



Catalyzing Energy Breakthroughs for a Secure American Future

As Director of ARPA-e, you are uniquely positioned to see both the landscape of the energy industry as well as the barriers and challenges in implementing the DOE-DOD MOU. We would be honored if you could address the audience regarding interagency and industry cooperation. As a keynote speaker, your experience and leadership could highlight the new partnerships between our agencies while giving the attendees a glimpse of where "new energy" can take us. Currently,

# Key Ingredients for Partnerships

## 1. Win-Win: Mutual Benefit & Value Proposition

- DOD: *Save Energy, Save Money, Save Lives (General Martin Dempsey)*
- DOE: *Accelerate technology development; Early adopter market*

## 2. Transparency & Awareness

## 3. People-to-People Interactions

- Joint ownership
- Team empowerment
- Accountability

## 4. Manage Expectations

- Short and long term wins



# Fostering DoE – DoD Partnerships

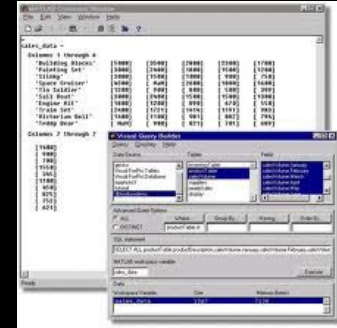
## Institutional Level

## Among Personnel

## Project Transparency



People Exchange



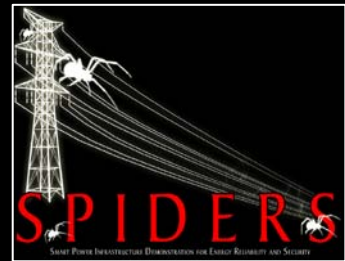
Database



Ens Pedicini, ARPA-E Summer Intern (Naval Academy, Class of 2011)

Integrated Product Teams

Microgrid



Create, Enable, and Hold Accountable



Vehicle R&D



# Low-Cost Long-Term Capital (>20 years)

<\$10M  
(2-5 yrs)

\$10-100M  
(5-10 yrs)

\$100M-1B  
(>10 yrs)

>\$1-10B

Appliance Standards, CAFE, Clean Energy Standards (80% clean energy by 2035) to Create Demand Pull

US Markets  
Businesses  
Consumers  
US Gov't

Global Markets

DoD Long-Term Market Signal



Breakthrough Technologies to Create New Learning Curves

Technology Innovations

Manufacturing/Scaling Innovations

Deployment

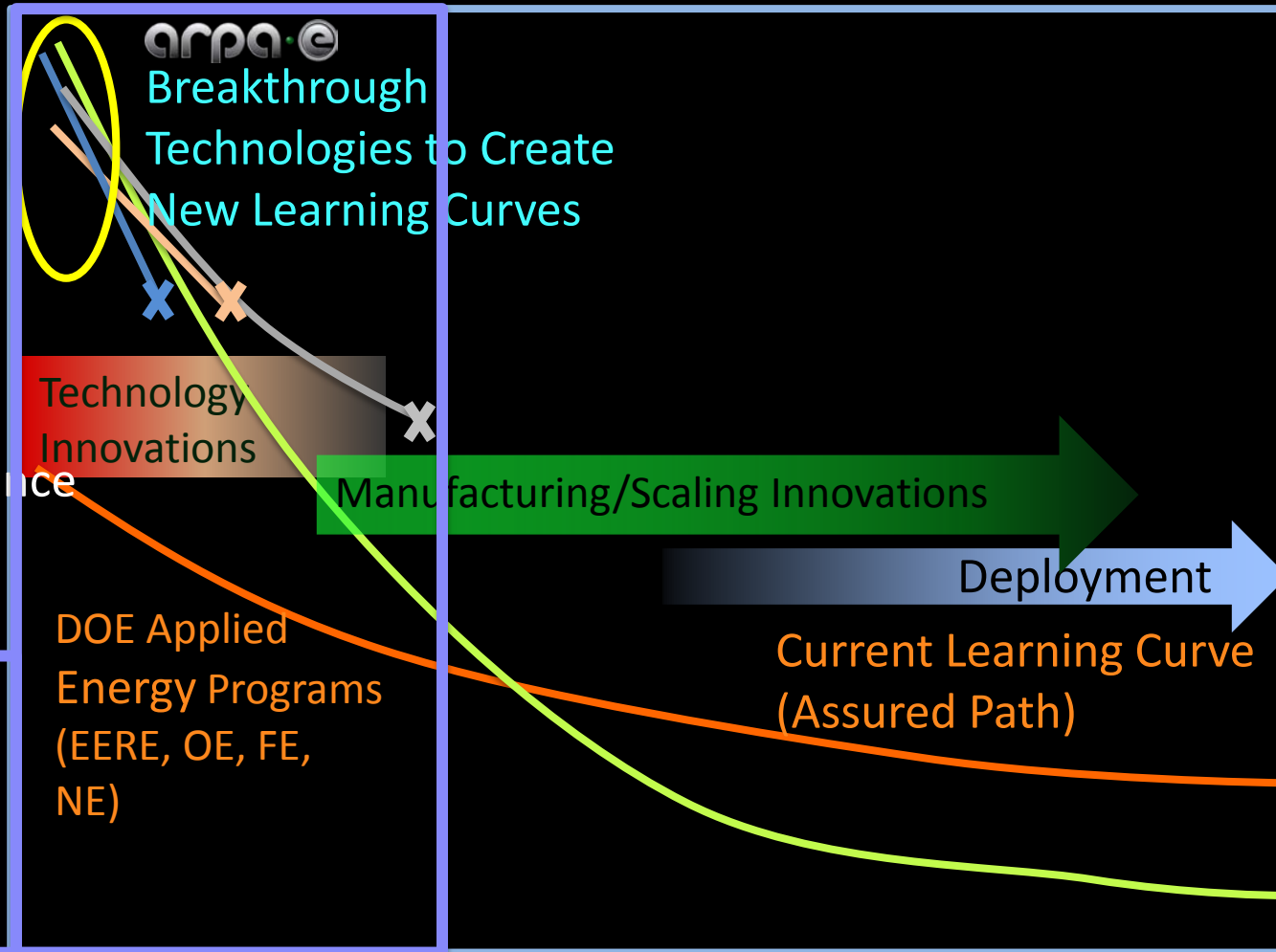
Current Learning Curve (Assured Path)

