Wireless Futures: Energy Storage and Communications?

Presentation to WCA Wireless Futures SIG

October 2011

Benjamin A. Rolfe

Principle, Blind Creek Associates

Co-Founder, Element Energy

ELEMENT ENERGY

Overview

- Context and Connections
- Storage and the Grid
- Storage Technology
- Conclusion

Context and Connections

Connections

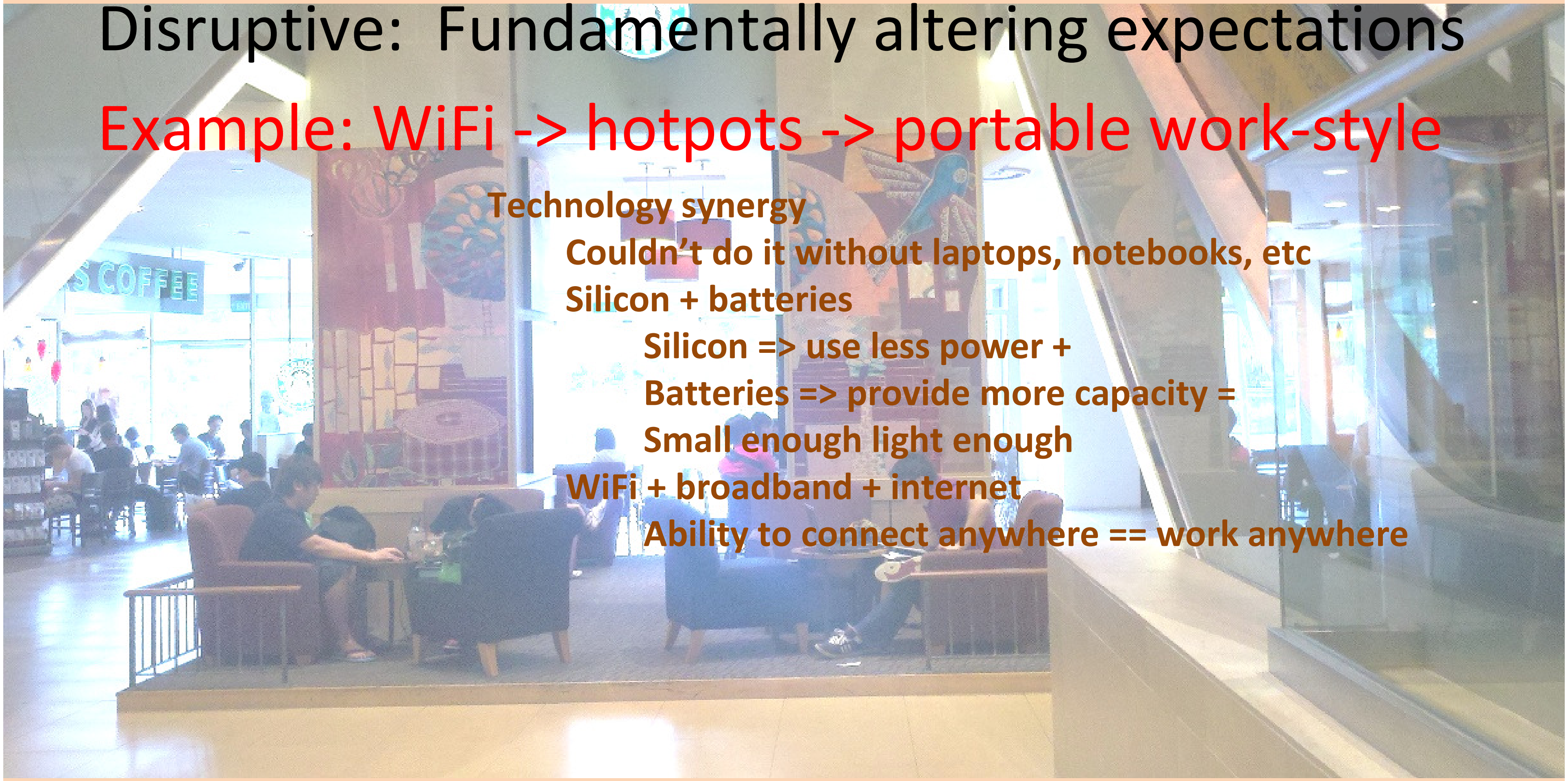
Wireless and energy storage?

