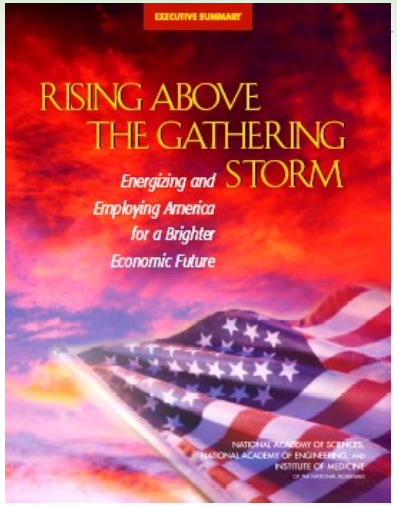
ARPA-E Storage Overview

Mark Johnson

September 26, 2012

DOE Energy Storage Review

A Brief History of of ARPA-E



FY12 Budget
($275M appropriated)

FY11 Budget CR
($180M appropriated)

2009 ARRA
($400M appropriated)

2007
America COMPETES Act

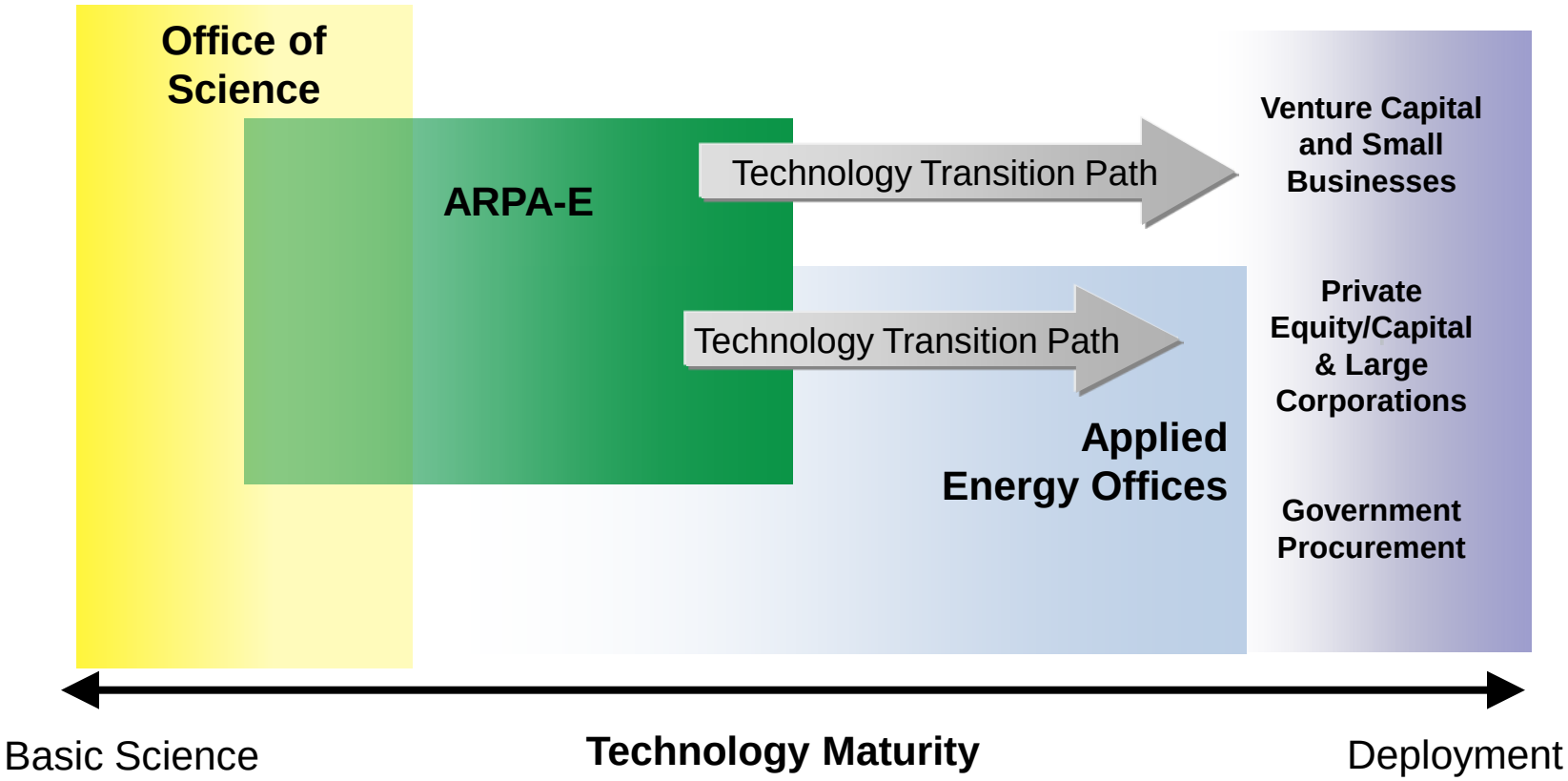
2006
Rising Above the Gathering Storm
(National Academies)

