IPRO 362

Design and Testing of a Lithium-Ion Battery System for Hybrid Electric Vehicle (HEV) Applications

Members of IPRO 362

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Introduction to IPRO 362

- Lithium-Ion cell technology
- Most promising battery technology
- Inability to be used with high current applications
- Our mission

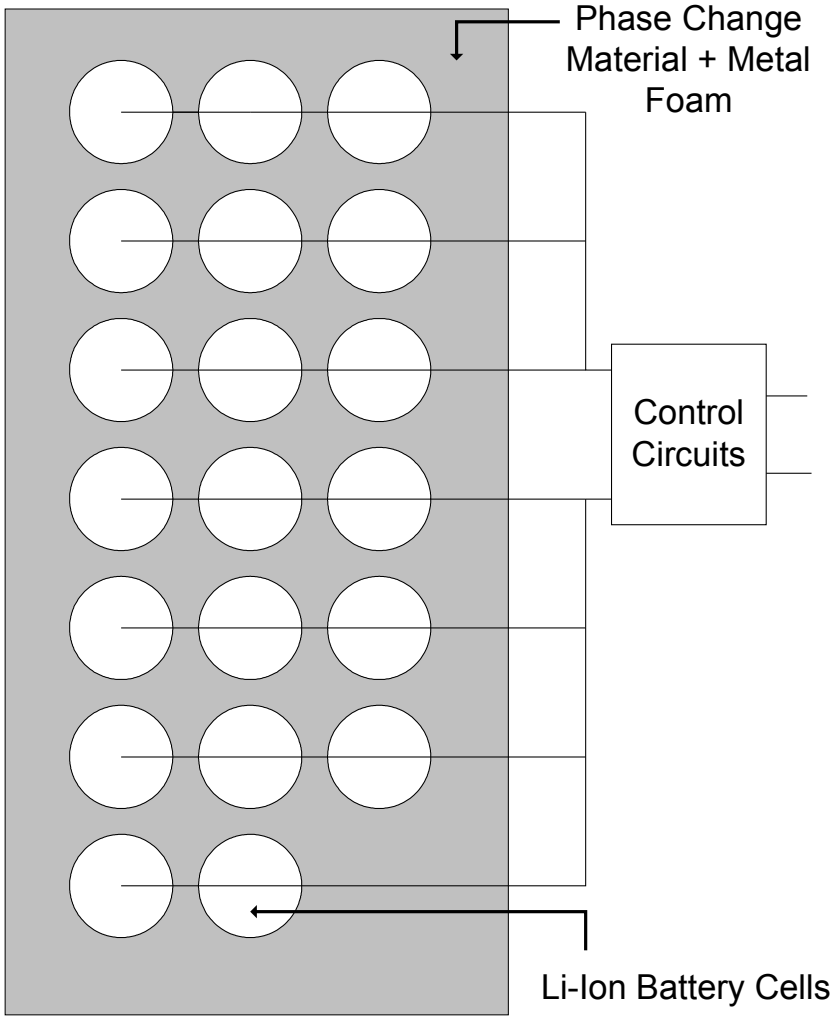
Our Product

- Li-Ion battery with a novel thermal management system
- Allows Lithium-Ion batteries to be used for high current applications
- Faster charging time for applications.
- Lighter overall weight than competing technologies
- Potential for further improvement

Thermal Management of Lithium Batteries

- The problem with Lithium-Ion Batteries
- The solution to this problem
- The Technology behind this solution
- Relative merits of this solution

