Energy Storage Trends and Challenges

Understanding and Realizing the Costs and Benefits of a New Resource for the Grid

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Today's Key Takeaways

Energy Storage has Real Possibilities: Even after cutting through the tremendous hype, grid energy storage has substantial potential to make inroads into the electricity industry, through niche applications and specialized technologies at first, but proceeding into broader uses, with potential widespread adoption beginning between 2020 and 2025.

Lithium Ion Batteries are the Immediate Opportunity: A sharp drop in lithium ion prices in the last two years, and strong interest among developers and regulators, have resulted in a number of prominent deployments in niche applications. If successful, these deployments point the way towards broader application of battery storage in specific locations and uses, though prices are still far too high for more "classical" uses of storage such as load leveling or bulk storage of renewables. Other storage technologies will find it difficult to compete in the near term but may benefit from a mature storage market in the 5-10 year time frame.

Long-Term Research is Critical to Success: Present-day technologies meet some needs on the grid, but future needs require radically better technologies with more energy density, higher efficiency, better reliability and lower cost. These technologies cannot be developed without a systematic approach to research and development covering the entire spectrum of Technology Readiness Levels, from early proof-of-concept through demonstration, pilots, and deployment.

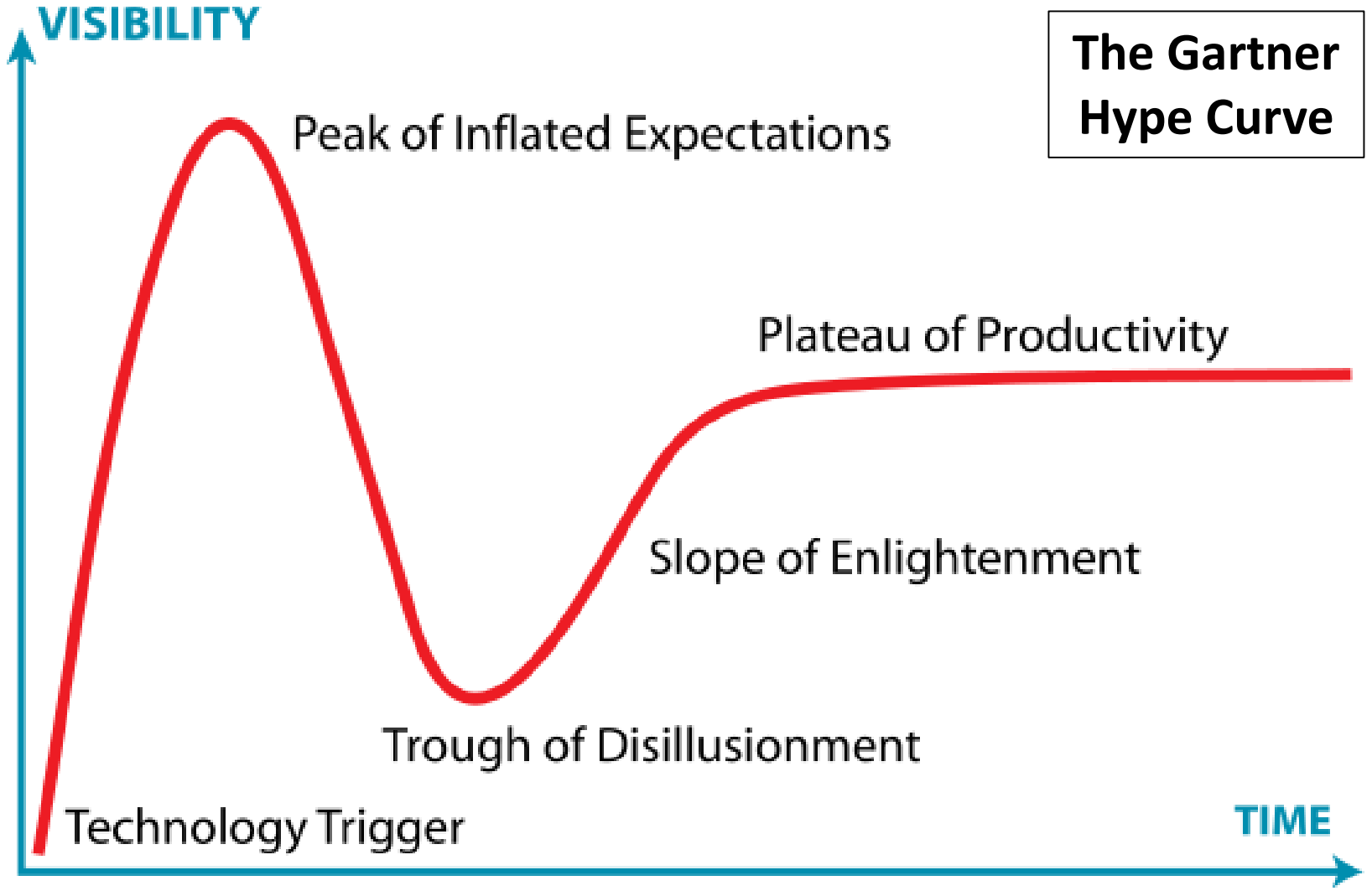
Storage Changes Supply Chains

- Refrigeration transformed food supply by allowing preservation of a highly perishable product
  - Changed delivery mechanisms
    - E.g. No more milk man
  - Created new supply and demand patterns
    - E.g. Winter produce from Chile
- Energy storage may similarly transform when and where electricity is produced, transmitted, and used

GE Monitor-Top refrigerator, c. 1927

Picture rom digital collection of Mike Manning, retrieved 31 Oct 2013 from http://en.wikipedia.org/wiki/File:Monitor_refer.jpg