ARPA-E Launched at National Academies: April 27, 2009

First Funding Announcement: May 2, 2009

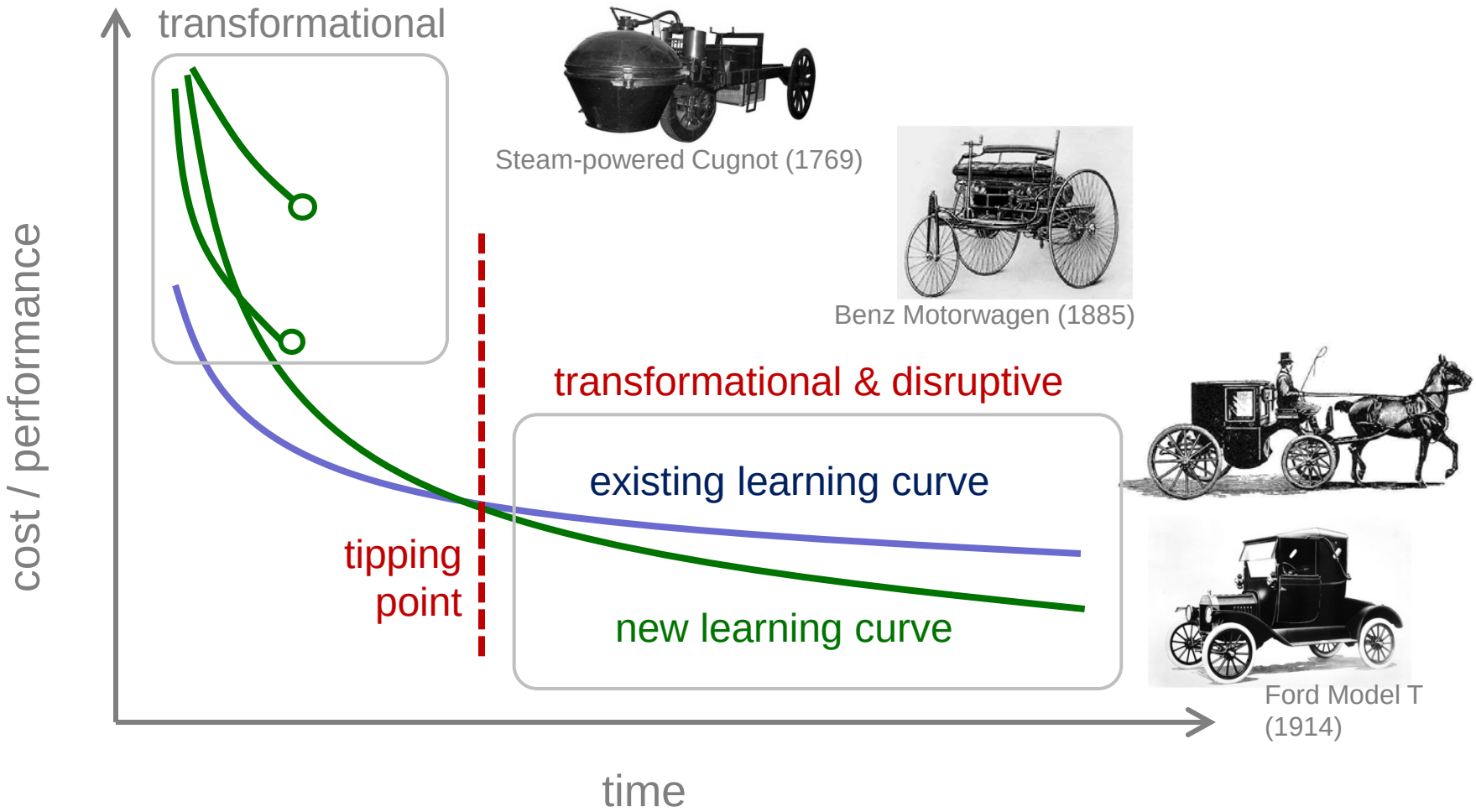
Innovation based on science and engineering will be primary driver of our future prosperity & security

Energy Innovation Pipeline



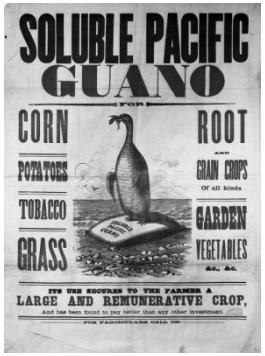
Progress of Disruptive Technologies

Transformational & disruptive technologies that lead to new learning curves



Societal Problem Driven Fundamental Research: Industrial Synthesis of Ammonia

Fertilizer



Gunpowder

Food Global Population, on Track to Exceed 2,000,000,000

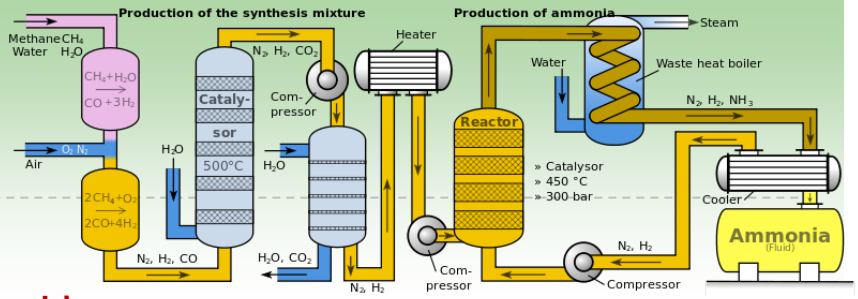
Food Production (Wheat) in Concentrated Locations (US)

$$N_2 + 3H_2 \rightarrow 2NH_3$$

"…the fixation of Nitrogen is vital to the progress of civilized humanity"

William Crookes (1898)

Ammonia R&D Timeline



Royal Academy "Wheat Problem"

Understanding Properties Of Ammonia

Academic Fight

Contract

Lab Demo

Pilot Scale

Production

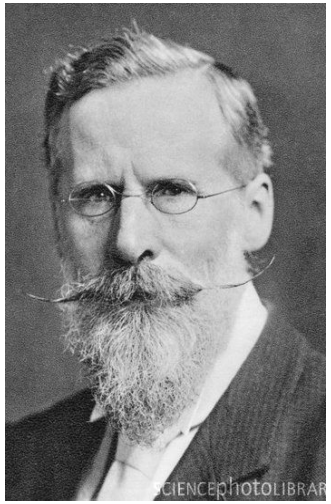
"Grand Challenge"

