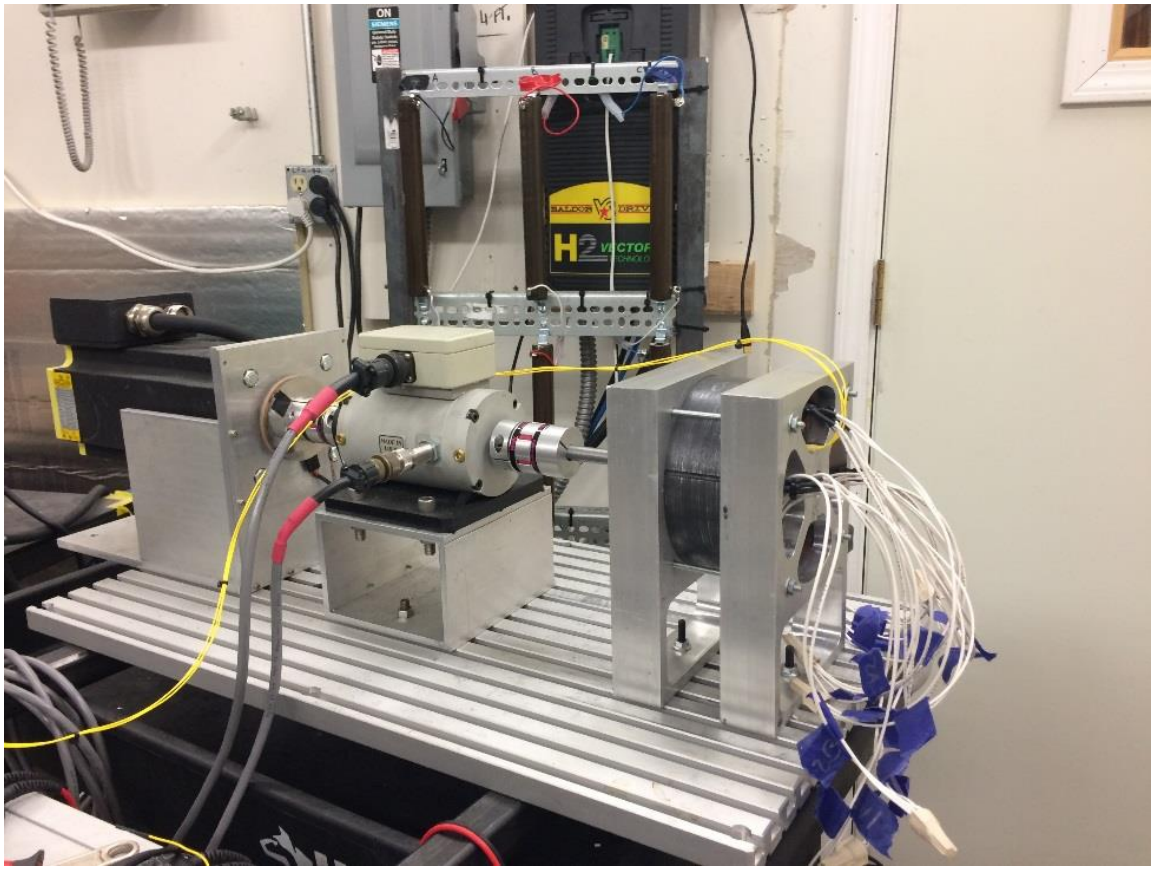
# Higher Efficiency HVAC Motors

2016 Building Technologies Office Peer Review



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**PJ Piper, pjpiper@qmpower.com**
**CEO, QM Power, Inc.**

# Project Summary

**Timeline**:

Start date: 10/1/14

Planned end date: 9/30/16

Key Milestones

1. Target Application and Machine Specs; 2/13/15
2. Motor Design; 9/30/15
3. Build prototype; 3/31/16
4. Performance validation; 8/1/16

**Budget**:

**Total Project $ to Date**:

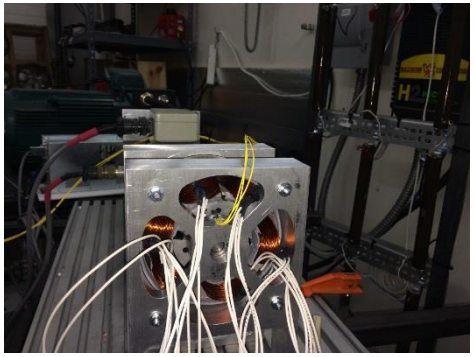
- DOE: $239,947
- Cost Share: $189,801

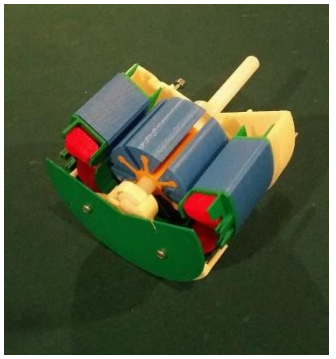
**Total Project $:**

- DOE: $750,000
- Cost Share: $635,756

**Key Partners**:

| | |
|---|---|
| UTRC | Carrier |





**Project Outcomes**:

Produce higher efficiency HVAC Motor

Validate motor performance

Reduce building energy consumption

Bring high efficiency cost effective motor to the market



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# Purpose and Objectives

**Problem Statement**: Most of the hundreds of millions of residential and smaller commercial HVAC units in the U.S. contain low efficiency induction fan motors. Higher efficiency Electronically Controlled Motors (ECM) that have become available have low power factors and thus give up much of their efficiency advantage in the form of higher current draw.

