U.S. DEPARTMENT OF ENERGY
Office of Electricity

DOE Energy Storage Coordination

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Outline

- Energy Storage Coordination Efforts: A History
- Current-Day Storage Related Metrics Survey
- Future DOE-Wide Storage Strategy Components

Need for Coordination: External Perspectives

EAC

2018 Biennial Energy Storage Review (June 2019)

- Offices within DOE could have a more holistic view of their different program goals and coordinate their activities better, especially with respect to determining those goals and focusing specific RD&D activities toward solving issues that meet program goals in different offices.

House

H. Rpt. 115–697 Energy And Water Development Appropriations Bill, 2019

- Within available funds for Energy Storage, the Department is encouraged to launch a new initiative aimed at aggressively driving down costs and improving the performance of a diverse set of grid-scale storage technologies.
- The Electricity Delivery program is urged to coordinate its efforts with the Office of Science and EERE to ensure this new initiative best leverages the storage work being conducted within the Basic Energy Sciences program of the Office of Science and programs within EERE where appropriate.

Senate

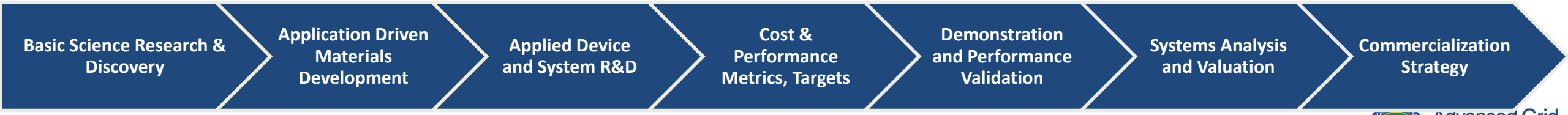
S. Rpt. 115–258 Energy And Water Development Appropriations Bill, 2019

- The Department shall continue to use all of its capabilities to accelerate the development of storage technologies[.]
- The Committee directs the Department to coordinate efforts among various existing Department programs to maximize efficiency of funds and expand vital research.

FY2019 (v 1.0): Beyond Batteries

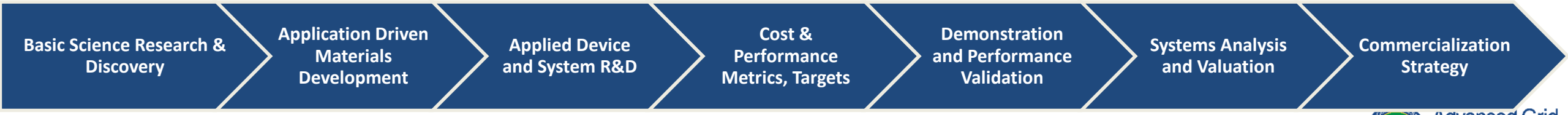
EERE

- Flexible Generation and Controllable Loads



FY2020 (v 2.0): Advanced Energy Storage Initiative

EERE	• Flexible Generation and Controllable Loads • Transportation Storage
OE	• Bidirectional Electrical Storage
FE	• Chemical and Thermal Storage
NE	• Hybrid Systems



FY2021+ (v 3.0): A Holistic Storage Strategy

Science

ARPA-E

EERE	• Flexible Generation and Controllable Loads • Transportation Storage
OE	• Bidirectional Electrical Storage
FE	• Chemical and Thermal Storage
NE	• Hybrid Systems

OTT

LPO

Basic Science Research & Discovery → Application Driven Materials Development → Applied Device and System R&D → Cost & Performance Metrics, Targets → Demonstration and Performance Validation → Systems Analysis and Valuation → Commercialization Strategy

DOE

Bi-directional Energy Storage: Example Goals & Targets

Basic Energy Sciences (BES): Conduct underlying basic/fundamental research to establish the science base for early-stage applied research and subsequent manufacture of bi-directional energy storage technologies

Objective/Goal	Metric	Minimum	Stretch Target
Vehicle Technologies Office (VTO): Advanced automotive battery targets	• High-energy EV battery • Fast charge battery • Low cobalt/no cobalt batteries	• $100/kWh (pack) • 350 Wh/kg (cell)	• $80/kWh (pack) • 500 Wh/kg (cell)
Office of Electricity (OE): Stationary power targets	• Aqueous soluble organic (ASO) redox flow battery capacity & cost • Large format (300Ah) Zn-Mn dioxide batteries capacity & cost	• $100/kWh(system) • 150Wh/l, (system)	NA
Fuel Cell Technologies Office (FCTO): Reversible fuel cell targets	• System round trip efficiency • System capital cost by power • System capital cost by energy	• 60% • $1,400/kW • $250/kWh	• 75% • $900/kW • $150/kWh
ARPA-E: Grid storage goals	"DAYS" program: $0.05/kWh-cycle	10 hr	100 hr

Advanced Manufacturing Office (AMO): R&D and technical partnerships with national laboratories, companies, state/local governments, and universities to investigate new manufacturing technologies.