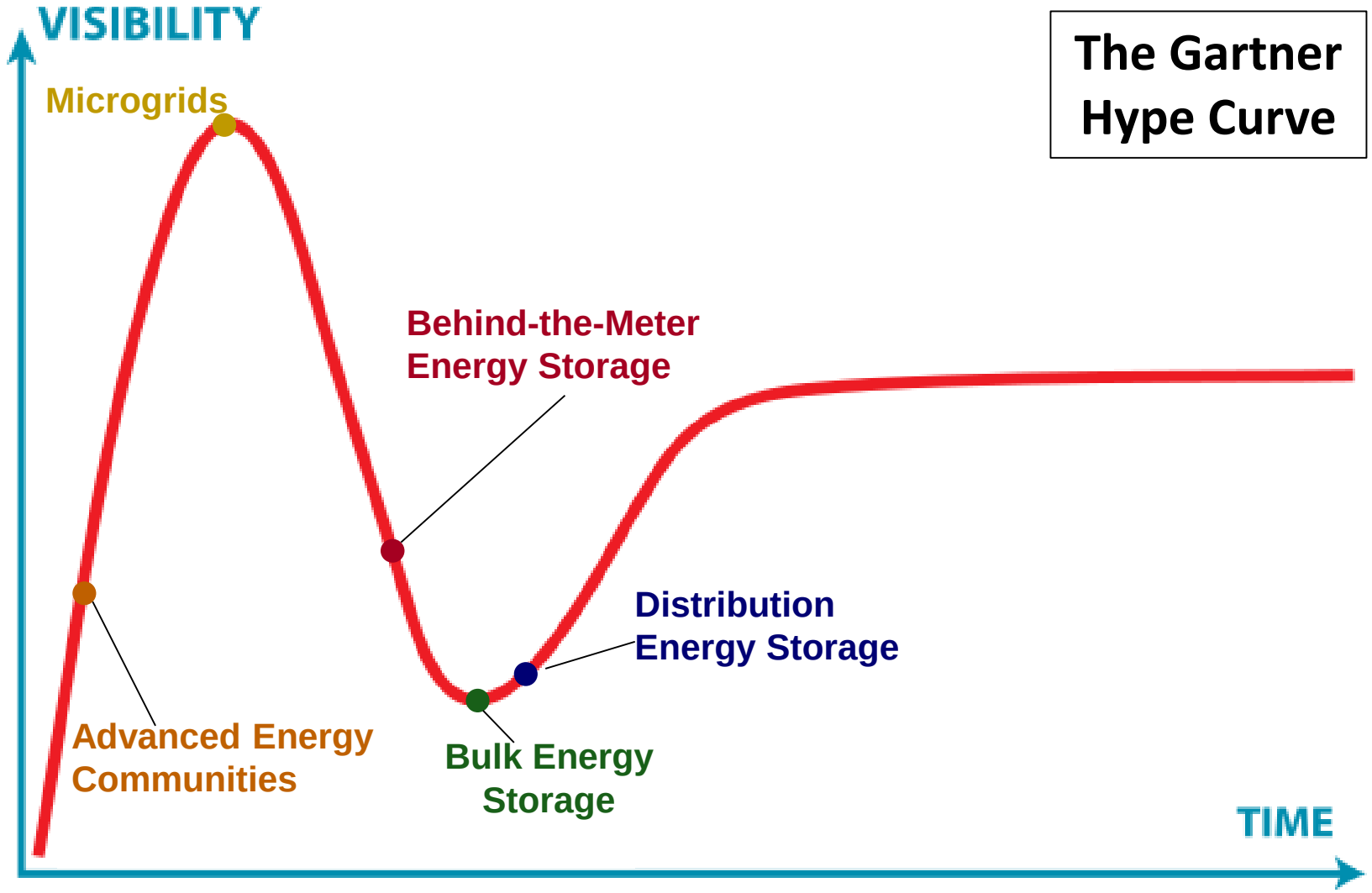
Moving beyond the hype cycle…



The Gartner Hype Curve

Understanding the facts will help us to move beyond the peak of the hype cycle

Moving beyond the hype cycle…



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Are we reaching the Tipping Point for Storage?

- Massive investment in lithium ion battery manufacturing has caused the cost of the technology to plummet over the last two years
  - Installed costs less than $500/kWh are being reported for 2016
  - EPRI estimates have been $350 - $500/kWh by 2020

- Prices have reached a very interesting level
  - Still too high for “classical” storage applications such as load leveling
  - But applicable in niche applications such as peak shaving for asset deferral, and peaker replacement

Residential Storage: The Difference a Year Makes

Tesla PowerWall
Announced April 30, 2015

Power: 2 kW
Energy Capacity: 6.4 kWh
Weight: 214 lbs.
No Integrated Inverter

Installed Cost: ~$950/kW per hour of storage

2x Energy
2x Power
60% less space

Tesla PowerWall 2
Announced October 28, 2016

Power: 5 kW
Energy Capacity: 13.5 kWh
Weight: 264 lbs.
Fully Integrated Inverter

Installed Cost: ~$580/kW per hour of storage

Kauai: The Difference a Year Makes

- September 2015: Kauai Island Utility Cooperative signs a PPA with Solar City for peak evening power
  - 17 MW solar array + 52 MWh battery
  - 13.9 cents / kWh under 20 year PPA
  - To begin operation in February 2017