- Wireless communications and scalable energy storage are enabling technologies
- Both present multiple dimensions of innovation opportunities
- Both enable new ways of thinking about connecting things
- Combine the two and it gets really interesting

Communications thinking creates innovative energy technologies

- Applying principles in networking to energy storage
  - Distributed intelligence
  - Distributed control
  - Information distribution and aggregation
- Storage technologies as a dynamic medium
  - Like wireless, the ‘channel’ is never static
  - Continuous changes in ‘medium’ require adaptation for optimal performance
- Multi-dimensional trade spaces
  - Capacity/Cycle-life/mass is much like speed/range/energy consumption/radio power trade-space
- Technology domains
  - Leveraging techniques, semiconductor advances, and commodity technologies
  - Benefit from scale of expanded application domains

Impacts of Wireless



Disruptive: Fundamentally altering expectations

Example: WiFi -> hotpots -> portable work-style

- **Technology synergy**
  - **Couldn’t do it without laptops, notebooks, etc**
  - **Silicon + batteries**
    - **Silicon => use less power +**
    - **Batteries => provide more capacity =**
    - **Small enough light enough**
  - **WiFi + broadband + internet**
    - **Ability to connect anywhere == work anywhere**

Storage and the Grid

Impacts of scalable storage

- Distributed energy resources
  - Put energy where needed
  - Reduce transmission loss and infrastructure required
  - Enable more rapid adaptation

- Scalable storage enables DER
  - Storage as peak-reduction
  - Enables effective use of “clean” opportunistic energy sources

Opportunistic Energy

- Energy source not time-coupled to need
  - Solar and Wind are popular examples
  - Available when available, not when needed
- Storage allows *time-shifting* energy to *when* needed
- Storage allows *scaling* capture/conversion
- Past barriers:
  - Battery cycle life
  - Density ($$/kWh)
  - Environmental: Lead, heavy metals
  - Aesthetic: where to put the battery room

Energy supply and Demand: the zero-sum game (1)

- Generation and consumption must be balanced
  - Little or no storage in grid, generation/distribution must meet demand
  - Generation needed at time of demand
- Demand not constant
  - Peak handled by more expensive “peakers”
  - Over-supply typical to avoid transient outages

Energy supply and Demand: the zero-sum game (2)

- Current effort to get consumers to shift demand away from peak
  - Time of Use pricing, Demand/Response, Real Time Pricing are examples
  - Suggests that consumer behavior and/or lifestyle must change
- Storage enables new models:
  - store excess off-peak (when cheap), use when needed
  - Lifestyle improvements, no perceived sacrifice
  - Technology adapts to consumer instead of adapting consumer to technology
- Communications enables new models
  - Two-way com => two way energy flow

Storage Technology

Storage Advances

- Battery chemistries
  - Improved environmental costs
  - Improving density and $$/kWh
  - Improving manufacturing techniques and volumes
- Battery control technologies
  - Enabling increased effective capacity and/or cycle life
  - Enables trade-space mass/cycle life/effective capacity
  - Increasing volumes -> improving costs
  - Intelligent control == smart batteries

