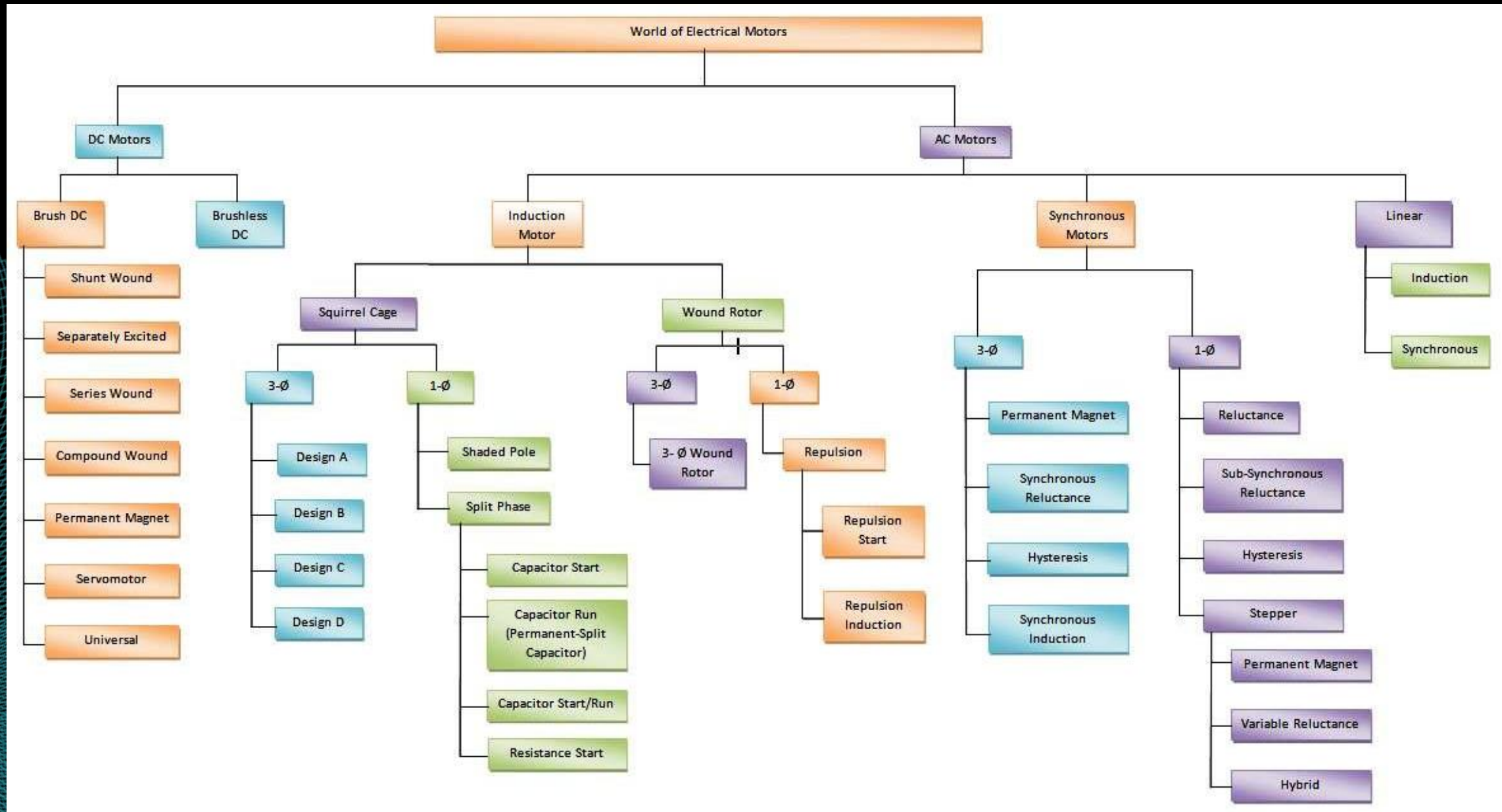
RAZVOJ ELEKTRIČNIH POGONOV ZA ELEKTRIČNA VOZILA