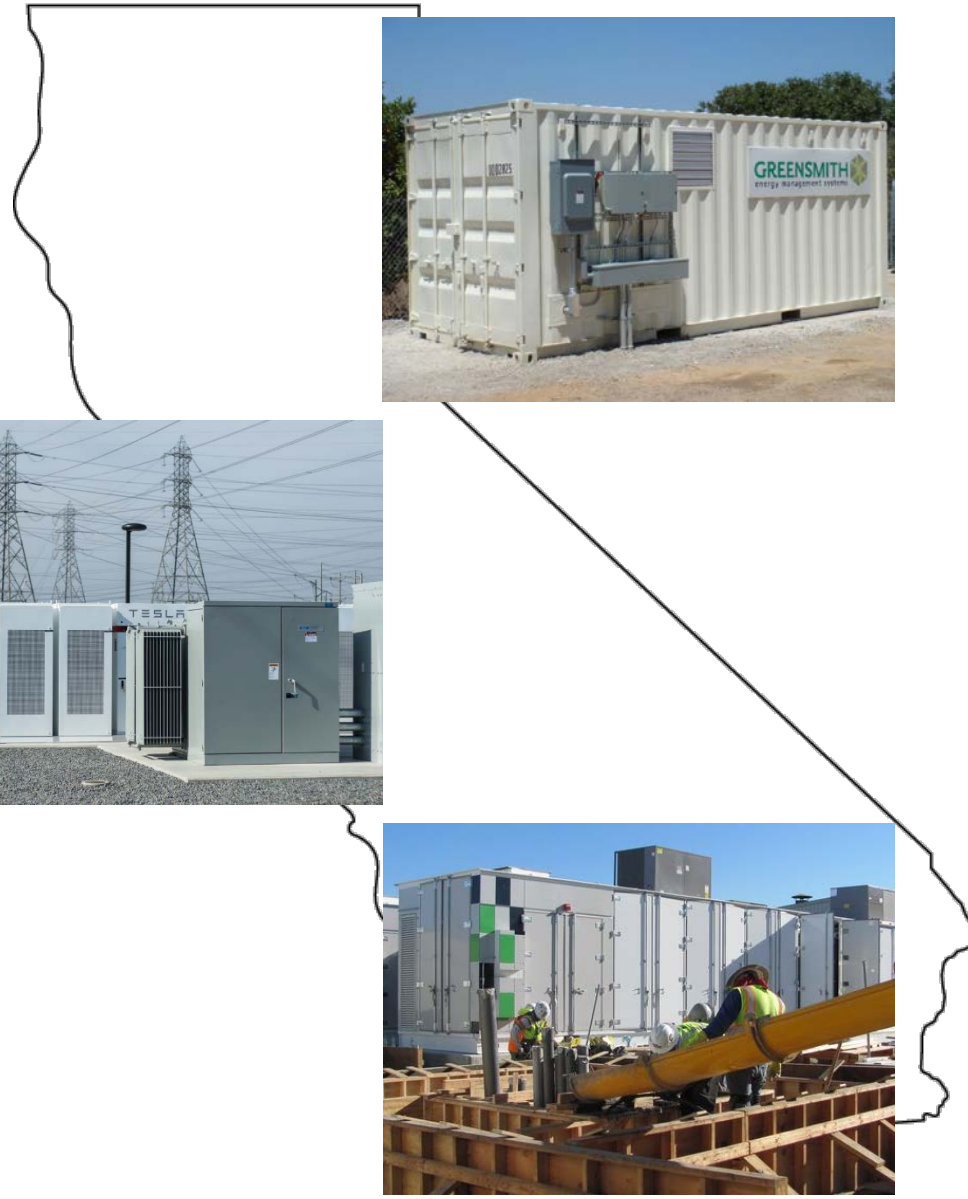
- January 2017: Kauai Island Utility Cooperating signs a PPA with AES for peak evening power
  - 28 MW solar array + 100 MWh battery
  - 11 cents / kWh under PPA (unspecified period)
  - To begin operation in late 2018

Source: Solar City

Aliso Canyon: Less than a year from inception to installation

- Aliso Canyon: Gas storage plant issues pushed CPUC to call for energy storage to be installed to replace gas peakers by the end of 2016
- Several large-scale battery systems installed
  - 20 MW / 80 MWh AltaGas Pomona Energy (SCE)
  - 20 MW / 80 MWh Tesla Energy at Mira Loma (SCE)
  - 2 MW / 8 MWh Powin Energy system at Irvine (SCE)
  - 30 MW / 120 MWh AES Energy Storage at Escondido (SDG&E)
  - 7.5 MW / 30 MWh AES Energy Storage at El Cajon (SDG&E) (
  - Other systems to come

- Systems were installed at breakneck speed
  - RFO / RFP issued in June 2016
  - Awards / CPUC Approval in September 2016
  - Several systems online by December 31st, 2016
  - Final commissioning Jan/Feb 2017



Has energy storage arrived?

