



Super-Premium Efficiency Class Electric Motors

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NEW MOTOR EFFICIENCY CLASSIFICATION STANDARD

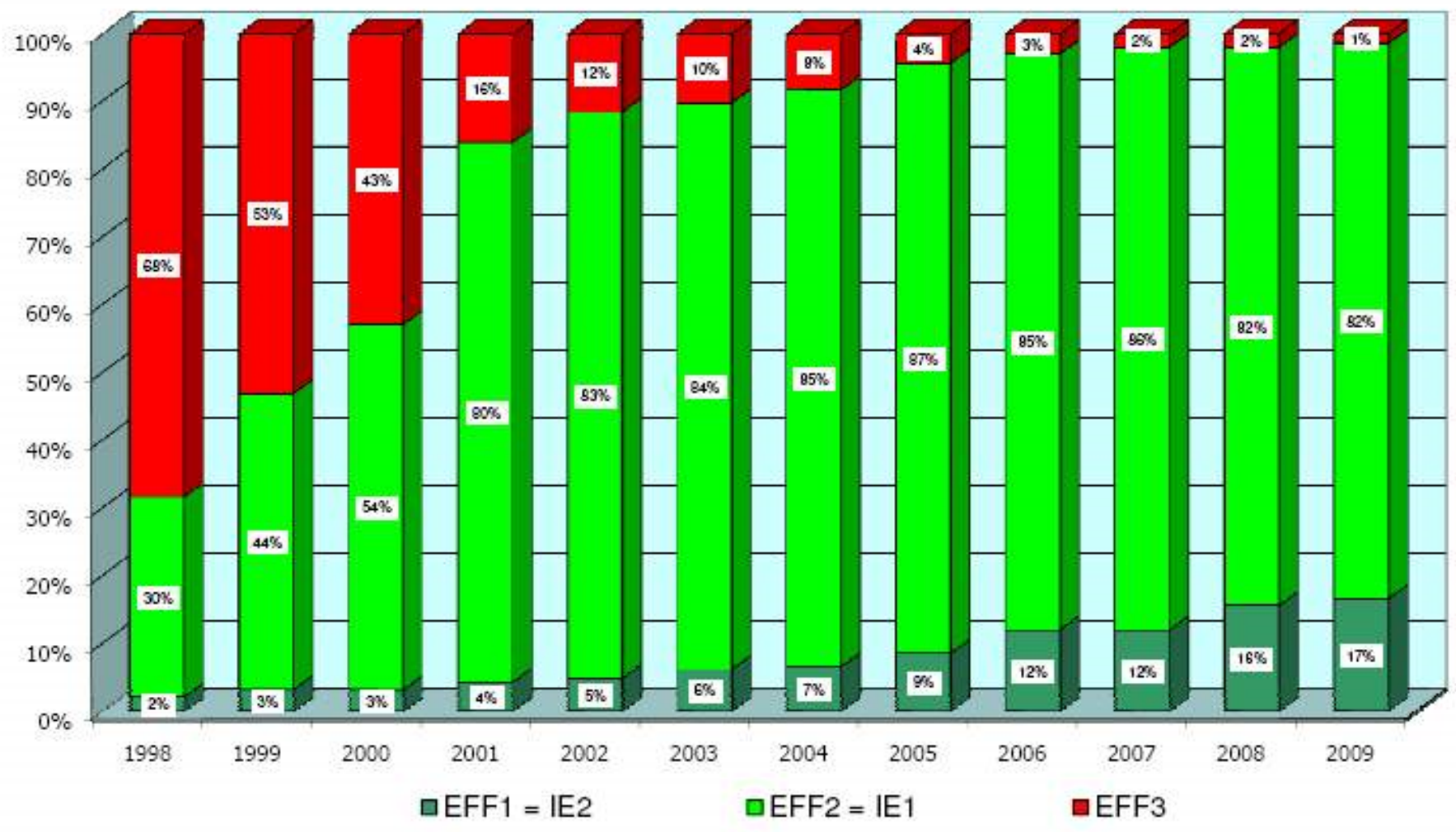
- In order to promote a competitive motor market transformation, a new international standard, **IEC 60034-30** has been approved – Nov 2008
- This standard globally harmonizes motor energy-efficiency classes in general-purpose, line-fed, three-phase, single speed squirrel-cage, induction motors (IMs) in the range 1-500 hp (0.75-375 kW).
 - Four efficiency classes are proposed, namely:
 - Standard Efficiency (IE1),
 - High-Efficiency (IE2) equivalent to EPAAct,
 - Premium Efficiency (IE3) equivalent to NEMA Premium and
 - **Super-Premium Efficiency (IE4)**
- IE1, IE2 and IE3 classes were normative,
IE4 class was intended to be informative, since no sufficient market and technological information is available to allow IE4 standardization.-

IEC 60034-31



How far are we from IE4 in EU?

Market share of EFF-motors in the scope of the Voluntary Agreement of CEMEP





Electric motor efficiency classes, testing standards and regulation over time - No IE4

Efficiency Levels	Efficiency Classes	Testing Standard	Performance Standard
	IEC 60034-30	IEC 60034-2-1	Mandatory MEPS
Premium Efficiency	IE3	Low Uncertainty	USA 2010 Europe 2015/17
High Efficiency	IE2		USA 2001
			Canada 1997
			Australia 2006
			Korea 2008
			Brazil 2009
			Europe 2011
			Switzerland 2011
			China 2009
Standard Efficiency	IE1		China
			Taiwan 2003
			Switzerland 2010

Source: A+B International 2009 (updated by the IEA)



What is a Super-Premium Motor ?

- -NEMA Premium (IE3) have at least 15% lower losses than EPEX (IE2) motors
- A Super-Premium (new IE4 Class) must have at least a 15% loss difference in relation to IE3
- What is the feasibility and the ambition?