Simon Mandelj
28.2.2023

GEMmotors
The future of eMotion

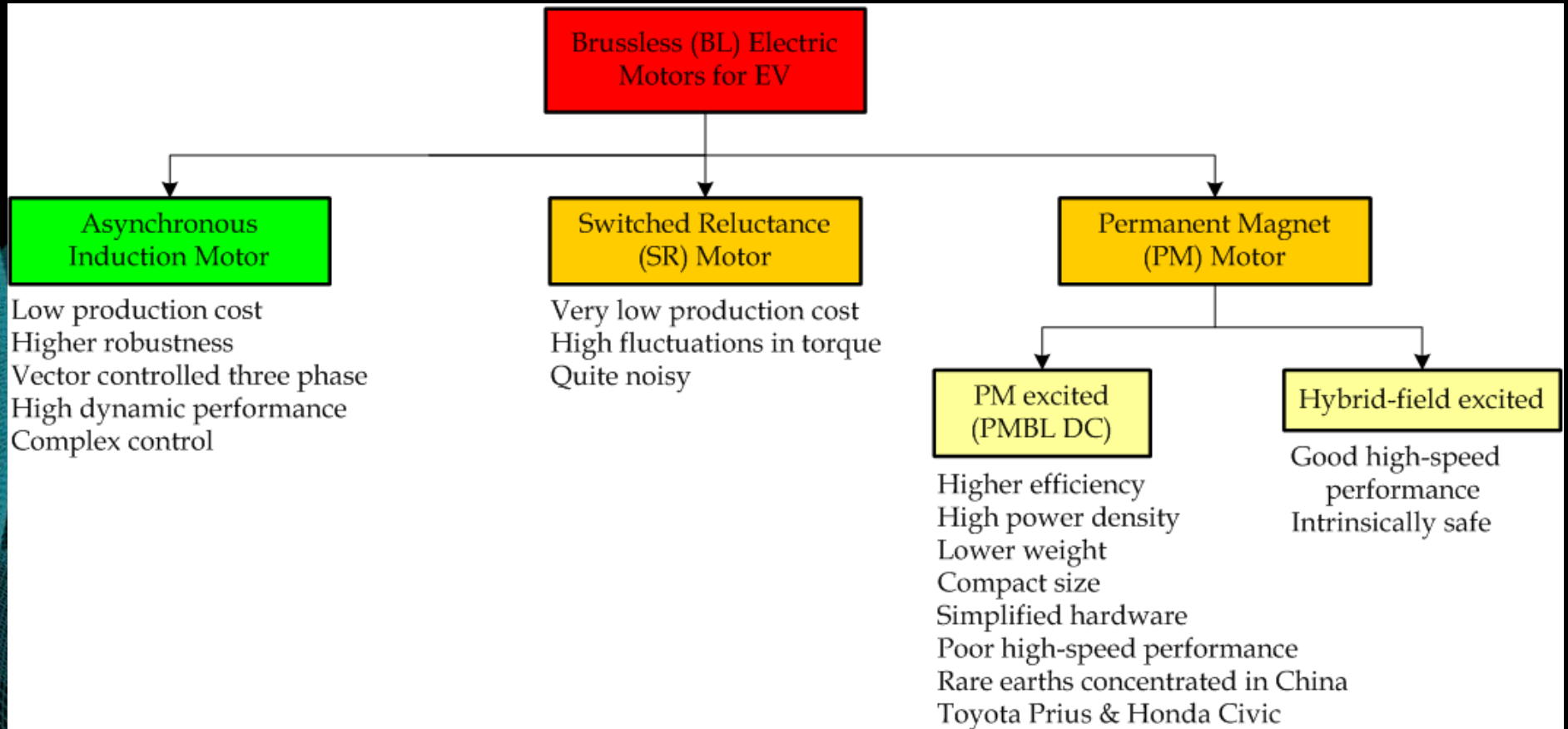
VRSTE ELEKTROPOGONOV

GEMmotors



ELEKTROPOGONI V VOZILIH

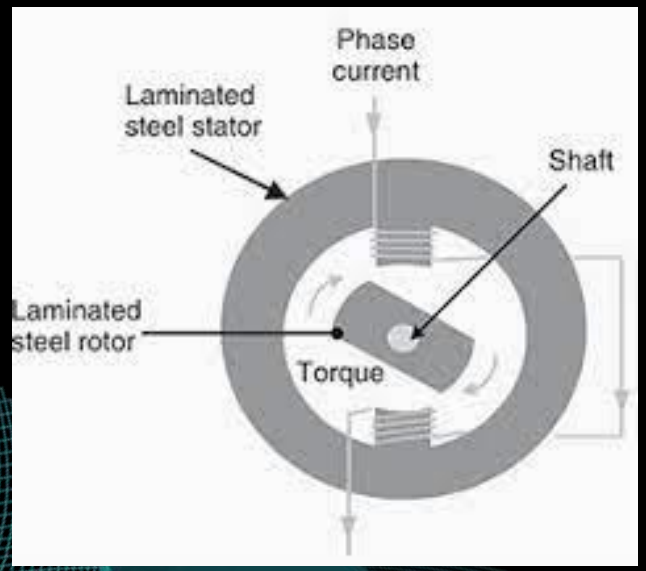
- **Reluktančni elektromotor** – SRM
- **Asihronski ali indukcijski elektromotor**
- **Sinhronski elektromotor s trajnimi magneti – SPM in IPM**

