



Providing Vehicle OEMs Flexible Scale to Accelerate Adoption of Electric Drive Vehicles

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Remy Inc.

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Project ID: ARRAVT025

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Timeline

Start: December 17th, 2009

End: December 16, 2013

Status: Approx. 24% complete

Barriers and Risks

- Market Acceptance Timing
- Manufacturing Expansion
- Supply
- Application Integration

Budget

Total: \$120,400,000

DOE Share: \$60,200,000

Contractor Share: \$60,200,000

Partners (subawardee)

Phoenix International

(division of John Deere)

Project Lead: Kevin Larson



Objectives

- Accelerate the adoption and use of electric drive vehicles in the market by developing a standardized platform of lower cost, higher performance hybrid electric motors and controls
- Invest in the expansion or refurbishment of U.S. based manufacturing facilities, as well as new product tooling and engineering, production and test equipment, and product commercialization



Technical Feasibility:

- The new motor and inverter products proposed in the project are based on an extension of existing product and process technology.
- Remy has been producing rotating electrical products for over 100 years and hybrid electric drive motors since 2003.
- Phoenix has been producing electronic controls for over 20 years.

Ability to Complete Facility:

- Manufacturing processes, including site expansions and supply chain management, are well-established at both Remy and Phoenix International.
- Phase I of the project began with the refurbishment of existing facilities to support initial production capacity.
- Phase II of the project includes the addition of capacity in a second existing facility to support high volume production.



Ability to Deliver Commercial Ready Product:

- For this project, many of the target customers are Remy's existing customers in both the automotive and heavy duty market where Remy has the leading share of rotating electrical products in North America.
- These customers have been very enthusiastic regarding Remy's new approach to reduce costs through creating a family of standardized electric drive motors, and have launched new product development efforts with Remy.

Ability to Estimate Costs:

- Remy's facilities planning group continues to provide direction for the manufacturing site costs based on several previous plant relocations in the United States.
- Phoenix International has very current costs for site expansion and equipment having commissioned a new power electronics facility in January of 2009.
- New product designs are extensions of existing products.
- Material prices are reviewed by global purchasing and supplier quality teams at both companies.



Ability to Recycle:

- Remy is the largest U.S. remanufacturer of starter and alternator products, recycling and refurbishing 4 to 5 million units per year in its two U.S. facilities in Virginia and Oklahoma.
- Planning for such recycling of hybrid motors is already underway in joint meetings between Remy, its customers, and its suppliers.
- Remy has standard workflow procedures in all of its manufacturing operations which define and control the segregation and recycling of various scrap raw materials used in its process, including byproduct materials and nonconforming products.
- Phoenix International's recycling plan is to leverage Remy's existing capability in the product recycling area.
- If re-manufacturing is called for, the inverter parts could be returned to Phoenix facilities for rebuild or Phoenix could supply the required subcomponents back to Remy to facilitate the remanufacturing.
- In cases where scrapping of the inverter is called for; the housing and bus bar metals are recyclable.



Environmental Impact:

- Existing facilities are being utilized for all phases of the project so that no new construction will be required.
- Phase 1 production does not require any new environmental permits.



Phase 1 Manufacturing Facility



Technical Accomplishments and Progress



Key Milestones for 2010	
Concept Stage Motor Hardware Available	COMPLETE
Phase 1 Production Facility Complete (Low Volume)	COMPLETE
Inverter 1 Rev 1 Hardware Available	COMPLETE
Inverter 2 Rev 1 Hardware Available	COMPLETE

This project has helped to fund 152 direct jobs at Remy and our sub-awardees.

Another 730 jobs are estimated to have been funded at our suppliers and vendors.



Production Intent Design Motor Samples:

Multiple configurations of the HVH410 and HVH250 motors have been produced.

Configurations include:

- Oil Cooling
- Water Cooling
- 3 motor lengths
- Multiple Winding Patterns
- Customer Specific Assemblies





Production Intent Design Samples:

- Sample motors have been tested to meet initial performance and durability targets.
- Validation to customer specific specifications has also been complete.



