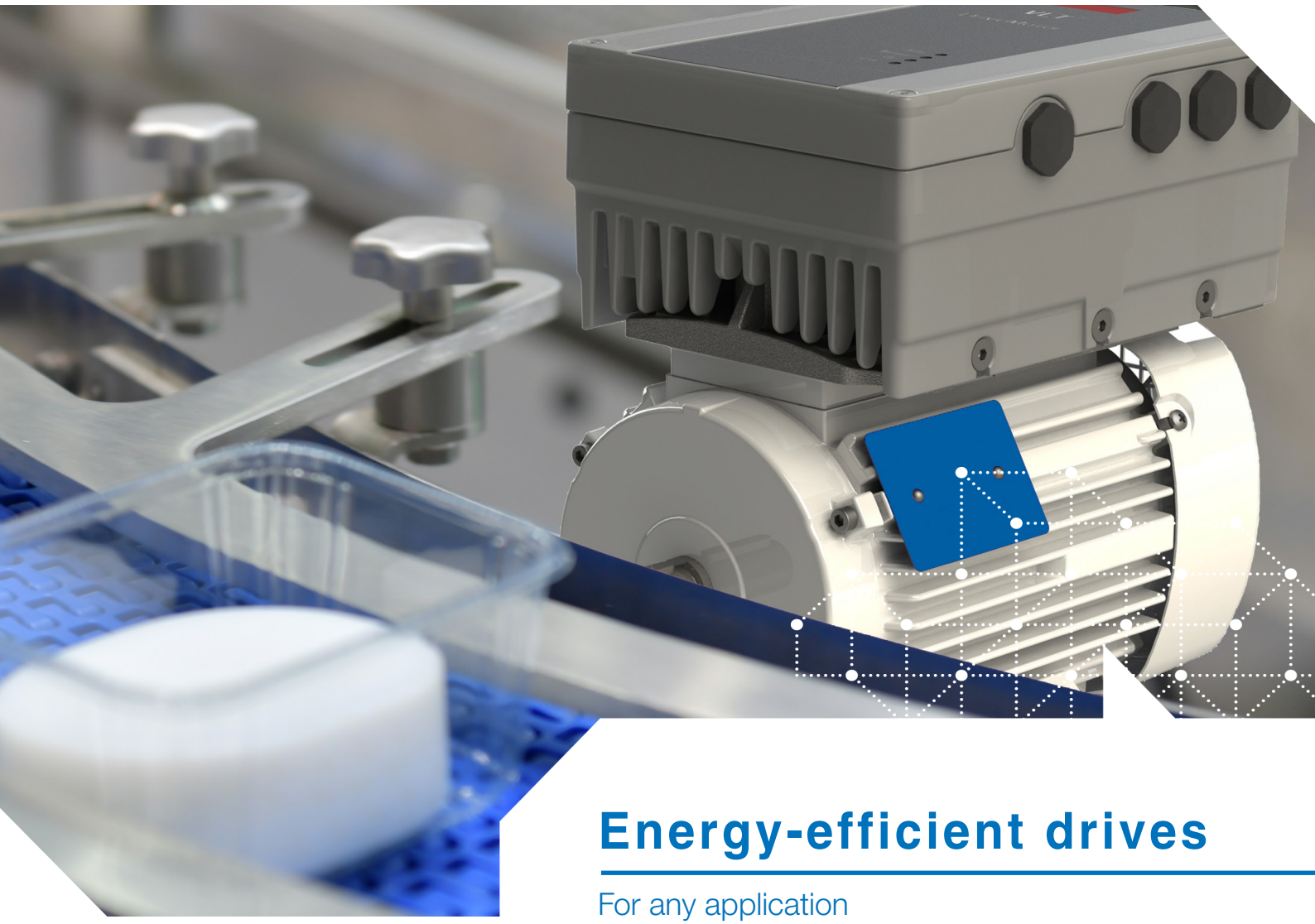
VEM

ELECTRIC DRIVES

FOR EVERY DEMAND



Energy-efficient drives

For any application

IE5 (interim release 02/2020)

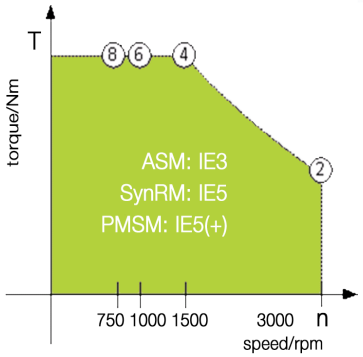
Power being supplied as demanded – not needed energy is the cheapest available

Many processes do not require a constant power input. Be it because compressed air is only used from time to time, the amount of cooling water required depends upon the ambient conditions or a mounted tool must only be moved during certain phases. In case each respective motor would run at a constant operating point, the design or selection would be easy and the motor could be connected directly to the grid. However, the power consumption would be on a constant level as well, which meant a significant waste of electrical energy.

