Expanding U.S.-based Lithium-ion Battery Manufacturing

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Overview

Timeline

- Start January 2010
- End April 2013
- > 50% Complete

Barriers

- Lagging Customer Demand
- Financing
- Long Development Cycle(s)

Budget

- Total Project Funding $236 M
  - DOE - $118 M
  - EnerDel - $118 M
- Funding Received FY 2011: $54 M

Partners

- Equipment Suppliers
- EV Partners (Volvo, HHI, ATC)
- Purdue University
- USABC

Objectives - Relevance

- Develop competitive mass production capability for Lithium-ion battery cells & battery pack systems
  - Vertically integrated cell fabrication through pack assembly
  - Create domestic manufacturing capacity & skilled workforce
- Enhance supply chain & competitiveness of base materials
  - Develop and qualify domestic & international material suppliers
  - Improve performance, cost, & availability

Objectives - Relevance

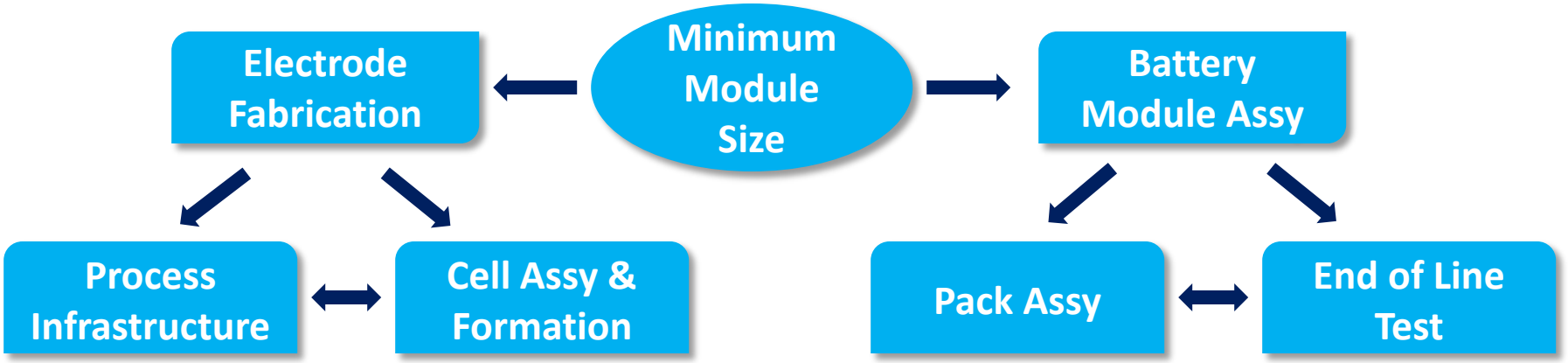
- Position EnerDel as a tier-one transportation supplier of advanced Lithium-ion battery pack systems
  - Implement APQP product development framework
  - Meet standards and acquire industry certification

Approach

- Scalable facility footprint
  - Adapt & upgrade existing cell fabrication site
  - Acquire a new mixed-use manufacturing facility
- Achieve maximum leverage of process infrastructure
  - Achieve break-through process cycle times to minimize equipment & people footprint

Approach

- System/equipment optimization approach



Approach

- “Seed” initial capacity installation; scale upon customer acquisition
  - Design-in batch & serial production build capability
  - Flex capacity with manpower/line-shifts
  - Address system bottlenecks as needed
  - Develop capability to process alternative source rolled or cut electrode materials
    - Develop material packaging & storage methods

Approach

- Layout and automation guidelines
  - Follow lean manufacturing principles
  - Focus automation on Special Process Characteristics (SPC)
  - Flex through-put with manpower +/-

Approach

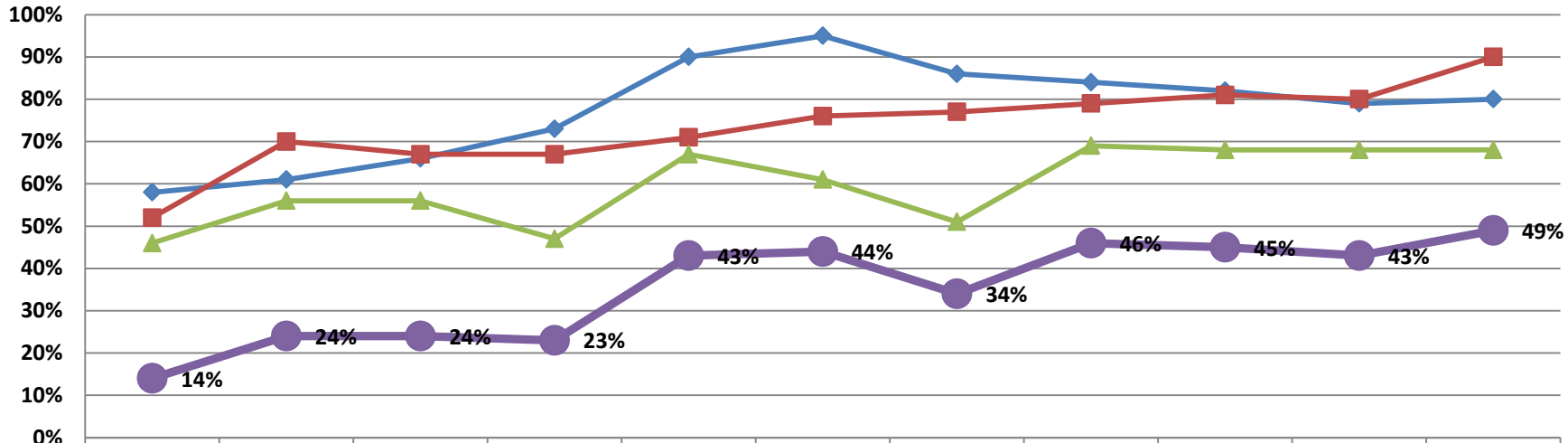
- Tool to one standard form factor for cell
  - Adjust chemistry or electrode content to specialize cell characteristics
- Tool to one standard form factor for battery module
  - Standardized piece stack-up
- Customize for applications at pack level