Basic Research

Break-Through

"Catalyst Genomics"

1898 | 1900 | 1902 | 1904 | 1906 | 1908 | 1910 | 1912 | 1914



Crookes

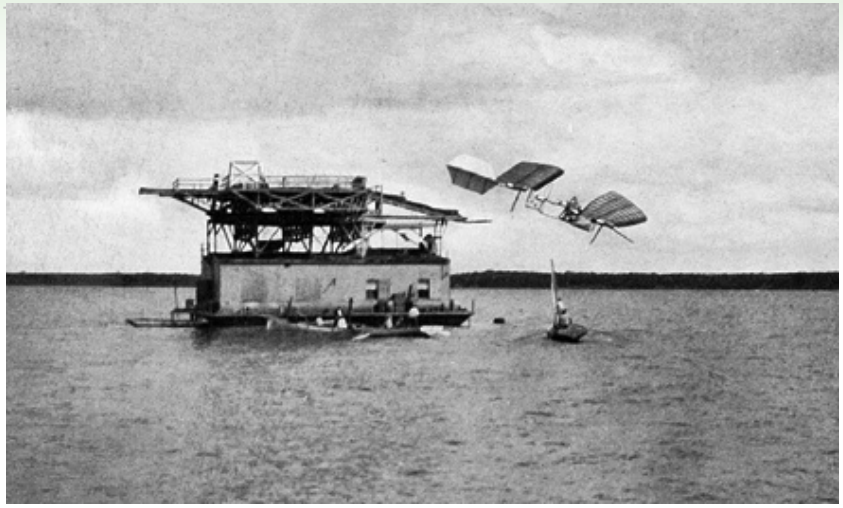
Ostwald & Nernst

Haber

Bosch

Mittasch

Technology Innovators Might be Found in Unlikely Places



<u>Samuel Langley</u>
Ivy League Faculty
Smithsonian President
Well Funded

<u>Wright Brothers</u>
Little Education
Bicycle Mechanics
Boot-Strapped