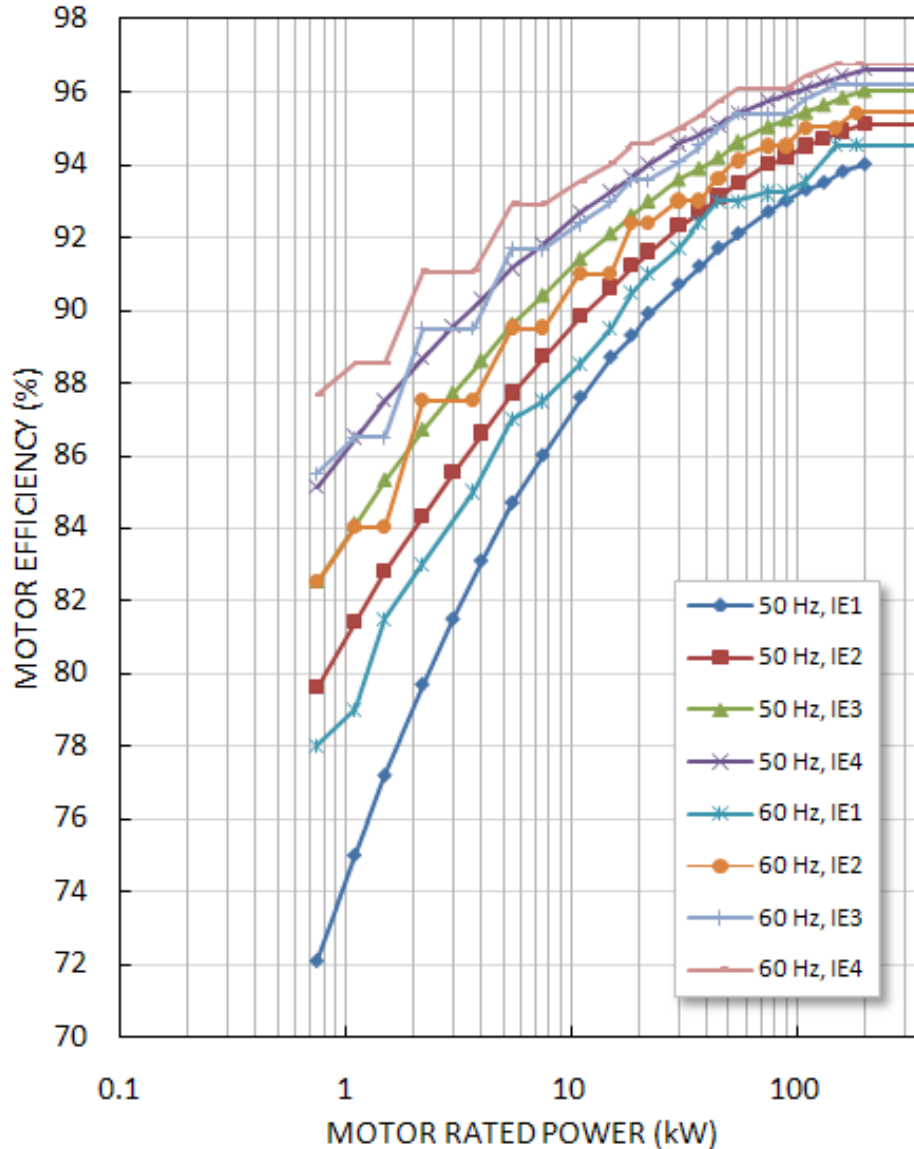


NEW MOTOR EFFICIENCY CLASSIFICATION STANDARD

- The IE4 Super-Premium class, under discussion, can be applied both to line-fed motors and to inverter plus motor units.
- In fact, for low-power levels (up to 10 hp) moving away from IM technology, and considering emergent or best-available technologies such as permanent-magnet synchronous motors (PMSMs) can achieve efficiency levels considerably significantly higher than those defined by Premium IE3 class.
- Feasible limits for IE4 class are analysed taking into account the efficiency levels of commercial and expected best available technology.
- The presented results can be useful to define future international standard “Super-Premium” or IE4-class levels as well as to set market transformation strategies.



EFFICIENCY LIMITS FOR INDUCTION MOTORS

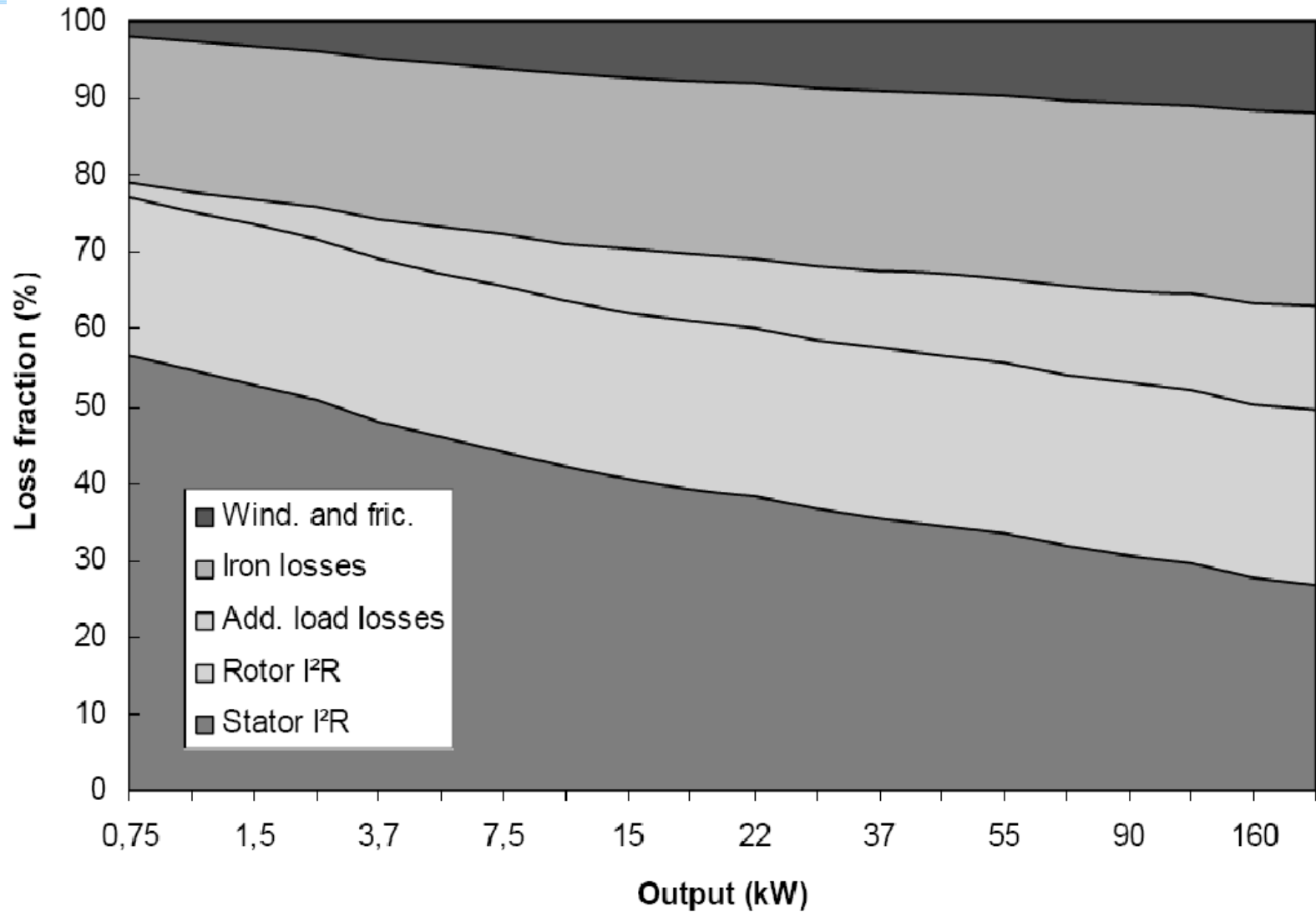


IEC 60034-30 and CEMEP/EU efficiency levels (4-pole IMs) for 60 & 50 Hz.

