ENERGY STORAGE FOR THE GRID: POLICY OPTIONS FOR SUSTAINING INNOVATION

(MIT ENERGY INITIATIVE WORKING PAPER)

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Overview and Framing

-- *William B. Bonvillian*

- The electric power sector *must* be transformed to meet climate goals
- Grid-scale storage has potential for making this transition easier, quicker, cheaper
  - *Storage can better enable intermittent renewables,*
  - *Utilities can better manage peak loads and stabilize consumer prices*
- We are seeing a shift from a federal R&D focus -
  - *"Technology push" strategy*
  - *Also - federal demonstration projects and regional pull (PJM)*
- To: State-led "technology pull" strategy,
  - *Using utility regulatory authority – market-forcing*
  - *States control much of the implementation in grid sector – need their entry*
  - *Creates the option for "bottom up" vs. federal "top down" only*
- Coincides with a consolidation of the grid storage market around Li-ion batteries
  - *Li-ion dominates consumer electronics and now electric vehicle transport*
  - *Seeks to add an additional major market: grid storage*

Li-ion Ramp Up/Technology Alternatives

- Li-ion –relatively light weight and high-power density - works well for electronics and transport
- Entered production in 1991, since then enjoying a "virtuous cycle" of innovation and scale-up
- Li-ion production is ramping up in expectation of electric vehicles (EVs)
  - *The top five Li-ion battery producers plan to triple production by 2020*
- But is it the optimal technology for grid scale storage?
  - *Pumped hydro – around for a century, but limited sites for expansion*
  - *Other battery technologies (redux flow, liquid metal, etc.) may offer longer term storage and longer cycle life*
  - *A half day or day(s) greatly increases utility options compared to a half hour*
  - *But these are new technologies, just entering a development cycle*
  - *Li-ion is already driving down the production price curve*

Technology Lock-in?

- Li-ion has a major "first mover" advantage –
- Can engage in price-cutting to dominate the grid storage market
- "Technology lock-in"?
  - *Historically, a "dominant design" emerges*
  - *This accelerates further incremental innovation and price efficiency*
  - *Which expands adoption*
- Technology lock-in can be ***BENEFICIAL***
  - *It can speed adoption of the new innovation*
- It can break through the "legacy sector" barriers
  - *The grid is a legacy sector – it resists technical change*
  - *Thomas Edison would very familiar with current grid technologies*
  - *Storage could disrupt the grid legacy sector, assisting lower carbon entry*