Battery Layout



Phase Change Material

- Absorbs heat from chemical reaction

Metal Foam

- Holds battery cells in place
- Evenly distributes heat in box

Control Circuits

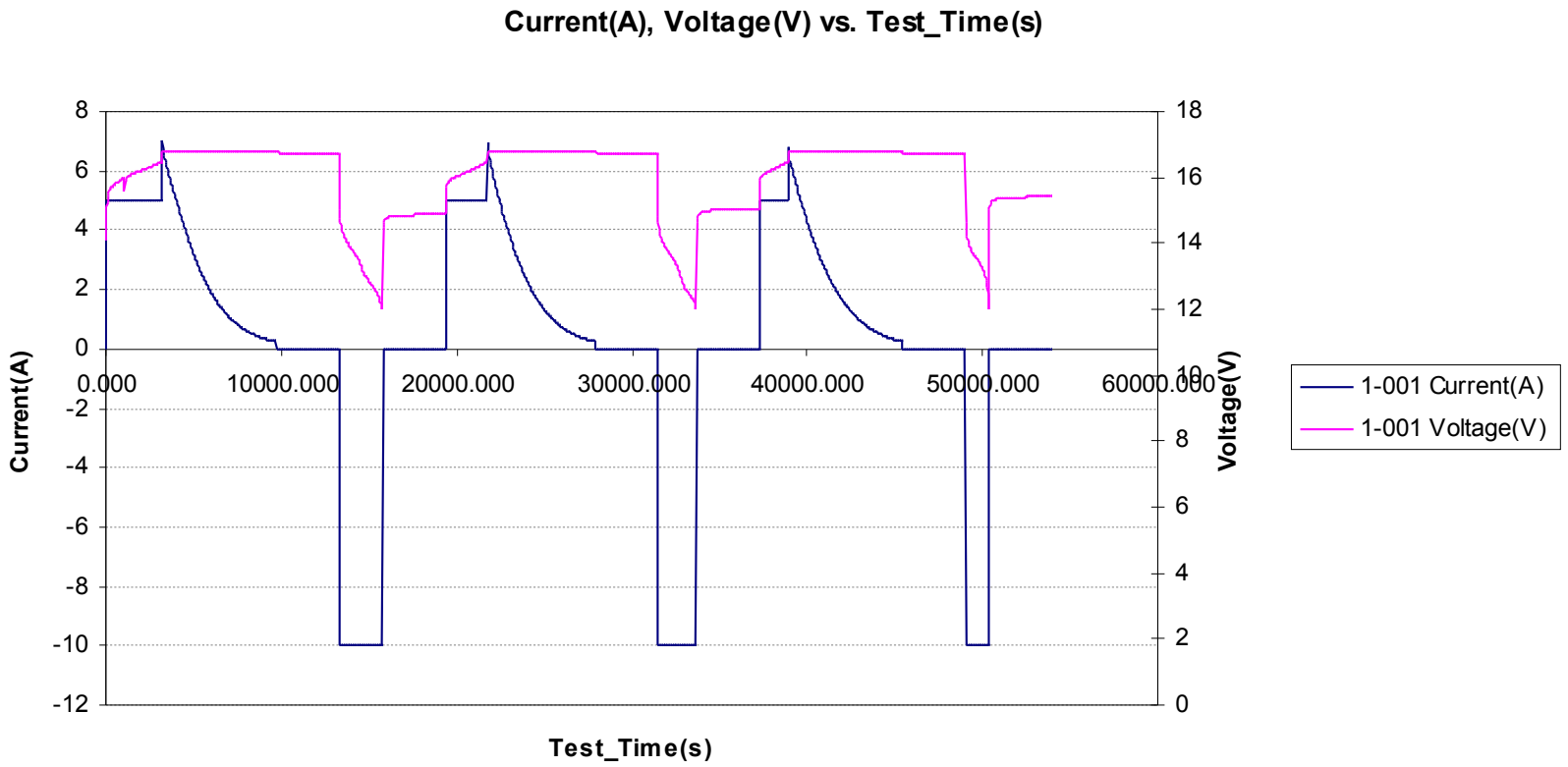
- Protection from overcharging

Battery Safety Testing

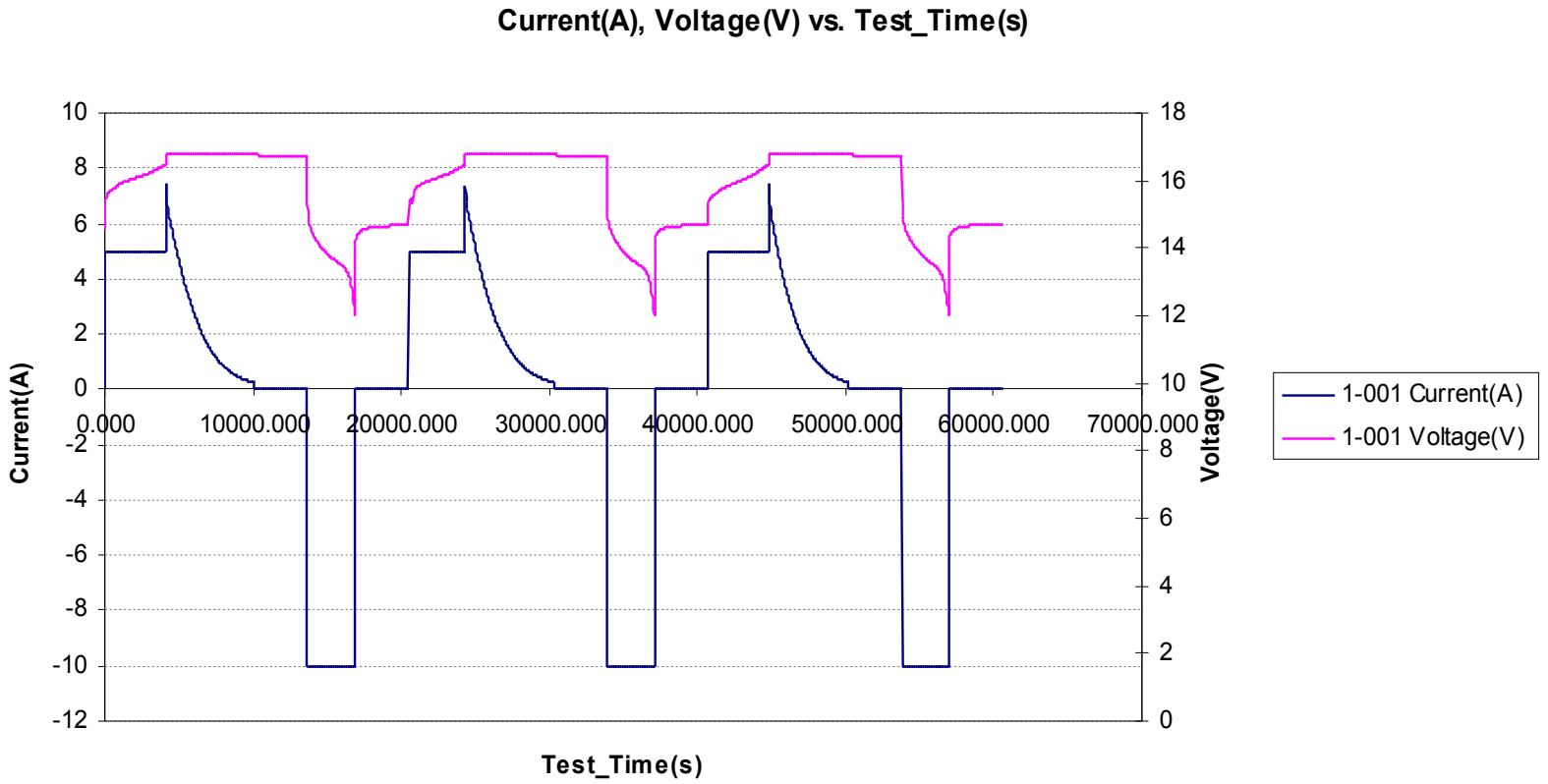
- Objectives of Battery testing
  1. Voltage and Current Characteristics
  2. Thermal Characteristics
  3. Thermal Hazard Evaluation

