WG1
Harmonization Issues

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Global electricity consumption for industrial motors

	Unit	Value
Electricity production global (2006)	TWh/a	19.000
Electricity for industrial motors (40% of total consumption)	TWh/a	7.400
Capacity for electric motors (peak)	TWe	1.6 to 2.3
Motor electricity, greenhouse gas emissions	Mt CO2/a	4.300
Motor system energy efficiency improvement potential (average within life cycle 10..20 years)	Range 20-30%	25%
Electricity savings potential	TWh/a	1.850
Greenhouse gas emission reductions potential	M t CO2/a	1.250
Electricity cost savings potential (industrial end-users)	Billion Euro/a	100

Motor efficiency testing

- **IEEE 112-B (2004)**

-North America and Latin America.

-**Input-Output method** where output power is obtained measuring the torque and rotation speed at different load levels.

-Requires accurate measuring instrumentation, including precision dynamometers, for the different power ranges.

- **IEC 60034-2 (1996)**

-**Indirect method**, avoiding the need to measure Mechanical Power and the associated costs. Mechanical Power is calculated by measuring the electrical input power and the losses.

-All losses are measured using laboratorial tests except stray load losses which are assumed.

-Overestimated efficiency values because the value considered for stray load losses (0.5 % of the full load input power) is not realistic.

-In fact, in the most cases, particularly in the low and medium power motor ranges, stray load losses assume real values well above 0.5%.

Motor efficiency testing

- **IEC 61972 (2002)**

-Developed as a possible replacement of IEC 60034-2 allows two methods to determine motor efficiency.

-Input-Output method (similar to IEEE 112-B);

-Indirect method (assigns variable allowance for SLL).

- **IEC 60034-2 (CDV Ed.4/2, 2006)**

-New version of IEC 60034-2.

-Allows three different test methods to obtain the motor efficiency:

-Input-Output method (just like IEEE 112-B);

-Indirect method (assigns variable allowance for SLL);

-Eh Star (measurement of SLL) - This is an inexpensive method with fairly good accuracy where stray load losses are calculated mathematically.

Motor efficiency testing

- **C390-98 (2005) - Canadian Std.**

-Very similar to IEEE 112-B, being used for the definition of minimum energy performance standards (MEPS) in Canada.

- **AS 1359.102 - Australian Std.**

-Gives the possibility to choose between 3 different methods: indirect, direct and calorimetric.

-Indirect method similar to IEC 60034-2, Amd.2.

-Calorimetric method: very accurate but it is very expensive and time consuming.

-Input-Output method in accordance with IEC 61972.

It is expected that the Australian Standard will shortly collapse to follow the revised international standard IEC 60034-2 (Edition 4).

IEC 60034-2 Ed. 4

Three test methods:

-Input-Output Method
(similar to IEEE112-B)

-Assigned Variable Allowance for SLL
(as in IEC 61972)

-Measurement of SLL with Eh-Star method

Eh – Star Evaluation

- Eh-Star is an inexpensive method with fairly good accuracy where stray load losses are calculated mathematically.

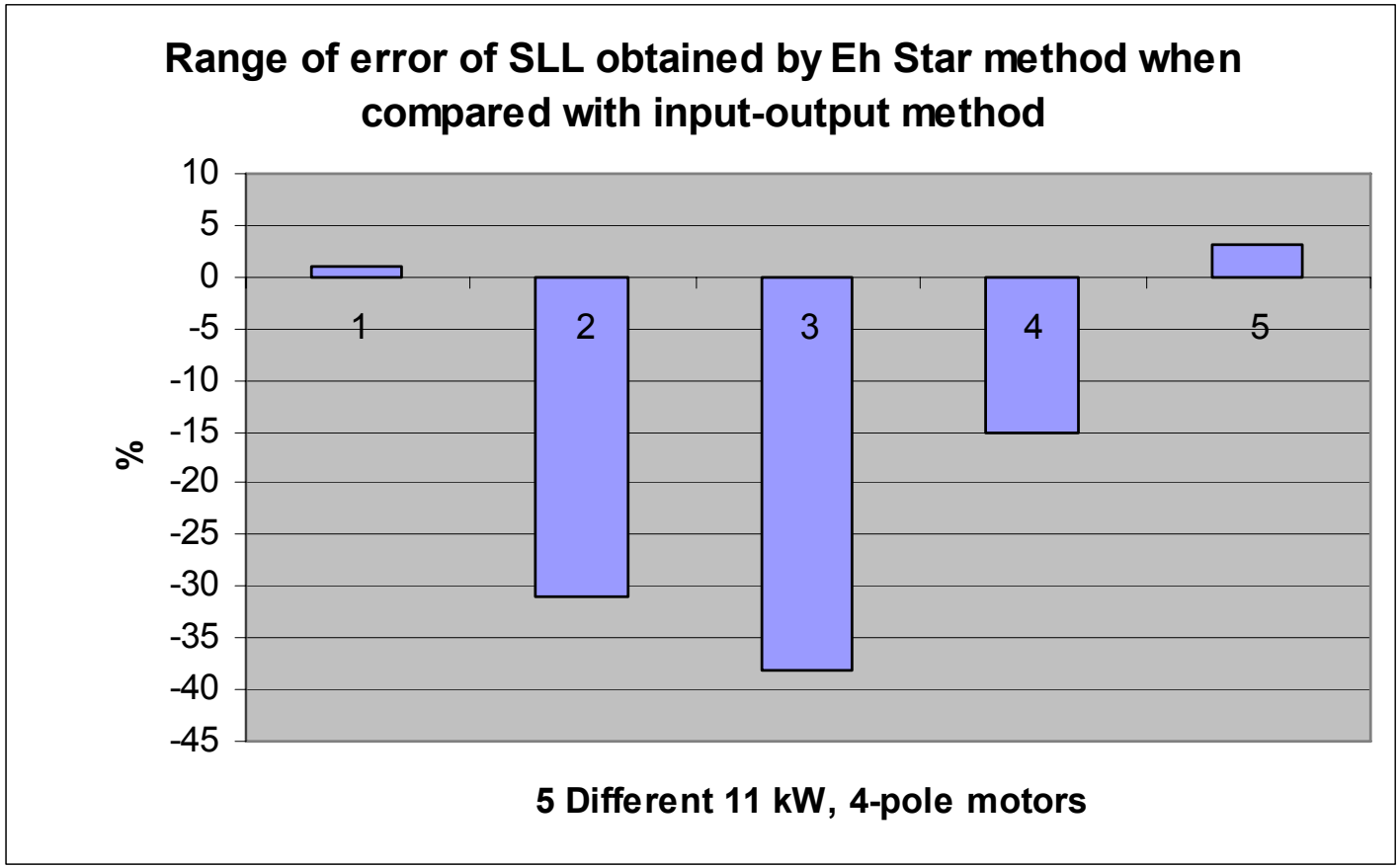
- Comparison between a limited set of comparative tests using input-output methods and the Eh-Star method show a fair to good matching of the test results.