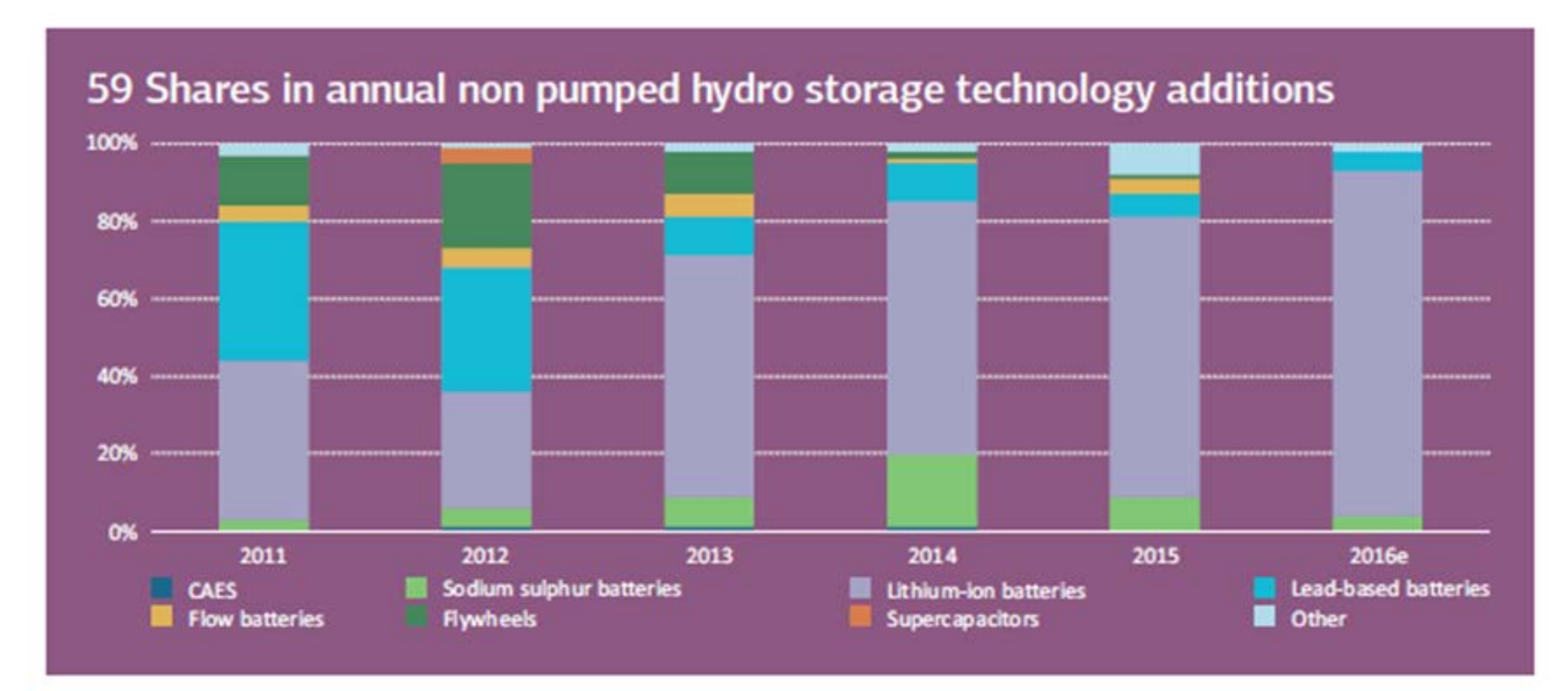
The Risk of Technology Lock-in:

- *Alternative interpretation:*
- If Li-ion locks-in as a dominant technology…
- This:
  - *Risks excessive market concentration*
  - *That blocks possible entry of more optimal alternative technologies*
  - *That may be longer lasting with a longer cycle life*