Technical Accomplishments/Progress

Facility II	3 mos.	1 mos.	2 mos.
Electrode	14 mos.	2 mos.	2 mos.
Cell Assy	7 mos.	2 mos.	7 mos.
Formation	9 mos.	3 mos.	3 mos.
Module/Pack	9 mos.	1 mos.	1 mos.

Technical Accomplishments/Progress

- Cell manufacturing
  - Production approval for EnerDel's first Lithium-ion cell mass production system
  - Validation phase productivity improvement



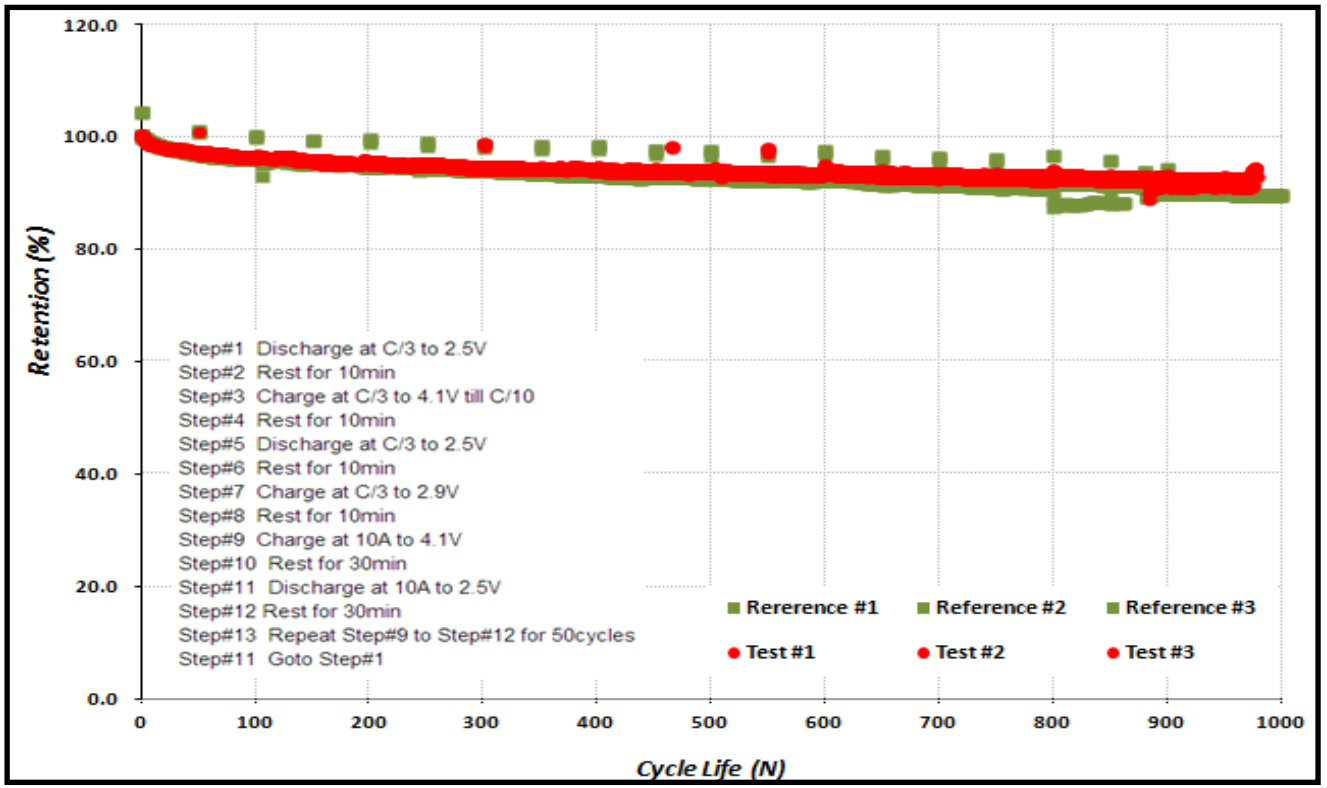
	Arp	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
QR	58%	61%	66%	73%	90%	95%	86%	84%	82%	79%	80%
AR	52%	70%	67%	67%	71%	76%	77%	79%	81%	80%	90%
PR	46%	56%	56%	47%	67%	61%	51%	69%	68%	68%	68%
OEE	14%	24%	24%	23%	43%	44%	34%	46%	45%	43%	49%

Technical Accomplishments/Progress

- Production validation cell test results

10A Cycle @ 30C

Production Validation cell: Line 2 / Reference Cell: Line 1 PVP&R



Technical Accomplishments/Progress

- Module & pack manufacturing
  - Capacity ramped in 6 months to 17k equivalent EV Packs
  - Packs in customer use

Technical Accomplishments/Progress

- Alternative material supplier evaluations completed
  - Cathode active material
  - Anode active material
  - Foils
  - Electrolytes
  - Packaging laminates
  - Separators

Collaborations/Partnerships

- Strategic alliances result in the most advanced solutions as technology and infrastructure evolve