- Battery Safety Tests
  1. Normal and Abuse tests
  2. Results and Conclusion

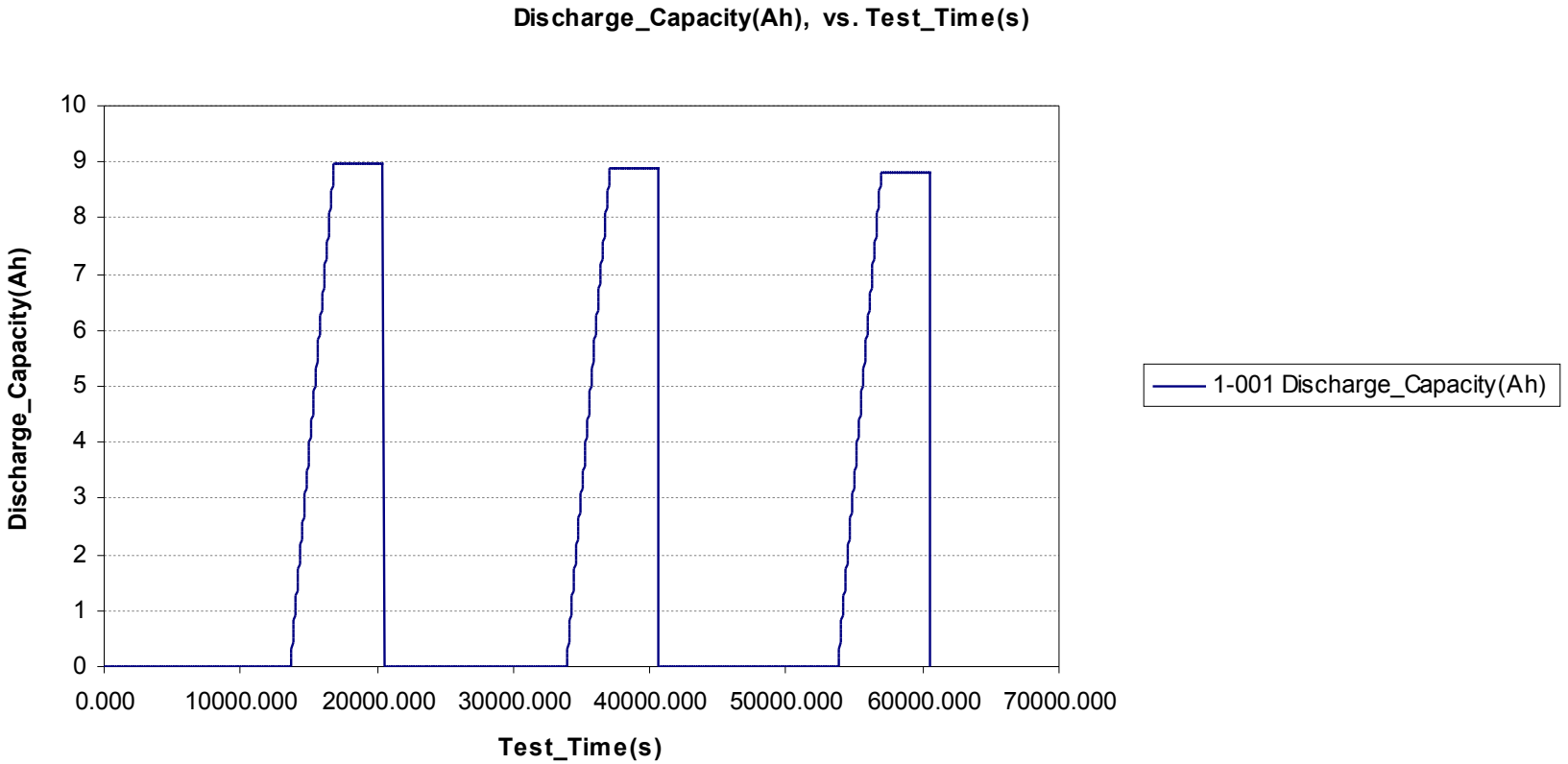
Battery Test Results



Current Voltage Characteristics



