



BNM M01: Electric Motors and Controls Government Standards Evidence Base 2009: Key Inputs

Version 1.1

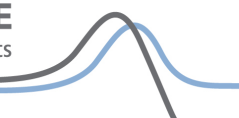
This Briefing Note and referenced information is a public consultation document and will be used to inform Government decisions. The information and analysis forms part of the Evidence Base created by Defra's Market Transformation Programme.

1 Introduction

- The aim of this Briefing Note is to provide details and reference sources of the underlying data in the model, along with the key assumptions used in the model.
- There are three main sections to this Briefing Note, corresponding to the main variables of the MTP modelling approach:
 - Stock
 - Sales
 - Usage & lifespan.
- Each section also includes an indication of the overall confidence in the dataset, to provide a sense of the robustness of the model.

1.1 Product definition

- Electric motors are machines that convert electrical energy into mechanical energy for powering various types of equipment. There are many motor designs available on the market, which range in size from a few watts (W) through to several megawatts (MW). Electric motors considered by MTP include those typically used in industry and commercial applications and that are applied to pumps, fans, compressors, materials handling, lifting and hoisting and other applications.
- The primary motor types considered under the Government Standards include AC induction, DC, permanent magnet, and switched reluctance designs. The range considered includes motors:
 - in the size range 0.75 – 400kW
 - with a rated voltage (U_N) up to 1000V.



- Electric motor efficiency is defined as the ratio of electrical input power supplied to the motor to the mechanical output power delivered at the motor shaft. The International Electrotechnical Commission (IEC) labelling standard IEC 60034-30 classifies fixed speed AC induction motors into four efficiency classes, namely IE1 through IE4, where IE1 is the least efficient and IE4 the most efficient. This standard supersedes the CEMEP (Comité Européen de Constructeurs de Machines Electriques et d'Electronique de Puissance) motor labelling scheme where motors were labelled EFF3 through EFF1, where EFF3 was the least efficient and EFF1 the most efficient. The EFF1 and IE2 classes are roughly equivalent.
- Government Standards also cover electric motor controls, and specifically variable speed drives (VSDs) (also known as adjustable speed drives (ASDs)). These adapt the electrical power supplied to the electric motor in order to control the mechanical power output according to the characteristics of the load being driven by the motor.

2 Stock

2.1 Summary

- Data presented in the following table indicate the Reference level stock of all electric motors in the modelled size ranges. Stock data are presented for 2003 as the most recent data since this is when the last full survey of the market took place. The survey was carried out by BSRIA on behalf of the MTP and the Carbon Trust and is referred to as the BSRIA UK Motor Market Survey (2003). Projected data are presented for the years 2010, 2020 and 2030.

