Battery Storage:
Welcome to a Brave New World

Dr. Andy Skumanich
Who we are

• SolarVision Co: technology business development
• Small group of technologists
  – Analysis and guidance
  – “Practical Visionaries”
  – Technologies, Market assessment
  – Due Diligence
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

• Power Requirements:

• Utility apps range:
Diversity of experiments

• Track record of battery start-ups
  – Research ideas: >1000’s
  – Funded startups: 100’s
    • But: since 2000, only 36 battery startups received more than $ ½ 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 basic chemistry and physics 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 $\frac{1}{2}$T by 2030
Drop in PV & battery prices

- Price learning curve for PV, batteries
• Historical trends
• Quantitative modeling
• Full costs: fixed/running
• Projection → Forecast

SVC: Li Ion Cost Learning curve

![Graphs showing historical trends and projections for Li-ion battery costs](image-url)
Chemistry or Cauldron?

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

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

<table>
<thead>
<tr>
<th>LFP</th>
<th>NMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li-iron-phosphate (Li-Fe-Ph)</td>
<td>Li-nickel-manganese-cobalt</td>
</tr>
<tr>
<td>NCA</td>
<td>LCO</td>
</tr>
<tr>
<td>Li-nickel-cobalt-aluminum</td>
<td>Li-cobalt-oxide</td>
</tr>
</tbody>
</table>
Conclusions

• 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!
More Info? Contact: Dr. Andy Skumanich
www.solarvisionco.com
askumanich@solarvisionco.com