- Additional tests may be used to confirm the repeatability and accuracy of test results

Eh – Star Evaluation

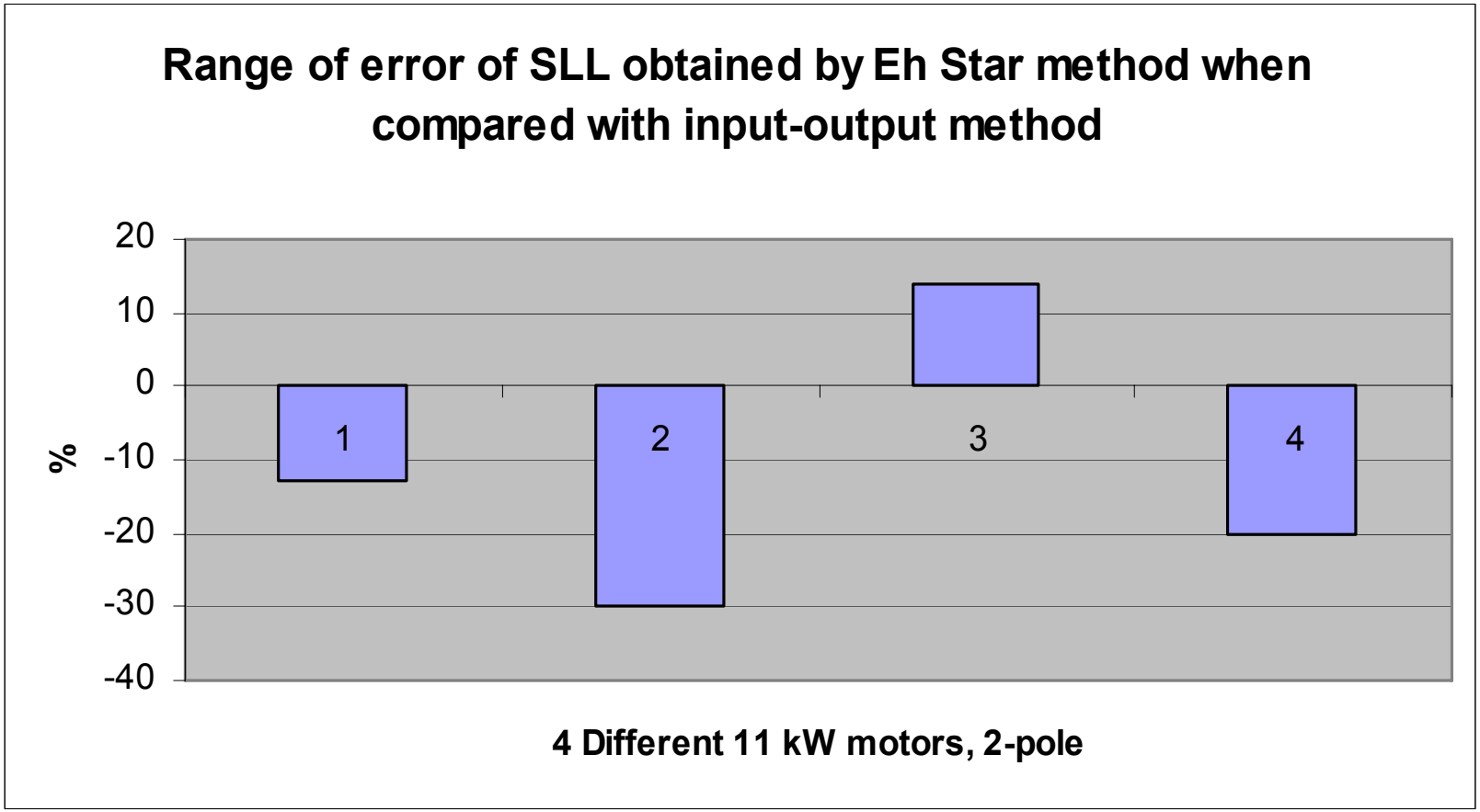
- *Darmstadt University Results:*

14 motors under investigation



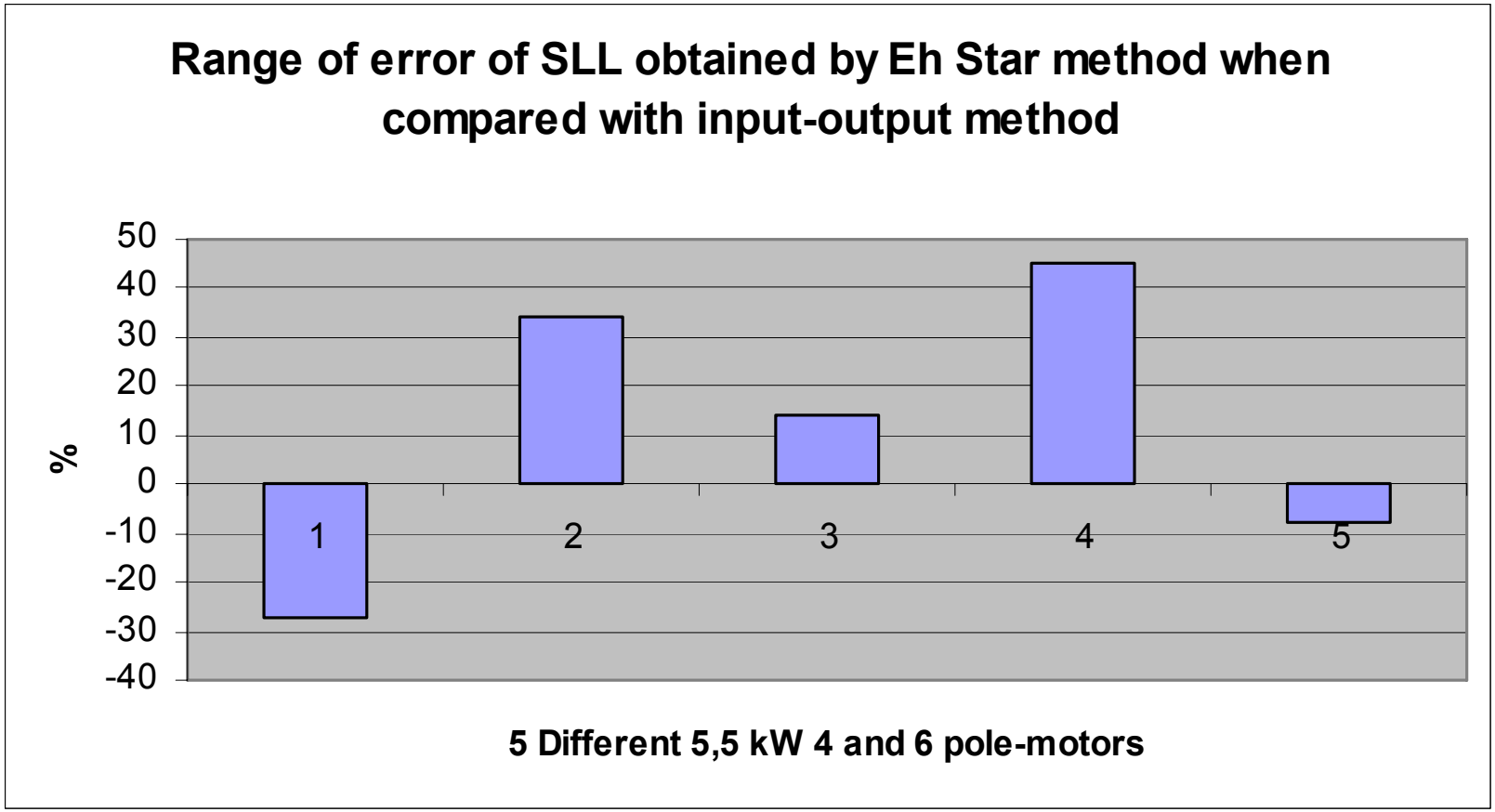
Eh – Star Evaluation

Darmstadt University Results:



Eh – Star Evaluation

Darmstadt University Results:



4-pole: Motor 1

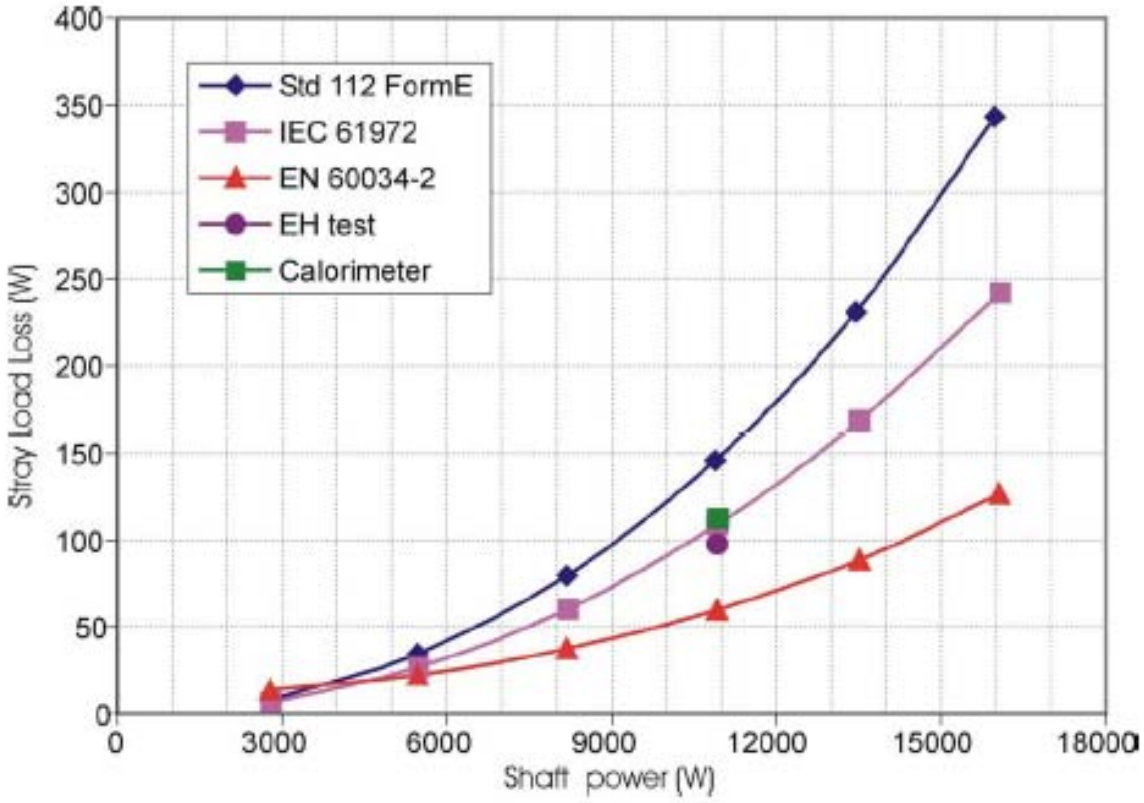
6-pole: Motors 2,3,4,5

Eh – Star Evaluation

University of Nottingham results:

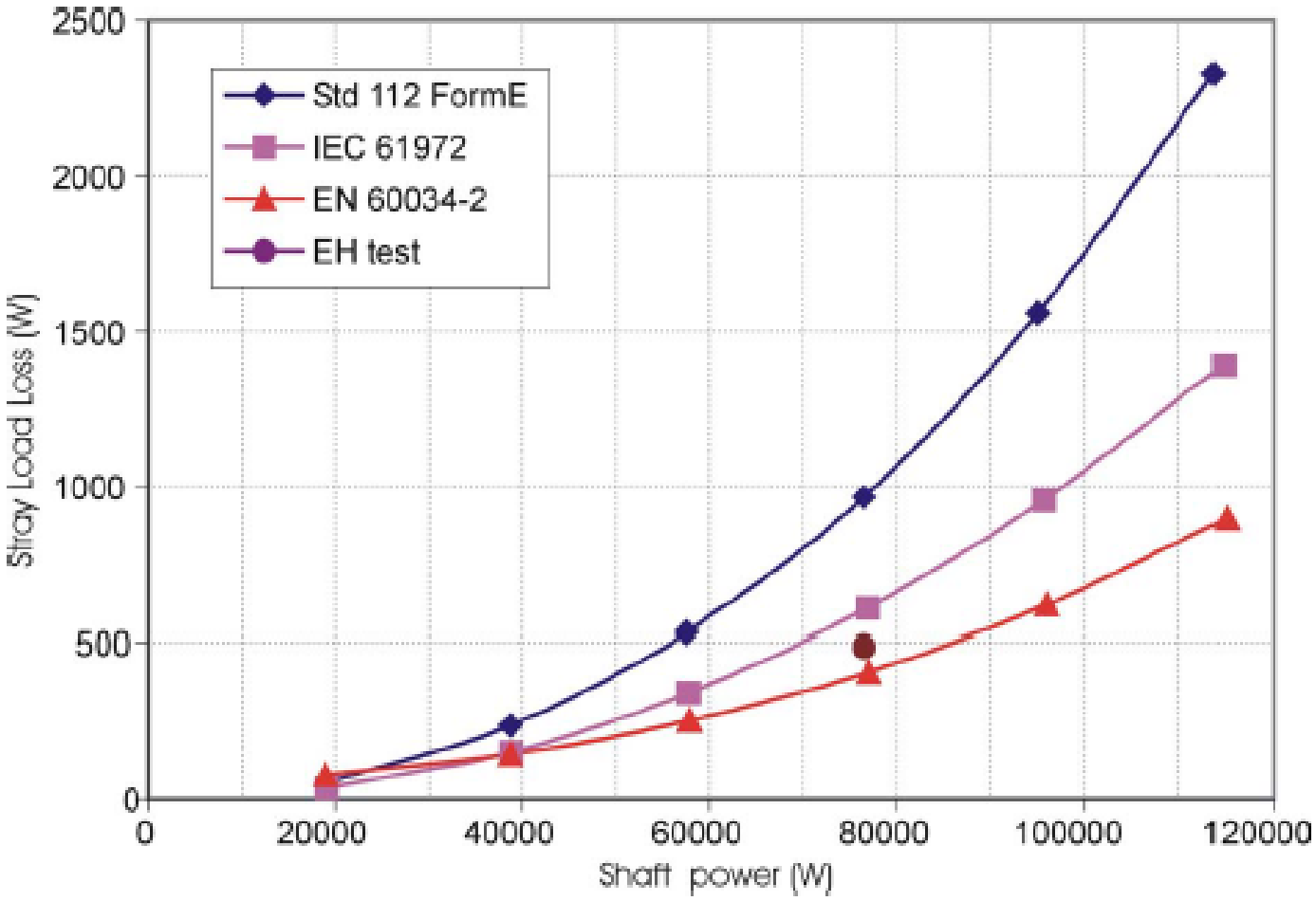
11 kW motor

3 motors under investigation



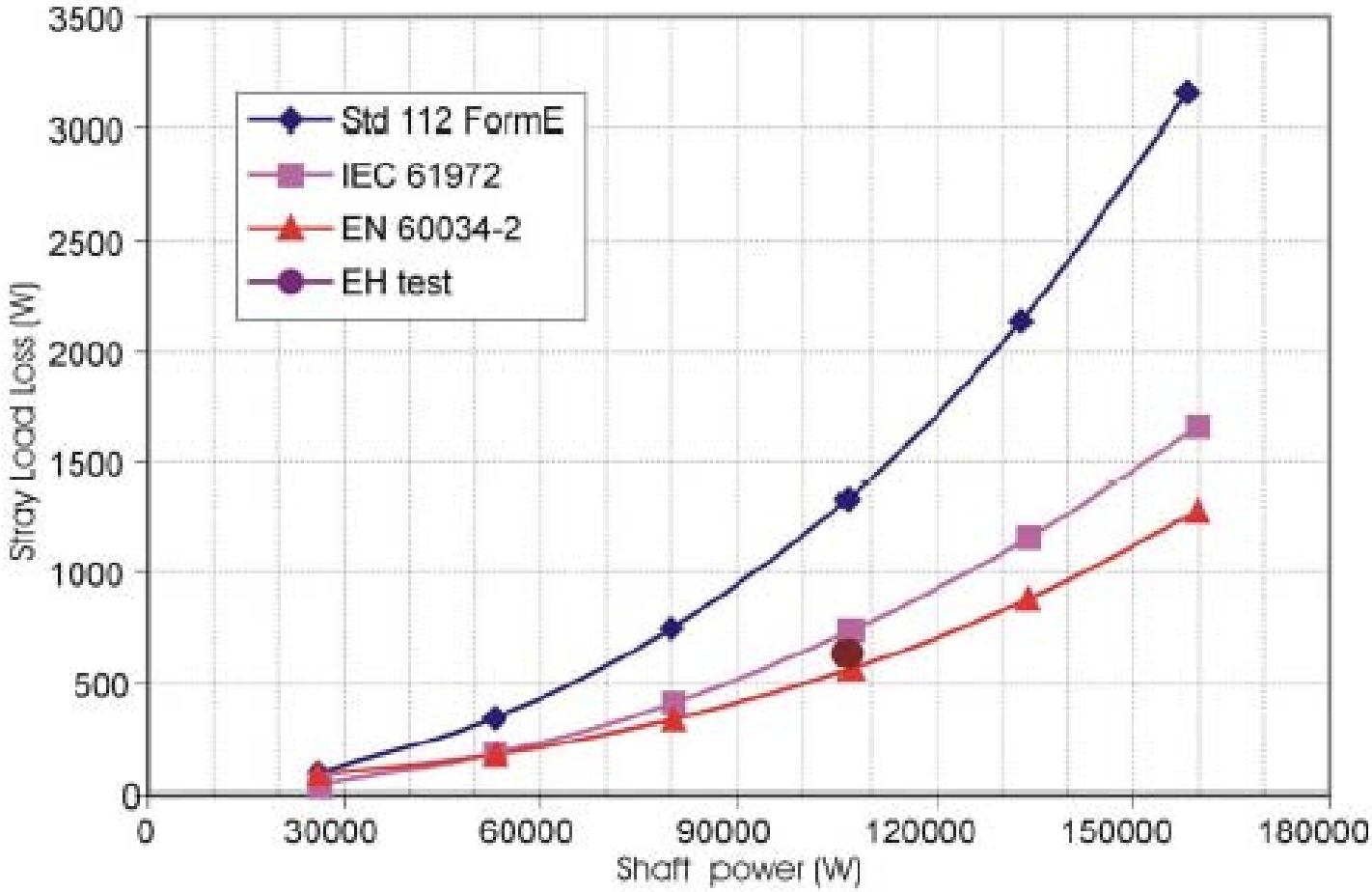
Eh – Star Evaluation

University of Nottingham results: **75 kW motor**



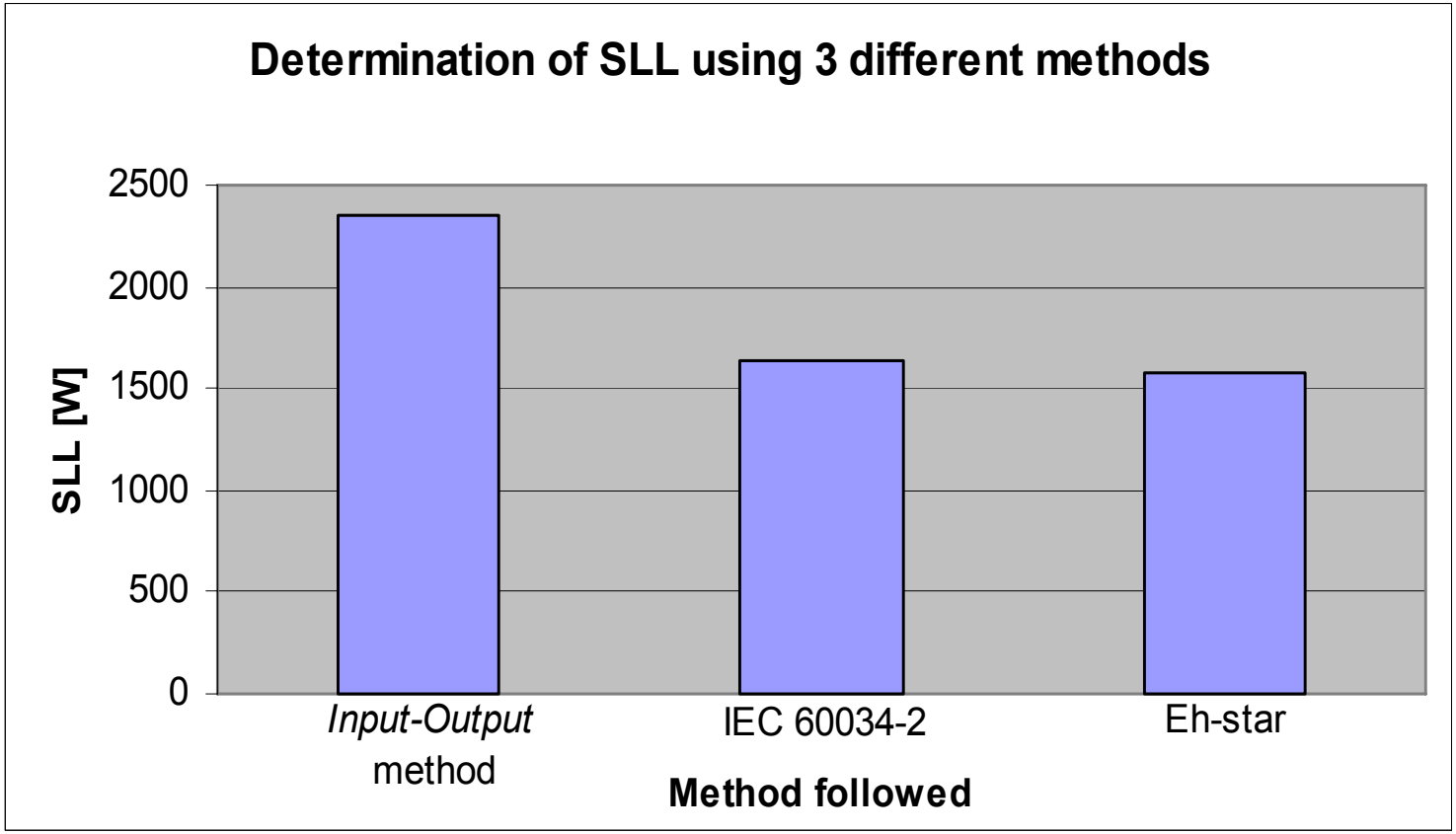
Eh – Star Evaluation

University of Nottingham results: **110 kW motor**



Eh – Star Evaluation

- *Siemens results:* Single 315 kW motor



Existing relevant legislation and self regulation inside and outside EU

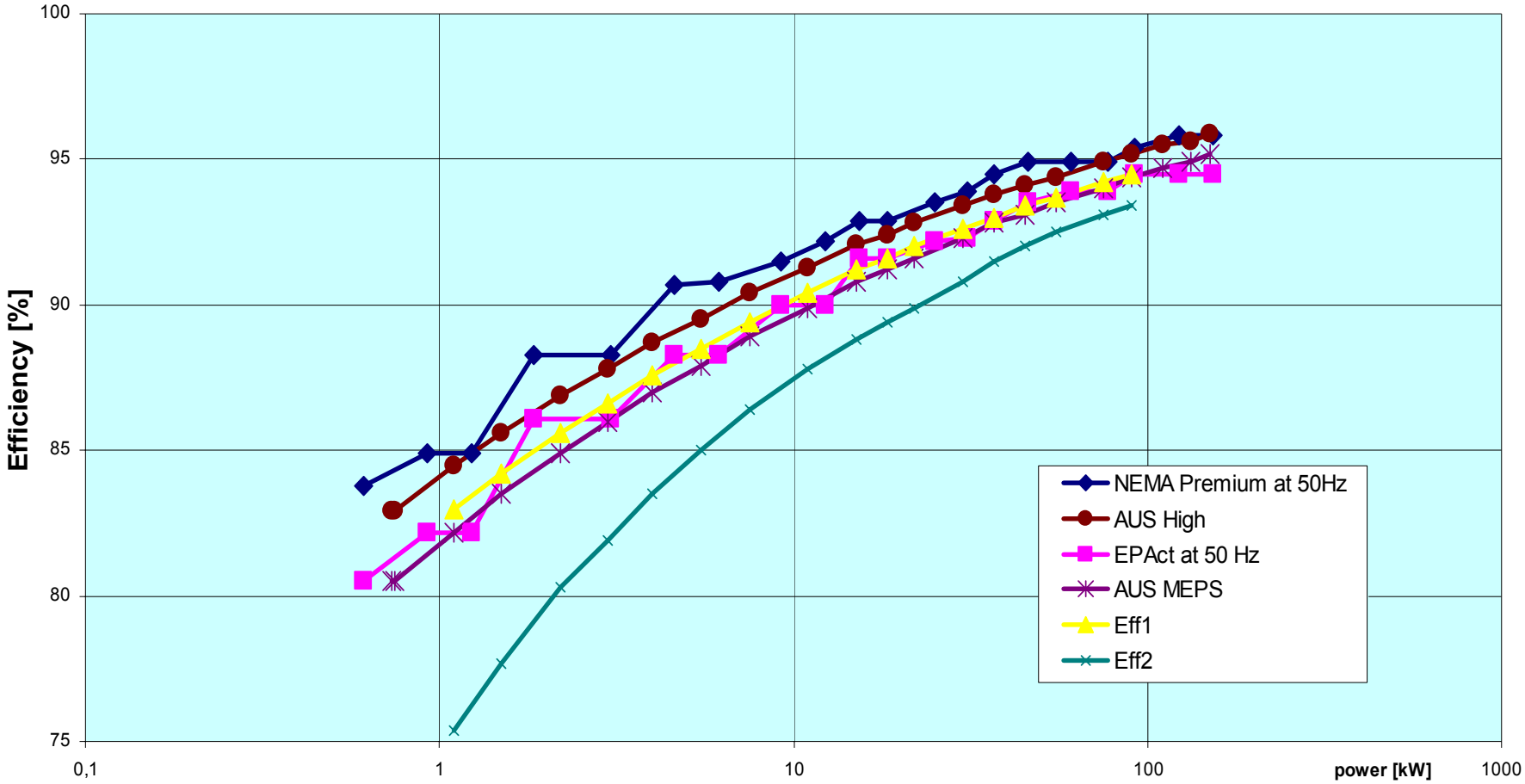
There are different approaches to motor efficiency voluntary agreements and minimum efficiency standards regulation around the world. North America was the first region to enforce MEPS.