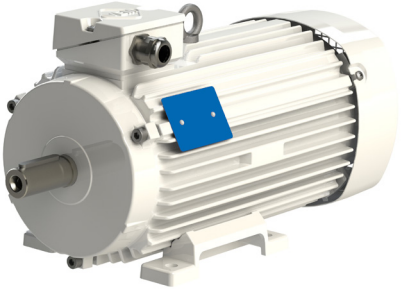
Adding a frequency converter to the motor enables this „drive“ to adapt to the actual requirements which means that energy is only used when actually needed. Additionally it becomes easier to overload the drive for certain periods—enabling the customer to buy a smaller motor.

Saving energy and benefitting additionally

Besides saving energy through running the drive only when needed and at an adjusted load level there are more aspects to consiger when choosing the right motor for an application. Weight can be reduced by selecting a smaller motor and overloading it when necessary or by permanent magnet synchronous motors (PMSM) that offer a very high torque to mass ratio. The diversity of spare motors in storage might be reduced by choosing synchronous reluctance motors (SynRM) that cover a wide torque-speed range. Recyclability can be maximized by only having iron sheets in the rotor, as with SynRM.
We at VEM are happy to help you clarify these questions and any others that may arise during a motor selection process. However, in any way highest efficiency levels are guaranteed as we offer both SynRM and PMSM at IE5 level for the complete standard range of each frame size, at reasonable pricing.

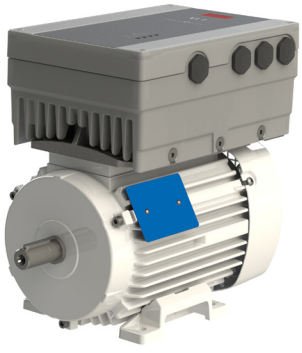


IE5-permanentmagnet synchronous machines and IE5-synchronous reluctance machines are available with external frequency inverters or as compact drives



IE5-RS1R 100 LZ4

Exemplary Inverter FC 302 for wall mounting



MRS1R 80 G4 as compact drive with directly mounted inverter (here FCP 106)

Thinking application, environment and drive together – in the optimal combination

We support you in your application specific selection of motor and inverter. Our portfolio of induction machines, permanent-magnet synchronous and synchronous reluctance machine provides an optimal solution for every application.