DOE Applied Energy Programs (EERE, OE, FE, NE)

Scale in Size or Volume

Cost (\$)/Performance

DoD-DoE Partnerships: Tech Innov. System Integ. Test beds





# Connective Tissue

## DoD-ARPA-E Partnership

Hybrid Energy Storage Module  
for Distributed Power  
Generation

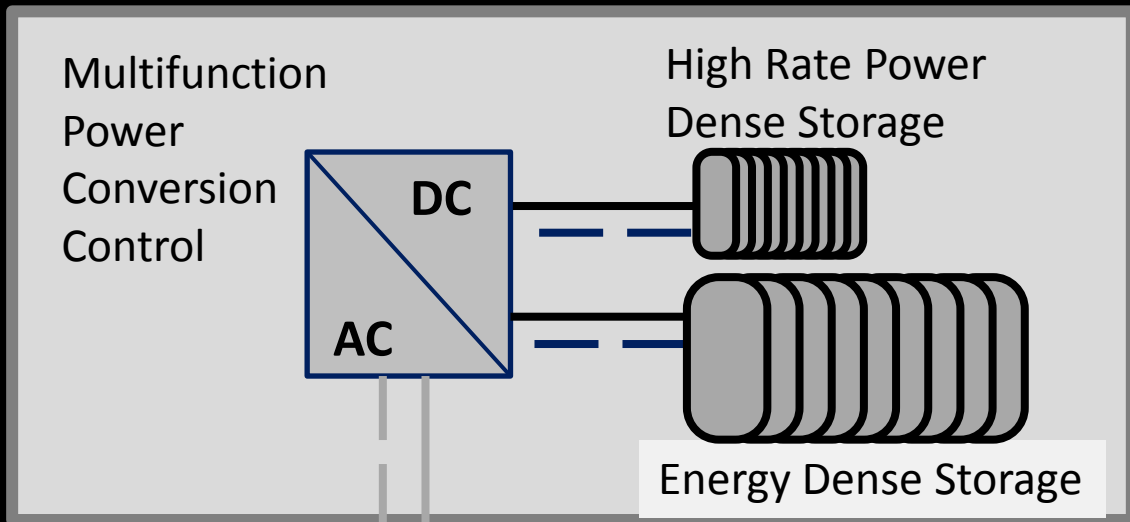


## Consortium on Stationary Energy Systems



# Hybrid Energy Storage Module

## HESM Unit



## Goal

- Maximize Fuel Economy
- Enable Increased Performance Capability

## Characteristics

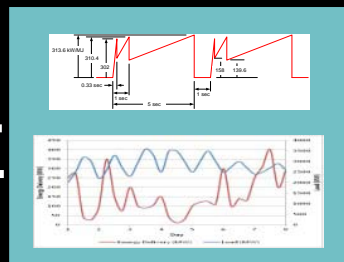
- Distributed Generation
- Distributed Varying Load
- Distributed Power & Energy Storage



Prime Power  
(Generators)



Isolation  
Switch



Loads

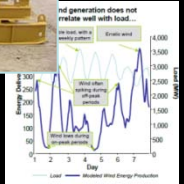
ARPA-E Lead: Dr. Srinu Mirmira  
DoD Lead: Mr. Don Hoffman (ONR)

IPT: Army (Kalio), AF (Jordan), Navy  
(Heinzel)

Operating System for Plug-n-Play Components, Automated Dispatch and Feedback Control for Stable, Resilient Power Management