In Canada and the US, the MEPS relating to motors that conform to National Electrical Manufacturers Association (NEMA) requirements are identical, but the Canadian regulation also covers metric motors.

Mexico has recently completed a revision of its MEPS, making the levels equivalent to those in the US and Canada.

In Europe here was a voluntary undertaking by motor manufacturers to reduce the sale of motors with the current standard efficiency (EFF3).

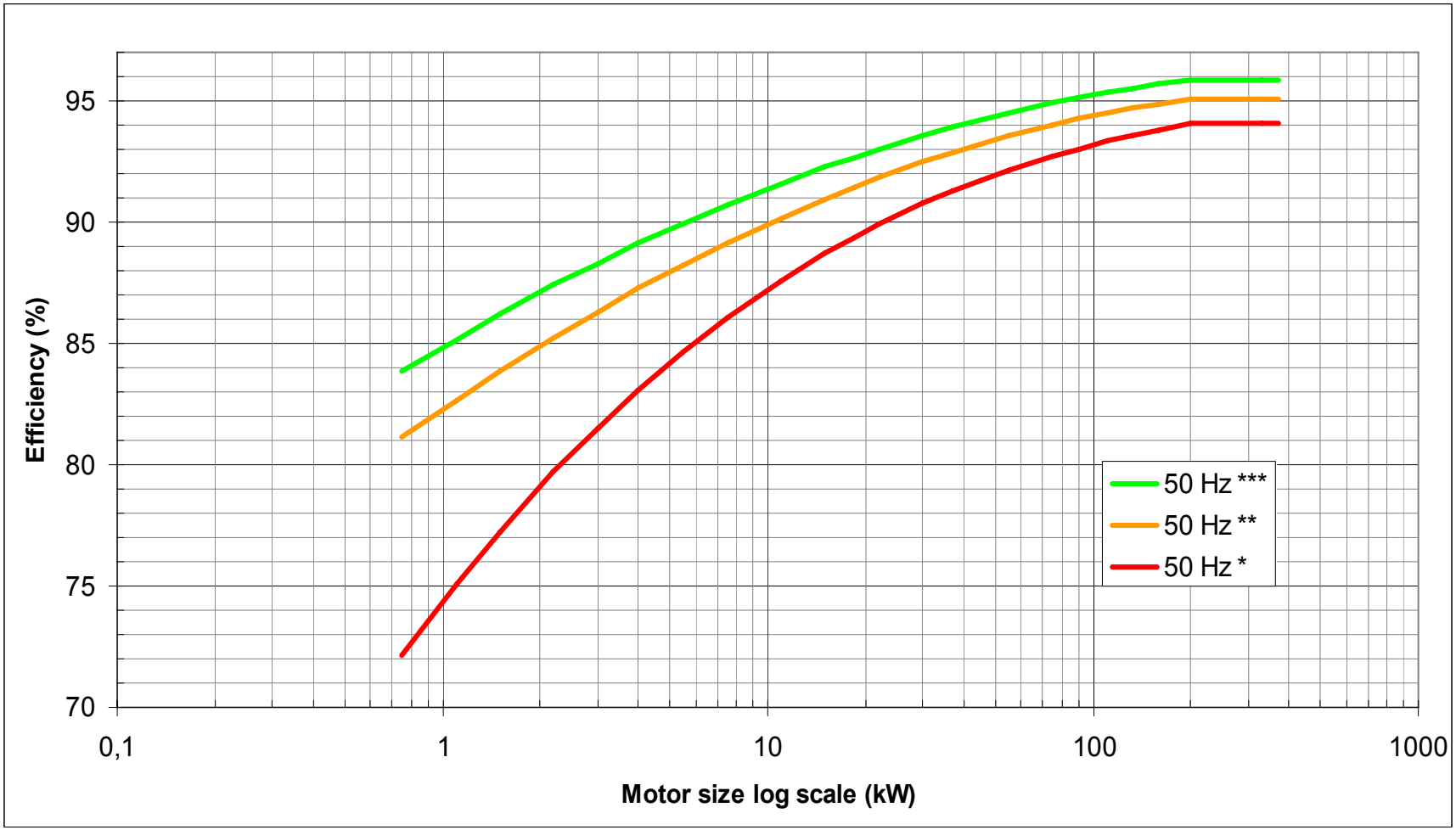
Comparison of Minimum Efficiency Requirements in Different Parts of the World



