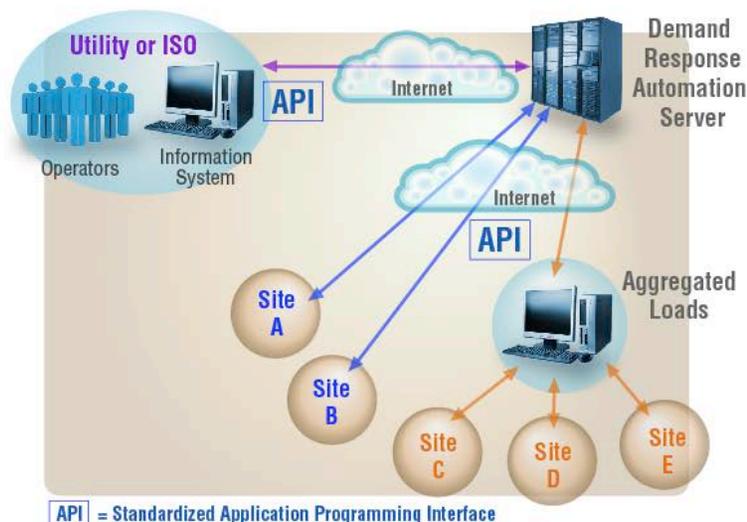
- When wind or solar drop, system automatically reduces electric power demand using predetermined, non-obtrusive methods in commercial buildings, industrial processes and residences.
- Pseudo-generation (i.e., nega-watts) can be sold into electric markets.

## ARPA-E Green Electricity Network Integration (GENI) Team:

**AutoGrid Systems, Inc.**  
**Lawrence Berkeley National Laboratory**  
**Columbia University**



# Automated Demand Response (OpenADR)



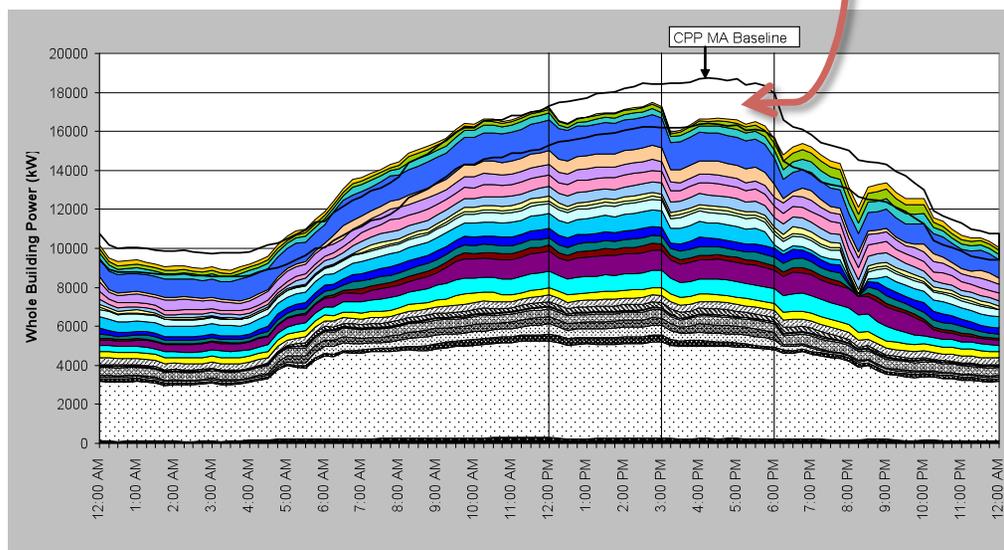
## Foundation based on LBNL research

- ver. 1.0 stable since 2005
- ver. 2.0 NIST standard to be released Q2
- Extensions & findings from ARPA-E project submitted for future versions

## New in ARPA-E:

- Forecasting based on machine learning algorithms
- Available 24x7x365
- Dispatchable in near “real-time”

2 MW shed  
OpenADR  
July 2008





# Advanced Li-ion battery manufacturing: Novel high energy density cell designs & innovative manufacturing process modules

**Gao Liu, LBNL Partner**

Environmental Energy Technologies Division

[gliu@lbl.gov](mailto:gliu@lbl.gov)

# ARPA-E BEEST PROGRAM

Advanced Lithium-Ion Battery Manufacturing:  
Novel High Energy Density Cell Designs &  
Innovative Manufacturing Process Modules

## Goals:

- ⌘ Improve power performance of high loading electrodes
- ⌘ Reduce costs by simplifying manufacturing processes
- ⌘ Reduce materials cost via integration of separator

