Facilitating the Integration and Commercialization of Energy Storage: How DOE can Leverage its Role and Resources

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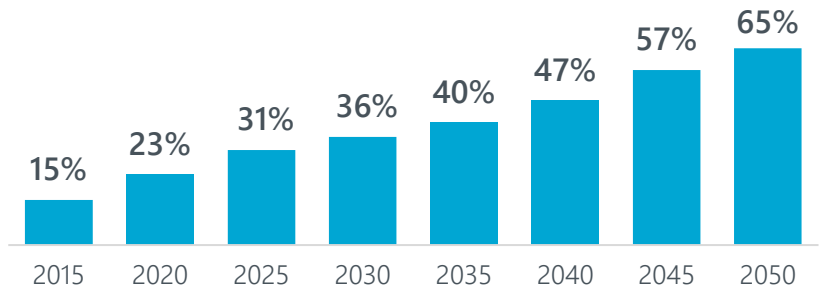
Today's Energy Transition

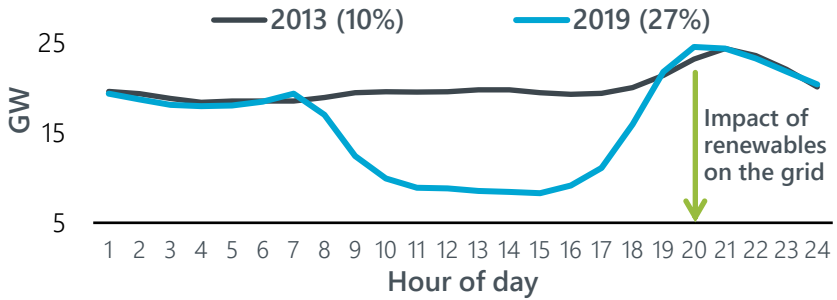
- Extreme climate-driven weather events are now the norm. Deadly extreme weather for US cost at least $145 billion in 2021.
- The world's appetite for electricity is growing unabated. Global electricity demand rose by 6% or 1,500 terawatt hours (TWh) in 2021.
- The risks of today's aging energy infrastructure are readily apparent – and more dangerous. Today's solutions need to last for decades.
- The cost for utility-scale solar PV power has declined 82% since 2010 and the costs for onshore and offshore wind have declined 39% and 29%, respectively (both are cheaper sources of electrons than burning fossil fuels).
- A global transition to a decarbonized world is underway. To preserve a livable climate, greenhouse-gas emissions must be reduced to net 0 by 2050.

The Challenge: Stabilize the Grid and Accelerate Renewables

US Renewable Energy Penetration (2015-2050)[1]



California Duck Curve and % Renewable Penetration[1,2]



Renewable intermittency creates challenges for the grid, particularly >25% penetration

- Carbon-free is the goal
- Intermittency and curtailment are barriers
- 4-hour storage does not efficiently bridge the duck curve
- Longer duration solutions enable peaker plant replacements

1 BloombergNEF.
2 IEA, "The California Duck Curve", December 2019. % figures represent solar and wind power penetration in each year.

Where does LDES Play?

Where are the opportunities for LDES? Everywhere…

- Bulk-shifting / Firmed supply (FTM)
- Grid resiliency / congestion management (FTM)
- Localized capacity management (FTM/BTM)
- Microgrids (FTM/BTM)
- Large customer DER / energy flexibility (BTM)
- Supply / Demand laterization (BTM)
- And more….

Of course, you all know this

US DOE Earth Shot already made the call!

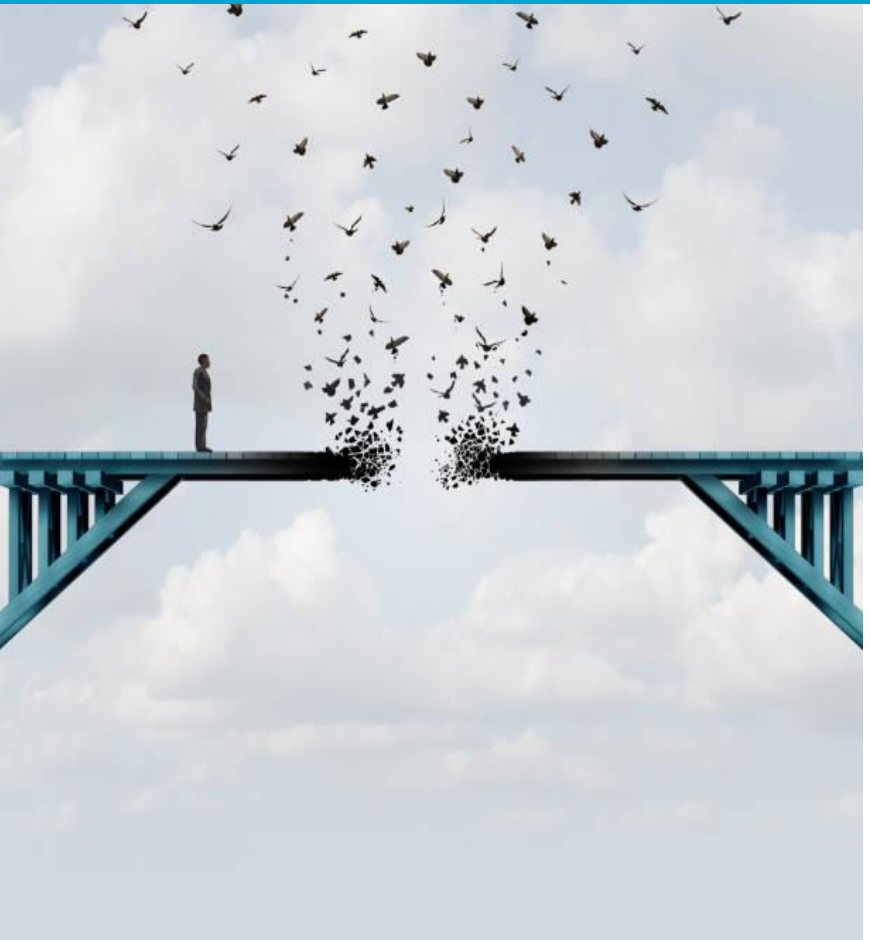
- Need at massive scale
- Drive cost (LCOS) ever lower
- Durations of 10 hours +