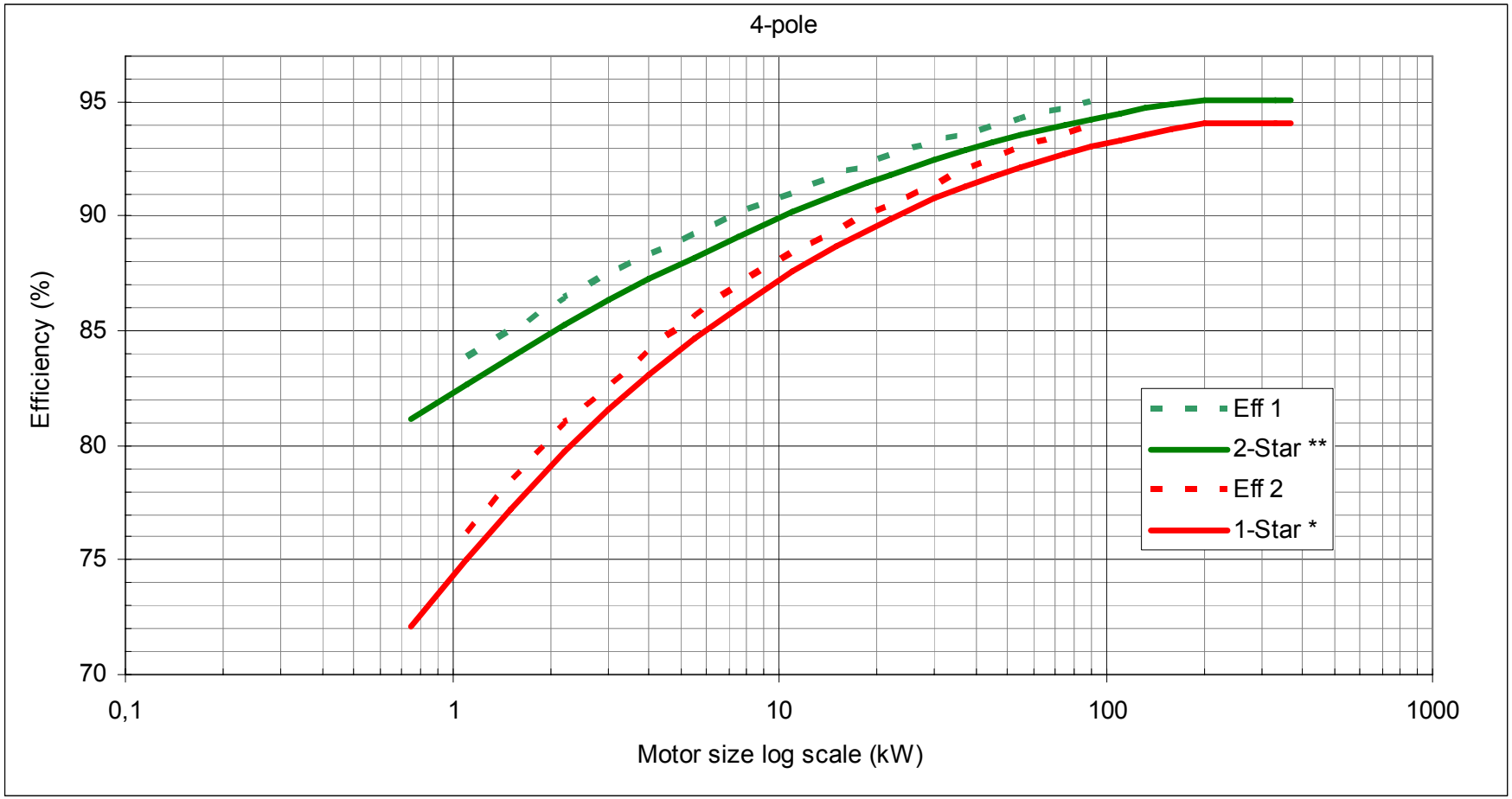
Existing relevant legislation and self regulation inside and outside EU

Country/Region	Mandatory Agreements (year of implementation)	Voluntary Agreements (year of implementation)	Market Share
U.S.A	EPAct – High Efficiency (1997)	Nema Premium (2001)	NEMA Premium (16%) EPACT (54%)
Canada	EPAct – High Efficiency	Nema Premium (2001)	NEMA Premium (16%) EPACT (54%)
Mexico	EPAct – High Efficiency (1998)	Nema Premium (2003)	n.a.
EU		Efficiency Classification and market reduction of EFF3 (1998)	EFF1 (9%) EFF2 (87%) for CEMEP agreement members
Australia	High efficiency (2006)	Premium efficiency (2006)	Premium (10%) High efficiency (32%) Standard (58%)
New Zealand	High efficiency (2006)	Premium efficiency (2006)	n.a.
Brazil	Standard Efficiency (2002) High Efficiency (2009)	High Efficiency	High Efficiency (15%)
China	Standard Efficiency (2002) High Efficiency (2010)	High Efficiency (2002) Premium (2010)	High (1%) Standard (99%)
Korea		Standard efficiency (1996)	High (10%) Standard (90%)

Proposed new IEC 60034-30 Energy Efficiency Classes 0.75 kW - 370 kW (4-poles, 50Hz)



Adaptation of Eff 1 and Eff 2 levels to new testing method in IEC 61972

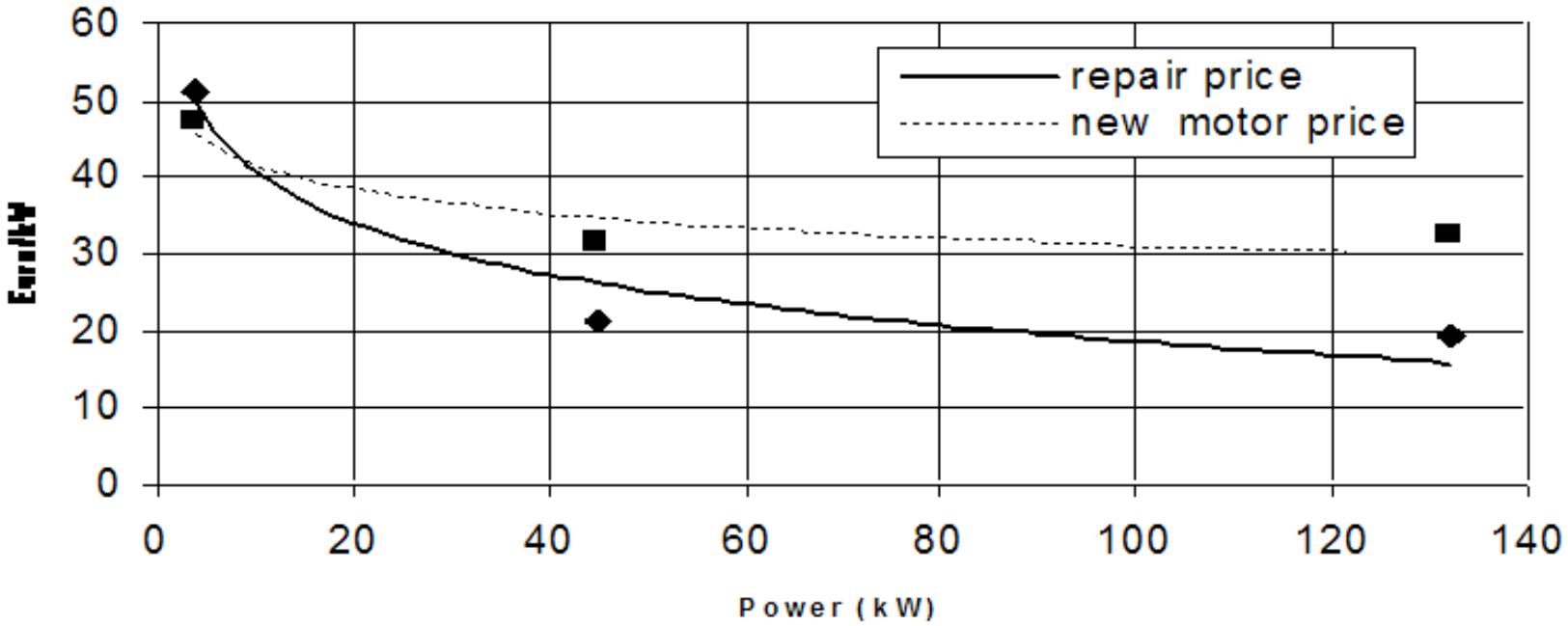


Motor Rewinding

- Motor larger than 5 kW are normally repaired when they fail. For small motors it is not in general economical to repair them.