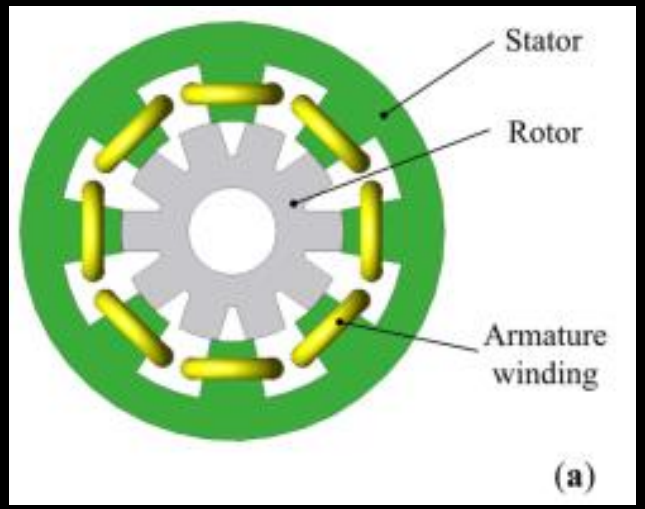


RELUKTANČNI ELEKTROMOTOR

GEMmotors

FIZIKALNI PRINCIP





UPORABA

PREDNOSTI

- **Preprosta** izdelava
- **Nizka cena** proizvodnje
- **Brez magnetov** redke zemlje

SLABOSTI

- **Valovitost** navora
- **Hrup**
- **Slabši izkoristek**

INDUKCIJSKI ELEKTROMOTOR

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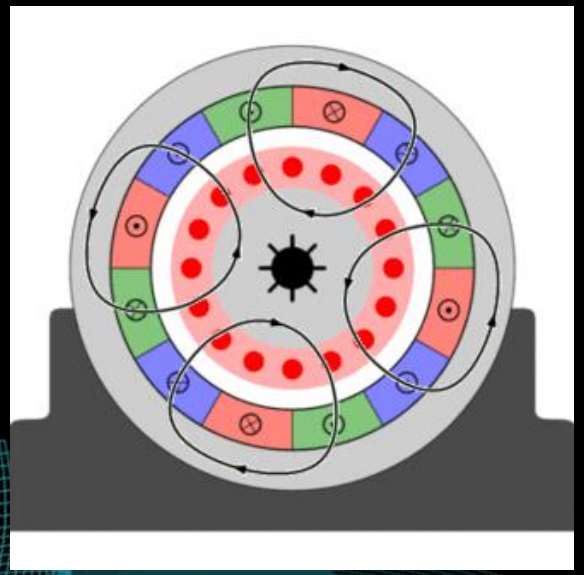
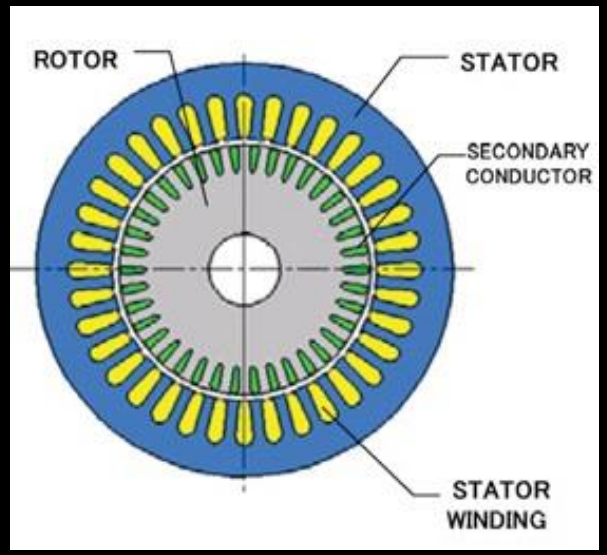
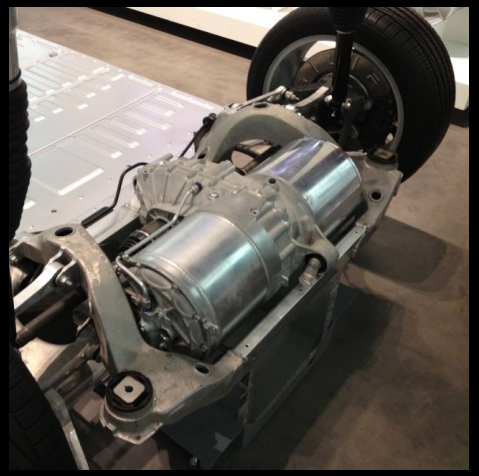
FIZIKALNI PRINCIP







PREDNOSTI

- **Nizka cena** proizvodnje
- **Robustno** delovanje
- **Brez magnetov** redke zemlje