## Ships

Enables Future Electric Weapons & Sensors  
Increases Shipboard Fuel Efficiency



# HESM



## Forward Operating Bases

Enables Reduction in Fuel Use at Forward Operating Bases



## Utilities

Increases Efficiency of Islanded Generators



## Aircraft

Enables More Capable and Longer Duration Aircraft





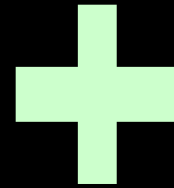
# Batteries for Electrical Energy Storage for Transportation (BEEST)

Electric cars with longer range and lower life-cycle cost than gasoline cars: Subsidy-free business

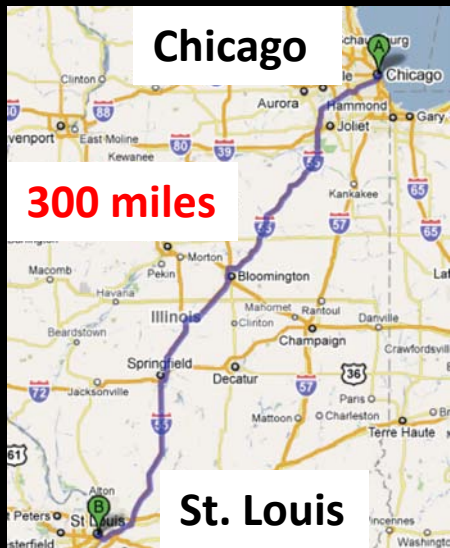


## BEEST Targets

Double the energy density



One third the cost



## BEEST Competition

All Electron Battery

Lithium-Oxygen

Lithium-Ion, Flow Battery

Lithium-Sulfur

Metal-Air

Magnesium-Ion



# Grid-Level Power Conversion & Storage

Today

Future



10,000 lbs

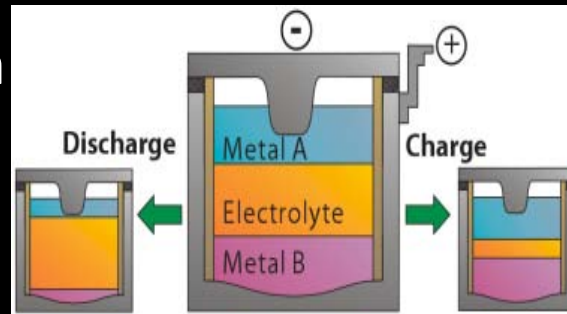
100 lbs

And Smart!

Cree Inc, North Carolina



\$100/kWh



Use anywhere in the world

MIT, Cambridge, MA



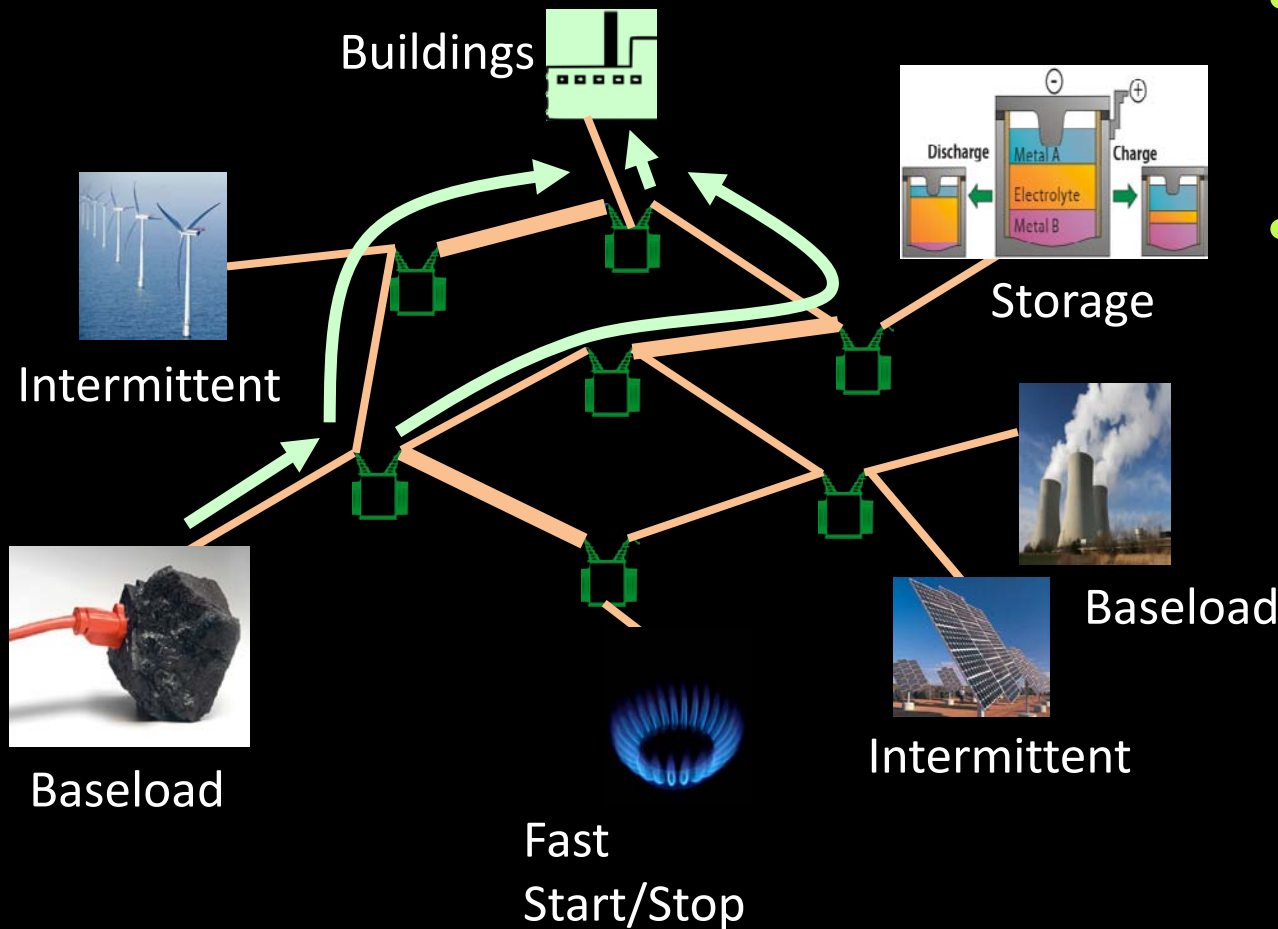
PRESS RELEASE:

Liquid Metal Battery Corporation Secures MIT Patent Rights and First Round of Funding; Gates & TOTAL Invest to Commercialize ARPA-e Funded Technology



# Green Electricity Network Integration (GENI)

Telephone → Fiber Optics, Wireless, Internet  
Today's Grid → ?



- Electric Power Routers
- Grid Operating System



# Clean and Inexpensive Electricity

Scaling without subsidies

15-20¢

5-20¢



10-15¢

10-15¢

6-13¢



4-10¢



Sunshot

Wind

Geothermal

Clean  
Coal

Nuclear

NGCC

2017

5 cents/kWh

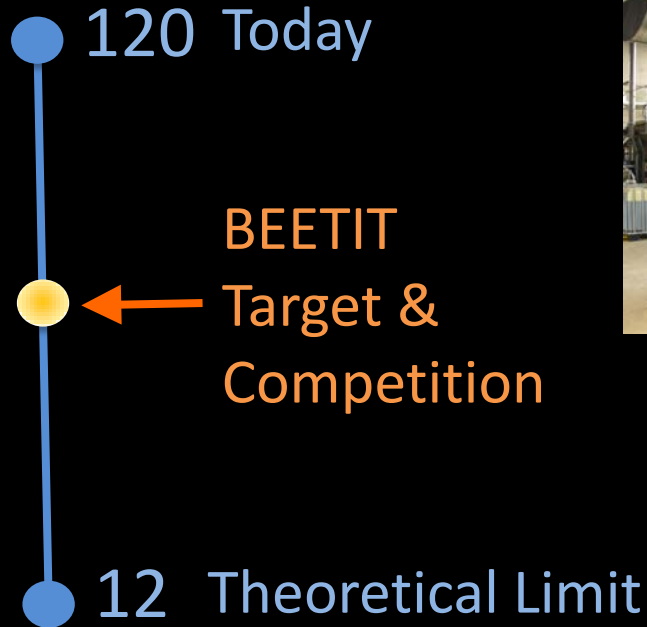




# Building Energy Efficiency Through Innovative Thermodevices (BEETIT)



Primary Energy Use  
for Cooling (kJ/kg)



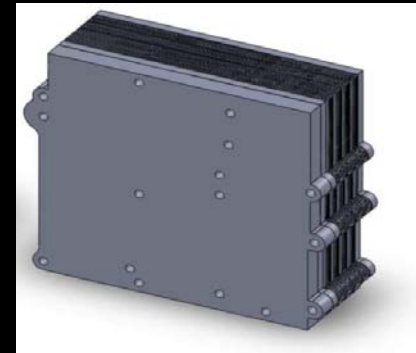
Today



180 lb/ton-cooling

3X  
→

Future



60 lb/ton-cooling

Georgia Tech,  
Georgia

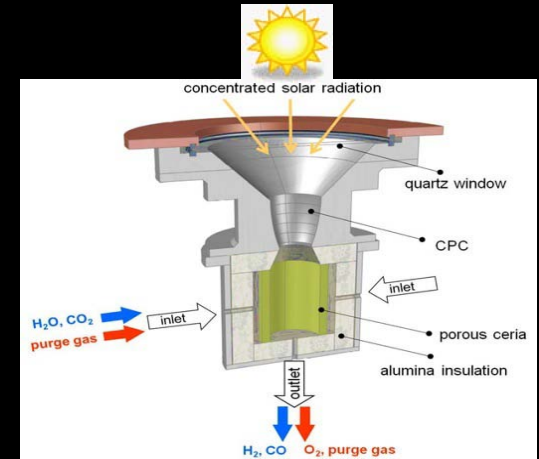


# High Energy Advanced Thermal Storage (HEATS)

Grid level storage using heat pumps



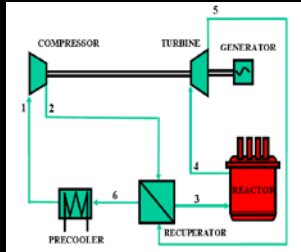
Base load Solar and Peaking High-Temp Nuclear