Minimum IE4 is shown



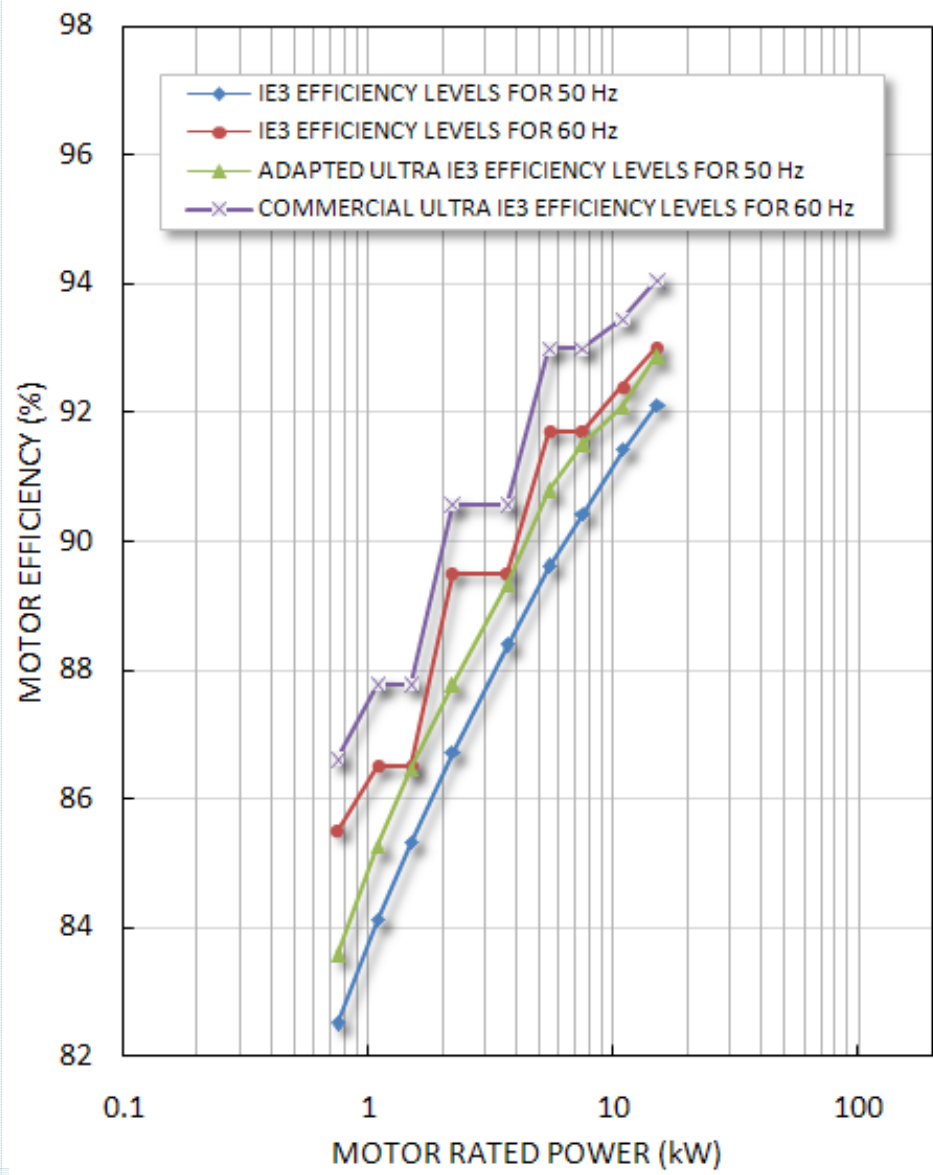
EFFICIENCY LIMITS FOR INDUCTION MOTORS



Typical fraction of losses in 4-pole, 50-Hz IMs.



EFFICIENCY LIMITS FOR INDUCTION MOTORS



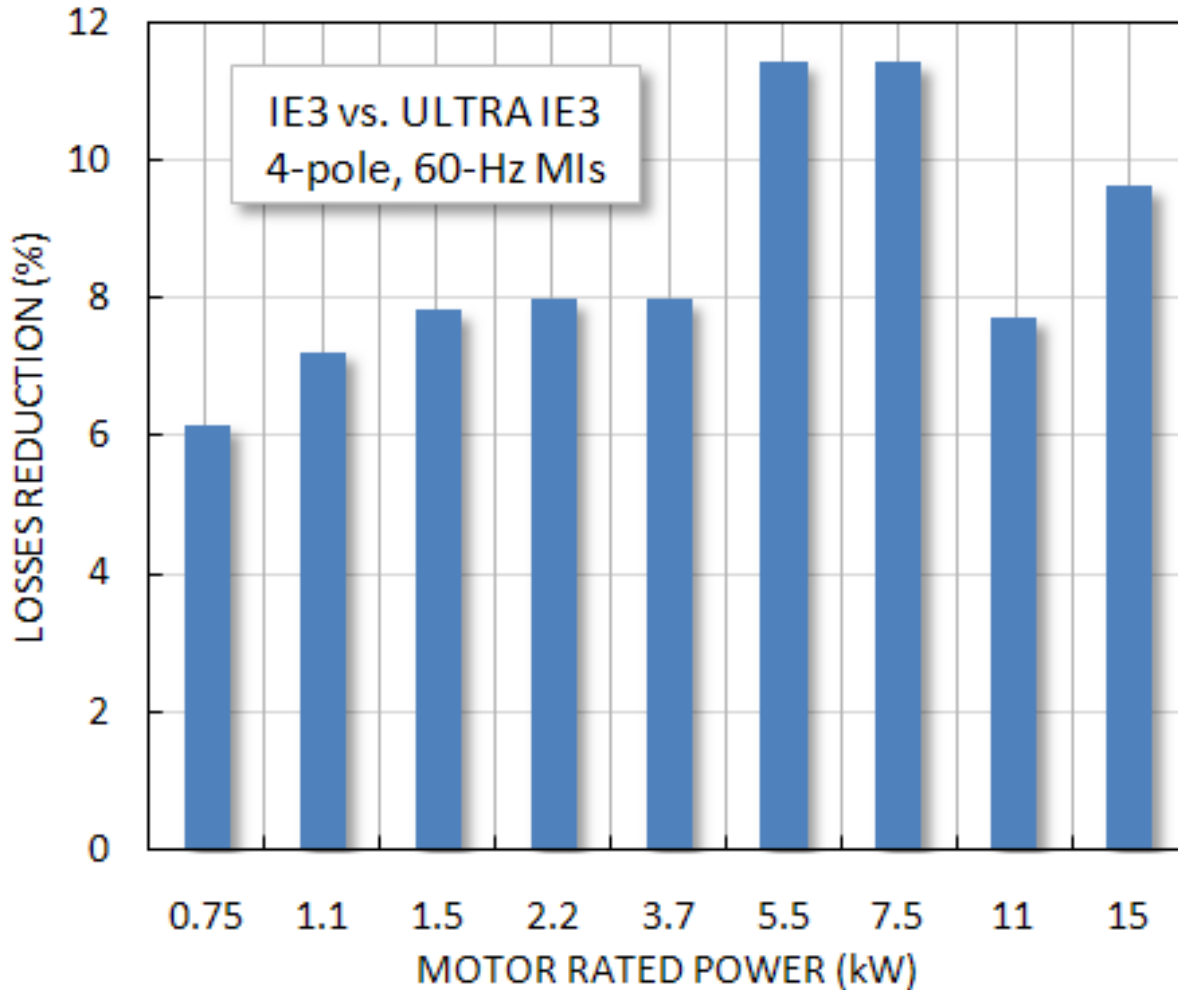
Commercially available “ultra” IE3 efficient 4-pole, 60-Hz IMs.

-Copper rotors

-More active materials



EFFICIENCY LIMITS FOR INDUCTION MOTORS



Losses variation between IE3-class efficiency levels and commercially available “ultra” efficient 4-pole, 60-Hz IMs.



