Unwinding Electric Motors:
Strategic Perspectives and Insights for Automotive Powertrain Applications
Other SAE books of interest:

**Advanced Hybrid Powertrains for Commercial Vehicles**  
By Haoran Hu, Simon Baseley, and Rudolf M. Smaling  
(Product Code: R-396)

**Automotive 2030--North America**  
By Bruce Morey  
(Product Code: T-127)

**Hybrid-Powered Vehicles, Second Edition**  
By John German  
(Product Code: T-125)

For more information or to order a book, contact

SAE INTERNATIONAL at  
400 Commonwealth Drive,  
Warrendale, PA 15096-0001, USA;  
phone +1-877-606-7323 (U.S. and Canada only)  
or +1-724-776-4970 (outside U.S. and Canada);  
fax +1-724-776-0790;  
e-mail CustomerService@sae.org;  
Table of Contents

Foreword .................................................................................................................. vii
Acknowledgments ................................................................................................. ix
Introduction ............................................................................................................. xi

Chapter 1 .................................................................................................................. 1
Megatrends Influencing the Electric Motor Industry ............................................. 1
  1.1 Market Environment ....................................................................................... 1
  1.2 Product and Technology Landscape .............................................................. 7
  1.3 Manufacturing Landscape and Trends .......................................................... 15
  1.4 Product Cost Trends ..................................................................................... 17
  1.5 Business Models and Strategies .................................................................. 19
  1.6 Summary and Recommendations ................................................................ 24

Chapter 2 .................................................................................................................. 27
Technology Trends and Benchmarking ................................................................. 27
  2.1 Motor Requirements for Hybrid/EV Applications .......................................... 28
  2.2 Benchmarking and Assessment of Technology Solutions ............................. 33
  2.3 Summary and Recommendations ................................................................ 49

Chapter 3 .................................................................................................................. 53
Electric Motor Manufacturing ................................................................................. 53
  3.1 Classification of Motor Manufacturing Facilities ........................................... 53
  3.2 Factors Affecting Manufacturing Plant Location ........................................... 57
  3.3 Electric Motor Manufacturing Processes ..................................................... 62
  3.4 Analysis of Strategic Manufacturing Processes .......................................... 64
  3.5 Summary and Recommendations ................................................................ 70

Chapter 4 .................................................................................................................. 73
Electric Motor Sourcing and Supply Chain ........................................................... 73
  4.1 Overview of Electric Motor Supply Chain ................................................... 73
  4.2 Electric Motor Cost Breakdown and Supply Chain Analysis ......................... 76
  4.3 Supply Chain Factors Influencing Cost of Electric Motors ............................ 78
  4.4 Geographic Distribution of Electric Motor Supply Base ............................... 84
  4.5 Emerging Supply Chain Models and Trends .............................................. 86
  4.6 Summary and Recommendations ................................................................ 95

About the Author .................................................................................................... 99
Foreword

Clarity and good strategic decisions tend to go hand in hand.

From the choice of the right technology to the management of complex supply chains, the need for solid and lucid information is essential to stay ahead in a dynamic market. With the intention of providing exactly that, this market study, co-published by SAE International and P3 North America, delves into the fast-paced world of electric motors.

In a joint effort that brings together the technology and product strategy experience of the P3 Group and the focused reach of SAE International, Unwinding Electric Motors: Strategic Perspectives and Insights for Automotive Powertrain Applications covers a wide range of topics within this fascinating subject.

Starting with the megatrends that currently influence the industry, this study provides an in-depth assessment of the technological, manufacturing, sourcing, and supply chain factors that will be shaping this landscape for the next five years. The goal of this initiative is to provide insights through structured, data-driven analyses and frameworks.

Authored by Timothy G. Thoppil, electric powertrain technology lead at P3 North America, Unwinding Electric Motors: Strategic Perspectives and Insights for Automotive Powertrain Applications draws on extensive industry experience and is supported by surveys and interviews with industry professionals from original equipment manufacturers, Tier 1 suppliers, research institutions, and universities.

Its summaries and recommendations are invaluable to those looking for reliable intelligence and the tools to support good decision making.

SAE International
Acknowledgments

I would like to express my sincere appreciation to Dr. Samit Ghosh and Mr. David Woessner for making this study possible by dedicating resources and time toward this effort. I would also like to thank my colleagues Stephen Xu (coordination and planning); Jan Kuntz, Aaron Miers, and Florian Schaefer (research and analysis); and Priya Playle (review and editing).

Last but not least, I would like to thank the SAE team involved with this initiative, particularly Monica Nogueira, for support throughout the development and publication of this study.

Timothy G. Thoppil

30 July 2013