UPORABA

SLABOSTI

- **Kompleksno** krmiljenje
- **Nizek** začetni navor
- **Izkoristek**

SINHRONSKI ELEKTROMOTOR - SPM

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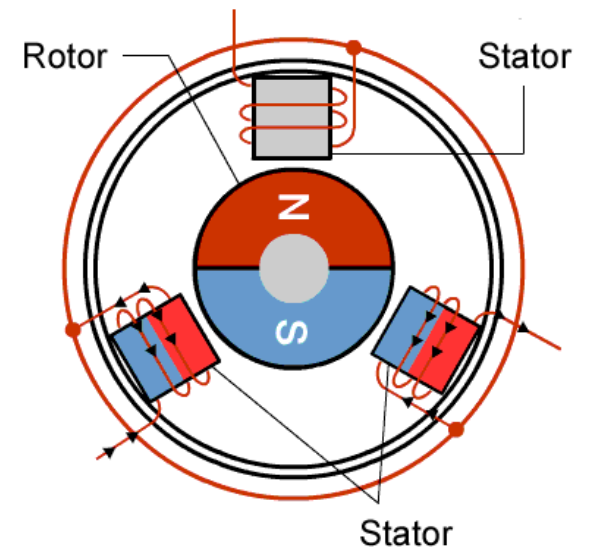
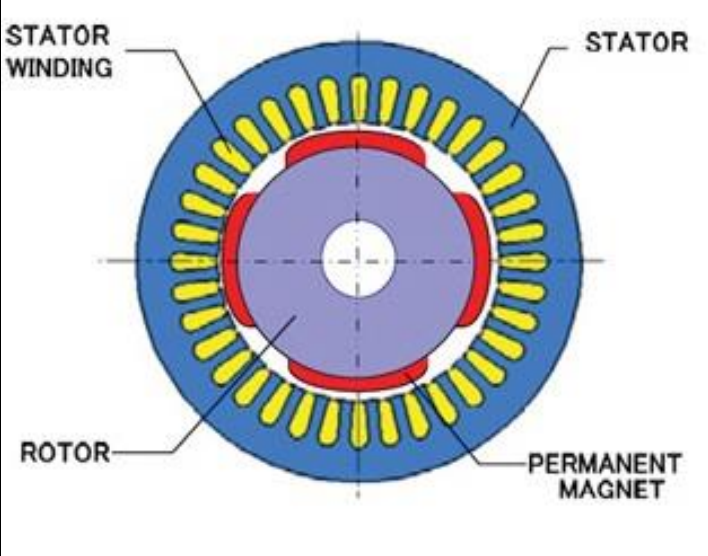
FIZIKALNI PRINCIP





UPORABA

PREDNOSTI

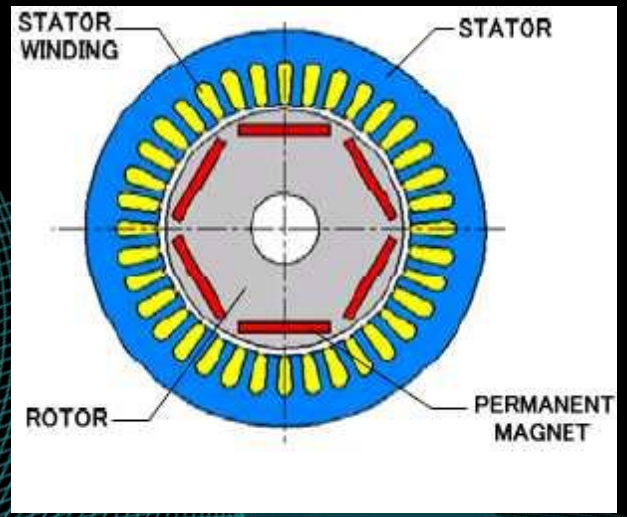
- Velika **specifična moč**
- Velik **izkoristek**
- **Kompakten** dizajn