Motor Test Stands



Technical Accomplishments and Progress



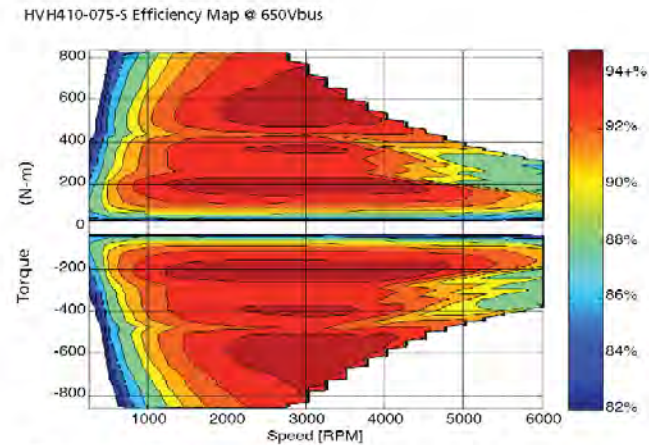
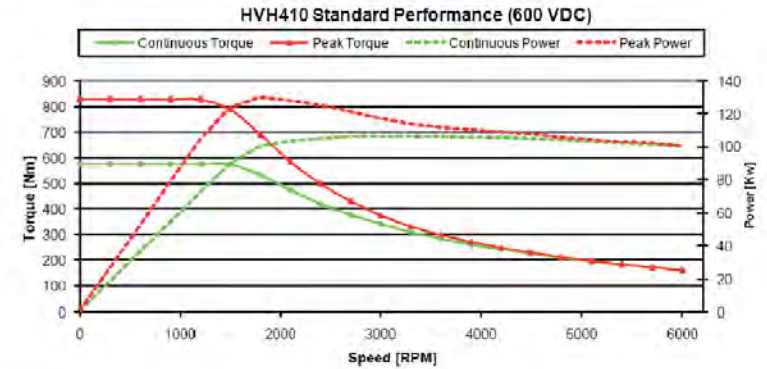
Specifications

	HVH410-075-POC6 Standard Winding Configuration A HVH410	HVH410-150-POC6 High Torque Winding Configuration B HVH410
Measurements		
Overall Length (mm)	135	210
Stator Outside Diameter (mm)	410	410
Rotor Inside Diameter (mm)	289	289
Mass - Complete Motor (kg)	59	91
Performance		
Continuous Power Output (kW)	92	185
Peak Power Output (kW)	133	275
Continuous Torque Output (N-m)	580	1110
Peak Torque Output (N-m)	830	1650
Max. Input Current Continuous/Peak (Amps)	240/480	240/480
Peak Efficiency (%)	See Efficiency Map	See Efficiency Map
Max. Operating Speed (rpm)	6,000	6,000
Base Speed (rpm)	1750	1750
Operating Voltage (VDC nom.)	650	650
Max. Temperature Limit	CLASS H (180°C)	CLASS H (180°C)
Internal Oil (ATF) Cooling		
	70°C Oil Inlet Temperature	
Conductor Type		
	High Voltage Hairpin	High Voltage Hairpin

- 1) Continuous data reflects stator temperature held at 180°C and 70°C oil flowing at 10 LPM
- 2) Actual performance dependent on application and cooling system.
- 3) Inverter control method is six-step for peak performance, and space vector for continuous performance - 5% voltage drop allowance.
- 4) Remy Motors insulation system can operate at 750VDC.
- 5) Optional content available: resolvers, housings, AC induction rotor, & high speed rotor.
- 6) Other motor sizes / configurations are available, consult your Remy representative.

Optional Content Available: Resolvers, Housings
 * Based on active magnetic material.

Patented Hairpin Stator technology.
 Highest output, efficiency and power density available.



Efficiencies recorded at temperature of 140° C.
 Lower temperatures would yield higher efficiencies.