Discharge Capacity



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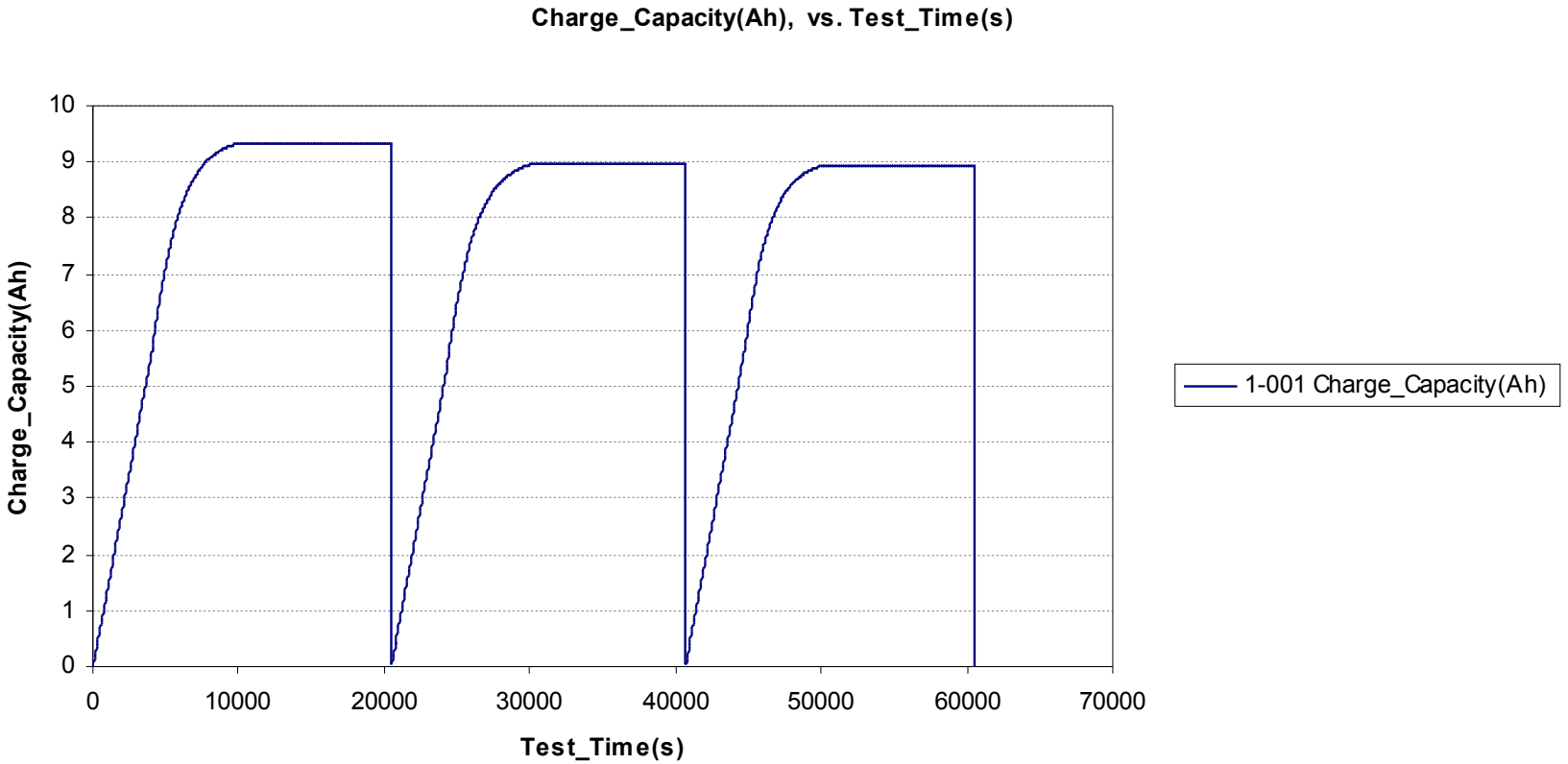
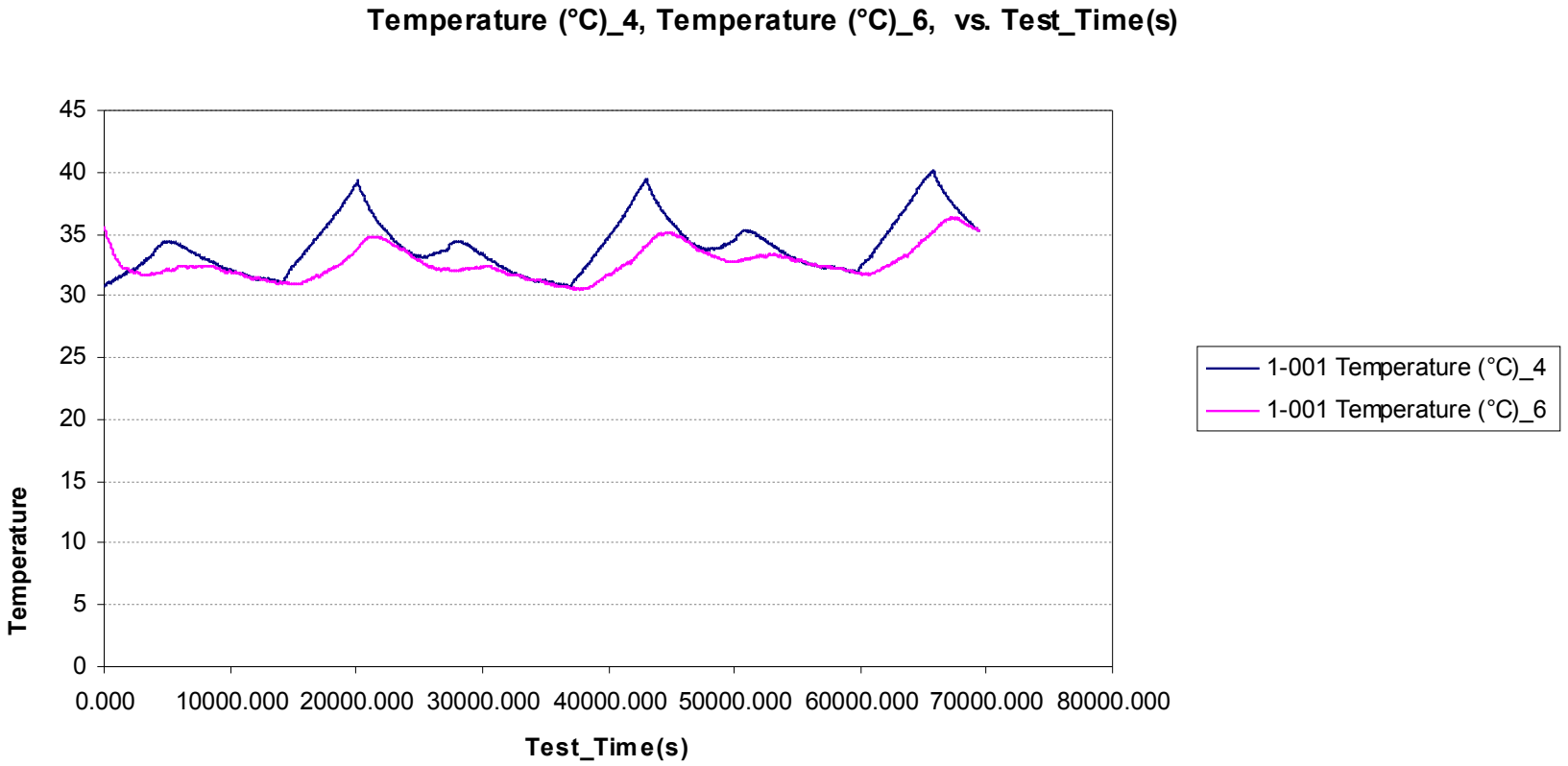
Charge Capacity