## Project lead



## Project subcontractor



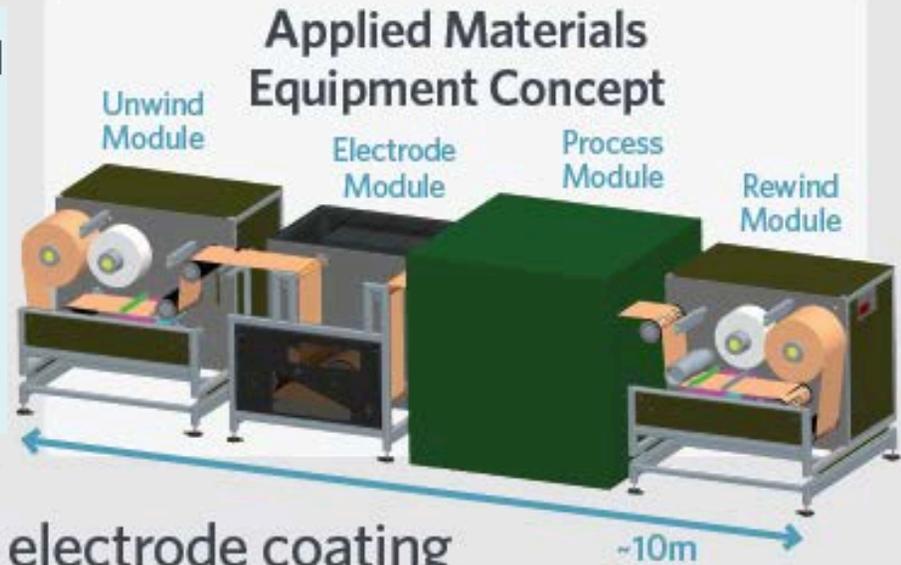
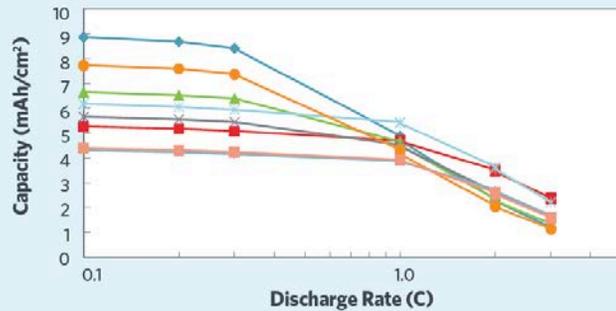
Unit Testing  
and Failure  
Analysis

LBLN brings onto table of  
fundamental knowledge of  
battery and electrode  
engineering.

Gao Liu and Vince Battaglia  
Environmental Energy Technologies Division

# New battery manufacturing instrument and process under development at Applied Materials

## 9mAh/cm<sup>2</sup> Electrode Loading Was Achieved



- High productivity electrode coating
- Enable high loading electrodes
- Multiple chemistry modular R2R tool

Disruptive technology: US imports all lithium-ion battery manufacturing instruments from overseas suppliers. Success of this project will lead to a highly competitive US supplier, and change the entire landscape of lithium-ion battery manufacturing!



additional slides

The Advanced Research Projects Agency – Energy (ARPA-E) is an organization within the Department of Energy, chartered by Congress in the America COMPETES Act to **support the creation of transformational energy technologies and systems** through funding and managing Research Development (R&D) efforts.

The mission of ARPA-E is to identify and **fund research to translate science into breakthrough energy technologies that are too risky for the private sector and that, if successfully developed, will create the foundation for entirely new industries.**

# Program Objectives



**To address the challenges imposed by the rapidly evolving global energy market, ARPA-E seeks to support transformational research in all areas of energy R&D including:**

- Resource identification
- Extraction
- Transportation and use
- Energy generation, storage, transmission and use in both transportation and stationary power sectors

**Research areas responsive to this FOA include (but are not limited to)**

- Electricity generation by both renewable and non-renewable means
- Electricity transmission, storage, and distribution
- Energy efficiency for building, manufacturing and commerce, and personal use
- All aspects of transportation, including
  - Production and distribution of both renewable and non-renewable fuels
  - Electrification
  - Energy efficiency in transportation

# Current ARPA-e program areas



- <http://arpa-e.energy.gov/ProgramsProjects/Programs.aspx>
- PETRO
- REACT
- HEATS
- GENI
- Solar ADEPT
- BEEST
- IMPACCT
- GRIDS
- ADEPT
- Electrofuels
- BEETIT
- Other