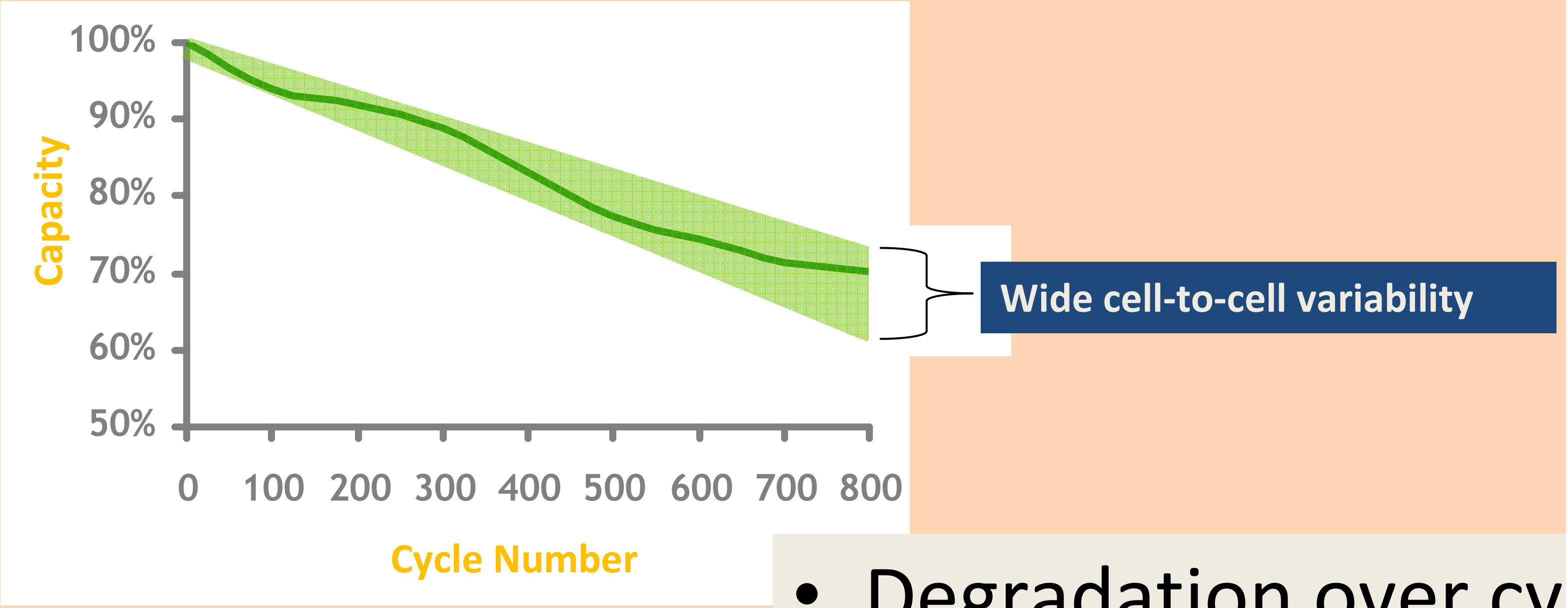
Scaling Storage

Large scale storage: Pump-up hydro, compress air in the ground, large-scale chemical storage: utility scale, typically don't scale down from

Mechanical storage: Flywheels, etc.: Scale mechanically to space/size available, slow to moderate response time; typically mid-scale apps

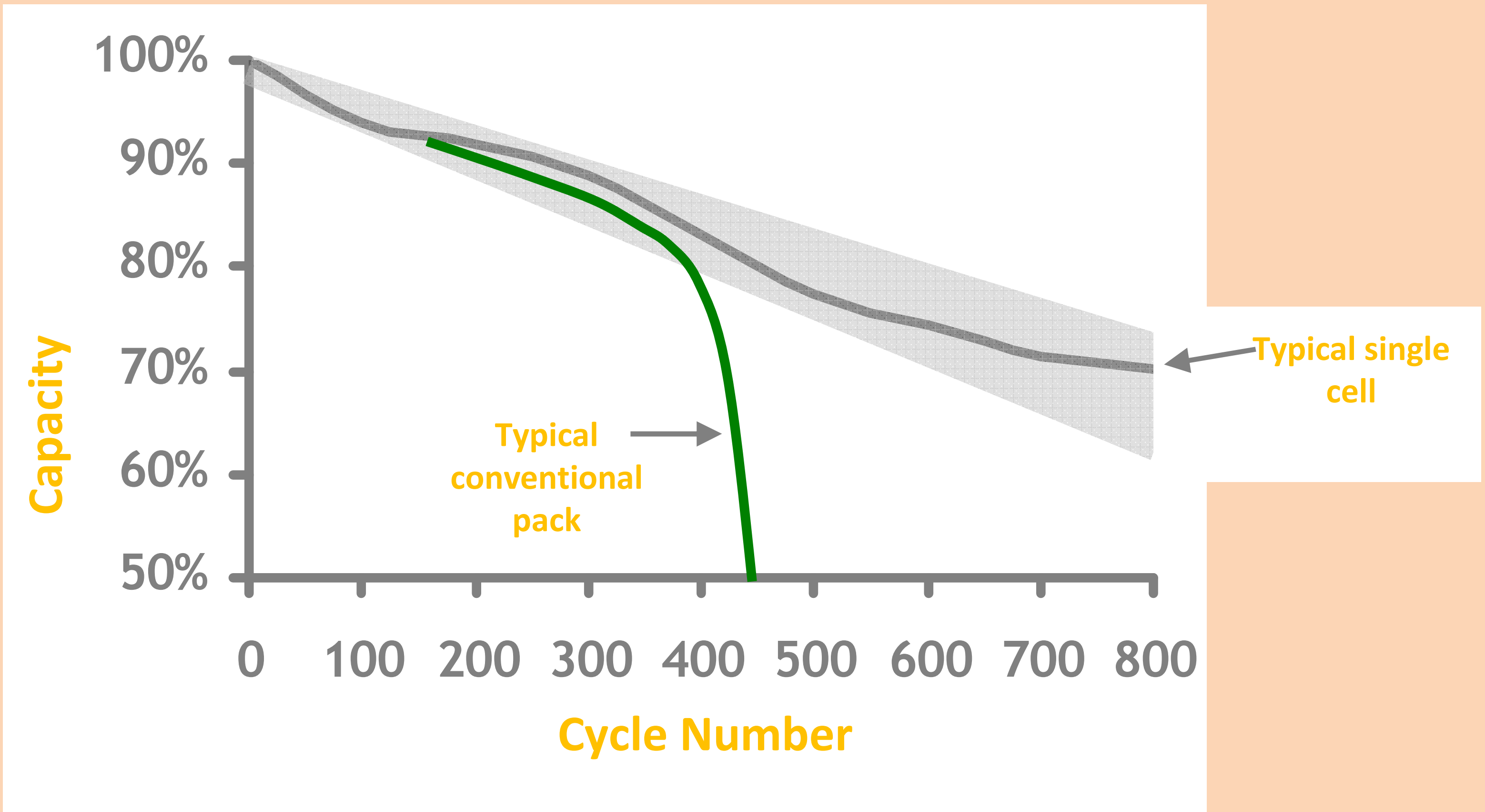
Batteries (small-scale chemical): Individual cells aggregated into packs; Series strings to desired voltage, parallel to desired capacity; small to medium scale (so far)