Typical aspects to consider during motor selection

energy efficiency

heating/cooling

reparability

recyclability

dynamic

number of different spare motors in storage

overload and field weakening capability

frame size

cost

robustness, maintenance and lifetime

noise

maximum speed

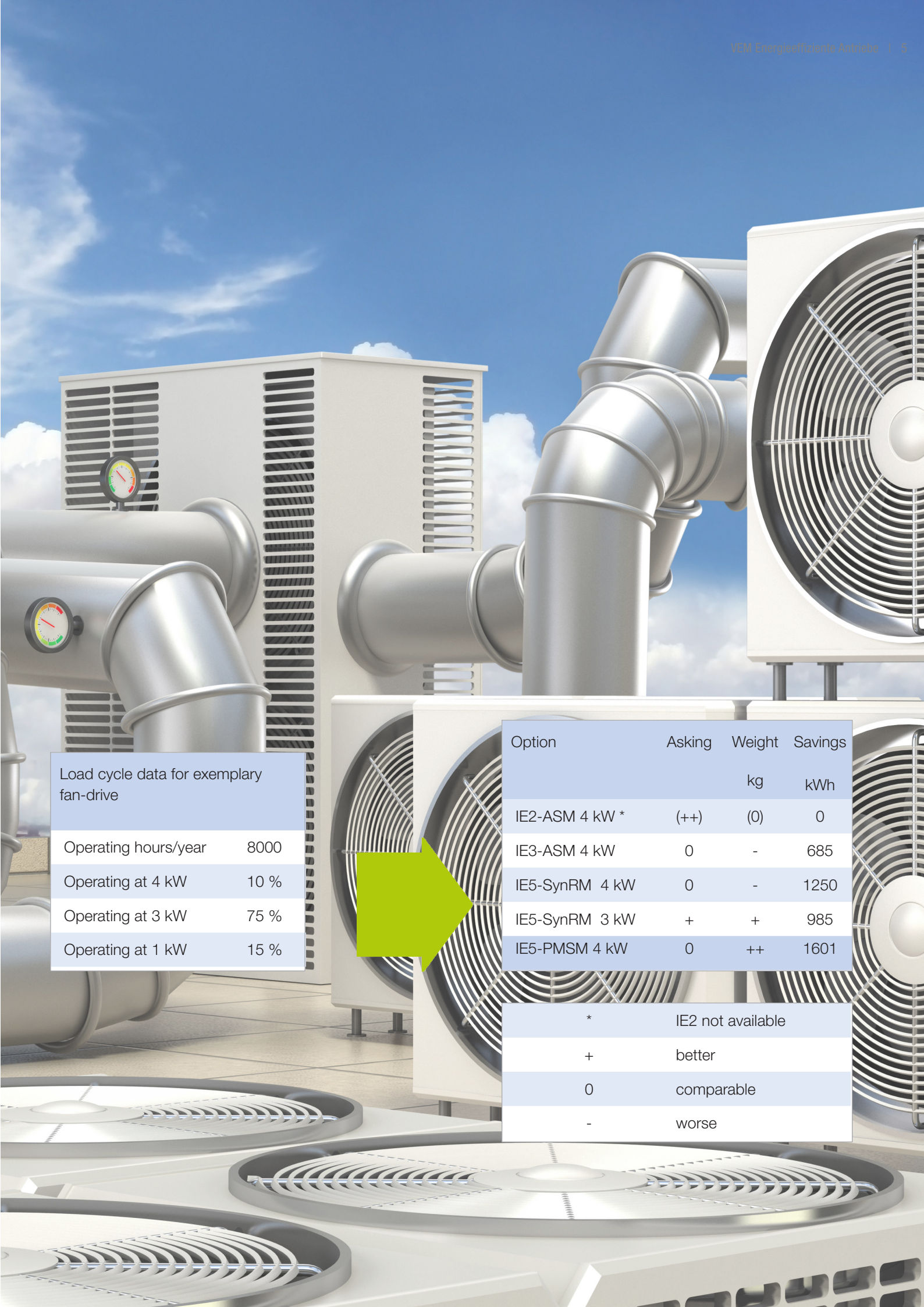
Example — replacing the motor for a fan:

An exemplary fan runs 24/7. During warm days with full load at 4 kW and 1500 rpm. More often however it needs to run at 3 kW, sometimes even just 1 kW.

The current motor is a 4 kW rated IE2 induction motor, equipped with a 4 kW standard frequency converter.

Which options are available to replace the motor?

While keeping the frequency inverter unchanged as a standard 4 kW model, different choices are possible for the motor. The options are:
1) IE3-Induction motor 4 kW rating
2) IE5-Permanent Magnet synchronous motor 4 kW rating
3) IE5-Synchronous reluctance motor 4 kW rating
4) IE5-Synchronous reluctance motor 3 kW rating
For the given example we would recommend selecting the 3 kW rated synchronous reluctance motor. For the given load variations it offers the best compromise between cost and energy savings, because of its overload capability and low weight.



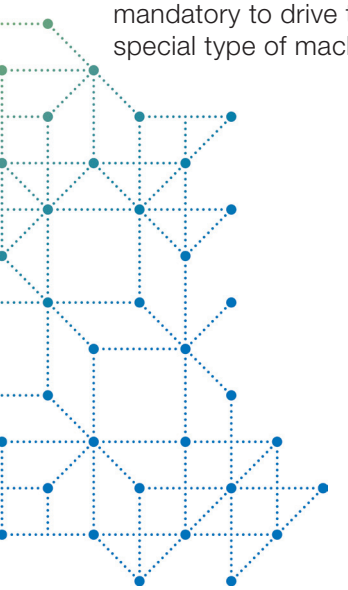
Load cycle data for exemplary fan-drive	
Operating hours/year	8000
Operating at 4 kW	10 %
Operating at 3 kW	75 %
Operating at 1 kW	15 %