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

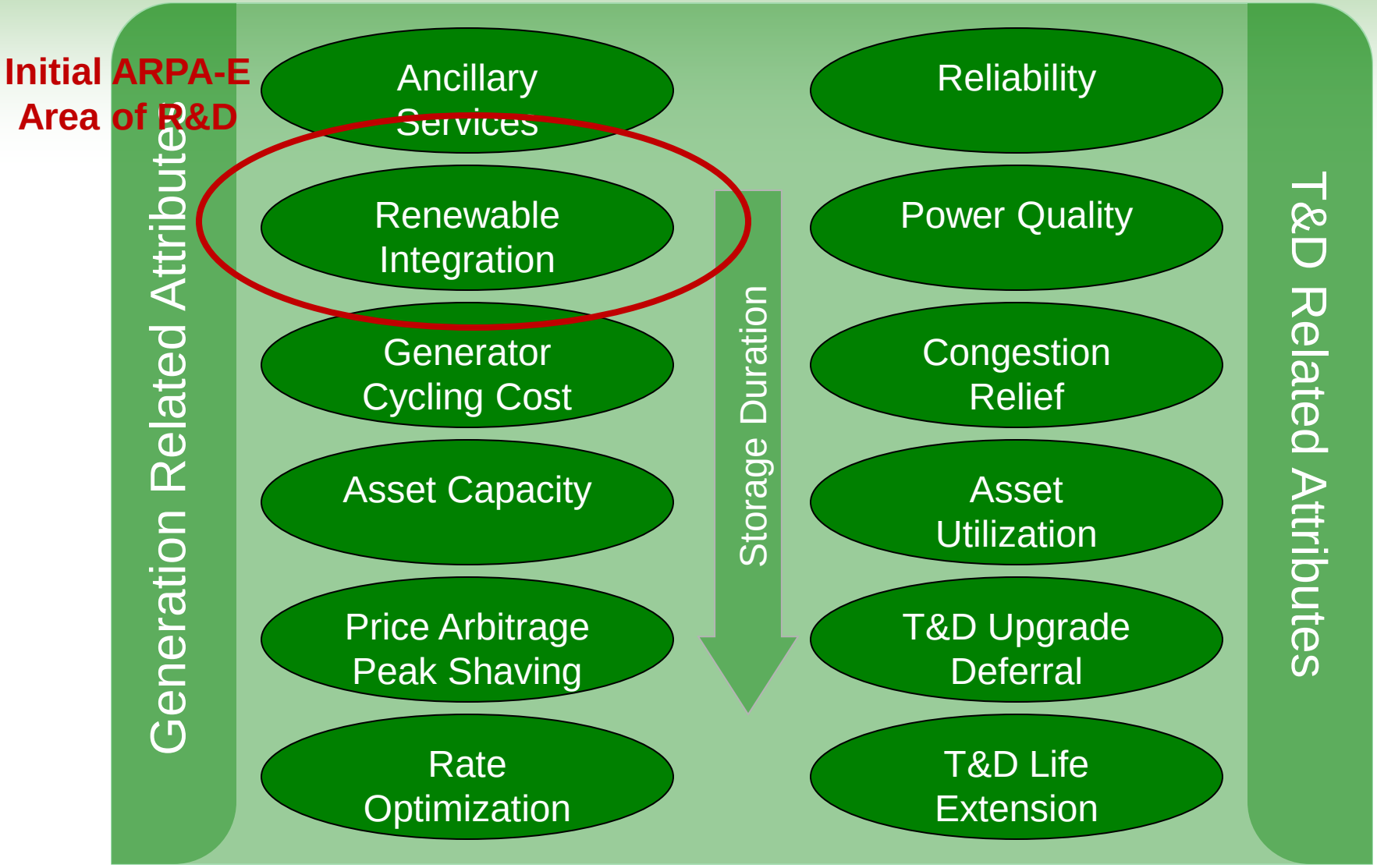
3. Bridge

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

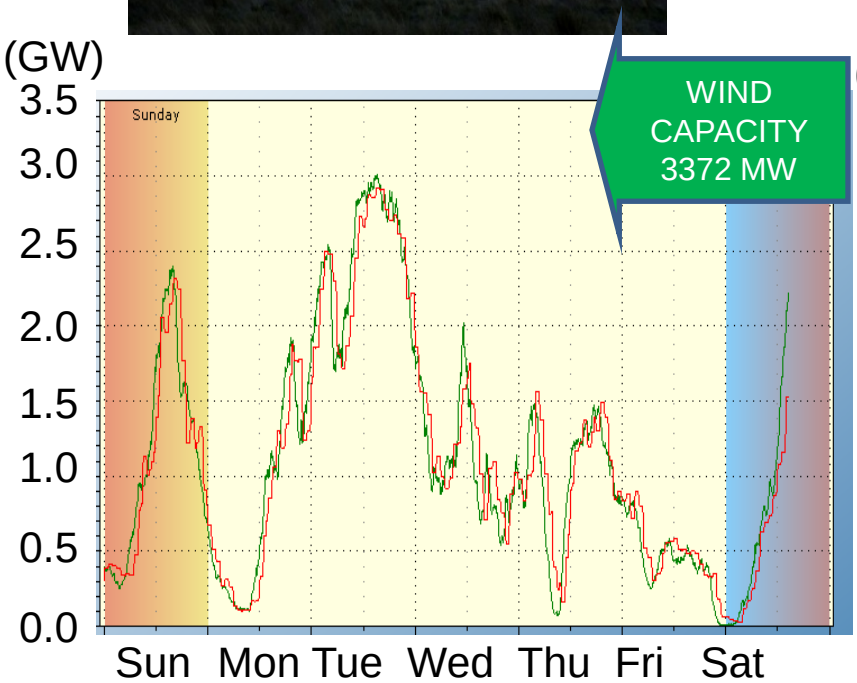
4. Team

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

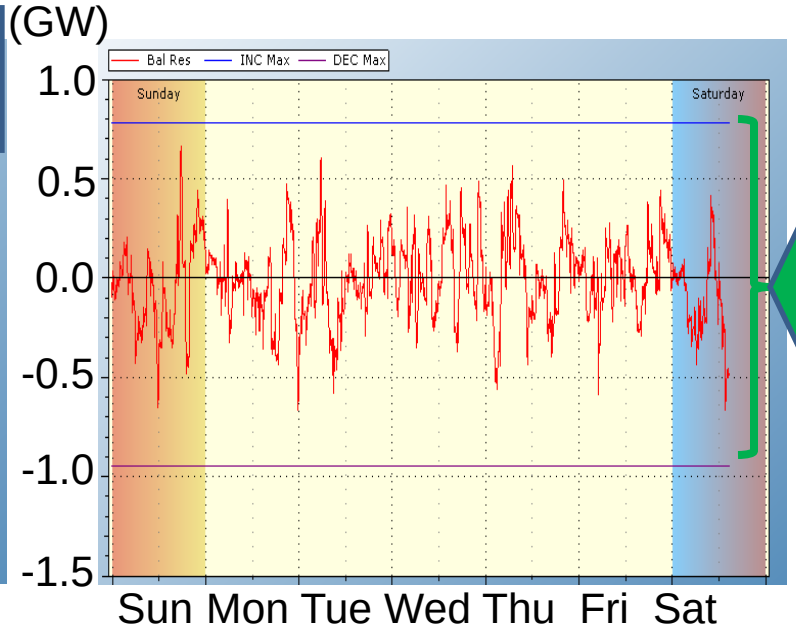
Electric Grid Energy Storage



Characteristics of Renewable Electricity Balancing Reserves Firm Wind Generation for High Renewable Penetration.