IE4 Motor Promising Technologies

- Line-Start Permanent Magnet with Auxiliary Rotor Cage for fixed speed applications.
- Permanent Magnet Motor driven by an electronic Variable Speed Drive (VSD) for variable speed applications
 - Speed and torque control is possible
 - Large energy savings possible (e.g. variable flow pump and fan applications)
 - Losses of VSD must be taken into account



PM MOTOR TECHNOLOGIES

- High Torque/weight ratio for motion control
(NeFeBo Magnets) for motion control – High cost
- Low starting torque applications
(ceramic magnets) – similar cost to induction motors,
excluding electronic controller.



EFFICIENCY LIMITS FOR LINE-START PM MOTORS

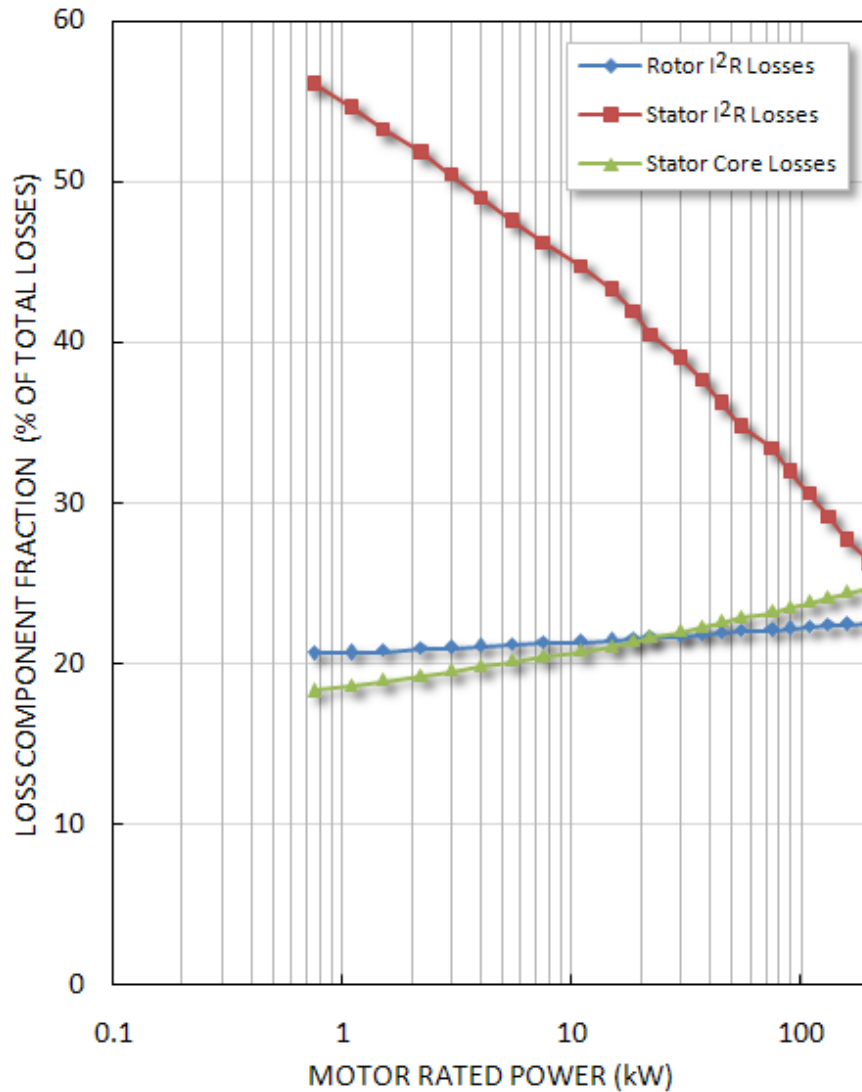


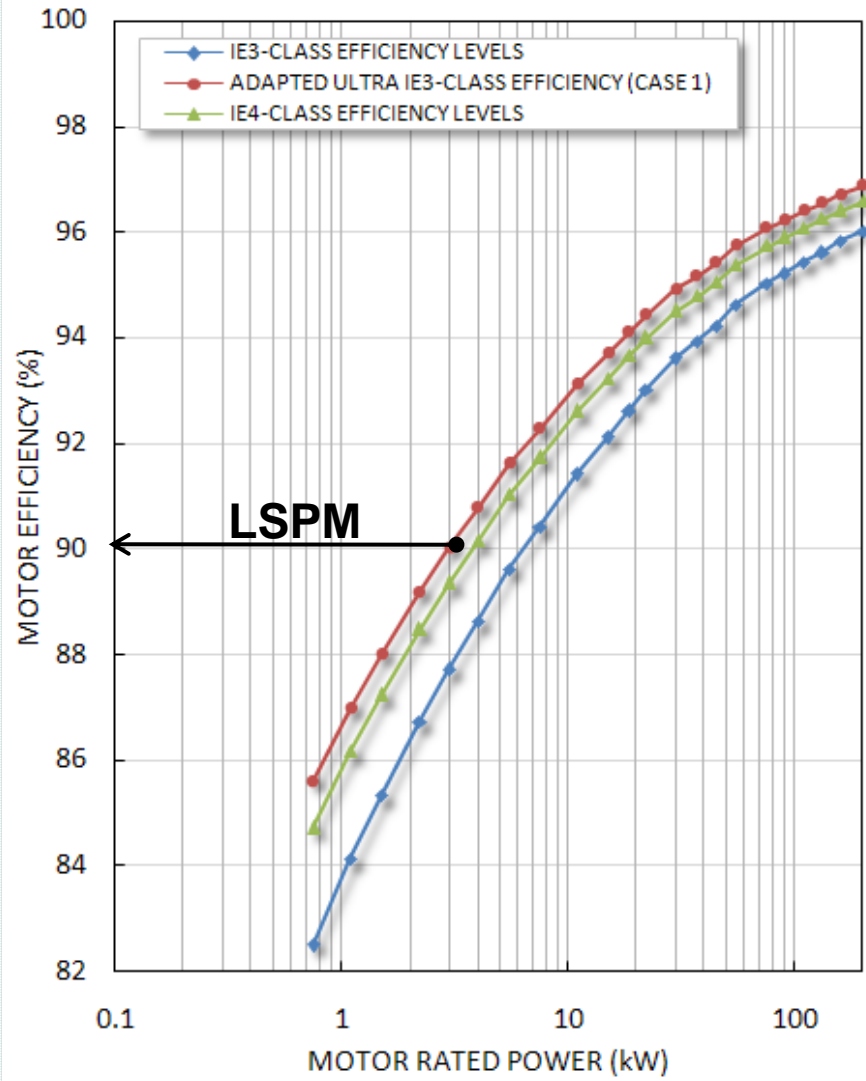
Figure shows motor loss component fraction (in % of total losses) in IMs (induction motors).

