

Battery Storage: Welcome to a Brave New World

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Who we are

- SolarVision Co: technology business development
- Small group of technologists
 - Analysis and guidance
 - "Practical Visionaries"
 - Technologies, Market assessment
 - Due Diligence



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Main themes

- Big challenges but Big opportunities
- Why batteries? Dispatchability vs intermittency
 - Power on demand
- Batteries are a chemistry experiment
- "Personal power" is on the way
 - The "Uberization" of power
- The grid is a giant battery
 - Elements generating current by chemistry (nuclear), by chemical reactions (burning coal, gas)
 - Battery generating current by chemistry: charge separation



Range of Storage Space





- Track record of battery start-ups
 - Research ideas: >1000's
 - Funded startups: 100's
 - But: since 2000, only 36 battery startups received more than \$ ¹/₂ M in funding
 - Positive returns: 2
 - only 2 returned more money than was invested into them
- Ideas-to-Money success rate to date: 0.2%
- Steady but incremental:
 - Over the last decade improvements have come largely from established companies steadily making small advances.



- Challenge for developing better batteries:
 - The technology is still poorly understood.
 - Changing one part of a battery (e.g. a new electrode) can produce unforeseen problems
 - Some of which can't be detected without years of testing
- The sad story of Envia (claim: 3x range and ½ cost)
 - To get the VC and ARPA-E type of advances they incorporated two experimental electrode materials
 - Showed excellent promise then it collapsed
 - Didn't understand the <u>basic chemistry and physics</u> of the material well enough to know what was going wrong, let alone to fix it
 - Envia's impressive battery had been a fluke
- Highlights the difficulties: too complex and too fast



Is there profit to be made?

- Battery market has margins <5%
- Semi equip: AMAT margins >40%
- Solar panels: SunPower margins -25%

- Yes ! But needs volume...
- Demand increasing & price dropping



The market is growing

• EV sales SVC report 2017



Micro-grids
SVC report 2017

Tot Market \$1/2T by 2030





Drop in PV & battery prices

- Price learning curve for PV, batteries
- SVC "Energy Storage & Battery Report 2016"





SVC: Li Ion Cost Learning curve

- Historical trends
- Quantitative modeling
- Full costs: fixed/running
- Projection \rightarrow Forecast









Chemistry or Cauldron?

- Nano materials
- Silicon nano-wires
- ALD coatings
- Trace elements



LFP: Li-iron-phosphate (Li-Fe-Ph) NCA: Li-nickel-cobalt-aluminum NMC: Li-nickel-manganese-cobalt LCO: Li-cobalt-oxide

Battery researchers are publishing papers that show how trace amounts of additives change the behavior of the materials

- Battery storage Tsunami is on the way
- It won't be easy and it won't be fast
- It's going to need Chemists, Physicists and Engineers!

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