What could be added:

- Wide range of duration ranges based on need
- Demand today, but will expand with transition
- Chicken / egg dynamic with broader transition
- US technology is in a leadership position

*"Long duration energy storage systems – defined as technologies that can store energy for more than 10 hours at a time – **are a critical component of a low-cost, reliable, carbon-free electric grid.**"*

Challenges



Inherent entropy of markets

- Existing solutions may be lacking, but are understood
- Support mechanisms / ecosystem in place
- Bankability well understood

Insufficient market mechanisms for LDES

- Current procurement designed for legacy capabilities
- Value creation inures to multiple stakeholders

Inconsistent support in tax code

The Outlook

- Corporate owners stepping in to control their own destiny(s)
- Utility-scale solar + storage becoming the norm for all solar projects; Wind projects aggressively assessing energy storage, particularly in longer durations (8+hrs)
- Solar + Storage beats Combined-Cycle Gas

Exhibit 7: Unsubsidized Solar + Storage at 5% Discount Rate vs. Combined Cycled Natural Gas

$/MMBTU	PV System Value ($/kWh)	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500
$1.00	$0.017	$0.30	$0.33	$0.36	$0.40	$0.43	$0.46	$0.49	$0.53	$0.56	$0.59	$0.63	$0.66	$0.69	$0.72	$0.76	$0.79	$0.82
$2.00	$0.025	$0.42	$0.47	$0.51	$0.56	$0.61	$0.66	$0.70	$0.75	$0.80	$0.84	$0.89	$0.94	$0.98	$1.03	$1.08	$1.12	$1.17
$3.00	$0.032	$0.55	$0.61	$0.67	$0.73	$0.79	$0.85	$0.91	$0.97	$1.03	$1.09	$1.15	$1.21	$1.27	$1.33	$1.39	$1.46	$1.52
$4.00	$0.039	$0.67	$0.74	$0.82	$0.89	$0.97	$1.04	$1.12	$1.19	$1.27	$1.34	$1.42	$1.49	$1.56	$1.64	$1.71	$1.79	$1.86
$5.00	$0.046	$0.80	$0.88	$0.97	$1.06	$1.15	$1.24	$1.33	$1.41	$1.50	$1.59	$1.68	$1.77	$1.86	$1.94	$2.03	$2.12	$2.21
$6.00	$0.054	$0.92	$1.02	$1.12	$1.23	$1.33	$1.43	$1.53	$1.63	$1.74	$1.84	$1.94	$2.04	$2.15	$2.25	$2.35	$2.45	$2.55
$7.00	$0.061	$1.04	$1.16	$1.28	$1.39	$1.51	$1.62	$1.74	$1.86	$1.97	$2.09	$2.20	$2.32	$2.44	$2.55	$2.67	$2.78	$2.90
$8.00	$0.068	$1.17	$1.30	$1.43	$1.56	$1.69	$1.82	$1.95	$2.08	$2.21	$2.34	$2.47	$2.60	$2.73	$2.86	$2.99	$3.12	$3.25
$9.00	$0.075	$1.29	$1.44	$1.58	$1.72	$1.87	$2.01	$2.16	$2.30	$2.44	$2.59	$2.73	$2.87	$3.02	$3.16	$3.31	$3.45	$3.59
$10.00	$0.083	$1.42	$1.58	$1.73	$1.89	$2.05	$2.21	$2.36	$2.52	$2.68	$2.84	$2.99	$3.15	$3.31	$3.47	$3.62	$3.78	$3.94
$11.00	$0.090	$1.54	$1.71	$1.89	$2.06	$2.23	$2.40	$2.57	$2.74	$2.91	$3.09	$3.26	$3.43	$3.60	$3.77	$3.94	$4.11	$4.29
$12.00	$0.097	$1.67	$1.85	$2.04	$2.22	$2.41	$2.59	$2.78	$2.96	$3.15	$3.33	$3.52	$3.71	$3.89	$4.08	$4.26	$4.45	$4.63

Sources: EIA, Edison Electric Institute, Oppenheimer & Co. Estimates

- With proper support, US can claim global leadership of LDES