Line-Start PMSMs with Auxiliary Rotor Cage can significantly reduce those losses, particularly the rotor losses



EFFICIENCY LIMITS FOR LINE-START PM MOTORS

Line-Start PM Motors with Auxiliary Rotor Cage

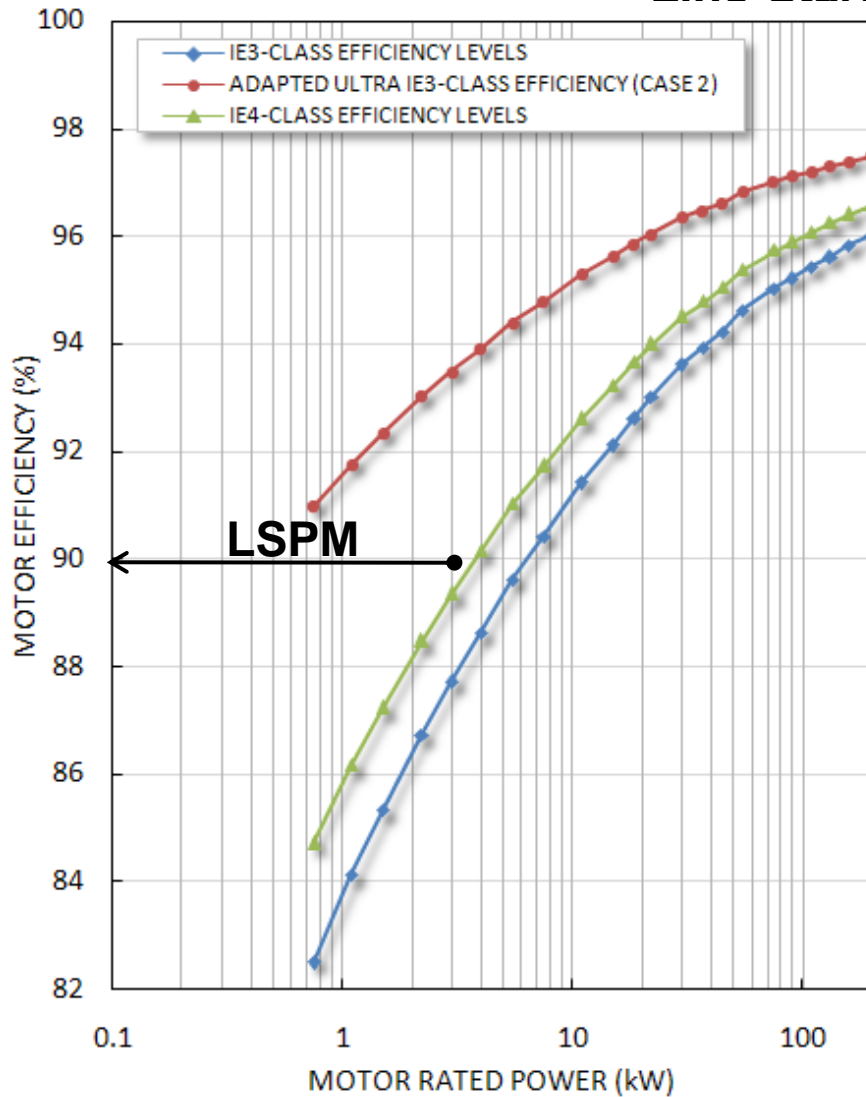


Full-load efficiency levels after rotor I²R losses elimination in 4-pole, 50-Hz, IE3-Class IMs



EFFICIENCY LIMITS FOR LINE-START PM MOTORS

Line-Start PM Motors with Auxiliary Rotor Cage

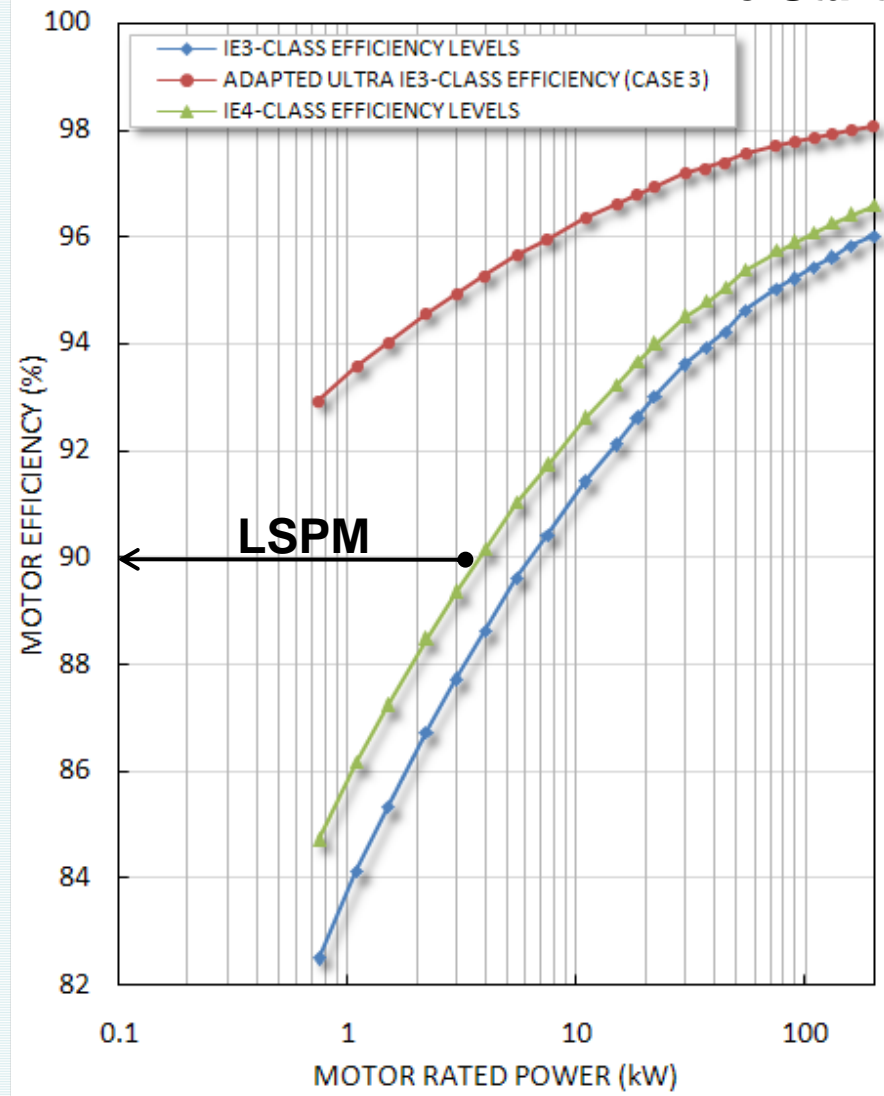


Full-load efficiency levels after rotor I²R losses elimination and stator I²R losses reduction in 4-pole, 50-Hz, IE3-Class IMs