Technical Accomplishments and Progress

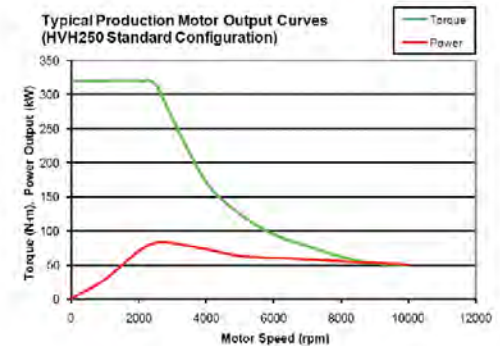


Specifications

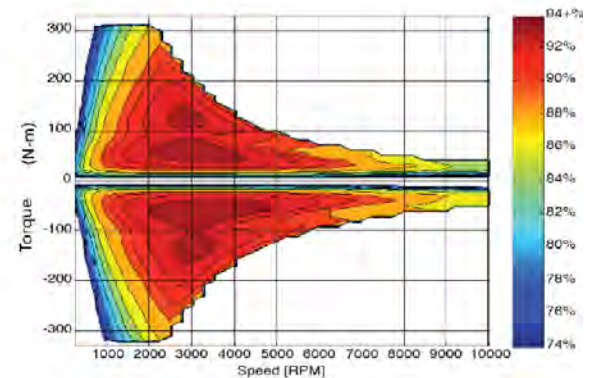
	HVH250-090-SOC3 Standard Winding Configuration A HVH250	HVH250-115-SOC3 High Torque Winding Configuration A HVH250	HVH250-090-POC3 Standard Winding Configuration B HVH250	HVH250-115-POC3 High Torque Winding Configuration B HVH250
Measurements				
Overall Length (mm)	147	180	147	180
Stator Outside Diameter (mm)	242	242	242	242
Rotor Inside Diameter (mm)	132	132	132	132
Mass - Complete Motor (kg)	33.5	43	33.5	43
Performance				
Continuous Power Output (kW)	60	63	176	185
Peak Power Output (kW)	76	78	297	305
Continuous Torque Output (N-m)	275	325	225	288
Peak Torque Output (N-m)	320	408	320	408
Max. Input Current Continuous/Peak (Amps)	200/300	200/300	300/600	300/600
Peak Efficiency (%)	See Efficiency Map			
Max. Operating Speed (rpm)	10,600			
Base Speed (rpm)	2300	1600	4000	3000
Operating Voltage (VDC nom.)	320		650	
Max. Temperature Limit	CLASS H (180°C)			
Internal Oil (ATF) Cooling	70°C Oil Inlet Temperature			
Conductor Type	High Voltage Hairpin			

- 1) Continuous data reflects stator temperature held at 180°C and 70°C oil flowing at 10 LPM.
- 2) Actual performance dependent on application and cooling system.
- 3) Inverter control method is six-step for peak performance, and space vector for continuous performance - 5% voltage drop allowance.
- 4) Remy Motors can operate at 700VDC system voltage.
- 5) Optional content available: Resolvers, water cooler jacket housings, AC induction rotor, and high speed rotor.
- 6) Other motor sizes / configurations are available, consult your Remy representative

Standardized and scalable solutions for seamless customer integration.



HVH250-090-S Efficiency Map @ 320Vbus



Efficiencies recorded at temperature of 140° C. Lower temperatures would yield higher efficiencies.

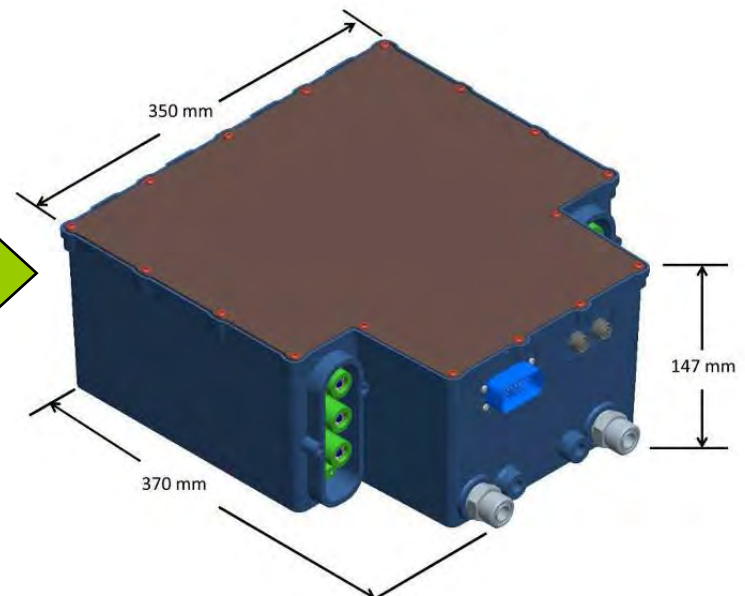
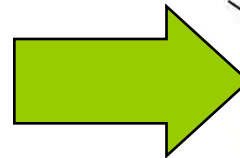


Inverter Samples:

- Concept stage sample inverters have been produced by Phoenix International.
- Production intent design samples will be available Q2 2011.



Concept Stage Sample



Production Intent



Phoenix International:

- Remy has collaborated with Phoenix International as a subawardee to this grant.
- The inverters will be developed and put in production by Phoenix International at a location in Fargo, ND.
- The inverter sizes required will match the motor sizes needed in the marketplace.
- The motors and inverters are typically matched to various customer requirements such as peak power of the motor and available voltage of the DC source.
- Inverter development will follow the same typical steps as the motor development with the delivery of prototypes and production devices availability at the same time.
- This will provide the customer with a matched set of motor and inverter drive systems.