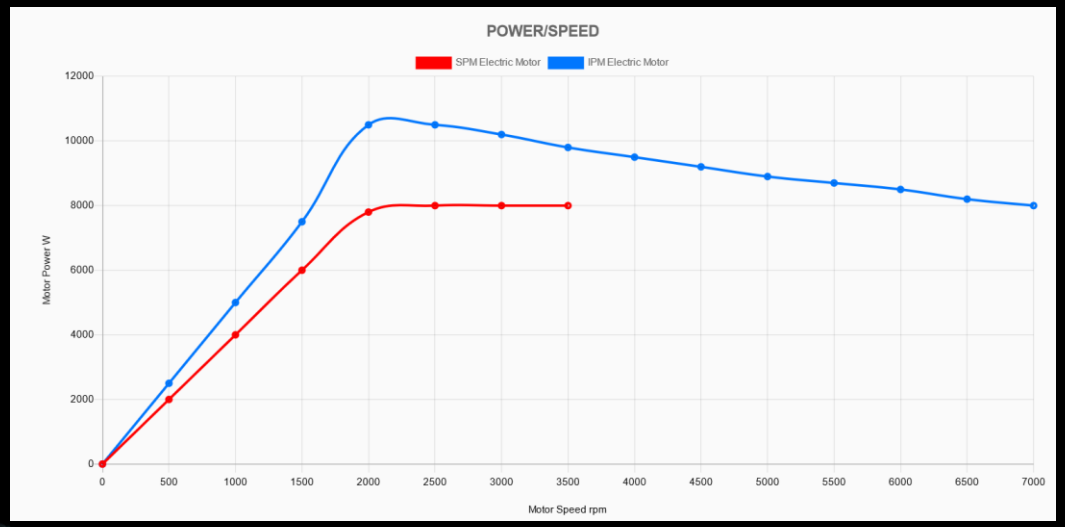
SLABOSTI

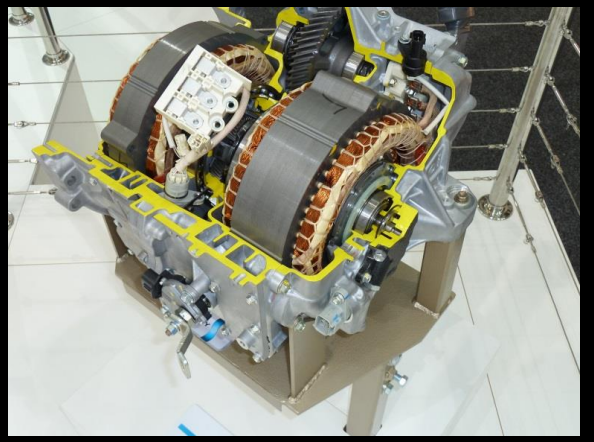
- **Magneti** z redkozemljski materiali

SINHRONSKI MOTOR - IPM

FIZIKALNI PRINCIP







UPORABA

PREDNOSTI

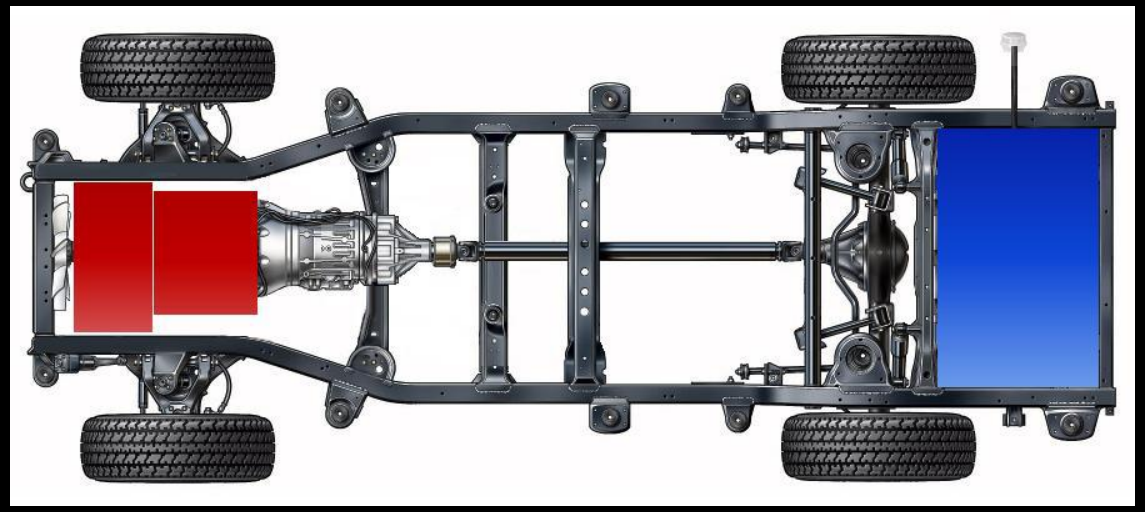
- **Združuje prednosti** magnetnega in reluktančnega motorja
- Območje **konstantne moči**
- Zmogljivost pri **velikih obratih**