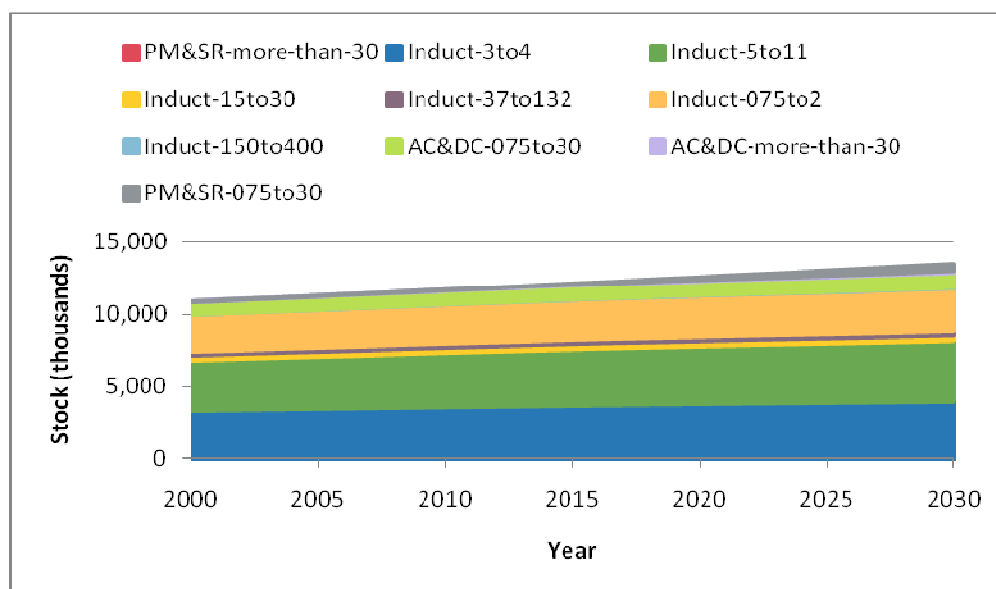


Figure 1: Total stock, electric motors (0.75 – 400 kW), 2000 to 2030

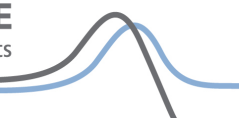


Table 1 Motor summary stock figures

Motor efficiency category ¹	Motor stock (000s)			
	2003	2010	2020	2030
Fixed Speed EE3	2,880	720	44	21
Fixed Speed IE1	6,550	7,570	6,530	5,620
Fixed Speed IE2	381	1,240	2,030	2,400
Fixed Speed IE3	0	4	63	243
Fixed Speed IE4	0	0	0	0
Variable Speed EE3	387	100	5	2
Variable Speed IE1	870	1,750	3,160	4,100
Variable Speed IE2	55	287	529	528
Variable Speed IE3	0	5	154	470
Variable Speed IE4	0	0.5	16	46
Total	11,130	11,680	12,530	13,430

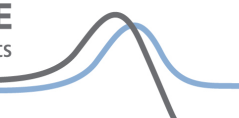
2.2 Data sources – stock

- This model is a stock-based model, which calculates sales using the stock projection and the product lifetime. Real sales data are put in as a check only, to help evaluate the output sales calculated from the model. This data series is usually incomplete. The sales shown in the previous charts and tables were to illustrate the full generated output (rather than input) sales data series.

Table 2 Stock data sources

Year	Reference	Reference date	Author	Justification	Confidence in sources (High/Low)
2003	BSRIA UK Motor Market Survey (2003). 17715/2.	June 2004	BSRIA	Comprehensive survey of the UK motors market & only data available	High
2009	Expert assumption	February 2009	MTP expert opinion	No external survey data available. Use	Medium

¹ Stock figures are presented by efficiency class and cover AC induction motors, permanent magnet & switched reluctance motors and other AC & DC motors. The 'Variable Speed' categories include motors which are controlled by VSD's.



Year	Reference	Reference date	Author	Justification	Confidence in sources (High/Low)
				expert opinion of market	

2.3 Methodology & key assumptions – stock

- The MTP model is a stock-based model, which calculates sales using a stock projection, the product lifetime and a stock churn calculation to account for products purchased in previous years gradually leaving stock. Real sales data are put in as a check only, to help evaluate the output sales from the model. This data series is usually incomplete.

2.3.1 Historic data

Table 3 Interpolation & background calculations – stock

Year	Methodology & assumptions
1960 - 2009	BSRIA UK Motor Market Survey (2003), Report 17715/2, provides actual stock data for 2003 only. Trends are extrapolated back to 1960 and forward to 2009 at a 0.7% growth per annum based on expert judgement derived from anecdotal evidence about the market. No further data are available.

2.3.2 Future analysis

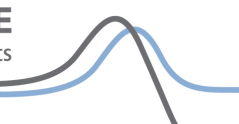
Table 4 Extrapolation & background calculations – stock

Year	Methodology & assumptions
2009 - 2030	Trends extrapolated forward to 2030 are based on 0.7% growth per annum based on expert judgement derived from anecdotal evidence about the market. No further data are available.
2009 - 2030	New motor types (permanent magnet - PM) are assumed to take market share from existing motor types (PM motors are not covered in BSRIA data). Permanent magnet stock numbers have then been estimated based on annual sales and stock decay (assuming a 12 year lifetime).

2.4 Data issues – stock

Table 5 Data issues – stock

Issue/risk	Approach taken/rationale
Lack of data on motor stock and uncertainty around growth rate	Data on motor stock are very limited. Stock levels are based on sales data in one year (2003) and extrapolated forward and back based on a linear growth rate. Hence there is a great deal of uncertainty around future and historic stock numbers. Stock levels have not currently been calibrated against any other associated metrics e.g. growth rate in non-domestic electricity consumption. There is a risk that future growth and stock levels have been overestimated; data from BERR on electricity consumption in the UK industry and service



Issue/risk	Approach taken/rationale
	sectors suggests that electricity consumption will decline slightly from present until 2020. As motors make up a significant part of UK electricity consumption it would be reasonable to reduce stock forecasts accordingly. This amendment is planned for future model iterations. New sales data (induction motors only) from IMS Market Research will also be incorporated into future model iterations.