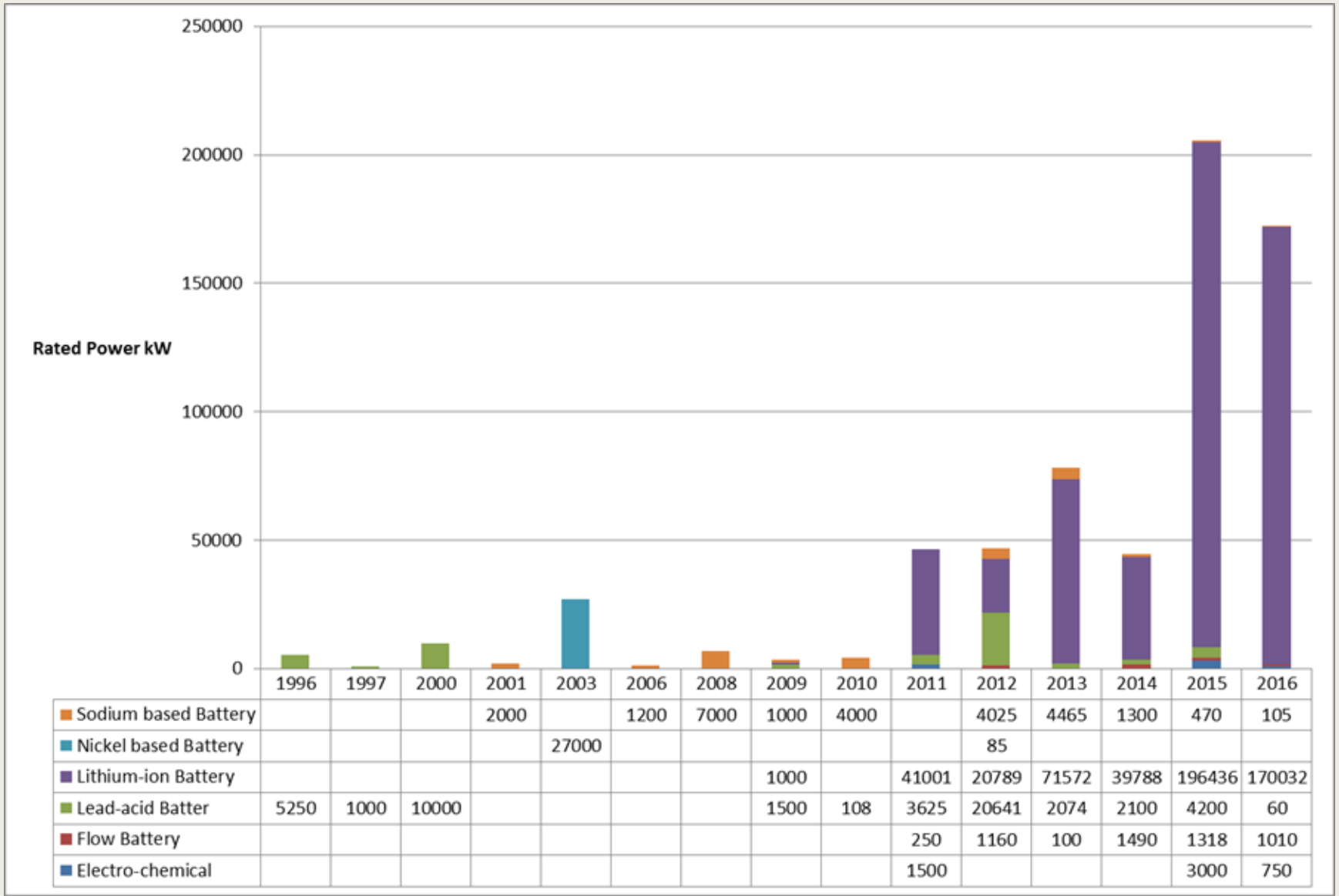
Stranded Innovation?

- Premature TECHNOLOGY LOCK-IN may mean that -
  - *Innovations that could improve on the current Li-ion dominant design become Stranded –*
  - *They won't receive development investment*
  - *Li-ion dominance is already making it difficult for alternative technologies to get into implementation stage*
  - *And global firms are scaling up Li-ion production beyond demand*
- *Creates a risk of **STRANDED INNOVATION***
- *So: will Li-ion become the dominant technology?*
  - *Will it lock-In?*
  - *Is there a risk of stranded innovation?*

David Hart:
Lithium-ion Batteries Dominate the Global Storage Market (IEA)