Temperature Profile



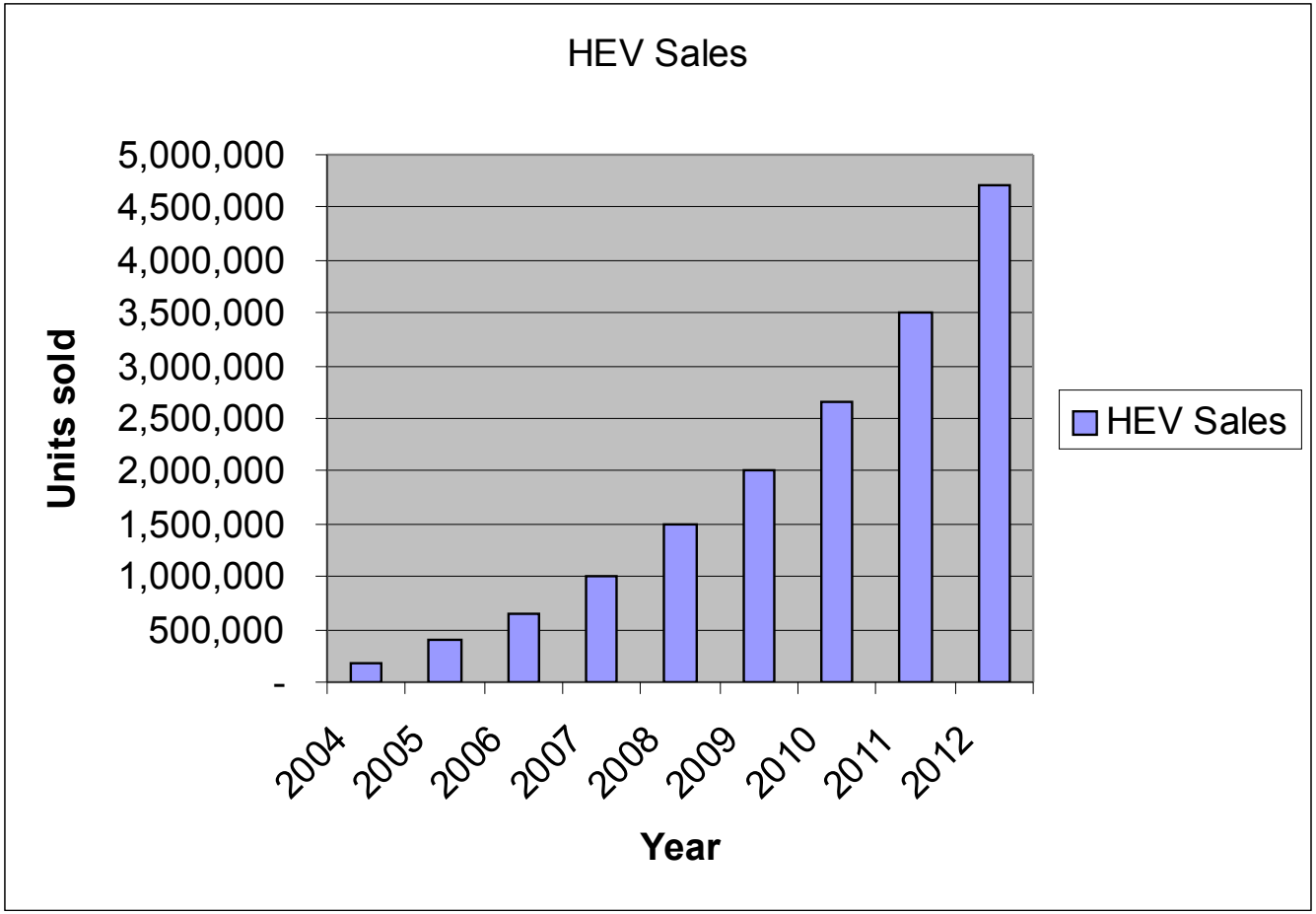
Future Tasks

- Conduct Field Tests with Scooter
- Final test with Hybrid Electric Vehicle (HEV)
- Commercialization of the Prototype Lithium-Ion Battery