Cycle Life of a Cell



- Degradation over cycle life
- Cell to cell variation

Conventional Pack Cycle Life
Effect of Weak Cells



Battery Control Evolution

Unbalanced:

- Each cell charged/discharged the same
- First to hit full/empty paces entire collection (pack)
- Weakest cell limits total capacity
  - healthy cells under used
  - First to die => dead pack

Battery Control Evolution

Charge balancing:

- When one cell get’s full, shift charge to others
- First cell to hit “full” no longer limits capacity
- Weakest cell incrementally degrades pack (to a point)
- Various techniques shunting and shuttling
  - Resistive shunting,
  - Capacitor and/or inductors for shuttling
- Capacity still limited by weakest cells

Battery Control Evolution

Intelligent power management

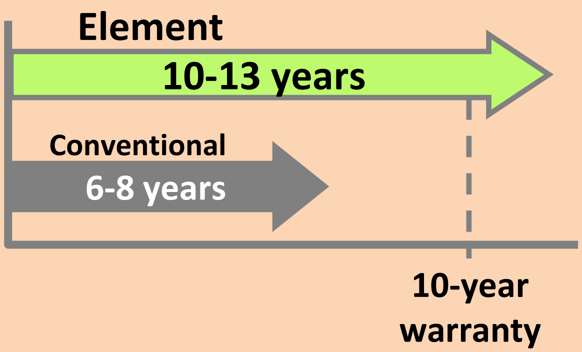
- Optimizes both charge and discharge for each cell
- Use full capacity of each cell
- Service life of the pack is determined by the average of all cells, rather than the life of the weakest cells

Element Energy Approach

- Innovative system for managing each cell of a multi-cell battery pack
- Leverages advances in communications, power electronics, digital electronics, software
- Distributes control and intelligence, high level of mixed-signal integration (coms thinking)
- Uses “learning system” to mange each cell individually on both charge and discharge
- Cost effective, scalable storage system solutions

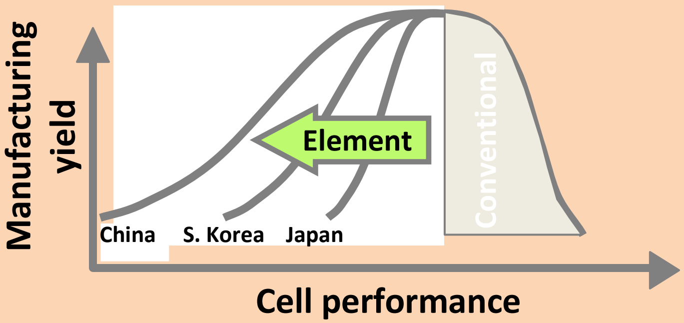
Summary: Element Technical Benefits

Lifetime



- **Substantial warranty cost savings**

Tolerance of Cell Variability



- **20-40% cell cost savings**

Numerous Other Benefits

- **Safety & reliability**
- **Provide regulated, stable pack voltage**
  - **Eliminate external DC-DC converter**
  - **Reduced peak current in motor controller**
- **Combine various electro-chemistries, even ultra-caps**
- **Field update of charge and discharge profiles**
- **More effective management of fast-charging protocols**
- **Discharge single cell or cell group while others are charging**
- **Capture detailed data on every cycle of every cell**

Conclusion

Coms + Storage = Smarter Storage

- Distributed grid-tied storage
  - Load/Peak signals enable real-time balancing and Dynamic adaptation
  - 2-way communication enables 2-way energy flow enables new ways of looking at the grid:
    - New energy management options
    - New business models
    - Abundant opportunities

The Beginning... of the next big thing?

Thanks for listening