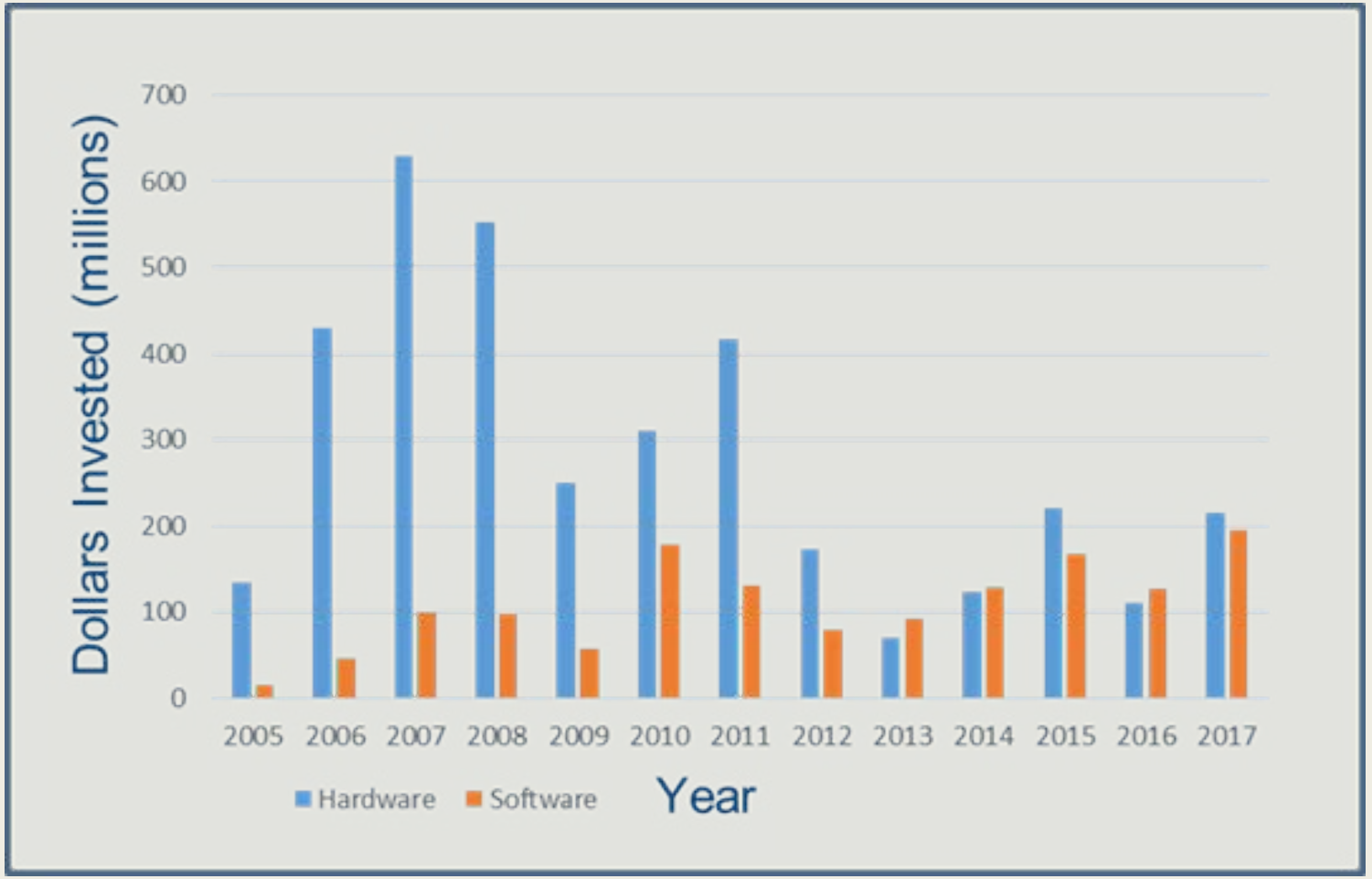


…and the U.S. Grid-Scale Storage Market (DOE)



	1996	1997	2000	2001	2003	2006	2008	2009	2010	2011	2012	2013	2014	2015	2016
Sodium based Battery				2000		1200	7000	1000	4000		4025	4465	1300	470	105
Nickel based Battery					27000						85				
Lithium-ion Battery								1000		41001	20789	71572	39788	196436	170032
Lead-acid Batter	5250	1000	10000					1500	108	3625	20641	2074	2100	4200	60
Flow Battery										250	1160	100	1490	1318	1010
Electro-chemical										1500				3000	750

Cleantech VC Declines, Shifts to Software (ITIF)



Source: Hart and Kearney, ITIF, 2017.

Non-Li-ion Companies in Distress

WESTMORELAND

Aquion Energy will move to China, close Westmoreland plant at former Sony site

JOE NAPSHA | Monday, Sept. 18, 2017, 4:27 p.m.