Future Work



2011:

- Complete development stage hardware validation for base motor and inverter products
- Expand production capacity at the Phase 1 facility
- Forecast market demand for additional production capacity

2012:

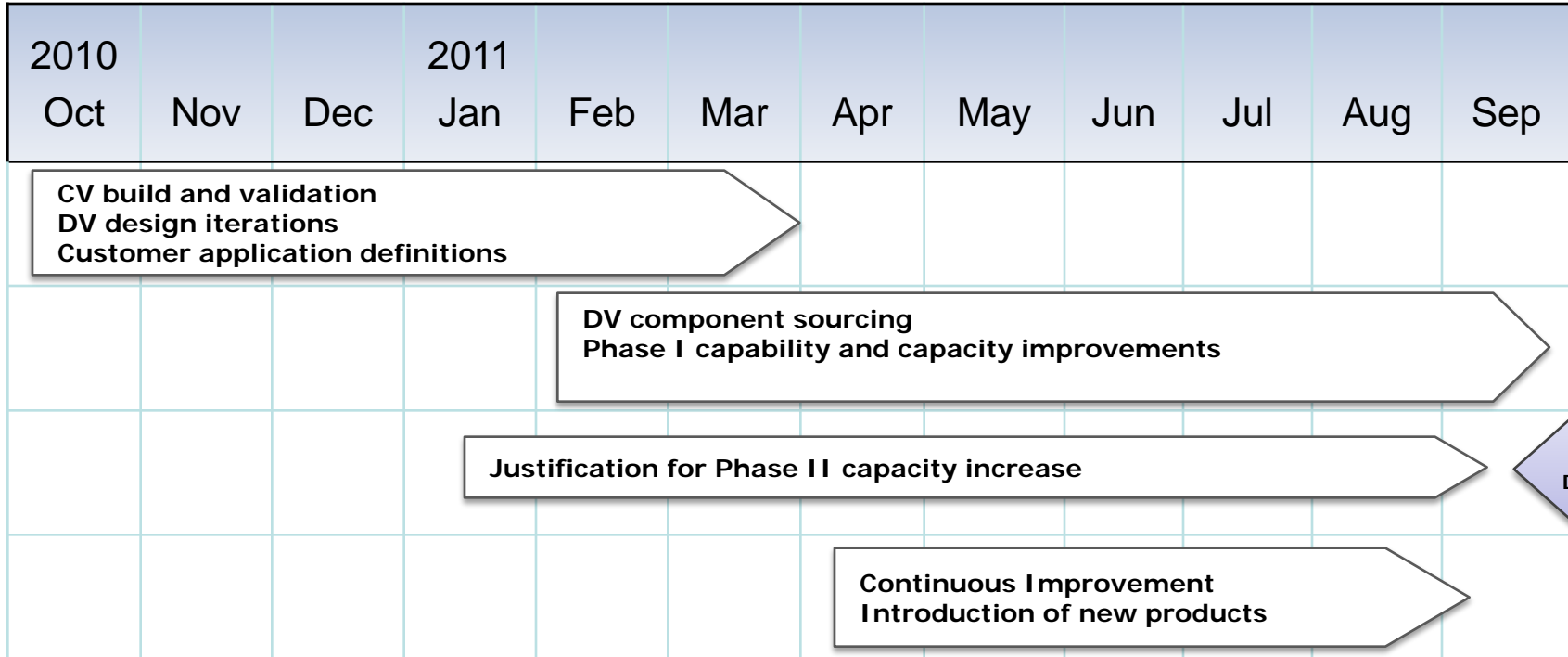
- Complete production stage hardware validation for base motor and inverter products
- Start production at Phase 1 production facility

2013:

- Expand production capacity to a Phase 2 facility based on market demand



Future Work



Go No/Go Decision Point: Phase II facility will be required for capacity above 20K units per year.

Challenges/Barriers: Market maturity and volume forecasting. System integration for each application.



Summary



- Accelerating the adoption and use of electric drive vehicles in the market.
- Developing a standardized platform of lower cost, higher performance hybrid electric motors and controls.
- Building on the proven success of existing product and process technologies.
- Matching product features and production capacity to real market requirements.
- Delivering technical accomplishments on time.