An anatomy of techno-scientific promise

The case of Li-ion batteries

Sjoerd Bakker
EV’s and other cars of the future

- Competing visions & technologies
- Why do we ‘believe’ in some and not in others?
  - By definition: underperforming technologies
  - Belief in EV’s relies on expected improvement of batteries
  - How are such expectations constructed?
Innovation and expectations

- In general we expect technology to improve
  - ‘an endless frontier’
- Expectations of specific technological options:
  - Individually inspiring
  - Collective expectations coordinate efforts
  - Risk of “hype & disappointment”

- Expectations relate to:
  - Technology as such
  - Other stakeholders’ behavior
  - Contextual factors
Example: Moore’s law

• “Density of computer chips will double every two years”

• Promise became requirement for industry

Microprocessor Transistor Counts 1971-2011 & Moore’s Law
Construction of expectations

Performance → Path forward → End goal

Recent progress → Today

Bakker et al 2012 – Credible Expectations
Expectations of Electric Vehicles

- Collective expectations positive
  - ‘Forcing’ stakeholders to move along
  - Some characteristics of hype?
- Collective ambiguity
  - Worries: range, charging times, costs
  - Consumers: negative Willingness-to-Pay!
- Much, if not all, depends on battery improvements?
Automotive industry statements

• Honda:
  • “vehicle electrification will accelerate only at the pace of battery innovation”

• Daimler:
  • “improvements on cost, safety and lifetime aspects have to be the main focus for the next generations of EV batteries”

• Elon Musk (Tesla):
  • “a weak Moore’s Law” of 8% annual improvements in the price/performance of lithium-ion batteries
Improving battery “performance”

- Many criteria apply to traction batteries:
  - Costs: cell/pack/system
  - Capacity: power & energy
  - Charging times
  - No. of charge and discharge cycles
  - Safety
  - Raw material availability and recycling

- Priorities vary per application
- Trade-offs between characteristics
Methodology

- Online and print sources:
  - www.cars21.com
  - Electric & Hybrid Vehicle Technology International
- January 2009 – January 2013
- Searched for: “li-ion”
- Database with 58 articles, statements coded:
  - Recent progress, Manufacturing, Chemistry, New principles, and End goal
Extrapolating recent progress

**Figure 11: Historical Prices and Specific Energy Trends for Li-ion Batteries**
The paths forward: manufacturing

- Scale effects
  - Factory level
  - Raw material
- Standardization
  - Standardized battery packs?
  - Quality and safety standards to enable competition
- More efficient packaging of cells

- **A123**: *Scale is not enough to bring down costs sufficiently*
- **BCG**: 65% cost reduction towards 2020
- **Roland Berger**: 230→320 Wh/kg
Path forward: chemistry

- **Anode** (graphite)
  - Silicon, Titanium
- **Cathode** (Cobalt oxide)
  - LiFePo$_4$
  - Manganese
  - Sulfur
- **Electrolyte** (organic solvents)
  - Solid state
- **Generic sources of hope:**
  - Engineering towards theoretical potential
  - Nanotech
  - NASA
Path forward: beyond li-ion

Current options
- Lithium-air!
  - No. of charge-discharge cycles?
  - Potentially 5-10x energy density
- Zinc-air
- Lithium-Sulphur
- “Re-inventing Lead Acid”

However
- “Not in 5yrs”
- “not commercial before 2025” (Volkswagen)
Defining an end-goal

Pragmatists & Idealists

• Nissan-NEC JV: “300 km range needed for mass market”
• “Car manufacturers ask for 5000 cycles”
• “Sakichi” ultimate battery for Toyota > gasoline
Conclusions

Performance

Time

Today
Certainty trough & Hype?

MacKenzie 1990

Developers – directly involved in knowledge production
Users - committed to technological institution/program, but users rather than producers of knowledge
Outside Experts - alienated from institutions/committed to different technology

Expectations

Time
Conclusions for practitioners

• Rely on existing technologies coming 5-10 yrs at least
  • Incremental improvements in manufacturing and chemistry
• New battery types in lab/prototype
  • Step change improvements (price x performance) uncertain, >10 yrs
• EV in “valley of death” between R&D and true commercialization
  • Challenge: maintain momentum without actual big improvements
  • Promises of new batteries do help
• For now: focus on applications that make sense today

• BMW:
  • “there are other promising technologies coming up and we do not know what the future will bring”