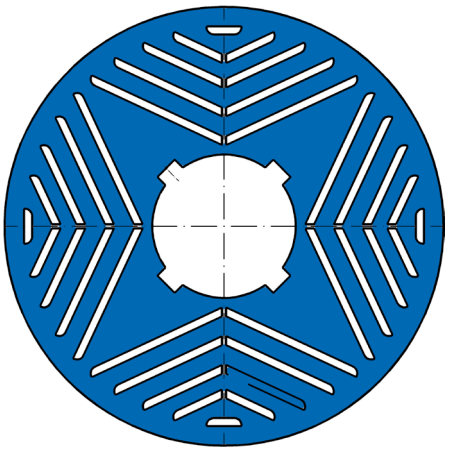
Option	Asking	Weight	Savings
		kg	kWh
IE2-ASM 4 kW *	(++)	(0)	0
IE3-ASM 4 kW	0	-	685
IE5-SynRM 4 kW	0	-	1250
IE5-SynRM 3 kW	+	+	985
IE5-PMSM 4 kW	0	++	1601

*	IE2 not available
+	better
0	comparable
-	worse

Synchronous reluctance machines

The only visible difference between an induction and synchronous reluctance machine (SynRM) is the rotor design. There are no permanent magnets or electrical conductors present. Instead of slots for copper bars or pockets for pernanent magnets the rotor presents a design with barriers that are filled with air. The design and structure of the barriers therefore determines the achievable torque and operating behaviour. This leads to a few advantages such as high efficiency or good recyclability but also makes it mandatory to drive the machine with an inverter capable of controlling this special type of machines.





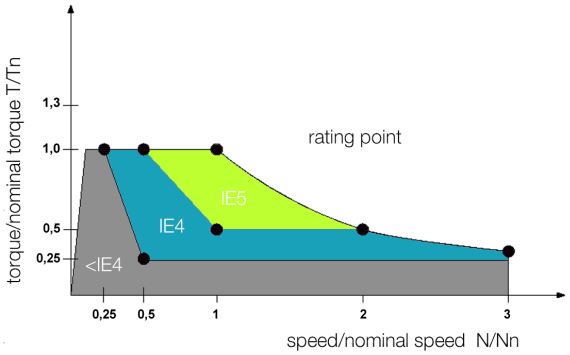
Exemplary cross section of a reluctance rotor

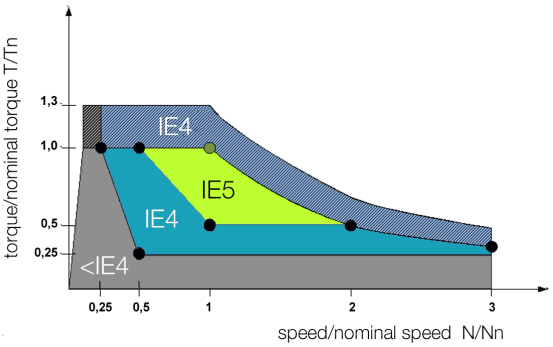
VEM is able to deliver a compatible unit of motor and frequency inverter (e.g. compact drive MRS1R)

High Efficiency and overload capability

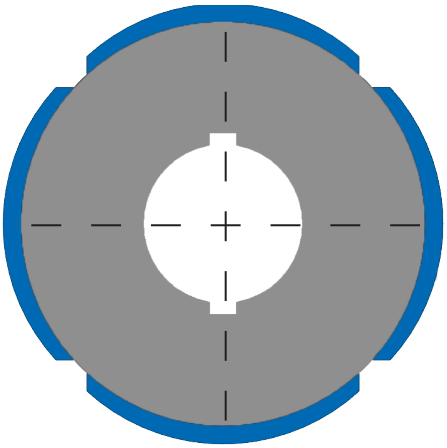
Synchronous reluctance machines (SynRM) from VEM excel with a very high efficiency level throughout the whole operating range. The machines achieve the highest currently defined efficency level “IE5“ (acc. to IEC-TS 60034-30-2) not only at the rated point, but in a range from half the rated power up to twice the rated speed. If an inverter type with higher current output capability is chosen, the machines can be overloaded with at least 30% more torque while remaining at least in IE4 efficiency level. Moreover all machines are capable of operating in the field weakening range up to 3600 rpm.