Thermochemical Fuel Production from Sunlight.  
Conversion efficiency > 10%

Scale

Building thermals



Increase in efficiency > 50% compared to current systems



Increase EV range by ~ 40%

<100 °C

>600 °C

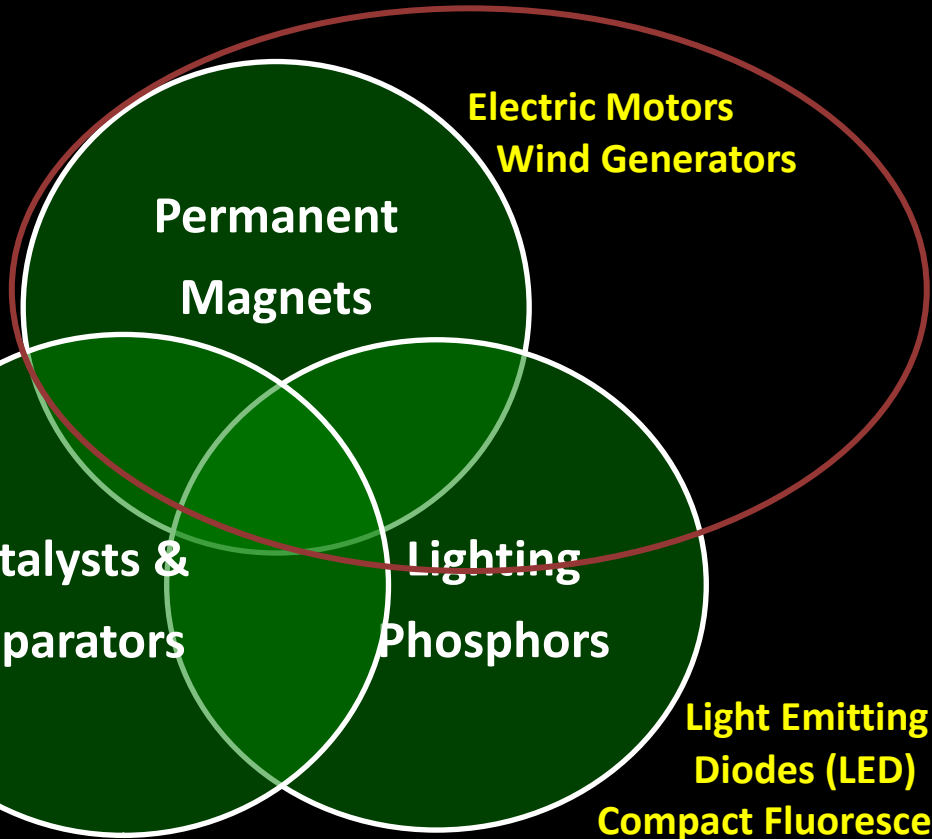
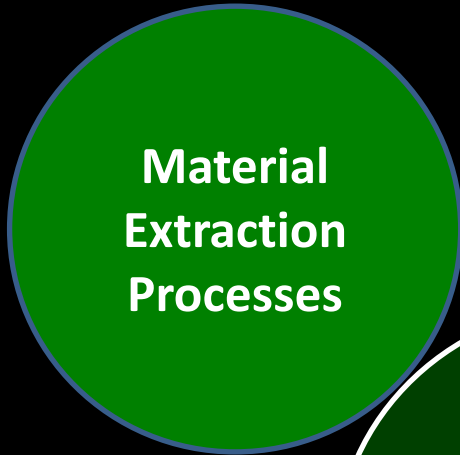
800-1500 °C

Temperature



# Rare Earth Alternatives in Critical Technologies (REACT)

Geologic or Recycled Feedstocks



Electric Motors  
Wind Generators

Solid Oxide Fuel Cells  
Gasoline Refining  
Auto Exhaust Conversion

Light Emitting Diodes (LED)  
Compact Fluorescent Lights (CFL)