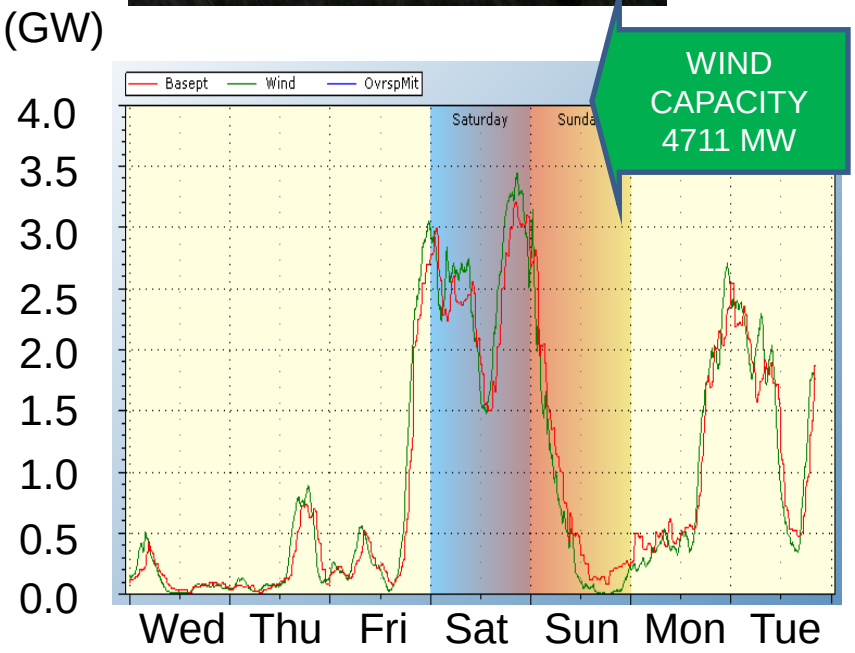
WIND CAPACITY 3372 MW



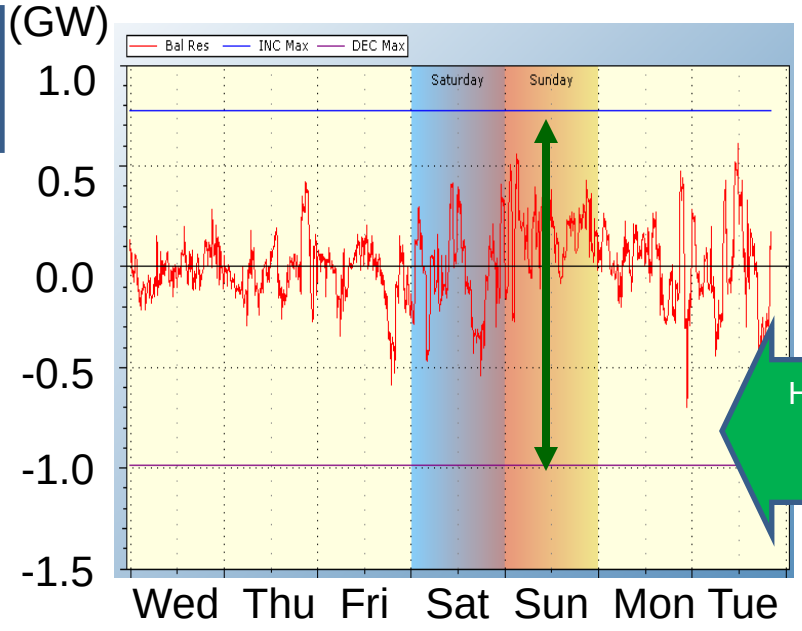
HYDROPOWER RANGE 1600-2000MW

System Challenge: Efficient Energy Storage at Minutes to Hours Duration to Firm Ramping Balance