SLABOSTI

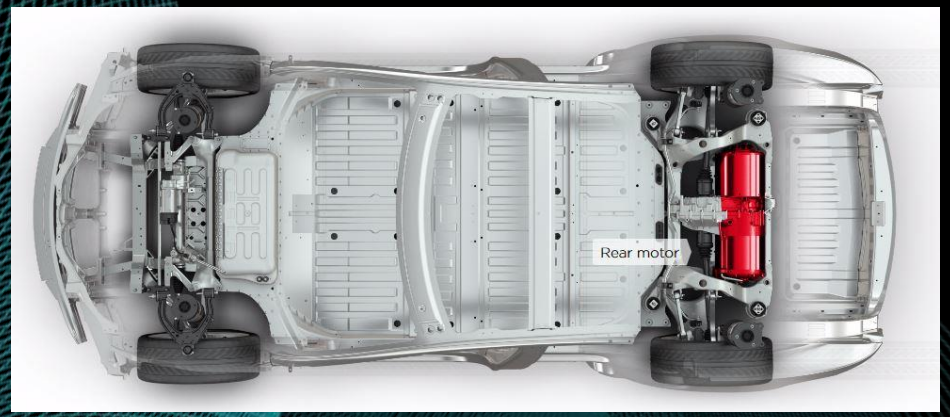
- **Kompleksna** zasnova in krmiljenje

KONCEPTI ELEKTROPOGONA V VOZILIH

- **Centralni motor** z mehanskim prenosom



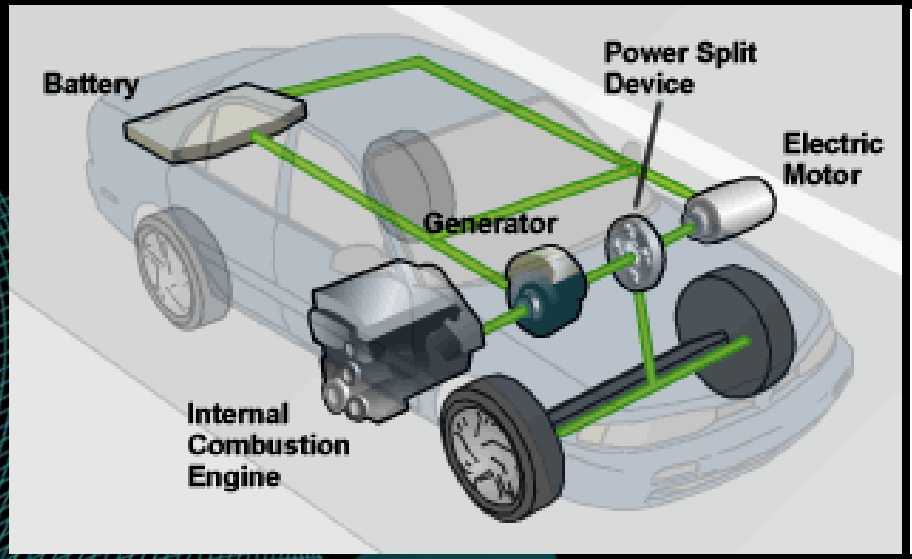
- **Blizukolesni motor s** prenosom

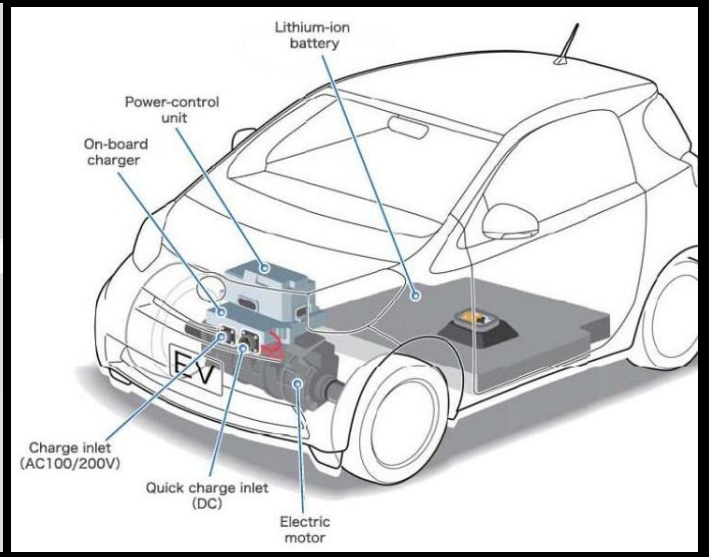


- **Elektromotor v kolesu**

CENTRALNI POGON

KONCEPT





UPORABA

PREDNOSTI

- **Majhna sprememba** koncepta vozila
- **Hibridna ali samo električna** rešitev pogona