- Aliso Canyon shows that lithium ion batteries can be attractive as peaker replacements *years before expected*
  - Special conditions (reduced availability of gas) make energy storage the preferred choice – even though prices may be somewhat higher than gas turbines ($2000/kW)
  - By 2020, storage at $1400/kW for 4 hours may be directly competitive with natural gas turbines in some locations

- But technology maturity is more than just cost!
  - Does storage have a track record of safety, reliability and predictable performance?
  - How are we using the storage, and what is the business model?
  - How do we incorporate storage into grid planning and operating practice?

Gaps to Energy Storage Implementation

- Real-world performance data
  - Testing and evaluation in lab and field settings
  - Collecting data from deployments to build track record
- Understanding the value of storage
  - Learning how storage can be used to improve grid design and operation
  - Getting the most value out of an energy storage deployment
- Organizational adaptation to new technology availability
  - Developing best practices for design, deployment, integration, operation, and disposal
  - Incorporating storage into existing planning and operations procedures

StorageVET™: Publicly-accessible storage valuation tool

- Goal: support common understanding of storage value between stakeholders
- Consistently analyze storage across range of uses, technologies, locations
- Ongoing collaborative effort to apply and refine tool through open forum - EPRI Energy Storage Integration Council (ESIC)
- More info at www.storagevet.com

Energy Storage Integration Council (ESIC)

Develop energy storage integration guidelines and tools through industry collaboration

Started in 2013, 700 participants from utilities, suppliers and research community