2.5 Confidence level – stock

- The robustness of the BSRIA data is high as it has been based on a comprehensive market study. However the output data was for 2003 only and in the interim MTP has not found any further data with which to align growth patterns and future projections so these are based on expert opinion and anecdotal evidence.

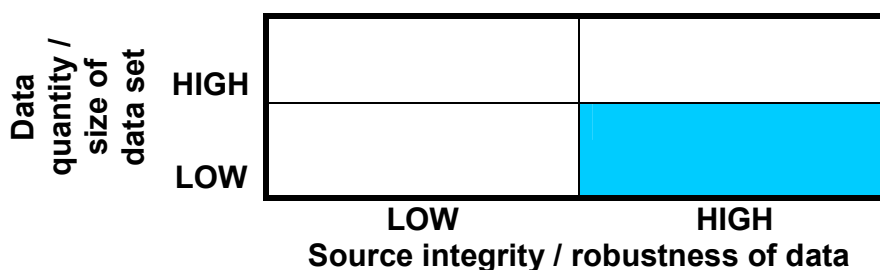


Figure 2 Confidence indicator for ownership data

3 Sales

3.1 Summary

- Data presented in the following table indicate the Reference Scenario sales for all electric motors for each motor efficiency category. Sales data are presented for 2003 as this is when the last full survey of the market took place. The survey was carried out by BSRIA on behalf of the MTP and the Carbon Trust and is referred to as the BSRIA UK Motor Market Survey (2003). Projected data are presented for the years 2010, 2020 and 2030.

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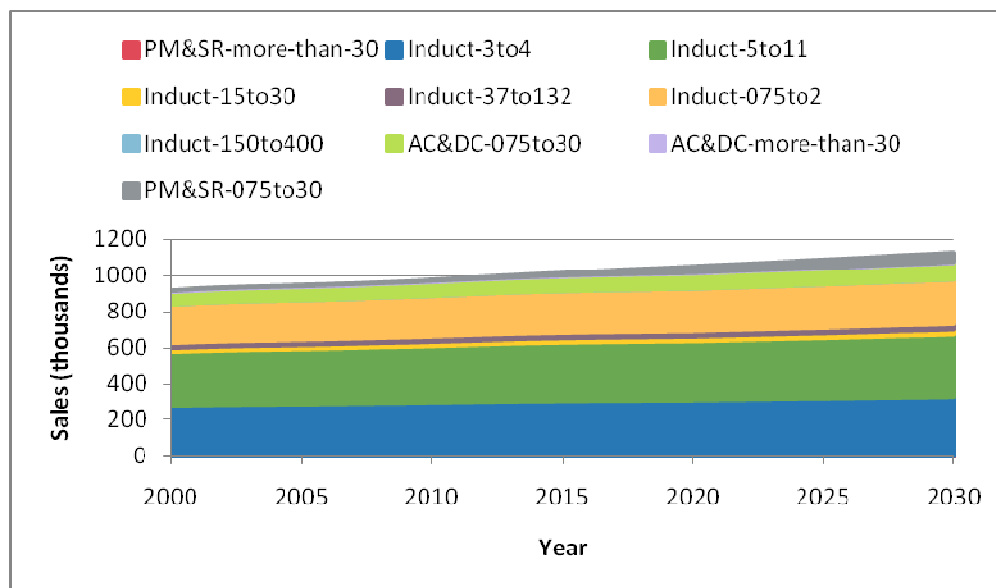
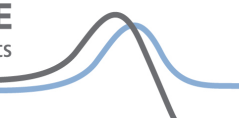


Figure 3: Total sales, electric motors (0.75 – 400 kW), 2000-2030

Table 6 Motor summary sales figures

Motor efficiency category ²	Motor sales (000s)			
	2003	2010	2020	2030
Fixed Speed EEf3	8	4	2	2
Fixed Speed IE1	687	552	456	424
Fixed Speed IE2	95	153	178	206
Fixed Speed IE3	0	2	13	33
Fixed Speed IE4	0	0	0	0
Variable Speed EEf3	1	0	0	0
Variable Speed IE1	129	212	322	357
Variable Speed IE2	17	47	41	44
Variable Speed IE3	0	3	31	52
Variable Speed IE4	0	0.5	3	5
Total	937	973	1,047	1,123