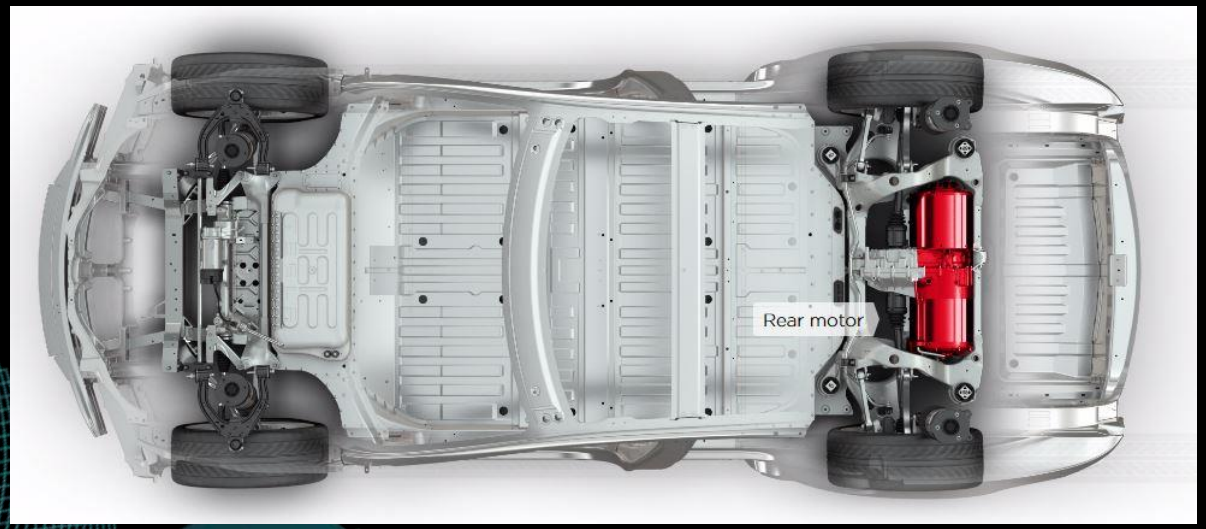
SLABOSTI

- **Kompleksno** rešitev
- **Izkoristek**

BLIZUKOLESNI POGON S PRENOSOM

GEMmotors

KONCEPT



UPORABA

PREDNOSTI

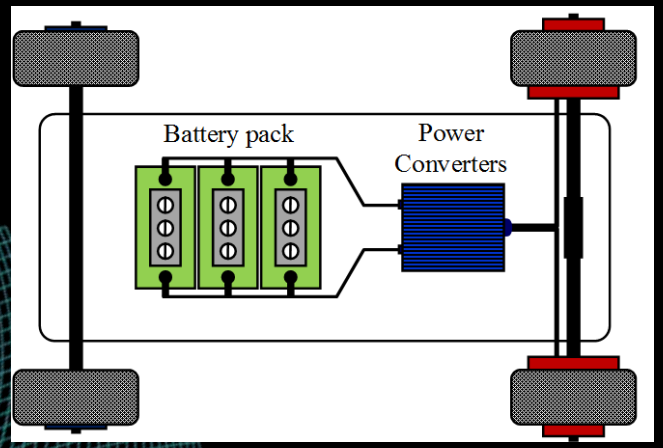
- **Enostaven** prenos
- **Majhen** volume in teža
- **Neodvisno** vodenje kolesa
- **Boljši** izkoristek

SLABOSTI

- **Nova** rešitev

KOLESNI POGON

KONCEPT



UPORABA

PREDNOSTI

- **Najbolj enostaven** prenos
- **Izkoristek** prostora
- **Neodvisno** vodenje kolesa
- **Boljši** izkoristek

SLABOSTI

- **Nova** rešitev in nov koncept

MOTOR DRIVES FUTURE TRENDS

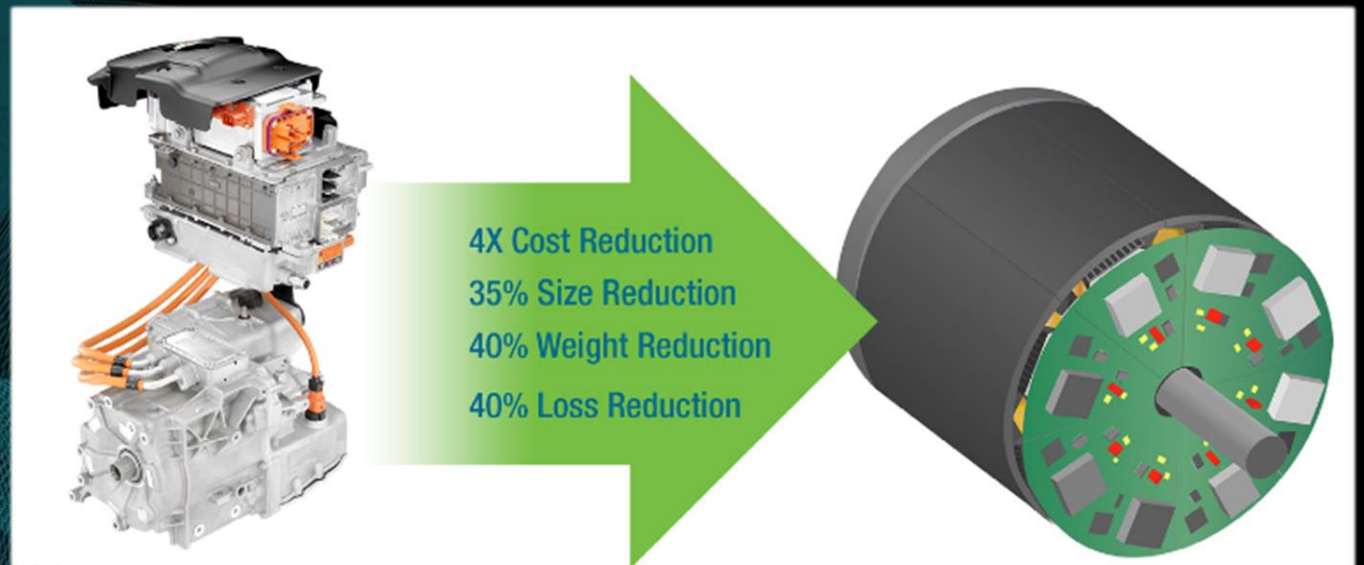
Clear trend of electric drives towards **complete integration** and position close to the wheel.

"**Integration** of mechanical, electrical and electronic parts."

- IDTechX study: http://www.idtechex.com/research/reports/future-powertrains-2016-2036-000468.asp

"**Increase** performance, efficiency and reliability, while **lowering** cost, weight, and volume."