Balancing Wind and Load Has Gotten More Challenging



WIND CAPACITY 4711 MW



HYDROPOWER RANGE 1600-2000MW

September 2012 Update Example

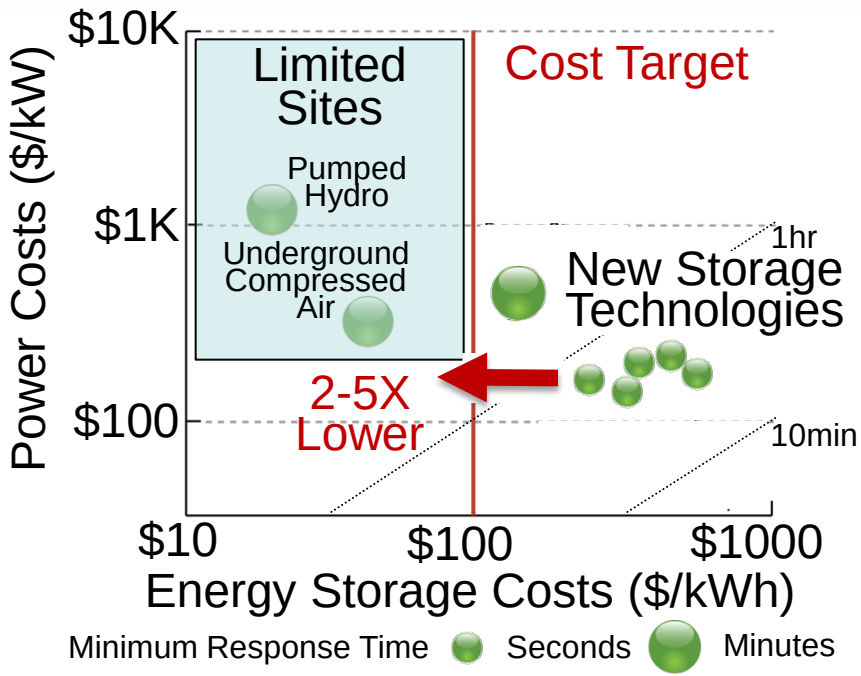
Externality

$2.50 / MBTU for Natural Gas

and $25-50 / MWh for Electricity

Storage Need to Be **Systems** Solutions
at **Low Cost**

Grid-scale Rampable Intermittent Dispatachable Storage (GRIDS) Program Metrics



Balancing Reserves at <$100/kWh

Greater than 5000 cycles and 80% RTE

Economics of Hydro / Deploy Anywhere

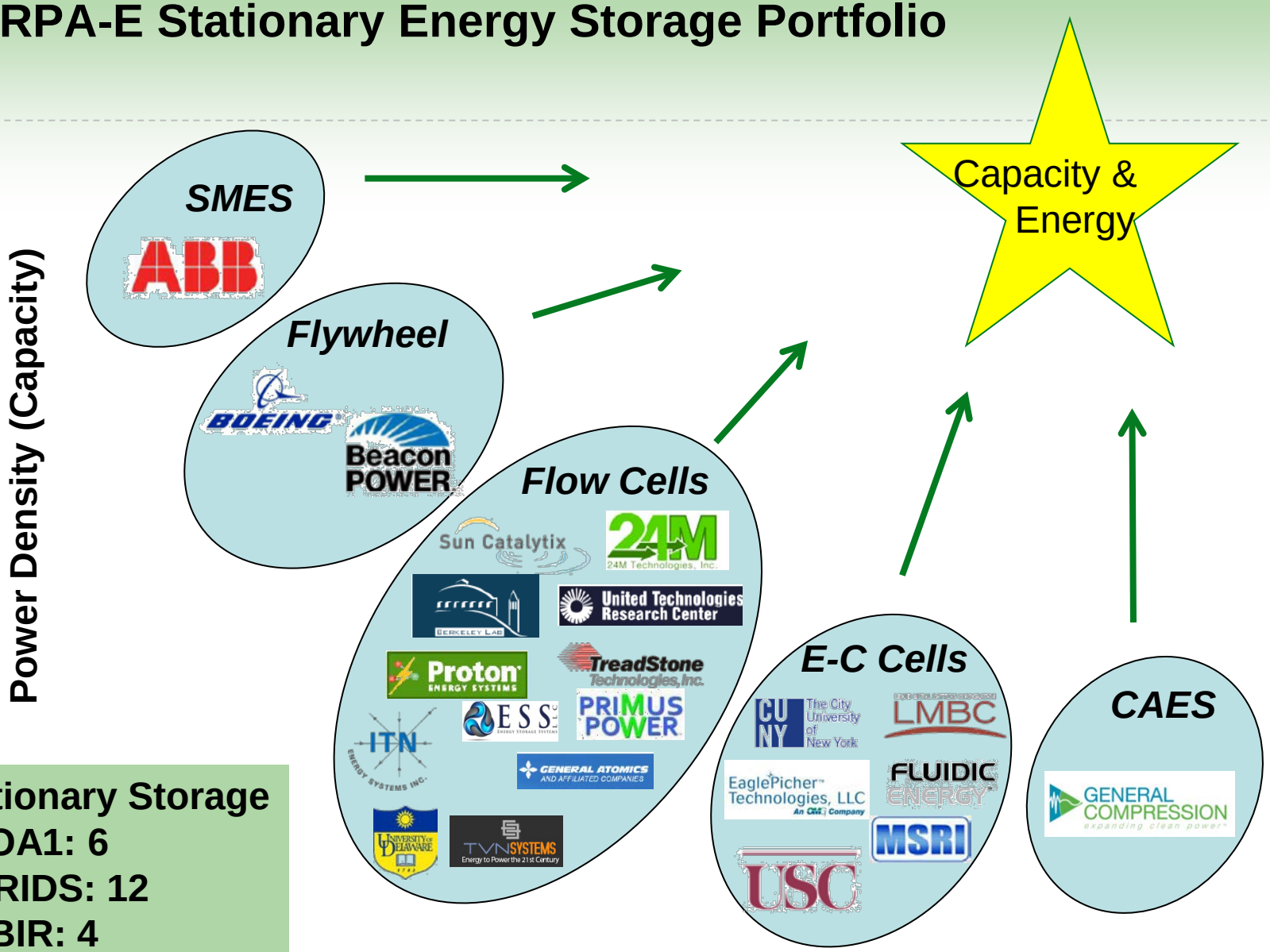
Technology Agnostic:
Chemical, Mechanical, Electromagnetic