**Target Market and Audience**: Residential and smaller commercial HVAC and commercial refrigeration equipment collectively use greater than 2 quads of primary energy according to DOE/BTO. QM Power will ultimately target HVAC OEMs, contractors, end users and utilities to commercialize its superior fan motors.

**Impact of Project**:

a. **Near-term:** Complete prototype assembly and testing, which will prove meaningful efficiency gains compared to induction and state of the art ECMs.
b. **Intermediate:** Expand the technology to additional sizes to address a broader set of HVACR applications, and adapt the technology to address the compressor and pump motor markets.
c. **Long-term**: When fully developed and commercialized, QMP's technologies have the potential to achieve over 1 quad of primary energy savings in residential and commercial building HVACR fan applications.

# Approach

**Approach**:

Develop, test, and commercialize advanced HVAC motors with the support of United Technologies Research Center (UTRC) and Carrier, a subsidiary of United Technologies and the world leader in HVAC and refrigeration solutions. Build to their performance and mechanical specifications and have them confirm superior performance through prototype testing.

**Key Issues**:

Key issues involved determining both the best motor topology to use for the design and creating controls for the motor to operate at five speed/torque-controlled speed settings.

**Distinctive Characteristics**:

The design combines an Internal Permanent Magnet Parallel Path Magnetic Technology (IPM-PPMT) topology with a Q-Sync based electronic controller, enabling higher efficiency and power factor than incumbents.



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# Progress and Accomplishments

**Accomplishments**:

- Selected a baseline application and specifications to achieve an immediate impact on energy savings
- Designed a ½ hp motor incorporating the benefits of IPM - PPMT and Q-Sync motor technologies.
- Initiated prototype fabrication.

**Market Impact**: The potential to achieve over 0.5-1.0 or more quads of primary energy savings in residential and commercial building HVACR applications using Q-Sync fan motors up to 1 hp. Successful demonstrations of smaller versions of QM Power's novel designs are helping to spread awareness of Q-Sync's superiority and should make the market fertile for these better HVAC motors, especially given many of the largest OEMs have both HVAC and refrigeration divisions.

**Awards/Recognition**: N/A
**Lessons Learned**: N/A

# Project Integration and Collaboration

**Project Integration**: Engaged UTRC/Carrier in the early design process to target specifications of the project, and to determine testing parameters and characteristics.

**Partners, Subcontractors, and Collaborators**:
QM Power is collaborating with the support of United Technologies Research Center (UTRC) and, by extension, Carrier to develop advanced HVAC fan motors.

**Communications**: N/A

# Next Steps and Future Plans

**Next Steps and Future Plans**:

- Complete Prototype Fabrication
- Demonstrate and validate the improved performance v. incumbents
- Expand the product range to address a broader market (1/4- 1 hp)
- Apply the technology to the compressor and pump motor markets
- Pair the superior motor with high efficiency fan blades in development



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# REFERENCE SLIDES

# Project Budget

**Project Budget**: The budget was revised upward as a result of QM Power changing from a single to multi-rate structure. This change, however, did not impact DOE's funding commitment; it did increase QM Power's cost share from 20% to 46%.
**Variances**: The project design portion required fewer funds than budgeted for. Though currently behind budget, the project is expected to catch up to projections through the more labor intensive prototyping and testing activities remaining.
**Cost to Date**: $429,748.32 through January 2016, or 31% of the budgeted total.
**Additional Funding**: Series C venture capital financing closed in March of 2016.

**Budget History**

| 10/1/14 – FY 2015 (past, actual) | | FY 2016 (current period, planned) | | Project Totals (planned) | |
|---|---|---|---|---|---|
| DOE | Cost-share | DOE | Cost-share | DOE | Cost-share |
| $171,136 | $120,158 | $578,864 | $515,598 | $750,000 | $635,756 |