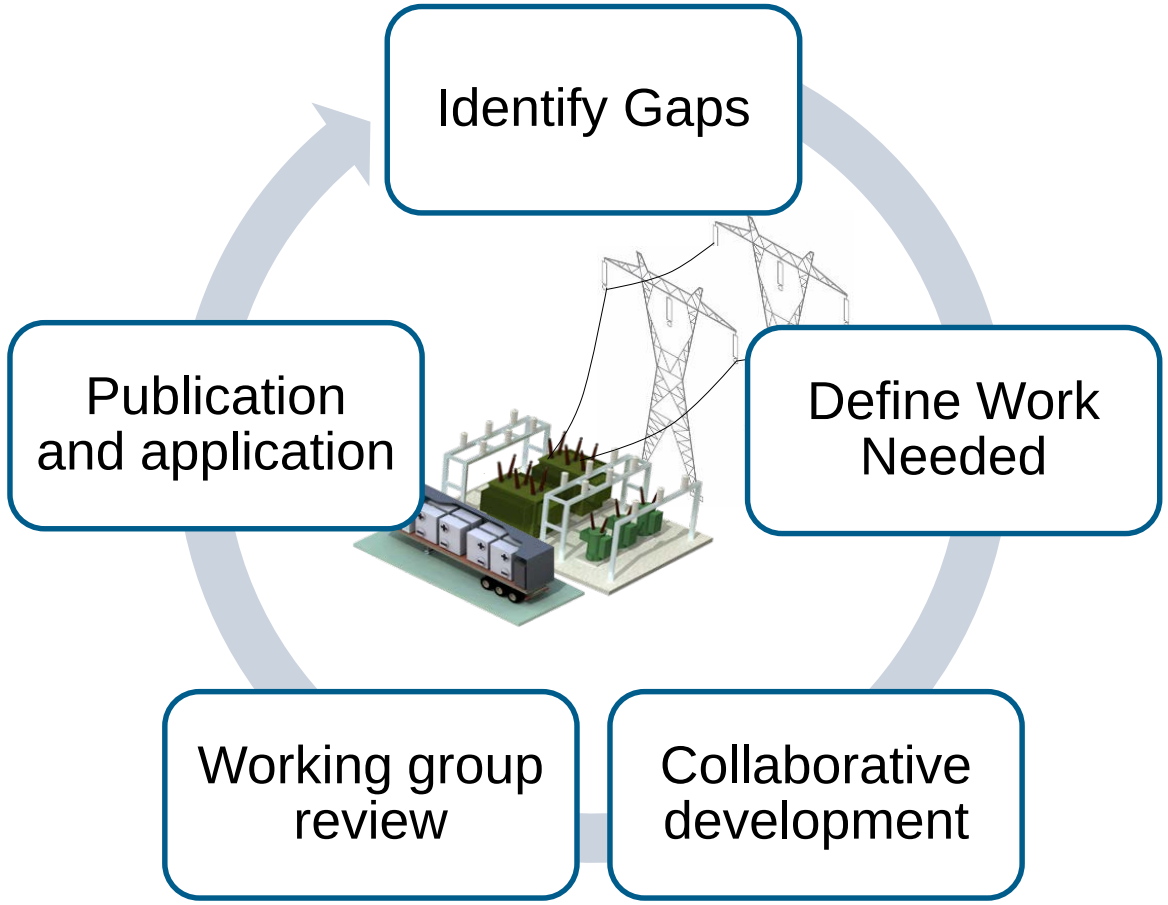
ESIC Published Resources

Energy Storage Cost Template and Tool: 3002006072

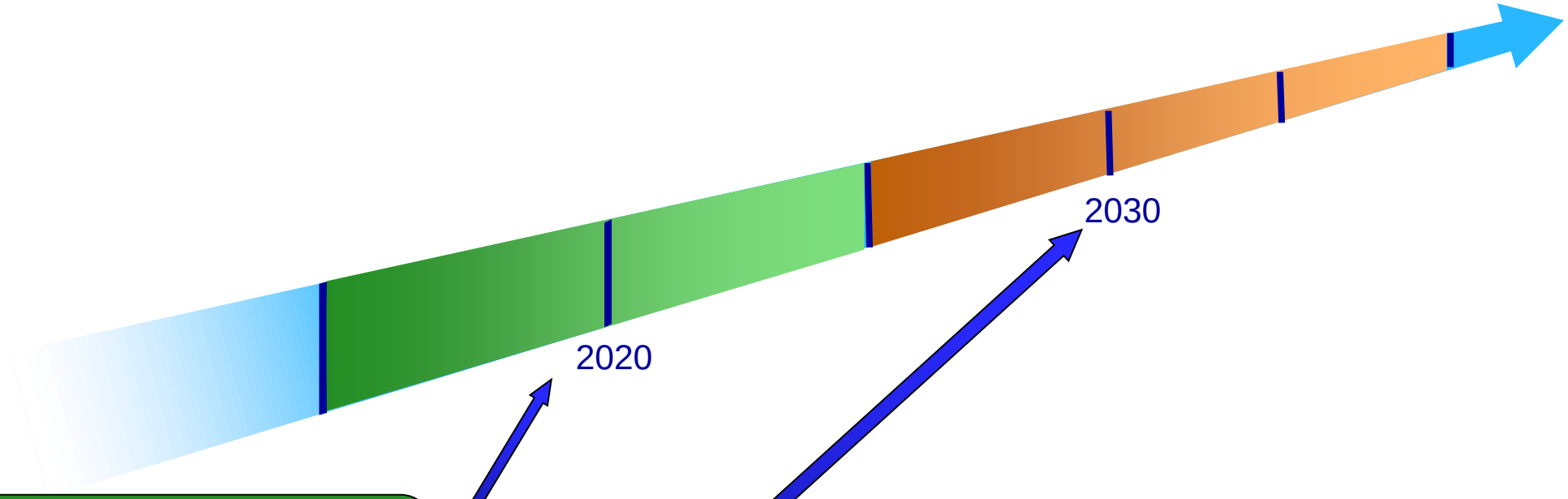
Energy Storage Safety: 2016 3002008308

Integration Guidelines for Energy Storage: 2015 3002006074