Flexible Generation and Load: Example Goals & Targets

Beyond LCOE: Develop a DOE-wide a technology-neutral taxonomy and framework to value grid services

Objective/Goal	Metric	Minimum	Stretch Target
Increase manufacturing plant dispatchable load/generation without process interruptions	Calculated increase in dispatchability for PCS use cases compared to existing plants	>10% over applicant defined baseline	20%

Objective/Goal	Metric	Minimum	Stretch Target
Decrease Manufacturing Cost of 10 kV SiC module-based power electronic assemblies	Cost per 13.8 kV inverter excluding cost of SiC die	<$30/kW	<$15/kW

Objective/Goal	Metric	Minimum	Stretch Target
Increase service life of 10 kV SiC module power electronic assemblies	Calculated using existing qualification standards and partial discharge tests	> 10 years	> 30 years

EERE is working to develop metrics to describe demand flexibility in buildings. This will complement external metrics such as the the New Buildings Institute/U.S. Green Buildings Council “GridOptimal” score.

Chemical Storage: Example Goals & Targets

	Objective/Goal	Metric	Target	Stretch Target
H2@Scale *FCTO & Collaborating Offices*	• Low cost renewable hydrogen produced from diverse domestic resources to enable cost competitiveness with alternative storage approaches • Widespread adoption of hydrogen to enable large-scale energy storage servicing multiple end uses	• $/gge H_2 (@ price of energy) • TWh (stored chemical energy) **Relevant FCTO Technology Metrics:** • $/kWh (onboard storage cost) • kWh/kg (gravimetric density) • kWh/l (volumetric density) • $/kW (electrolyzer cost)	• $2/gge (@ 2¢/kWh) • 1 TWh (~24000 tonne H_2) • $15/kWh • 0.7 kWh/kg • 1.0 kW/l • $400/kW (application specific)	• $1/gge (@ 1¢/kWh) • 250TWh (~6MMT H_2) • $8/kWh • 1.7 kWh/kg • 2.2 kW/l • $100/kW (application specific)
Synthetic Fuels *Multiple Collaborating Offices*	• Low cost synthetic fuels produced from diverse and abundant domestic resources • Widespread adoption of synthetic fuels servicing multiple sectors, including transportation and power generation	• $/gge (@ price of energy) • TWh (stored chemical energy) **Relevant DOE Technology Metrics:** • ¢/kWh (CSP at >600°C) • ¢/kWh (wind energy cost) • $/GGE (bio-based fuel cost) • kWh/l (CO_2 capture cost)	• $4/gge/TBD (@ 2¢/kWh) • 1 TWh (~25M GGE) • 2¢/kWh (SETO) • 2¢/kWh (WETO) • $2.5/GGE (BETO) • $40/ton (FE)	• $2/gge/TBD (@ 1¢/kWh) • 200 TWh (~5B GGE) • 1¢/kWh • 1¢/kWh • $2/GGE • $30/ton

Note: Targets still in development; application specific

Thermal Energy Storage: Example Goals & Targets

Research Underpinnings

- **Basic Energy Sciences (BES):** Conduct underlying basic/fundamental materials to facilitate early-stage applied research and subsequent manufacture of storage technologies, especially as applied to high temperatures (~700°C)

Grid Applications

Objective/Goal	Metric	Minimum	Stretch Target
Solar Energy Technologies Office (SETO) targets	• sCO_2 Cycle	• 50% Net Thermal to Electric • CapEx < $900/kW	• Turbine Inlet >700°C
	• Thermal Energy Storage	• >95% Exergetic • CapEx < $15/kWh thermal	• Discharge >700°C

Transformative Research

Objective/Goal	Metric	Minimum	Stretch Target
ARPA-E: Grid storage	"DAYS" : $0.05/kWh-cycle	10 hr	100 hr

Manufacturing

Advanced Manufacturing Office (AMO): R&D and technical partnerships with national laboratories, companies, state/local governments, and universities to investigate new manufacturing technologies.

DOE-Wide Storage Strategy Components

Objectives	Goals	Metrics	Technologies

• U.S. Leadership
• Grid User Benefits
  • Resilience
  • Reliability
  • Flexibility
	• Cost reductions
	• Accelerated deployments
	• Increased value
		• Application and operationally-aware
		• Technology independent
		• Scalable to appropriate market resolution
			• Bidirectional electrical storage
			• Technologies with storage-like functions
			• Technologies with R&D co-benefits (i.e. transport)

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DOE-Wide Storage Strategy: Emphasis Areas

Technology Development

Policy and Valuation

Partnerships

Manufacturing and Supply Chain

Workforce

DOE-Wide Storage Strategy: Development