EFFICIENCY LIMITS FOR LINE-START PM MOTORS

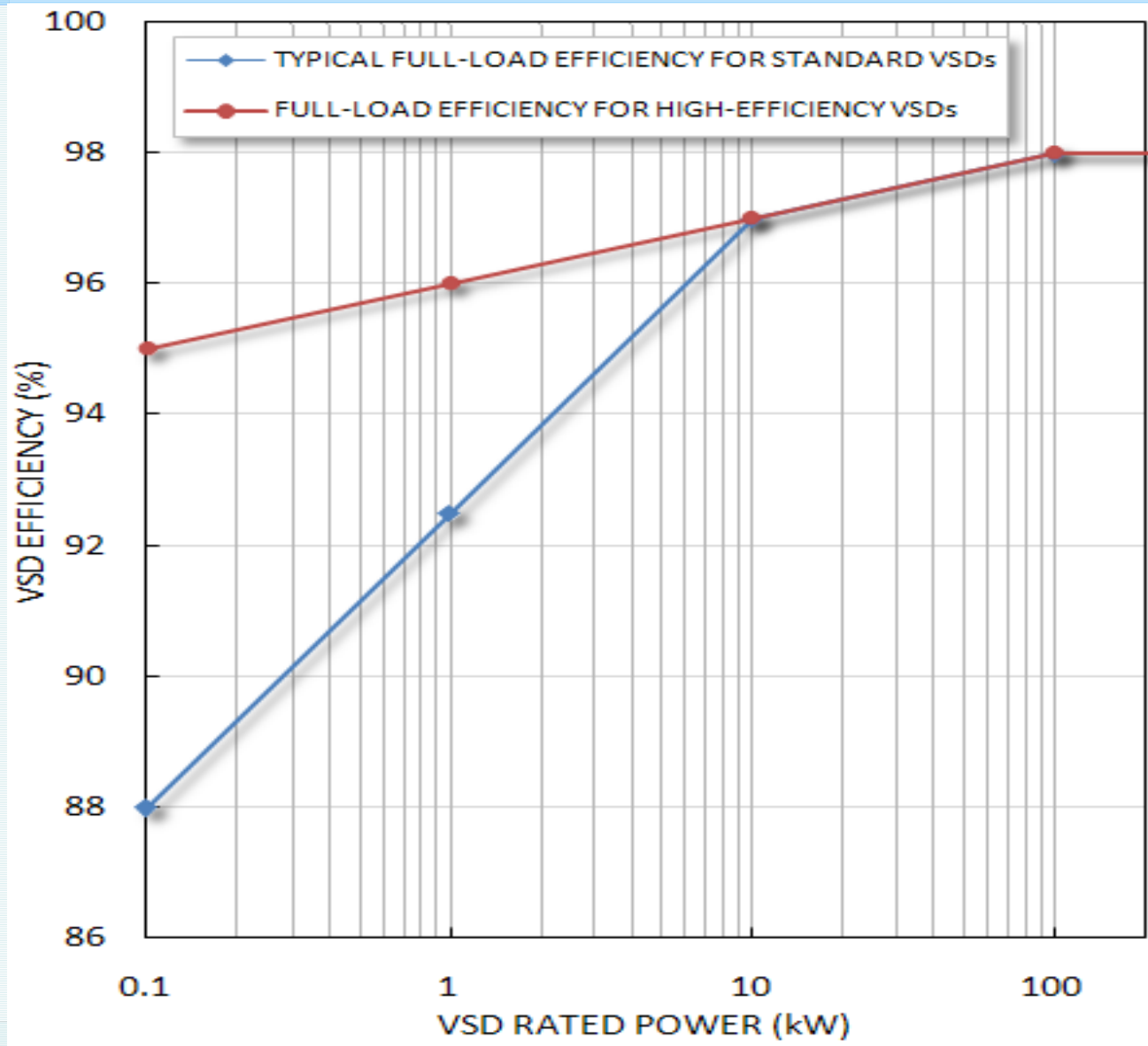
Line-Start PM Motors with Auxiliary Rotor Cage



Full-load efficiency levels after rotor I²R losses elimination and stator I²R and core losses reduction in 4-pole, 50-Hz, IE3-Class IMs