² Sales figures are presented by efficiency class and cover AC induction motors, permanent magnet & switched reluctance motors and other AC & DC motors



3.2 Data sources - sales

Table 7 Sales data sources

Year	Reference	Reference date	Author	Justification	Confidence in sources (High/Low)
2003	BSRIA UK Motor Market Survey (2003). 17715/2.	June 2004	BSRIA	Comprehensive survey of the UK motors market and only data available	High
2009	Expert assumption	February 2009	MTP expert opinion	No external survey data available. Use expert opinion of market	Medium

3.3 Methodology & key assumptions - sales

3.3.1 Historic data

Table 8 Interpolation & background calculations – sales data

Year	Methodology & assumptions
2003	UK Motor Market 2003. BSRIA Report 17715/2 presents sales data for 2003. Sales data for 2003 are only used as validation check.

3.3.2 Future analysis

- No future analysis of sales data

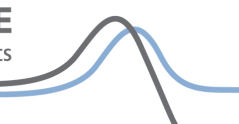
3.4 Data issues - sales

Table 9 Data issues - sales

Issue/risk	Approach taken/rationale
Only sales data for one year available	Limited data on which to base stock inputs and validate the stock model outputs.

3.5 Confidence level

- The quality and robustness of the BSRIA data is high as it has been based on a comprehensive market study. However the output data was for 2003 only. Since that



date MTP has not found any further data with which to align growth patterns and future projections. Consequently the models are stock based and do not rely on sales data.

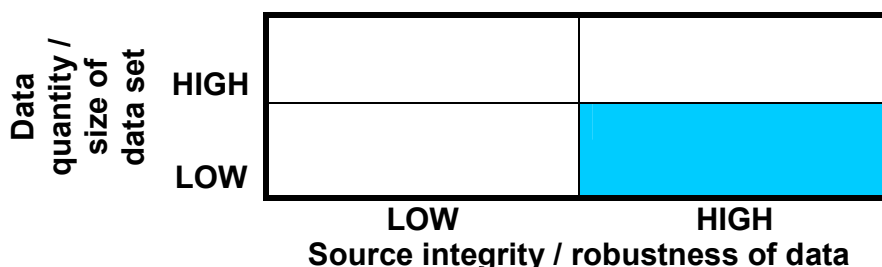


Figure 4 Confidence indicator for sales data

4 Usage & lifespan

4.1 Summary

Table 10 Data issues - sales

	Average life expectancy (years)		Usage (hours / year)	
	2009	2020	2009	2020
AC induction motors	12.5	12.5	2,120	2,120
Permanent magnet motors	12.5	12.5	2,120	2,120
Other motors	12.5	12.5	2,120	2,120

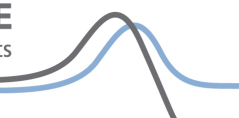
4.2 Data sources – usage & lifespan

Table 11 Usage & lifespan data sources

Year	Reference	Reference date	Author	Justification	Confidence in sources (High/Low)
Motor loading factors 2003	UK Motor Market 2003. BSRIA Report 17715/2	June 2004	BSRIA	Comprehensive survey of the UK motors market and only	High

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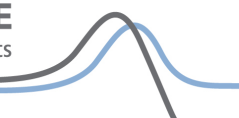
Year	Reference	Reference date	Author	Justification	Confidence in sources (High/Low)
				data available	
Motor run hours 2003	UK Motor Market 2003. BSRIA Report 17715/2	June 2004	BSRIA	Comprehensive survey of the UK motors market and only data available	High
Motor rating 2003	UK Motor Market 2003. BSRIA Report 17715/2	June 2004	BSRIA	Comprehensive survey of the UK motors market and only data available	High
Lifespan 1960-2030	ErP Preparatory Study on electric motors (www.ecomotors.org)	2008	AEA Energy & Environment, University of Coimbra & Fraunhofer ISI	Interpretation of expert knowledge of market	High