Market Situation

- USA is the largest auto market in the world
- Gasoline costs
- Money saved if hybrids are used
- Environmental benefits
- Forecasts

HEV sales growth



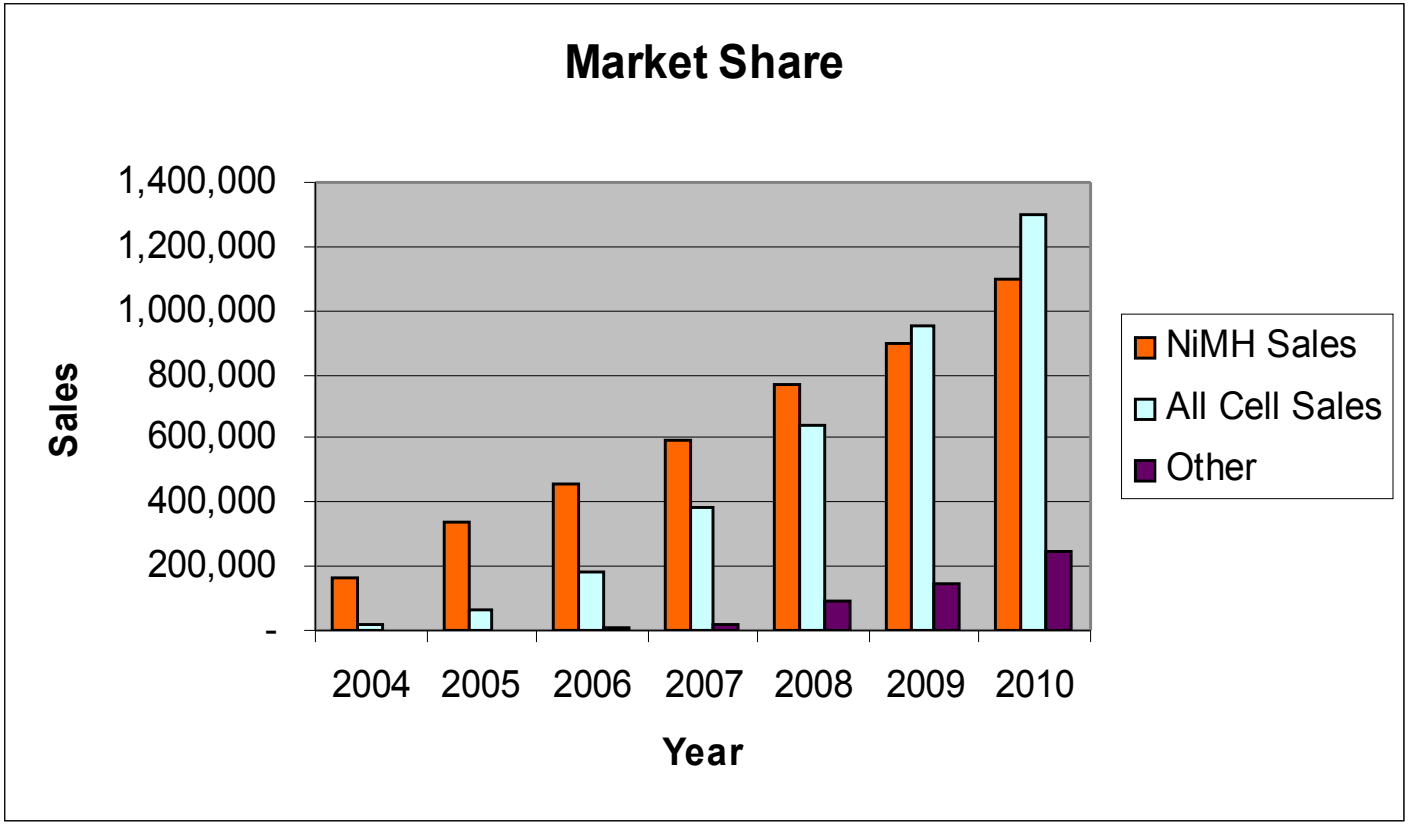
Batteries involved

- NiMH vs Lithium-Ion
- Advantages of Lithium-Ion
  - Twice the energy density
  - Flat discharge curve
  - Low maintenance
  - Self discharge half that of NiMH

Marketing Objectives

- To prove the Li-Ion/PCM technology
- Be the first mover in the Li-Ion Battery for HEV's segment and remain the market leader.
- Attain 30% overall share in the HEV market within five years of operations and retain at least 40% of the Li-Ion battery segment so as to be a significant player in the market.