We are currently developing motors that can be run up to 8000 rpm. Contact us if you are interested in high speed SynRM!





Permanent magnet synchronous machines



Exemplary cross section of a permanent magnet rotor

Permanent magnet excited synchronous machines (PMSM) differ from induction machines only by the rotor design. Often there is simply an isotropic rotor with a smooth surface on which permanent magnets are mounted. This type of machines achieves the highest efficiency levels because there is no extra current necessary to produce a rotor field component, as it is with induction and synchronous reluctance machines. However, while this advantage is even higher in the partial load area it is reduced in the overload and field weakening range. Especially in the latter the power output and efficiency reduce strongly because current is needed to weaken the permanent magnet excitation.

Thanks to these properties PMSM can be built one frame size step smaller at the same rated output power and are therefore extraordinarily compact. They need an inverter too, however and are not capable of starting while directly connected to the grid.

Aspect	SynRM	PMSM	Induction Motor
Efficiency at rated point	+	++	0
Power factor	0	+	0
Frame size	0	++	0
Overload capability	+	0	+
Field weakening capability	+	0	+
Recyclability	++	-	0
Dynamics	+	0	+
Robustness	+	0	+
Cost	0	- *	+

* Might be cheaper due to reduced size compared to SynRM

Catalogue data

SynPM Type	P [kW]	T_n [Nm]	T_{max} [Nm]	n [rpm]	η [%]	I [A]	cos φ
IE5-PS1R 71 G4	0.37	2.4	14	1500	84.3	0.77	0.99
IE5-PS2R 80 K4	0.55	3.5	14	1500	86.7	1.12	0.99
IE5-PS1R 80 G4	0.75	4.8	19	1500	88.2	1.6	0.99
IE5-PS2R 90 SX4	1.1	7	28	1500	89.5	2.35	0.99
IE5-PS1R 90 L4	1.5	9.5	45	1500	90.4	3.15	1
IE5-PS2R 100 L4	2.2	14	45	1500	91.4	4.5	0.99
IE5-PS1R 100 LX4	3.0	19.1	50	1500	92.1	5.65	0.99
IE5-PS1R 112 M4	4.0	25.5	70	1500	92.8	7.8	0.99
IE5-PS1R 132 S4T	5.5	35	100	1500	93.4	10.5	0.99
IE5-PS1R 132 MX4	7.5	47.8	120	1500	94	14.2	0.98
IE5-PS1R 160M 4	11	70	a.A.	1500	94.5	19.5	1
IE5-PS1R 160L 4	15	96	a.A.	1500	95.1	25.5	1
IE5-PS1R 180M 4	18.5	118	a.A.	1500	95.3	31.5	1
IE5-PS2R 180M 4	22	140	a.A.	1500	95.7	38	1
IE5-PS1R 180L 4	30	191	a.A.	1500	95.9	51	0.99
IE5-PS1R 200L 4	37	236	a.A.	1500	96.2	62.5	1
IE5-PS1R 225S 4	45	287	a.A.	1500	96.3	78	1
IE5-PS1R 225M 4	55	350	a.A.	1500	96.5	96	1

For SynRM the operating range and efficiency levels is valid according to the figures on page 6.
Currently we successfully tested these inverter families:
Wall mounting: Danfoss FC 302, Delta Electronics, Kostal Inveor
Compact drives: Danfoss FCP 106, Kostal Inveor

SynRM Type	P [kW]	T_n [Nm]	T_{max} [Nm]	n [rpm]	η [%]	I [A]	cos φ
IE5-RS1R 80 G4	0.75	4.8	1500	4500	88.2	1.80	0.62
IE5-RS1R 90 S4	1.1	7	1500	3600	89.5	2.65	0.71
IE5-RS1R 90 LX4	1.5	9.5	1500	3600	90.4	3.30	0.74
IE5-RS1R 100 L4	2.2	14	1500	3600	91.4	5.90	0.69
IE5-RS1R 100 LZ4	3.0	19.1	1500	3600	92.1	7.20	0.73
IE5-RS1R 112 M4	4.0	25.5	1500	3600	92.8	9.50	0.73
IE5-RS1R 132 S4	5.5	35	1500	3600	93.4	12.05	0.77
IE5-RS1R 132 M4	7.5	47.8	1500	3600	94	15.90	0.81