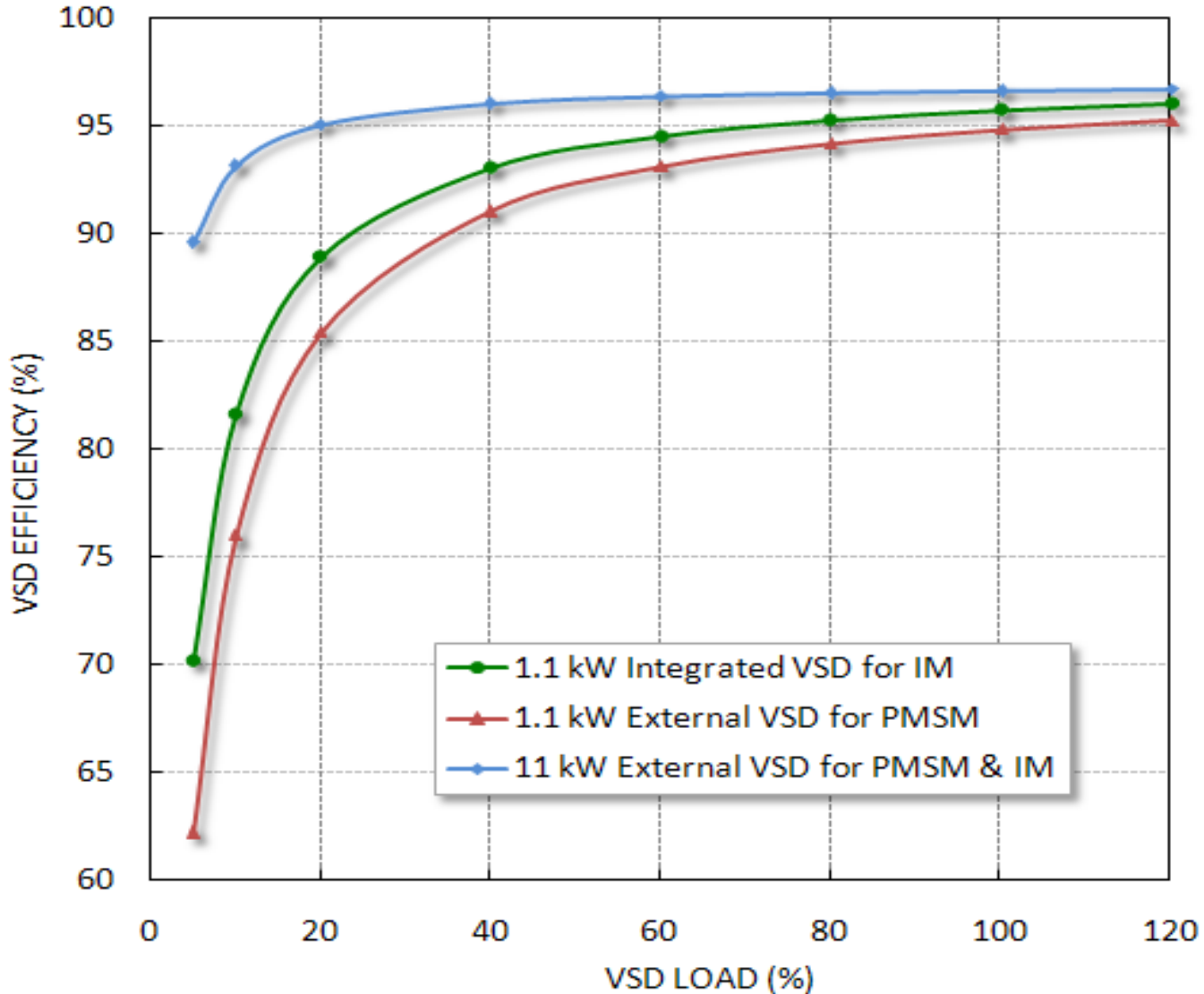


Typical full-load efficiency levels for VSDs



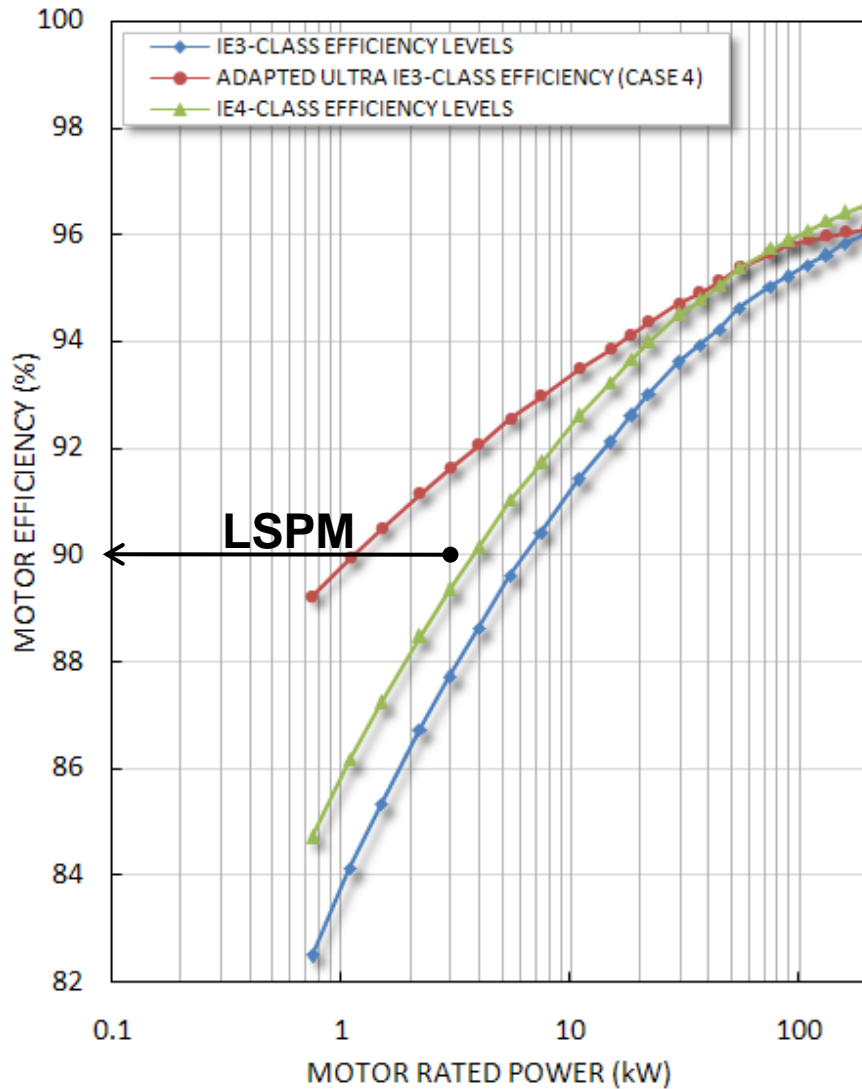


Performance for high-efficiency 1.1- and 11-kW VSDs





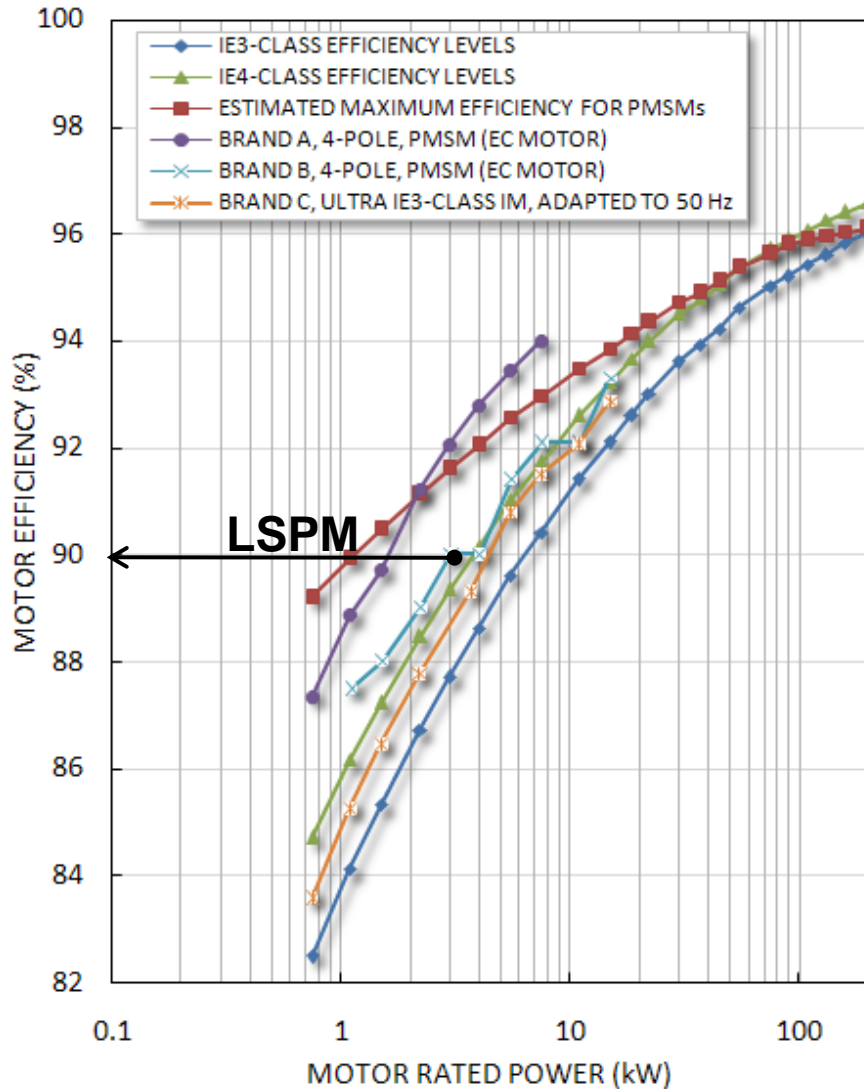
EFFICIENCY OF PM MOTORS COUPLED WITH VSDs



Full-load efficiency levels for motor-VSD units, considering rotor I^2R losses elimination and stator I^2R and core losses reduction in 4-pole, 50-Hz IE3-Class IMs, as well as the VSD efficiency