Connect Across Industry for Handoffs

Focus: Transformational approaches to energy storage to enable low cost

New Technology Need: Low-Cost Energy Storage Solutions

ARPA-E Stationary Energy Storage Portfolio

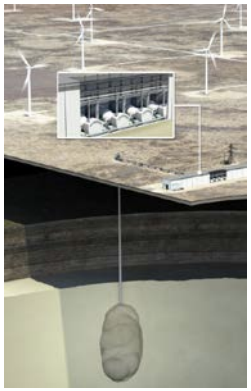


Stationary Storage
- **FOA1: 6**
- **GRIDS: 12**
- **SBIR: 4**

GRIDS: Sample Efforts

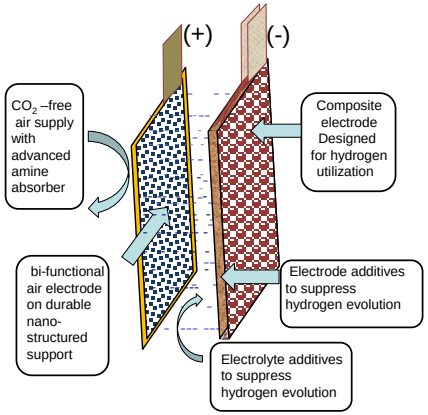
General Compression

Isothermal Compression: Technology Bridge to Commercial Follow-on



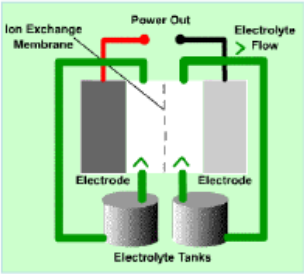
University of Southern California

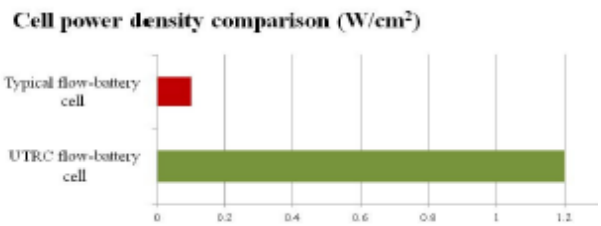
Iron-Air : Iron is Cheap & Air is Free



United Technologies

HIgh Current Density Flow Battery

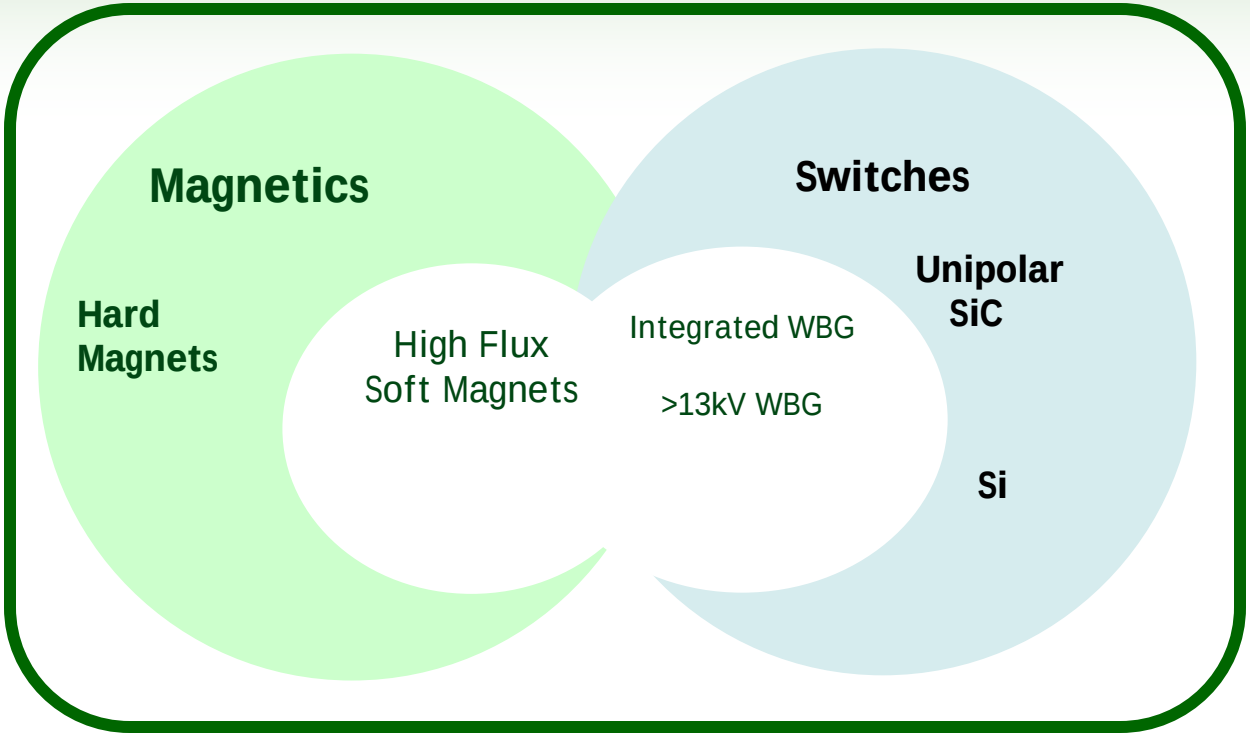




City University of New York

Cheap, Recyclable Alkaline Cell

ADEPT: Agile Delivery of Electrical Power Technologies



Integrated Circuits for Power Systems

- On-chip inductors and transformers
- High-voltage transistors (GaN and SiC)
- High-energy capacitors

Magnetics

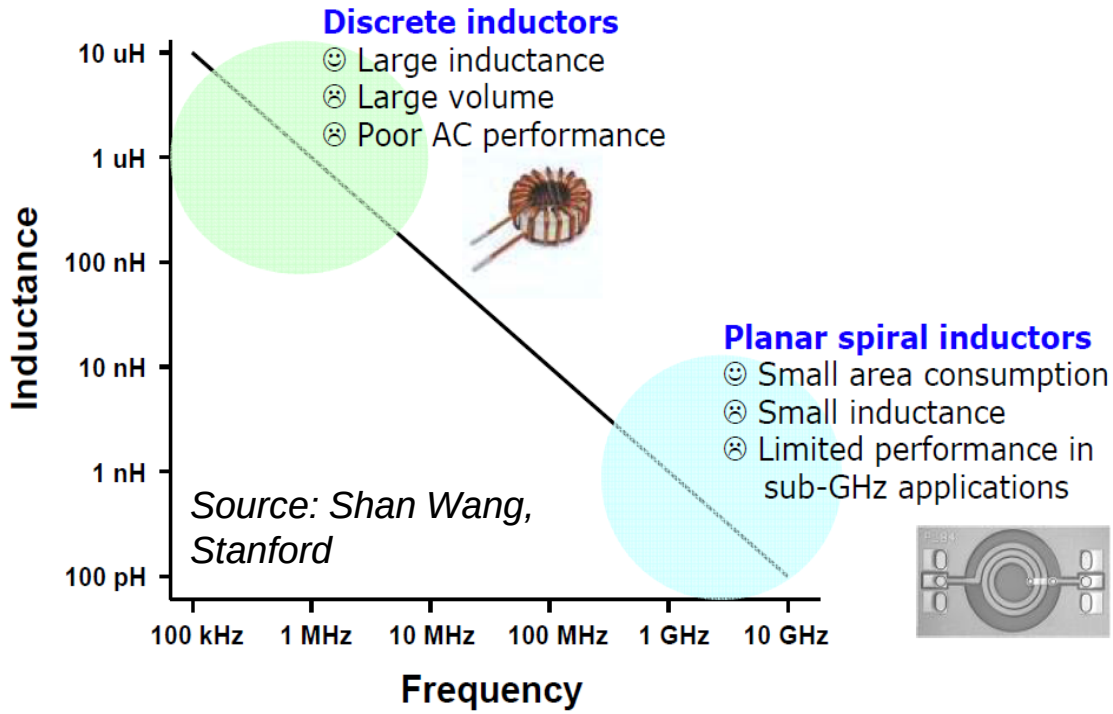
– largest, most expensive part of a power converter

>92% Dimmable LED Driver (comm. 37-50% of luminaire cost)

AC/DC Converter

Magnetics

$$Z = j\omega L$$



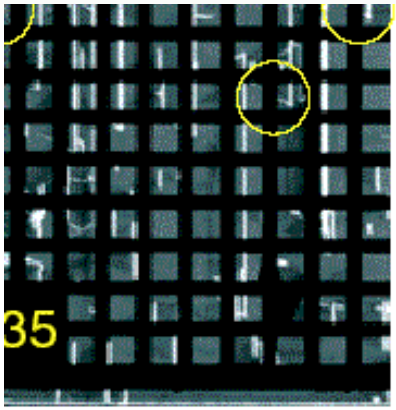
1MW Photovoltaic Inverter

($0.2/W)

