

Electric Motors for Hybrid and Pure Electric Vehicles 2015-2025: Land, Water, Air

Synchronous, asynchronous,
in-wheel, outboard etc. Forecasts,
technologies and players

Dr Peter Harrop and Dr Jon Harrop

IDTechEx

www.IDTechEx.com

Contents

Page

1.	EXECUTIVE SUMMARY AND CONCLUSIONS	1
1.1.	Scope of report	1
1.2.	Overview of markets and needs	1
1.3.	Many specific needs	2
1.4.	Common requirements	2
1.5.	Trends	2
1.5.1.	General	2
1.5.2.	Trend in motor types needed	2
1.5.3.	Trend in motors offered: synchronous, asynchronous, brushed	3
1.6.	Different requirements from pure electric vs hybrid EVs	4
1.7.	Regenerative braking considerations	4
1.8.	Reducing limitations: trend by type	4
1.9.	In-wheel motor adoption criteria	5
1.9.1.	In-wheel motors needed for envisioned sky taxis and personal VTOL aircraft	6
1.10.	Value chain becomes more complex	7
1.11.	Positioning of motor manufacturers	8
1.12.	Location of motor manufacturers	9
1.13.	Timelines of newly successful EVs	10
1.14.	Traction motor forecasts of numbers	11
1.15.	Global value market for vehicle traction motors	13
1.16.	Rapid increase in number of motors per vehicle	16
1.16.1.	Motor technology by type of vehicle	17
1.16.2.	Switched reluctance motors a disruptive traction motor technology?	18
1.16.3.	Three ways that traction motor makers race to escape rare earths	19
1.17.	Motor market value in 2015 and 2025	21
1.18.	Shape of motors	22
1.19.	Industry consolidation	22
2.	INTRODUCTION	23
2.1.	Definitions	23
2.2.	Needs	23
2.2.1.	Traction motors are different	23
2.2.2.	Where different types of traction motor are popular	24
2.3.	Vertical integration	24
2.4.	Quadcopter drone motors and controls	25

3.	DESIGN ISSUES	29
3.1.	Challenges	29
3.2.	Important aspects overall	29
3.3.	Basic design of traction motor	29
3.4.	Design choices beyond basic operation principle	30
3.5.	Intermediate solutions	30
3.6.	Tough challenges: no simple optimisation	30
3.7.	Efficiency multiplier effect	31
3.8.	Ways of using more than one motor	31
3.8.1.	Double motors for efficiency	33
3.8.2.	Coupling motors for extra power and series parallel hybrids	34
3.8.3.	Two motors for four wheel drive	36
3.8.4.	Tesla adds two motor model	39
3.9.	In-wheel and near-wheel multiple motors	39
3.9.1.	Two types of in-wheel motor	40
3.10.	Trend to integration	47
3.11.	Move to high voltage	49
3.12.	Motor controls	49
3.12.1.	Overview	49
3.12.2.	Cost and integration issues	50
3.12.3.	Wide band gap semiconductors	52
3.13.	Award winning 2-in-1 motor for electric cars	54
4.	ANALYSIS OF 159 TRACTION MOTOR MANUFACTURERS	57
4.1.	Traction motor manufacturers compared	57
4.2.	Lessons from eCarTec Munich	126
5.	MOTOR CONTROLLERS / INVERTERS	133
5.1.	Optimisation using new devices and integration	137
5.2.	Concern in Europe	142
6.	OTHER RECENT NEWS	145
6.1.	Yamaha uses ZYTEK's new electric powertrain for city concept vehicle	145
	APPENDIX 1: LESSONS FROM BATTERY/EV EVENT MICHIGAN	149
	APPENDIX 2: IDTECHEX RESEARCH REPORTS AND CONSULTANCY	157