COMPARISON OF COMMERCIAL EFFICIENCIES

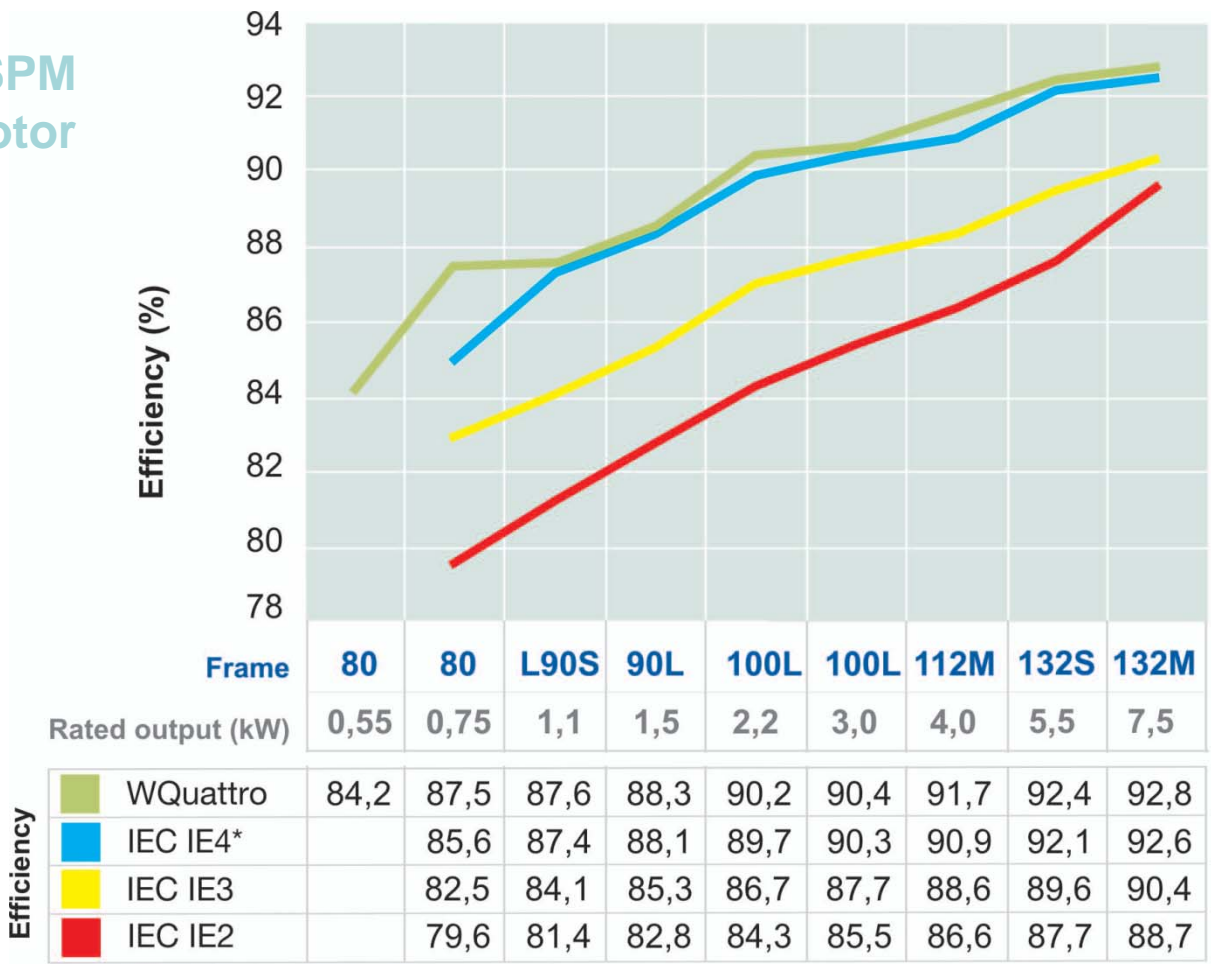


Comparison of standard efficiency levels, commercial PM full-load efficiency (including VSD), and the estimated maximum efficiency levels for PMSMs with integrated VSD



New Super Premium Efficiency Motor

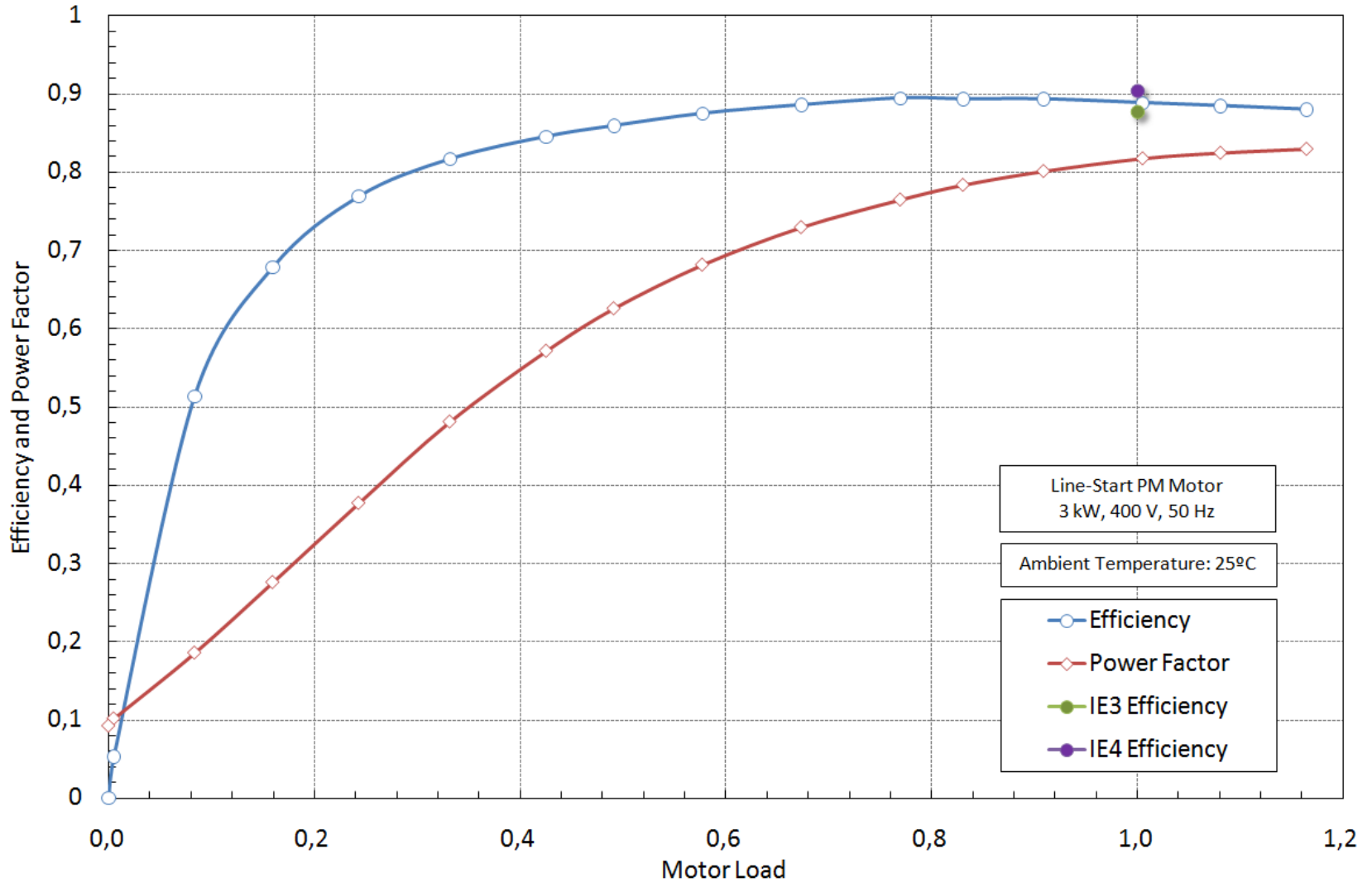
LSPM
Motor





Commercial LSPM motor at rated voltage

Source: ISR-UC





CONCLUSIONS

- PM motors can be significantly more efficient than IMs, in the low power range.
- Regarding single-speed applications, with direct mains operation, the IM still has some cost advantage, although line-start PMs may become a cost-effective alternative with new developments.
- Starting torque of line start PM motors is being improved.
- In variable speed applications, low power applications PMs motors with VSD have higher energy efficiency than IMs coupled with VSDs, and they may have similar costs.
- Since the energy-savings potential associated with super-premium IE4-class motors is large, and the technology to achieve such efficiency levels is already available to be produced in large-scale, it makes sense to promote such motors, by means of proper classification and labelling schemes



“SUPER-PREMIUM EFFICIENCY STANDARDS FOR ELECTRIC MOTORS”

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IEEE Industrial Applications Magazine

January 2011