Redox flow 'leader' VIZn admits cashflow difficulties, denies going out of business

ENERGY STORAGE

Alevo Administrators to Wrap Up Sale of Grid-Storage Assets in a 'Couple of Weeks'

The bidding process is still ongoing.

JASON DEIGN | FEBRUARY 05, 2018

VARUN SIVARAM

Bosch Drops Manufacturing Batteries

Unlocking Clean Energy

It's go big, go niche -- or get out.

Objectives for Grid-Scale Storage Technology Policy

- Sustained growth in the grid-scale energy storage market.
- Diversification of segments and use cases that make up the storage market.
- Open standards that allow diverse storage technologies to "plug and play" in any system.
- Complementary public and private investment in RD&D and early deployment of emerging storage technologies..
- Fair competition among energy storage technology vendors.

Policy Priorities - 1

Federal

- Expand funding for storage R&D
- Create tax incentives for energy storage that focus on emerging technologies
- Support national and international processes that will lead to open standards
- Work with international allies to counter unfair trade practices.

Federal and State

- Expand support for storage demonstration projects and early deployment
- Provide financial assistance to help storage hardware innovators overcome barriers to scaling up.

Policy Priorities - 2

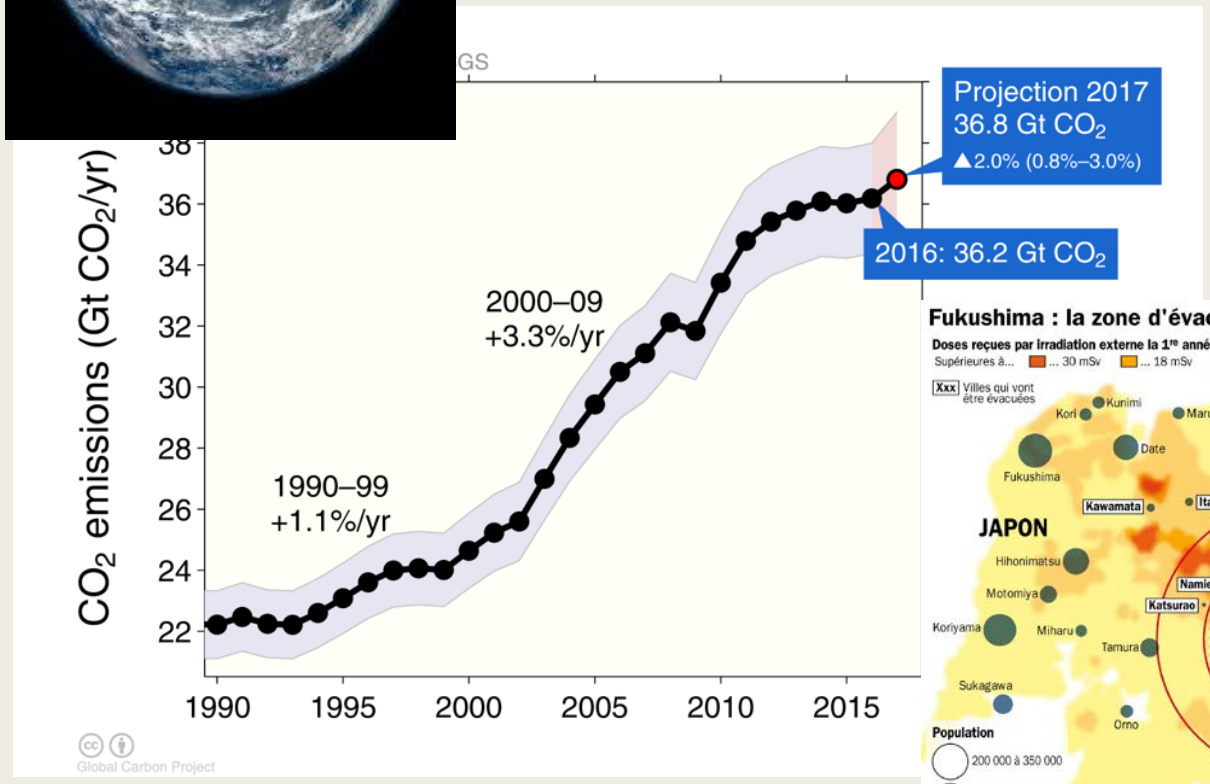
State

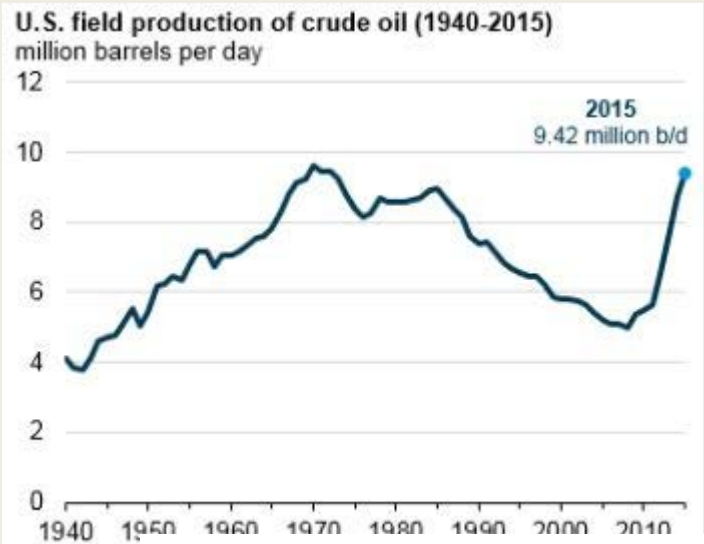
- Set smart and ambitious targets for storage deployment
- Establish subtargets that are reserved for alternative storage technologies

State and Regional

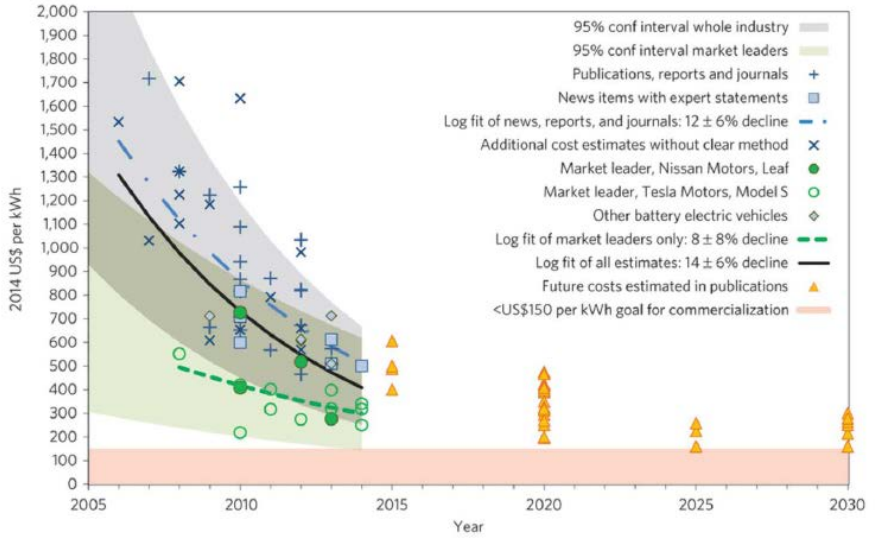
- Revise rules so that storage assets can participate fully in markets.
- Implement regulations to enable access to multiple value streams
- Explore new products and market signals
- Oversee IRPs and approve rate designs that encourage innovation
- Establish regional innovation and purchasing consortia
- Form an expert advisory system

Remember the Big Picture and Expect Surprises





Source: U.S. E



Source: Nature Climate Change 5, 329–332 (2015)

Graph 1. The cost evolution of vehicle batteries.