Published products at ESIC website:
www.epri.com/esic



Research Horizons

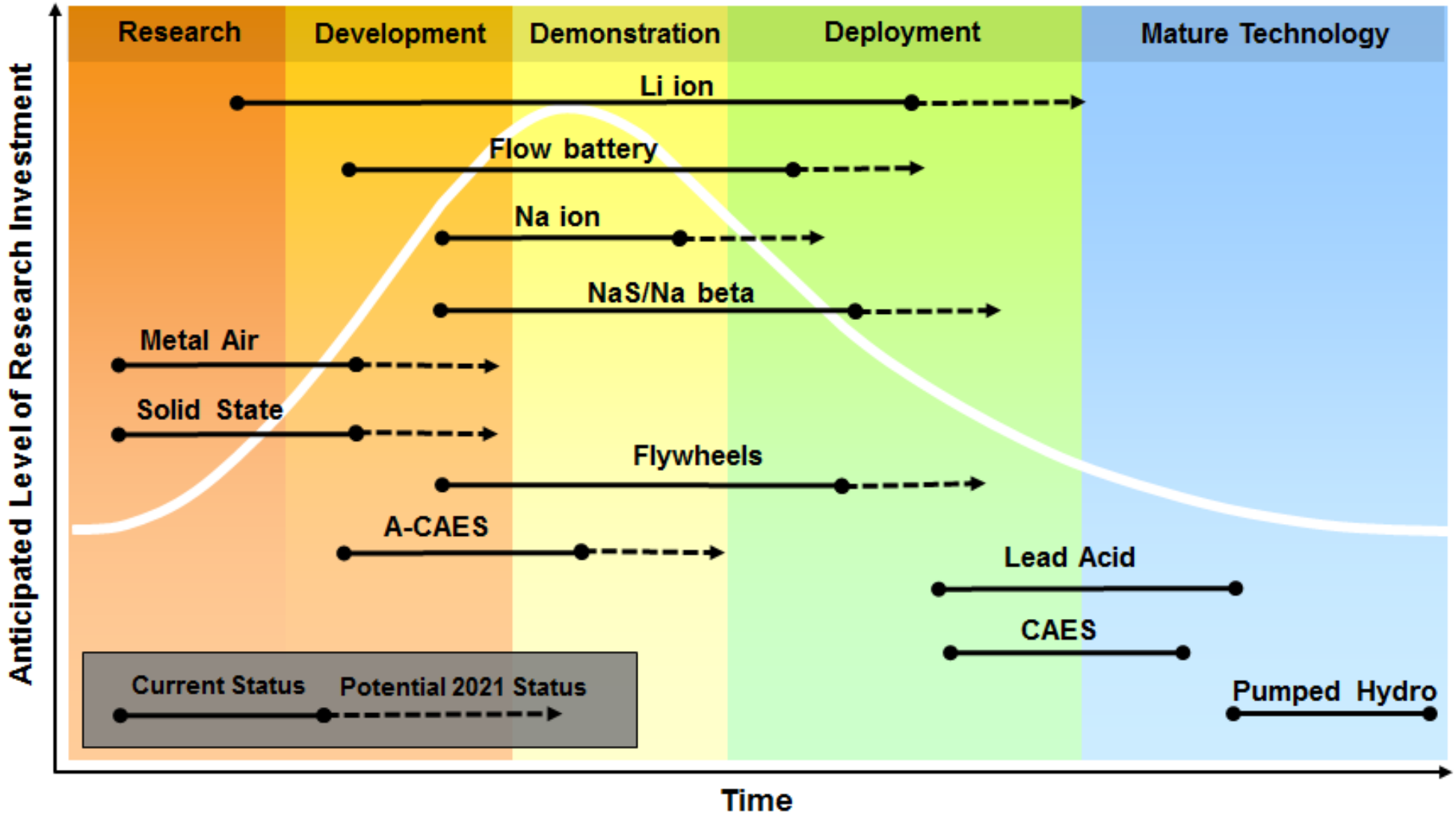


Near Term Research:
Facilitate solutions using present technology

Long Term Research:
Creating new technologies for the future

Without research today, we will not have solutions for tomorrow

Developing Technologies of the Future



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Together…Shaping the Future of Electricity