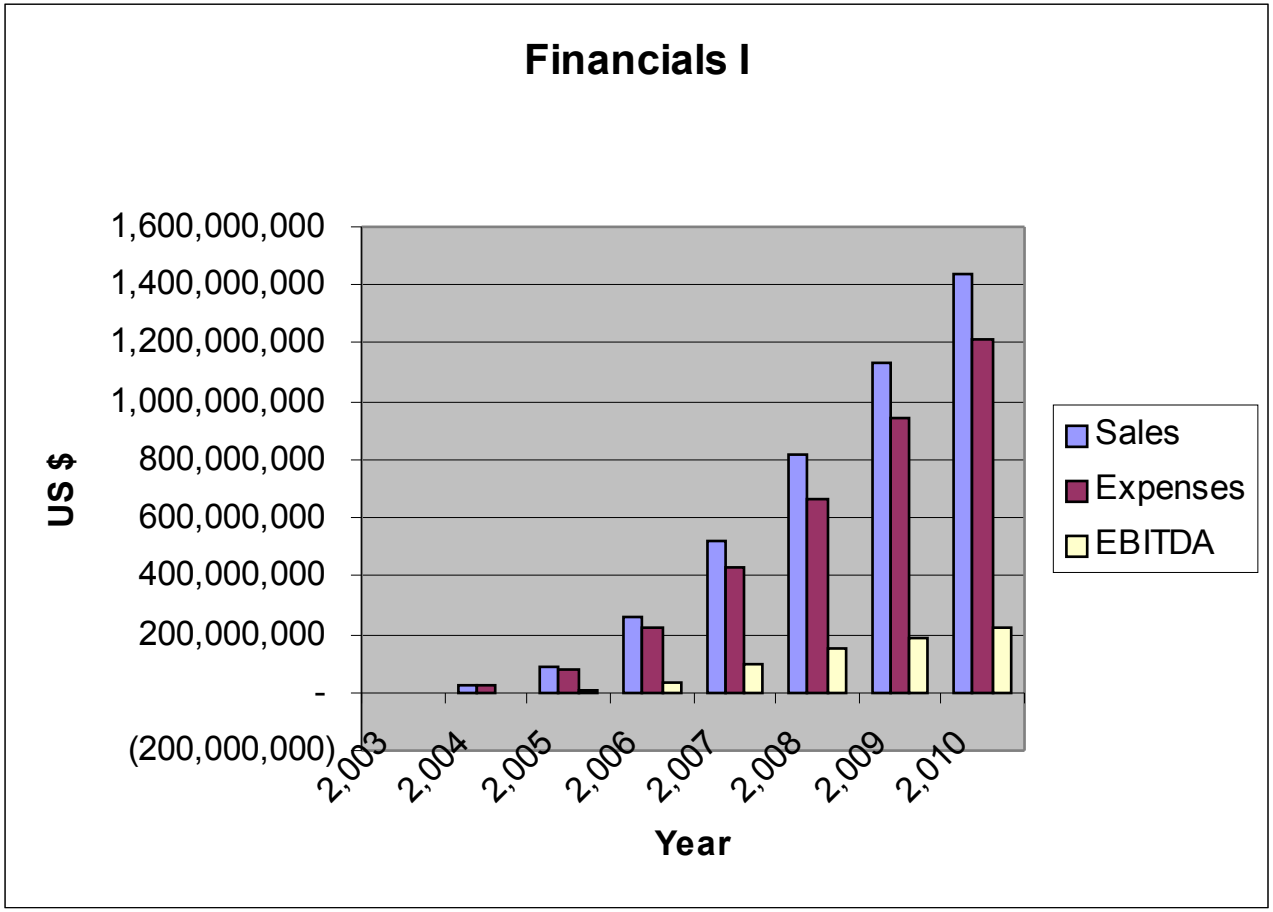
Projected Market Shares



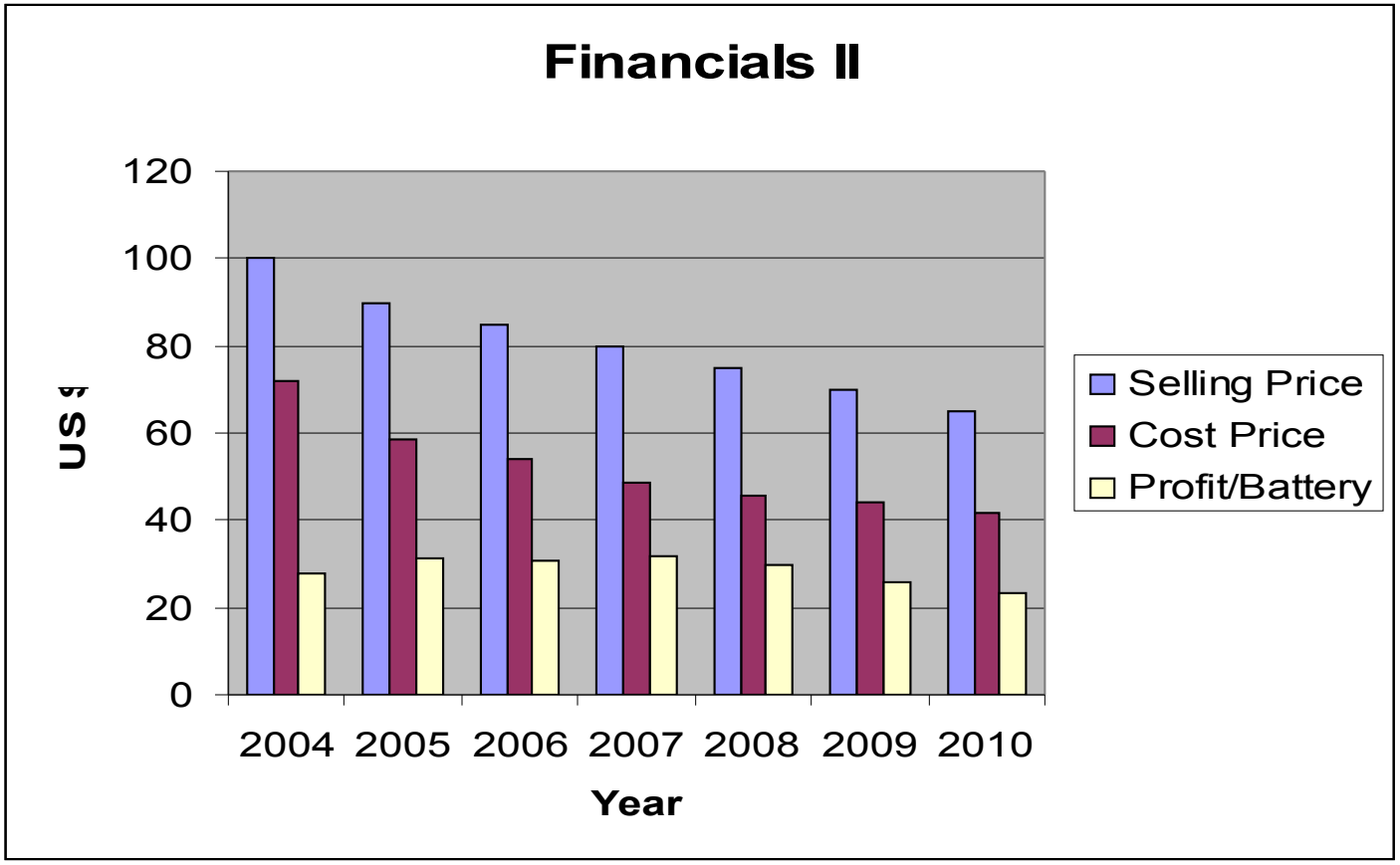
Financial Objectives

- To break even in the second year of operations on an EBITDA basis.
- To achieve at least US $ 1 million in operating profits by 2004.
- To raise an initial investment of US $ 3.5 million in 2003

Financials


Financials I
1,600,000,000
1,400,000,000
1,200,000,000
1,000,000,000
800,000,000
600,000,000
400,000,000
200,000,000
-
(200,000,000)
US $
2,003
2,004
2,005
2,006
2,007
2,008
2,009
2,010
Year
Sales
Expenses
EBITDA

Battery figures



Financial Figures_

	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
Units Manufactured:	-	275,959	1,103,836	3,311,507	6,993,288	11,625,205	17,034,932	23,310,959
Units Sold :	-	255,000	1,020,000	3,060,000	6,545,000	10,880,000	16,150,000	22,100,000
Selling Price	-	100	90	85	80	75	70	65
Total Sales A	-	25,500,000	91,800,000	260,100,000	523,600,000	816,000,000	1,130,500,000	1,436,500,000
Manufacturing Costs B	-	18,360,000	59,874,000	165,699,000	316,778,000	494,496,000	713,022,500	917,150,000
Administrative costs C	400,000	1,530,000	5,508,000	15,606,000	31,416,000	48,960,000	67,830,000	86,190,000
R & D Costs D	100,000	1,000,000	4,590,000	7,803,000	15,708,000	24,480,000	33,915,000	43,095,000
Sales & Marketing E	400,000	2,040,000	7,344,000	20,808,000	41,888,000	65,280,000	90,440,000	114,920,000
Total Costs (B to F)	900,000	22,930,000	77,316,000	209,916,000	405,790,000	633,216,000	905,207,500	1,161,355,000
Working Capital	-	2,768,219	5,885,712	18,007,438	22,717,575	39,334,928	31,810,072	63,368,969