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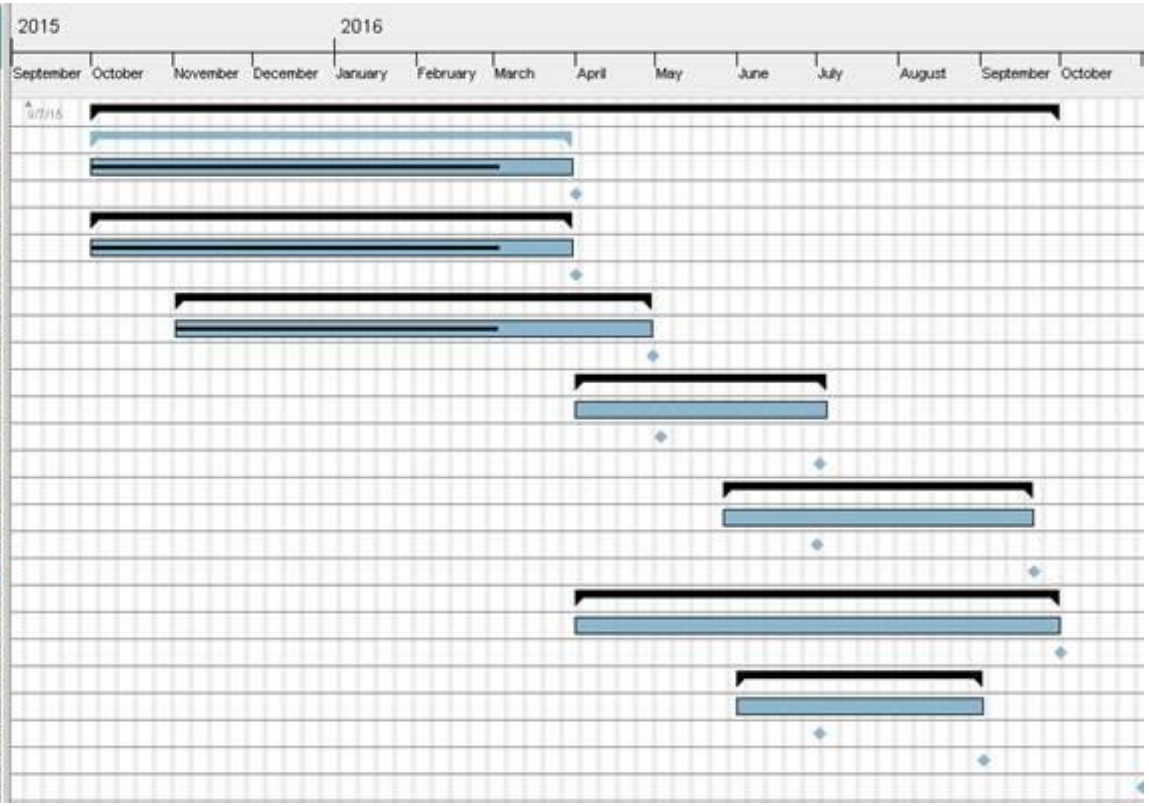
# Project Plan and Schedule

- Project began 10/1/14 & is scheduled to end 9/30/16.
- Schedule and Milestones shown below.
- Though there have been some delays relating to QM Power's move to their new office, the project is expected to be completed on schedule.
- Go/no-go- Achieved Phase II Go decision
- Current Work: Complete fabrication of the first prototype rotor and stator, assemble them in a temporary housing for initial dynamometer evaluation, and implement the control strategy in software using the breadboard prototype electronics. We will also fabricate the actual prototype rotor assembly using ferrite magnets, the actual motor housing and shaft components, and the final mechanical configuration circuit board.

| Name | Begin date | End date | Completion |
|---|---|---|---|
| Phase II Motor and Controls Fabrication an... | 10/1/15 | 9/30/16 | 41 |
| Task 6 | 10/1/15 | 3/30/16 | 84 |
| Motor Fabrication | 10/1/15 | 3/30/16 | 85 |
| 6.1 Fab and assembly of test motors | 3/31/16 | 3/31/16 | 0 |
| Task 7 | 10/1/15 | 3/30/16 | 84 |
| Motor Controller Fabrication | 10/1/15 | 3/30/16 | 85 |
| 7.1 Fab and assembly of controller | 3/31/16 | 3/31/16 | 0 |
| Task 8 | 11/2/15 | 4/29/16 | 67 |
| Controller Tuning and Testing | 11/2/15 | 4/29/16 | 68 |
| 8.1 Complete tuning and test report | 4/29/16 | 4/29/16 | 0 |
| Task 9 | 4/1/16 | 7/4/16 | 0 |
| Dynamometer Testing | 4/1/16 | 7/4/16 | 0 |
| 9.1 Verify test setup | 5/2/16 | 5/2/16 | 0 |
| 9.2 Dynamometer testing results | 7/1/16 | 7/1/16 | 0 |
| Task 10 | 5/27/16 | 9/20/16 | 0 |
| Characterization and Validation | 5/27/16 | 9/20/16 | 0 |
| 10.1 Experimental Setup | 6/30/16 | 6/30/16 | 0 |
| 10.2 Experimental Validation | 9/20/16 | 9/20/16 | 0 |
| Task 11 | 4/1/16 | 9/30/16 | 0 |
| T2M Strategy & Commercialization Pl... | 4/1/16 | 9/30/16 | 0 |
| 11.1 Manufacturing Analysis | 9/30/16 | 9/30/16 | 0 |
| Task 12 | 6/1/16 | 9/1/16 | 0 |
| Additional HVAC Applicaitons | 6/1/16 | 9/1/16 | 0 |
| 12.1 Prelim Analysis - Energy Savings | 7/1/16 | 7/1/16 | 0 |
| 12.2 Refined Analysis - Energy Savings | 9/1/16 | 9/1/16 | 0 |
| Final Report | 10/31/16 | 10/31/16 | 0 |





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