- A motor is normally repaired at least 2 times during its lifetime but this can happen up to 4 times.

Motor Rewinding

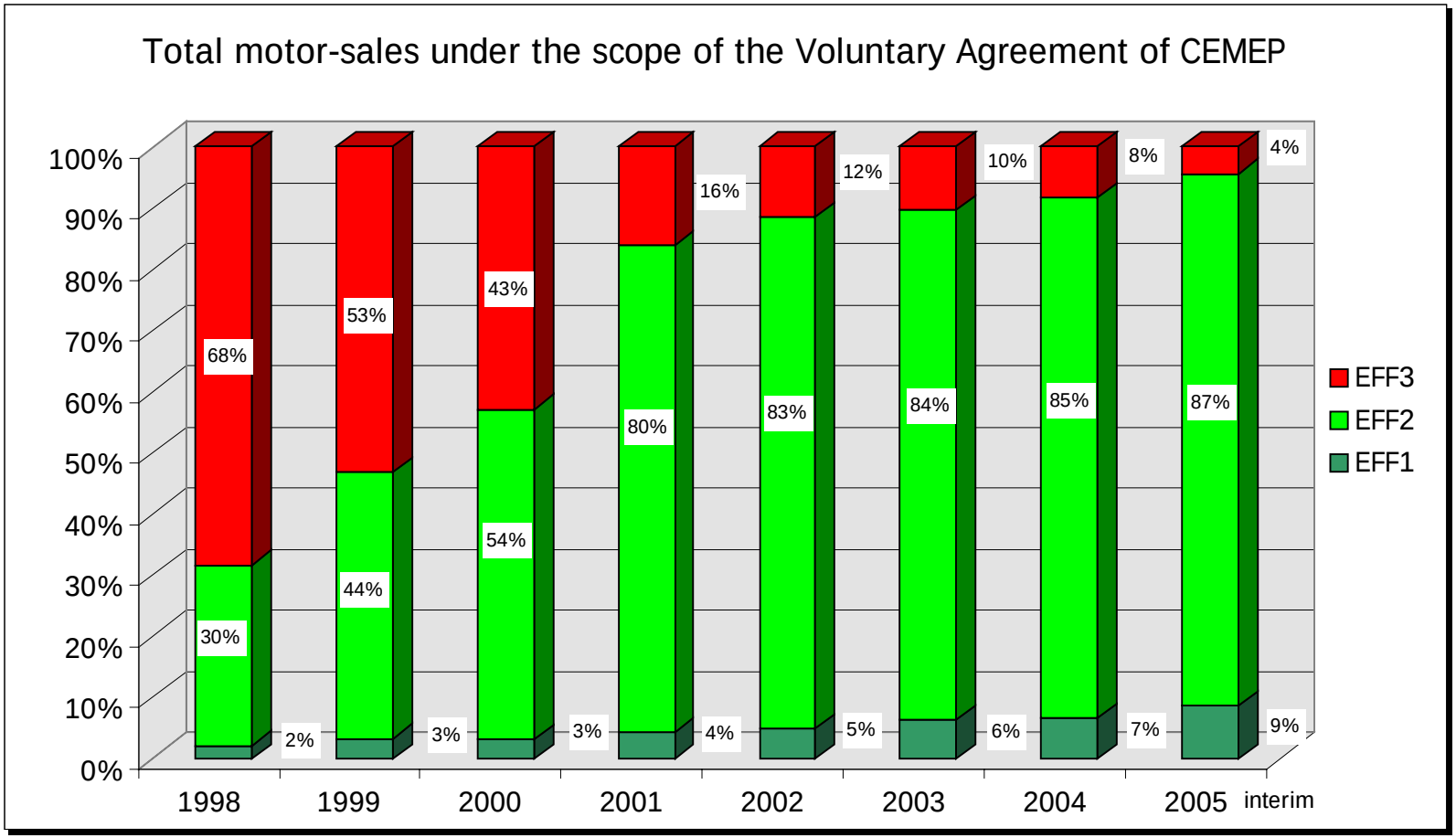


Motor Rewinding

- Typically, the repair process includes rewinding and bearing replacement.
- Provided that rewinding is done following good practice recommendations, no significant decrease in efficiency occurs.
- Of course, good practice recommendations are not always followed. Previous detailed studies identified an average **1.5 %** decrease in efficiency per rewinding but it can be as much as **5%.**

Motor Rewinding-Large stock (pre-2000) of EFF3 motors, whose efficiency may be degraded

Efficient Motors Market trends - EU



*** Star /Premium MEPS in USA ?

ACEEE and NEMA have agreed to a new set of proposed energy efficiency standards for industrial electric motors setting higher minimum mandatory efficiency levels but also broaden the scope of existing standards.

*** Star / Premium MEPS in USA?

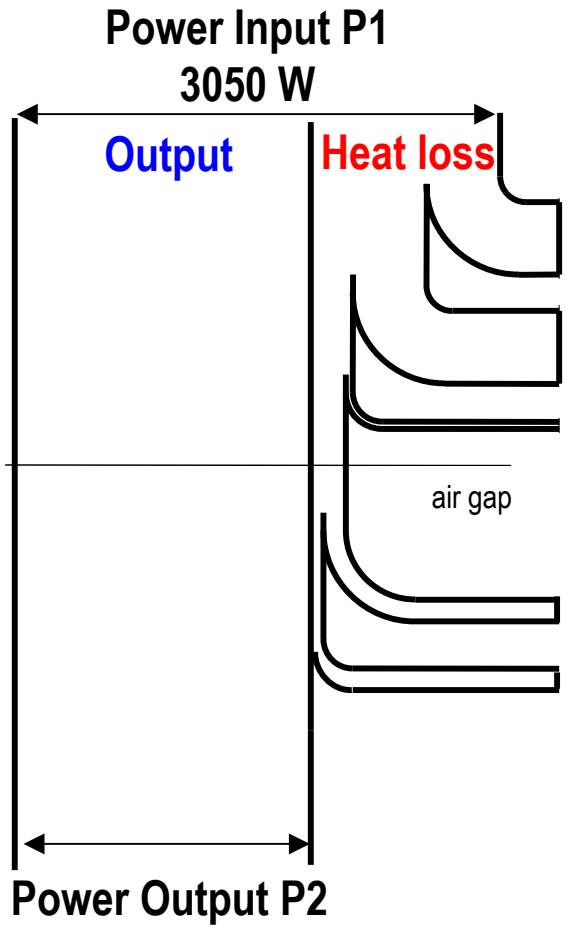
- Current minimum efficiency standards of general purpose induction motors as defined in 1992's EPAct and covered by federal legislation should be raised to NEMA Premium levels.
- Seven types of low voltage poly-phase, integral-horsepower induction motors not currently covered under federal law should be subjected to minimum efficiency standards at the levels defined in 1992's EPAct for general purpose induction motors.
- General purpose induction motors with power ratings between 200 and 500 horsepower should also meet minimum efficiency levels as specified in 1992's EPAct.