Dimensions and weight

SynPM Type	P [kW]	J [kgm²]	m [kg]	AC [mm]	L [mm]	HD [mm]	AB [mm]
IE5-PS1R 71 G4	0.37	0.00087	11	139	239	182	135
IE5-PS2R 80 K4	0.55	0.00107	11.7	139	249	191	168
IE5-PS1R 80 G4	0.75	0.00107	14.5	157	265	200	152
IE5-PS2R 90 SX4	1.1	0.00207	18	157	297	210	178
IE5-PS1R 90 L4	1.5	0.00260	22.5	177	321	217	178
IE5-PS2R 100 L4	2.2	0.00260	23.5	177	331	227	193
IE5-PS1R 100 LX4	3.0	0.00400	30	196	357	236	193
IE5-PS1R 112 MX4	4.0	0.00725	37	196	391	248	225
IE5-PS1R 132 S4T	5.5	0.00900	47	196	460	287	256
IE5-PS1R 132 M4	7.5	0.02000	68	217	527	310	256
IE5-PS1R 160M 4	11	0.03100	110	258	559	374	296
IE5-PS1R 160L 4	15	0.06800	143	313	609	402	296
IE5-PS1R 180M 4	18.5	0.06800	143	313	609	422	328
IE5-PS2R 180M 4	22	0.09300	190	313	609	422	328
IE5-PS1R 180L 4	30	0.12600	223	351	680	441	328
IE5-PS1R 200L 4	37	0.16200	216	351	680	461	372
IE5-PS1R 225S 4	45	0.26900	265	390	757	525	413
IE5-PS1R 225M 4	55	0.30800	314	390	797	525	413

SynRM Type	P [kW]	J [kgm²]	m [kg]	AC [mm]	L [mm]	HD [mm]	AB [mm]
IE5-RS1R 80 G4	0.75	0.0017	16	157	287	200	152
IE5-RS1R 90 S4	1.1	0.0024	21	177	321	217	178
IE5-RS1R 90 LX4	1.5	0.0032	29	177	376	217	178
IE5-RS1R 100 L4	2.2	0.0068	34	196	391	236	193
IE5-RS1R 100 LZ4	3.0	0.0083	43	196	421	236	193
IE5-RS1R 112 M4	4.0	0.0120	63	217	507	290	226
IE5-RS1R 132 S4	5.5	0.0120	63	217	527	310	255
IE5-RS1R 132 M4	7.5	0.0330	90	258	579	331	256

Measurement verification for SynRM data

All prototypes achieve the highest defined efficiency level “IE5“ according to IEC TS 60034-30-2 at their respective rated point. Additionally all VEM machines excel over a wide operating range as depicted on page 6 and can be permanently overloaded or driven far into the field weakening range.