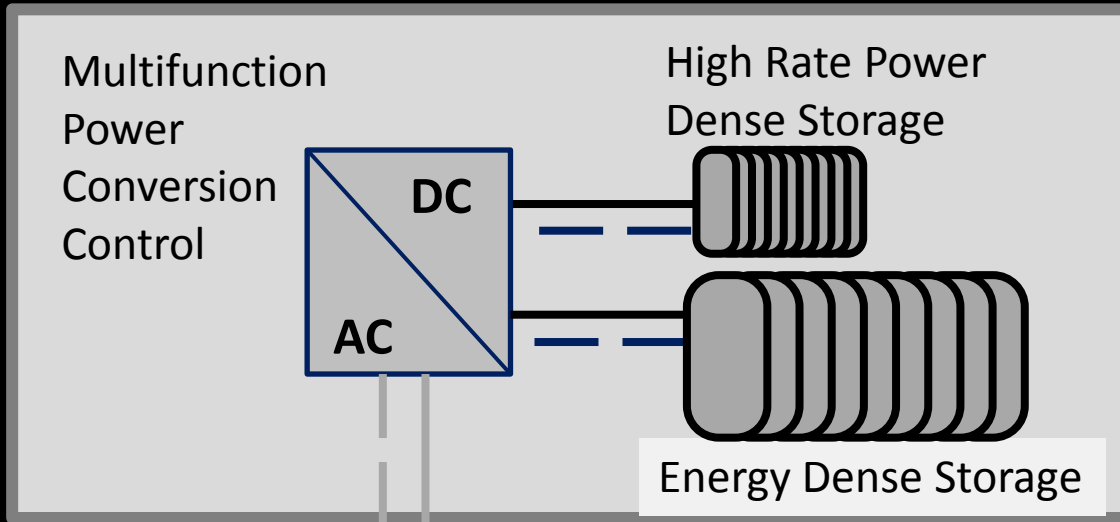
Supply Technologies



Application Technologies

# Hybrid Energy Storage Module

## HESM Unit

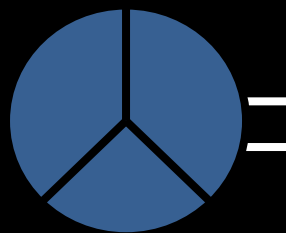


## Goal

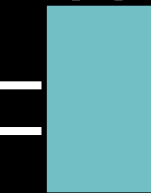
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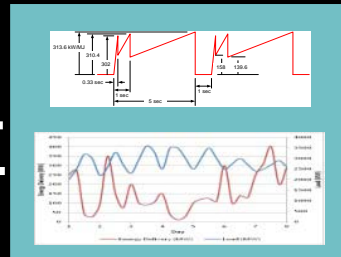
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# Photosynthetic Biofuels