4.3 Methodology & key assumptions – usage & lifespan

4.3.1 Historic data

Table 12 Interpolation & background calculations – usage & lifespan data

Year	Data	Methodology & assumptions
1960-2008	Motor loading factors	<p>Load factor is the relationship between rated load and actual load placed on the motor; most motors do not run at full rated load and this affects total energy consumption.</p> <p>Load factor data by industry sector and application are taken from the BSRIA report and reduced to an average figure. The loading factor used in the model is based on a single weighted average (LF) for all motor applications and sectors. The difference between fixed speed and variable speed applications is assumed to be LF+0.1 and LF-0.1 respectively and corresponds with a differential load of 20% due to the use of variable speed drives. The LF can be recalculated based on trends which impact on specific sectors or specific applications. Load factor is adjusted as part of the overall model calibration process and are assumed to remain constant</p>



Year	Data	Methodology & assumptions
		over time.
1960-2008	Motor run hours	Run hours are derived from the BSRIA report. As per load factor, run hours can be recalculated based on trends which impact on specific sectors or specific applications. Run hours are assumed to remain constant over time.
1960-2008	Motor rating	Motor rating is the weighted average power rating of the motors in the model. Motor rating is assumed to remain constant over time.
1960-2008	Lifespan	Average lifespan is taken from the ErP preparatory study on electric motors and is assumed to be constant across all years in the models.

4.3.2 Future analysis

Table 13 Extrapolation & background calculations – usage & lifespan data

Year	Data	Methodology & assumptions
2009-2030	Motor loading factors	Load factors are assumed to remain constant into the future.
2009-2030	Motor run hours	Run hours are assumed to remain constant into the future.
2009-2030	Motor rating	Motor rating is assumed to remain constant into the future.
2009-2030	Lifespan of equipment	Average lifespan is assumed to remain constant into the future.

4.4 Data issues – usage & lifespan

Table 14 Data issues – usage & lifespan

Issue/risk	Approach taken/rationale
Load factors for motors vary widely across industry sectors and individual applications. It is very difficult to calculate an 'average value'.	The load factor values used correlate well with the load factors used in the ErP preparatory study for motors and have been fine tuned as part of the model calibration process.
Motor run hours vary widely across industry sectors and individual applications. It is very difficult to calculate an 'average value'.	The run hour values used correlate well with the values used in the ErP preparatory study for motors and have been fine tuned as part of the model calibration process.

4.5 Confidence level – usage & lifespan

- The original usage data are derived from BSRIA data which are based on a comprehensive market study; in the interim MTP has not found any further data with which to align changes in usage patterns and so minor changes are based on expert opinion and anecdotal evidence. Lifespan data are based on a combination of the BSRIA data and information presented in the ErP preparatory study for electric motors.

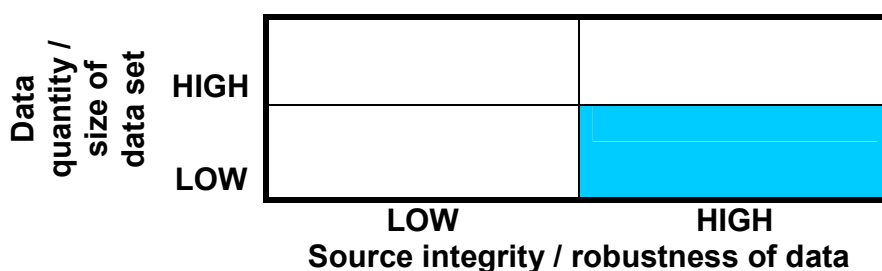


Figure 5 Confidence indicator for usage & lifespan data

Related MTP information

- BNM M02: Electric Motors Government Standards Evidence Base 2009: Reference Scenario
- BNM M03: Electric Motors Government Standards Evidence Base 2009: Policy Scenario
- BNM M04: Electric Motors Government Standards Evidence Base 2009: Best Available Technology (BAT) Scenario
- BNM M05: Electric Motors Government Standards Evidence Base 2009: Key Outputs

Changes from previous version

- Minor updates to the template.

Consultation and further information

Stakeholders are encouraged to review this document and provide suggestions that may improve the quality of information provided, email info@mtprog.com quoting the document reference, or call the MTP enquiry line on +44 (0) 845 600 8951.

For further information on related issues visit <http://efficient-products.defra.gov.uk>