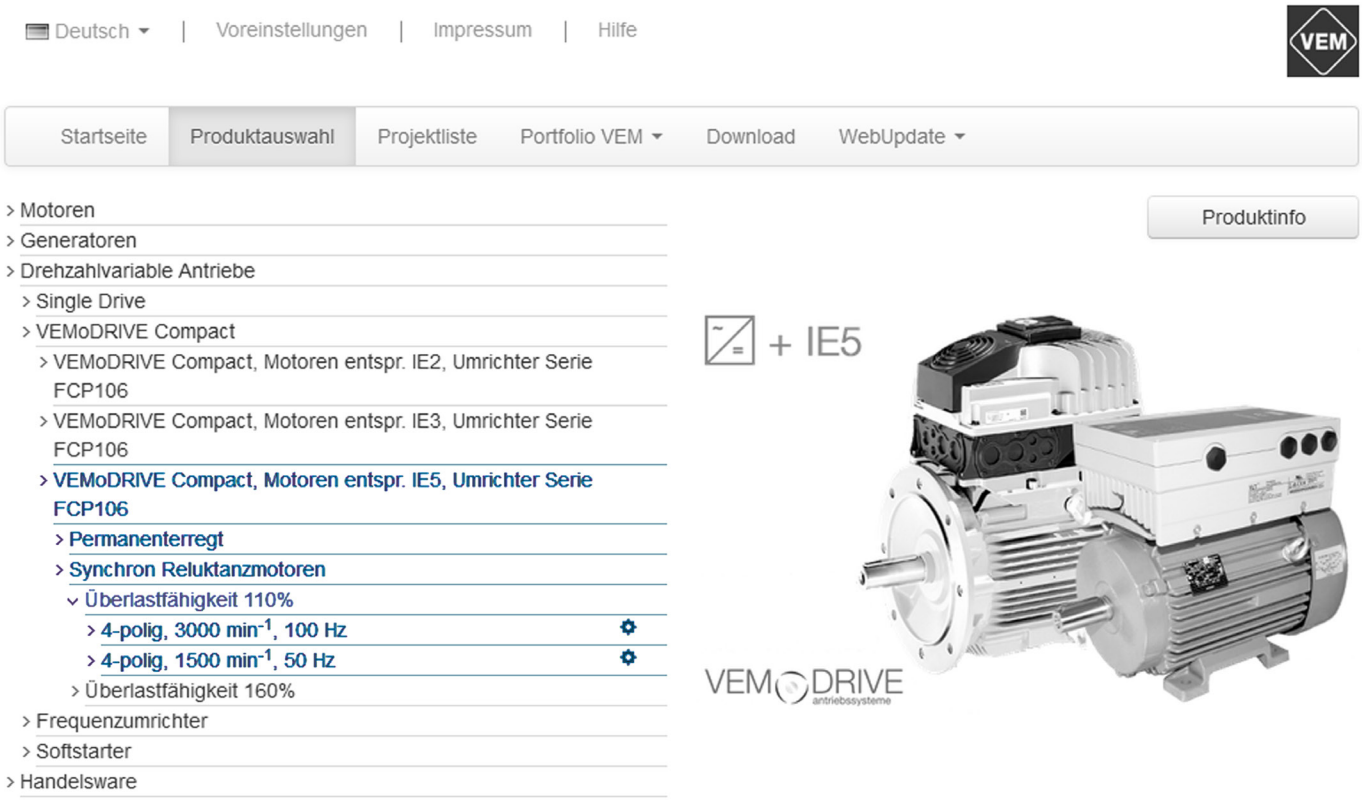
This can be supported by data obtained through measurement, here with a IE5-RS1R 112 M4 prototype, having a rated output of 4 kW at 1500 rpm. The machine can be permanently overloaded by as much as 86%, while also showing good efficiency in the field weakening range. It is therefore often reasonable to select a SynRM with less rated power than required by the load at its maximum. Due to the reduced mass the motor will then be more cost effective while still saving a lot of electrical energy. Ask us if you want to know which rated output would best fit your needs, we are happy to help you with that!

Test results of IE5-RS1R 112 M4

T [Nm]	n [rpm]	P_{mech} [W]	I1(1) [A]	U1(1) [V]	P_{input} [W]	η	IE-class
25.5	1500	4000	9.5	358	4310	92.81	IE5
12.75	1500	2000	6.4	346	2201	90.87	IE5
12.75	3000	4000	8.7	367	4317	92.66	IE5
10.6	3600	4000	9.5	368	4416	90.58	IE4 (IE5: 90.7)
35	1500	5500	12	371	5951	92.42	IE4 (IE5: 92.5)
47.75	1500	7500	15.9	370	8260	90.8	IE3 (IE4: 91.6)
28.6	1000	3000	10.4	261	3330	90.09	IE5
21	1000	2200	8.9	261	2459	89.47	IE5
7	750	550	6.9	197	715	76.92	IE4 (IE5: 78.3)

Where to continue

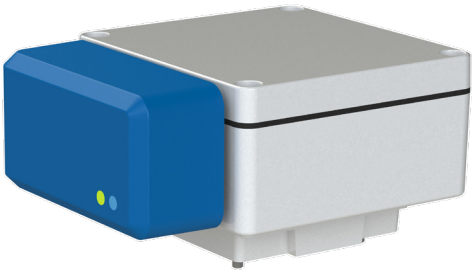
Online catalogue: VEMeKAT



Assessing necessary power and/or duty cycles

VEMoDiAC

Easy to mount motor monitoring system for any machine type, that can be fitted with almost all terminal boxes regardless of the machine producer.



We are happy to answer your questions and find the optimal solution for your drive. Do not hesitate to contact us.

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