40% Magnetics

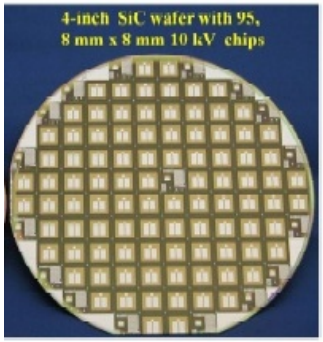
High Voltage Solid-State Devices

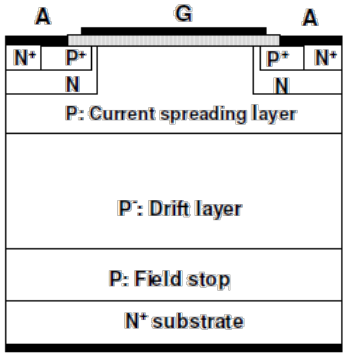
20kV & 1MW SiC Transistors



NRL

- **Significantly improved SiC IGBTs**
  - **High voltage (20kV)**
  - **Extremely efficient (>98%)**
  - **Fast switching (50kHz)**
  - **Higher minority carrier lifetimes, and blocking layers – improved reliability and lifetime**
  - **High device yields**



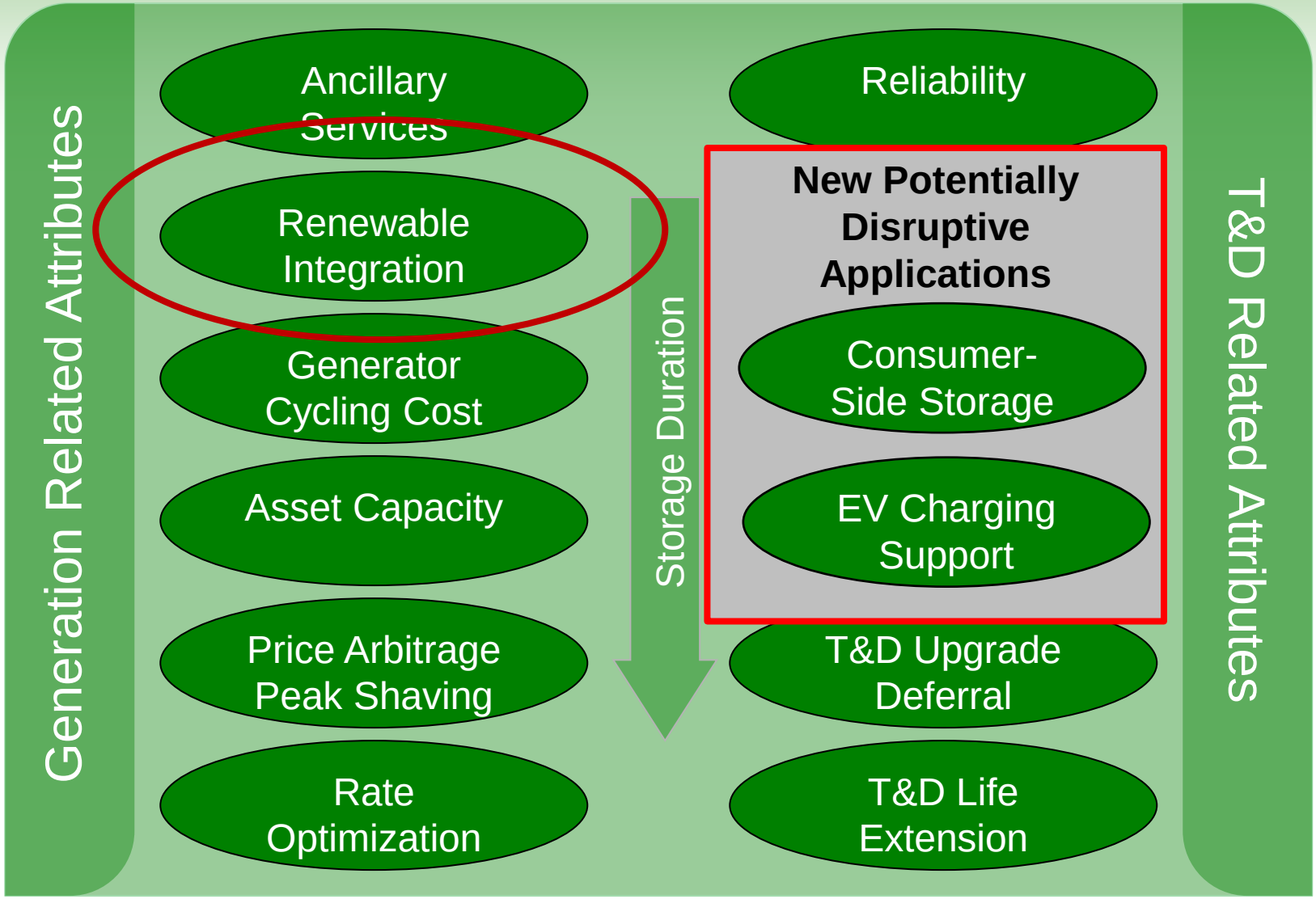


Cree

	Frequency	Mass	Volume
Today	60 Hz	8,160 lb	4.80m^3
Tomorrow	50 kHz	100 lb	0.14m^3

ABB

Electric Grid Energy Storage



Recent Opportunities

Energy Storage SBIR/STTR [7 new]

Advanced Management and Protection of Energy-Storage Devices (AMPED) [12 new]

Open FOA

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

Meet the ARPA-E Project Teams at Poster Session this Afternoon

Thank You

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