**** Star / Super Premium ?

- New technologies are emerging with very high efficiencies:
  - Brushless Permanent Magnet Motors
  - Switched Reluctance Motors

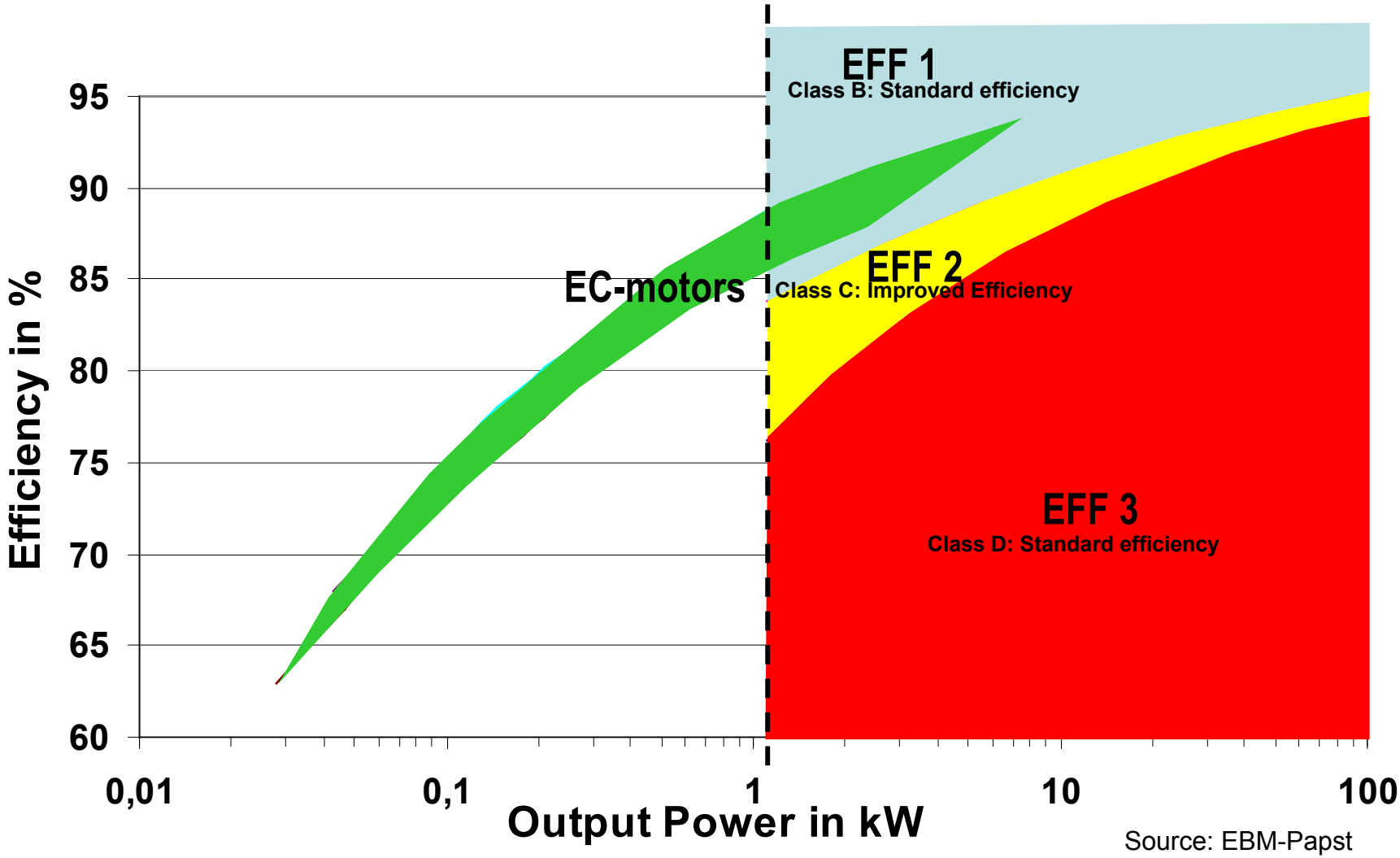
BLDC/EC versus AC induction

Flow of power through a standard AC motor (frame size 90L)



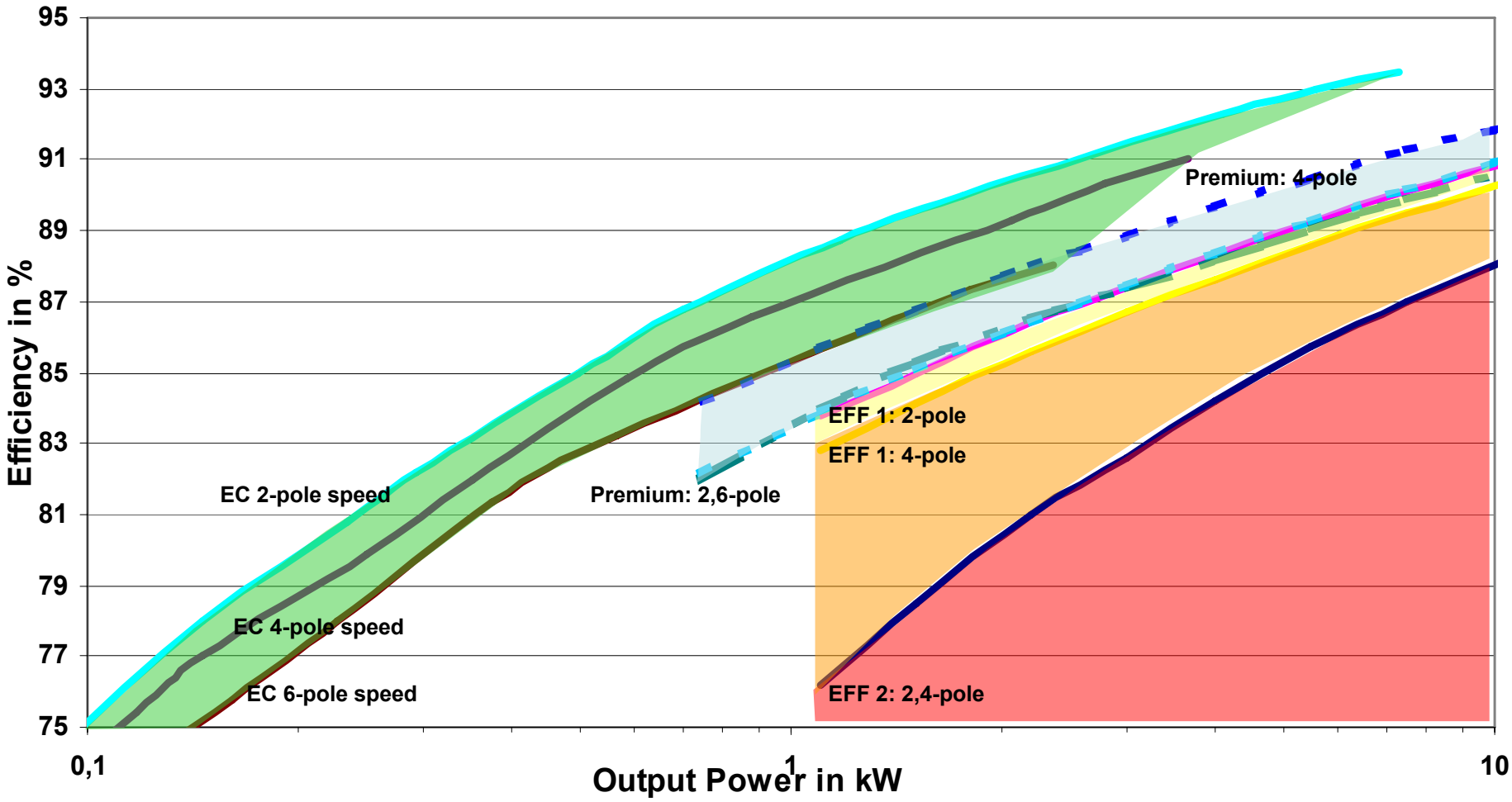
	AC	EC
Lamination loss	200W	80W
Copper loss	200W	120W
Additional losses		
Slip loss	60W	0W
Frictional loss		
+ Inverter loss	~160W	80W
System loss	~620W	280W

**** Star / Super Premium ?



Source: EBM-Papst

**** Star / Super Premium



Source: EBM-Papst

**** Star / Super Premium

- Does a new **** Star / Super Premium Efficiency Class make sense?