Sugarcane



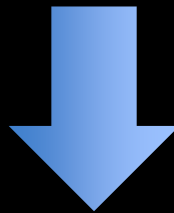
Corn



Algae

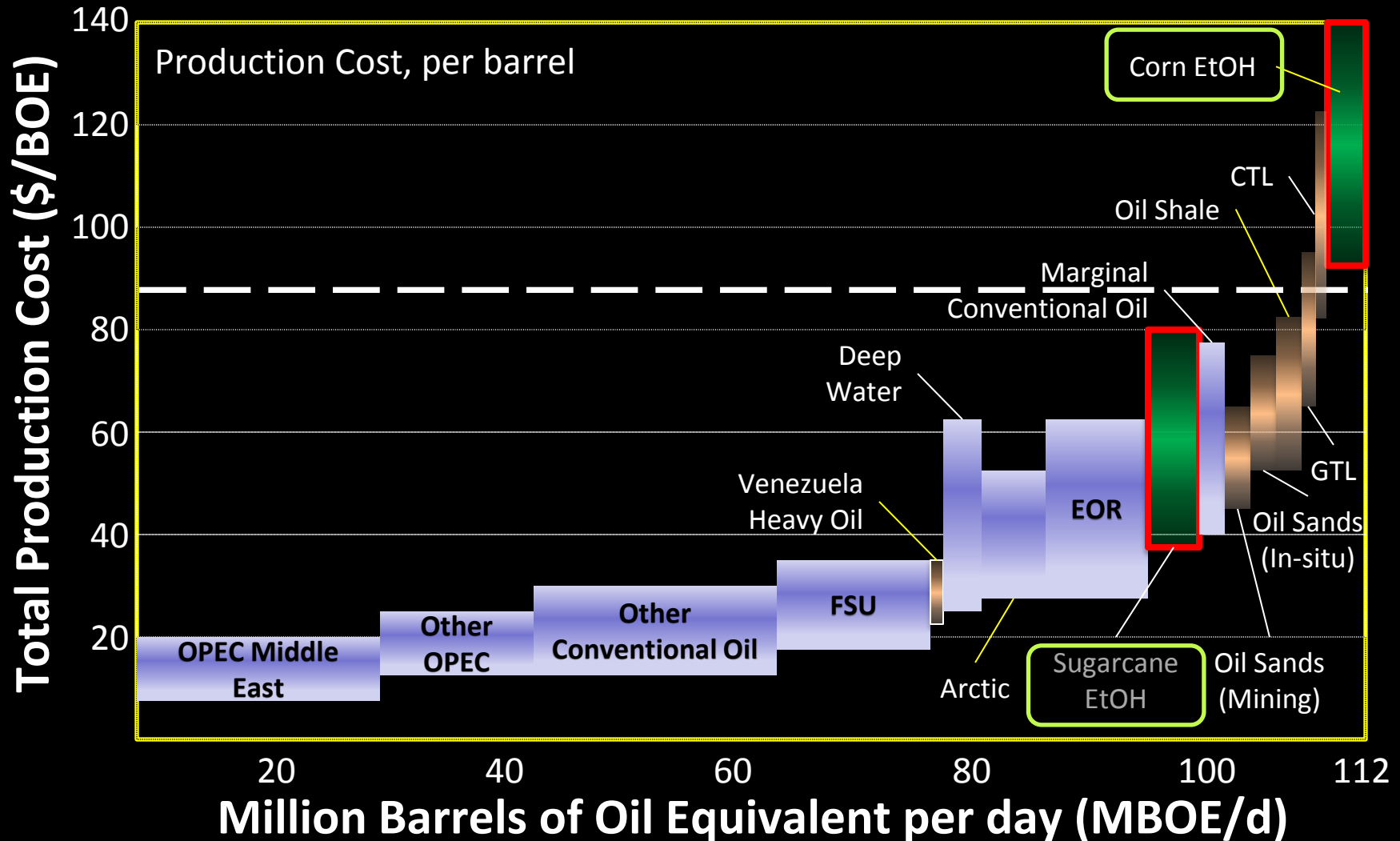


Cellulose



Less than  
1% efficient

# Biofuels in a Petroleum Context



Source: Analysis based on information from IEA, DOE and interviews with super-majors



# Plants Engineered to Replace Oil (PETRO)

Today

80 GJ/ha-yr



Future

160 GJ/ha-yr @ \$50/BOE

Algae



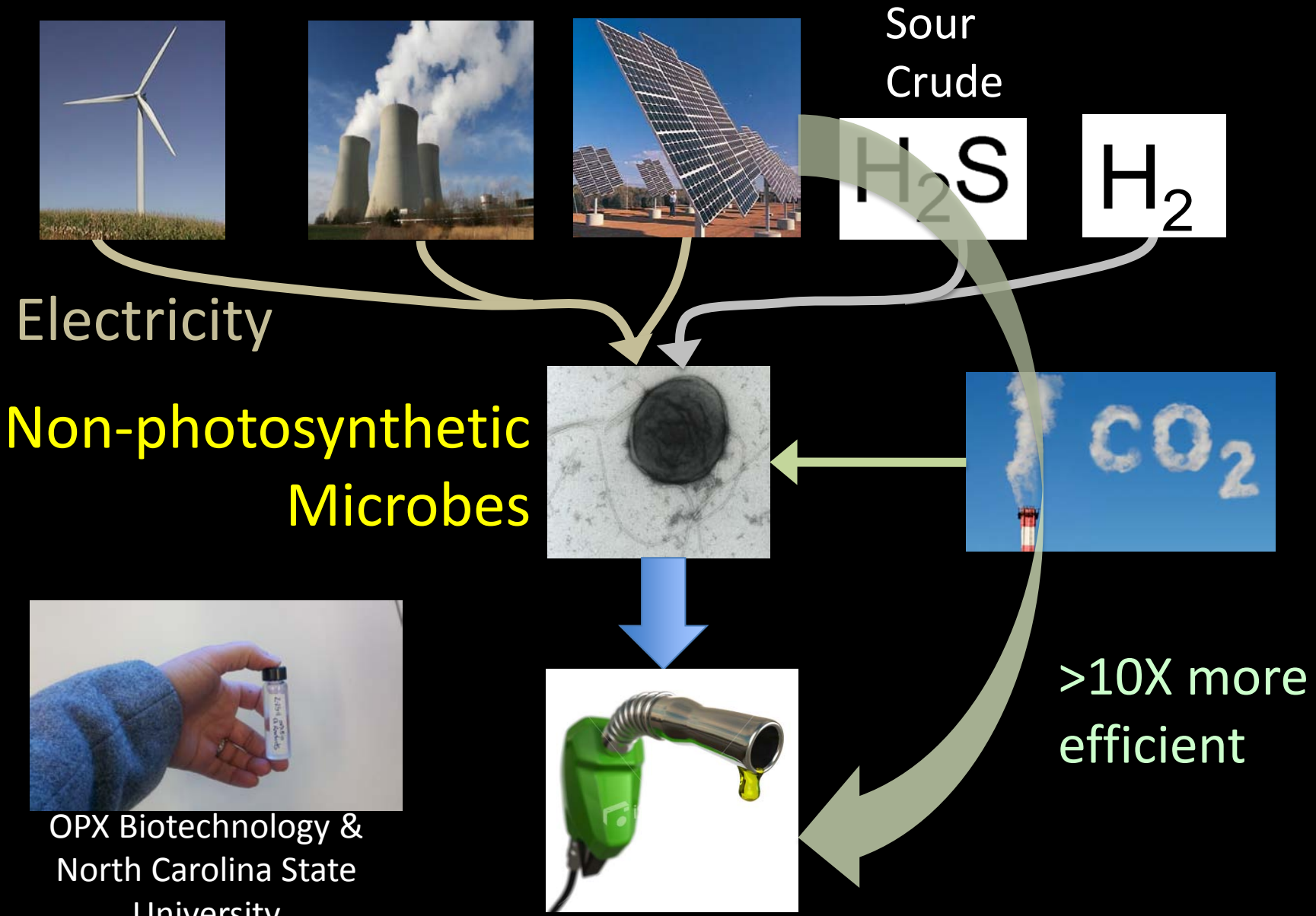
Tobacco



?