Cash Flow	(1,000,000)	(453,219)	7,680,288	29,575,562	89,856,425	135,289,072	125,503,357	153,170,000
Cumulative Cash Flow	(1,000,000)	(1,453,219)	6,227,068	35,802,630	125,659,055	260,948,127	386,451,484	539,621,484
EBITDA (A - total cost)	(900,000)	2,570,000	14,484,000	50,184,000	117,810,000	182,784,000	225,292,500	275,145,000
Capital Expenditures	100,000	255,000	918,000	2,601,000	5,236,000	8,160,000	11,305,000	14,365,000
Depreciation	14,286	50,714	181,857	553,429	1,301,429	2,467,143	4,082,143	6,120,000
Taxes	(365,714)	642,000	5,720,857	19,852,229	46,603,429	72,126,743	88,484,143	107,610,000
Net Profits	(548,571)	1,877,286	8,581,286	29,778,343	69,905,143	108,190,114	132,726,214	161,415,000

At a glance

- Initial Investment 3,500,000
- NPV15 Incl Terminal value 1,135,348,546
- NPV15 no Terminal value 217,664,202
- IRR 156%

At a glance (contd)…

- Target Market
- Segmentation and positioning
- Product Strategy
- Pricing
- R & D

Future Outlook

- Assemble prototype battery for HEV
- Test and prove technical assumptions
- Commercialize technology

Lead-Acid Battery Verification

- Zappy's Specifications
  - Speed: 13mph
  - Range: 8 miles
  - Recharge Time: ~6 Hours
- Verification
  - Individual Field Tests

Comparison Testing

- Is our idea as good or better than the existing technology?
  - What speed can each battery produce?
  - How long can each battery power the scooter?
  - Does the weight difference make a difference?

All Work and No Play? Nah...

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