# Electrofuels



OPX Biotechnology &  
North Carolina State  
University



# Low-Cost Long-Term Capital (>20 years)

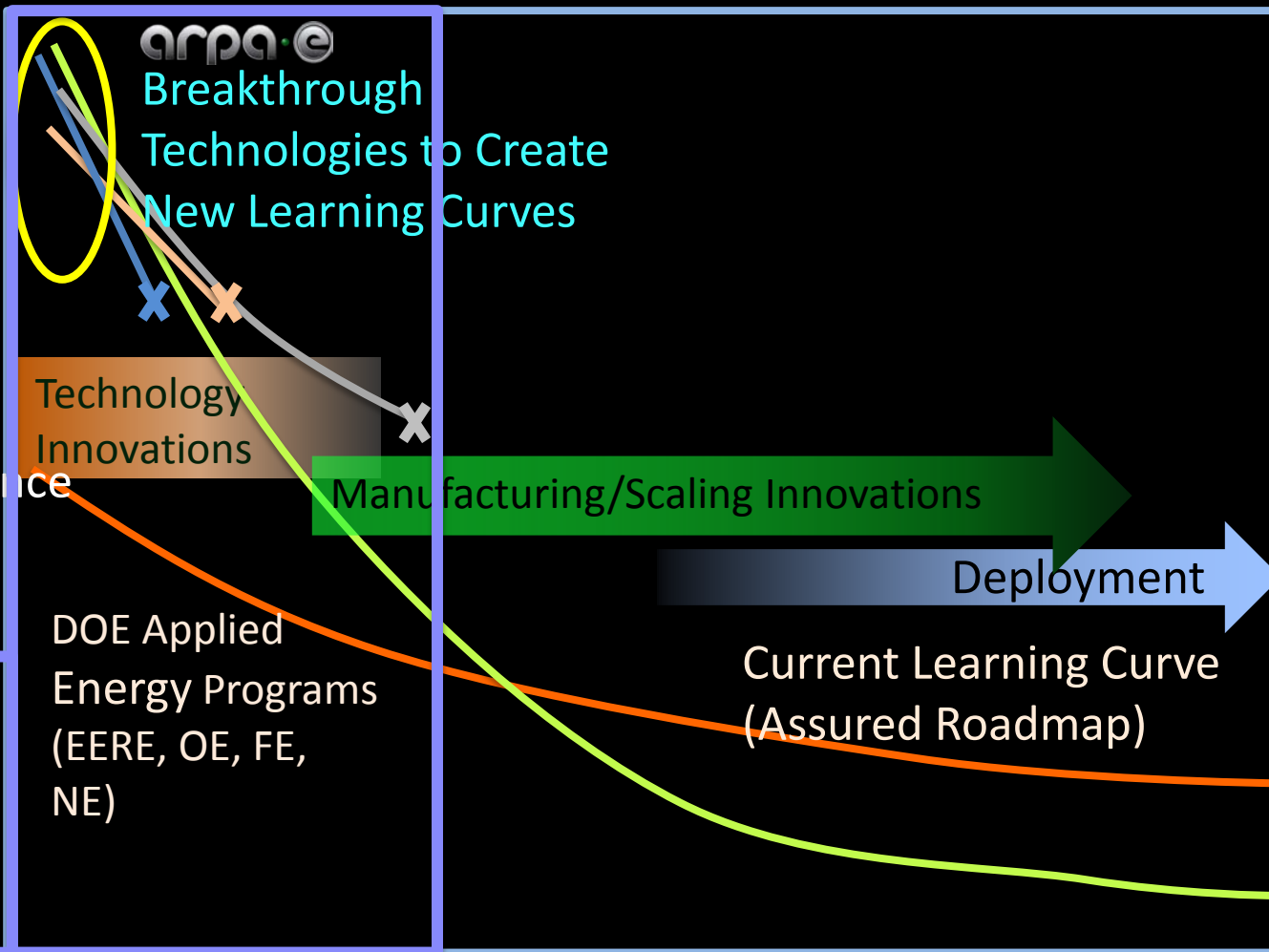
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2012feb27-29  
washingtondc

# energy innovation summit



**Ursula Burns**  
Chairman & CEO  
*Xerox Corp.*



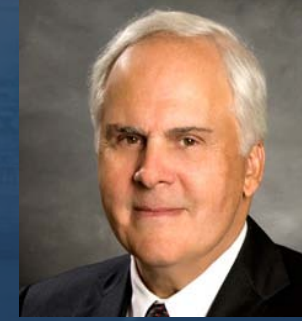
**Susan Hockfield**  
President & Professor  
*Of Neuroscience, MIT*



**Bill Gates**  
Founder and Chairman  
*Microsoft*



**Lee Scott**  
Former CEO  
*Walmart*



**Fred Smith**  
Chairman, President, and CEO  
*FedEx Corp.*

[www.energyinnovationsummit.com](http://www.energyinnovationsummit.com)