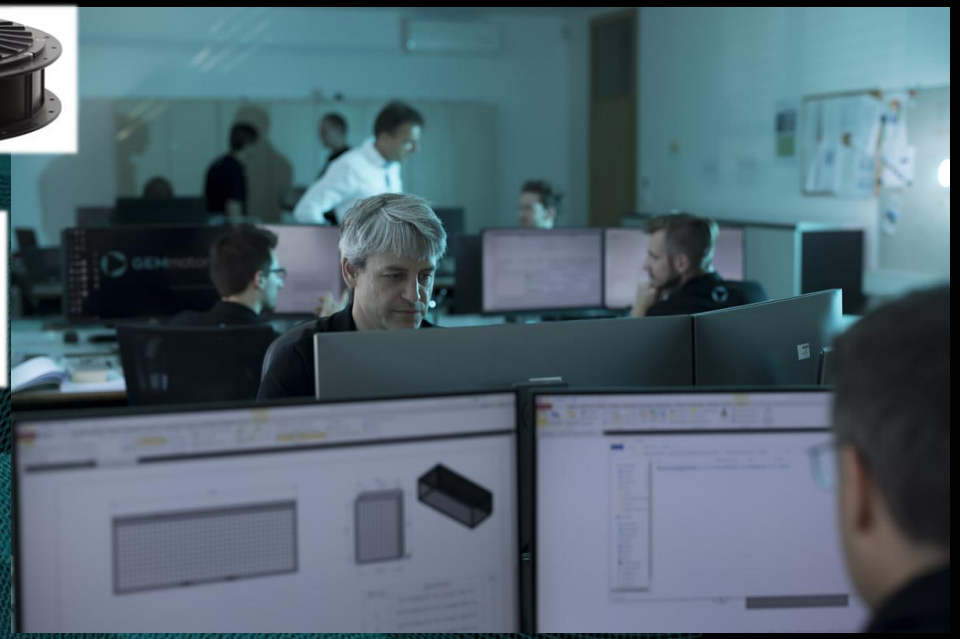
- US Department of Energy: https://energy.gov/sites/prod/files/2014/09/f18/fy_2014_vto_amr_apeem_overview-final_version.pdf



GEM R&D

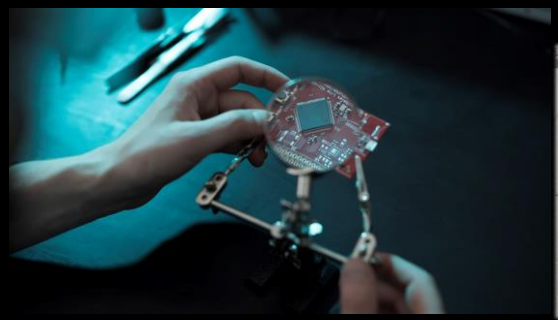
MOTOR DESIGN

- **New motor development,** from idea to final solution ready for serial production
- **Customizations** of the GEM in-wheel drive
- **Electromagnetics** simulation, electronics **HW** and **FW** development, **mechanical** design
- **Highly expert team** and more than 30 patents



ELECTRIC POWERTRAIN DESIGN

- Custom development of **complete electric powertrain** ready for vehicle installation
- **Complete system engineering**: schematics, battery package, display, GEM VCU (Vehicle control Unit), functional safety, e-differential, communication, integration, etc.
- The most **optimized solution** using GEM in-wheel drives



INNOVATIVE TECHNOLOGY

PATENT

- GEM motors has been granted a **global patent** called “Modular multi-phase electric machine” for complete product portfolio in EU, USA, India, China, Russia, Japan and other countries.

(43) International Publication Date
18 December 2014 (18.12.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/198663 A1

(51) **International Patent Classification**:
H02P 25/22 (2006.01)

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(71) **Applicant**: **GEM MOTORS D.O.O.** [SI/SI]; Ljubljanska 45, 1241 Kamnik (SI).

(72) **Inventor**: **MANDELJ, Simon**; Dvorzakova 10, 1230 Domzale (SI).

(74) **Agent**: **GRAY, Helen**; Zacco GmbH, Bayerstrasse 83, 80335 Munich (DE).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

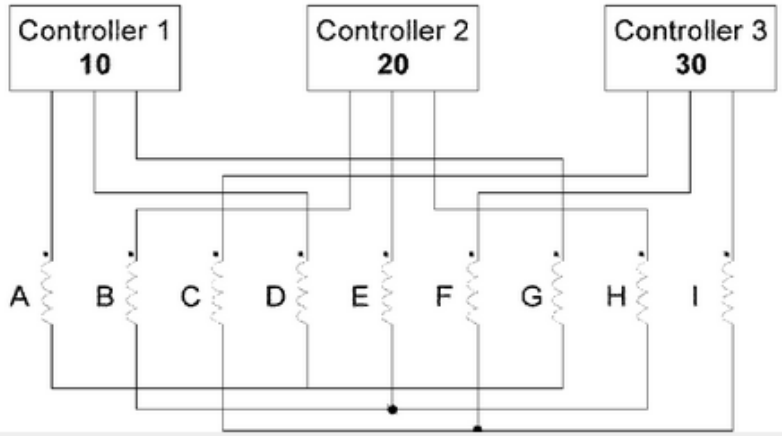
(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

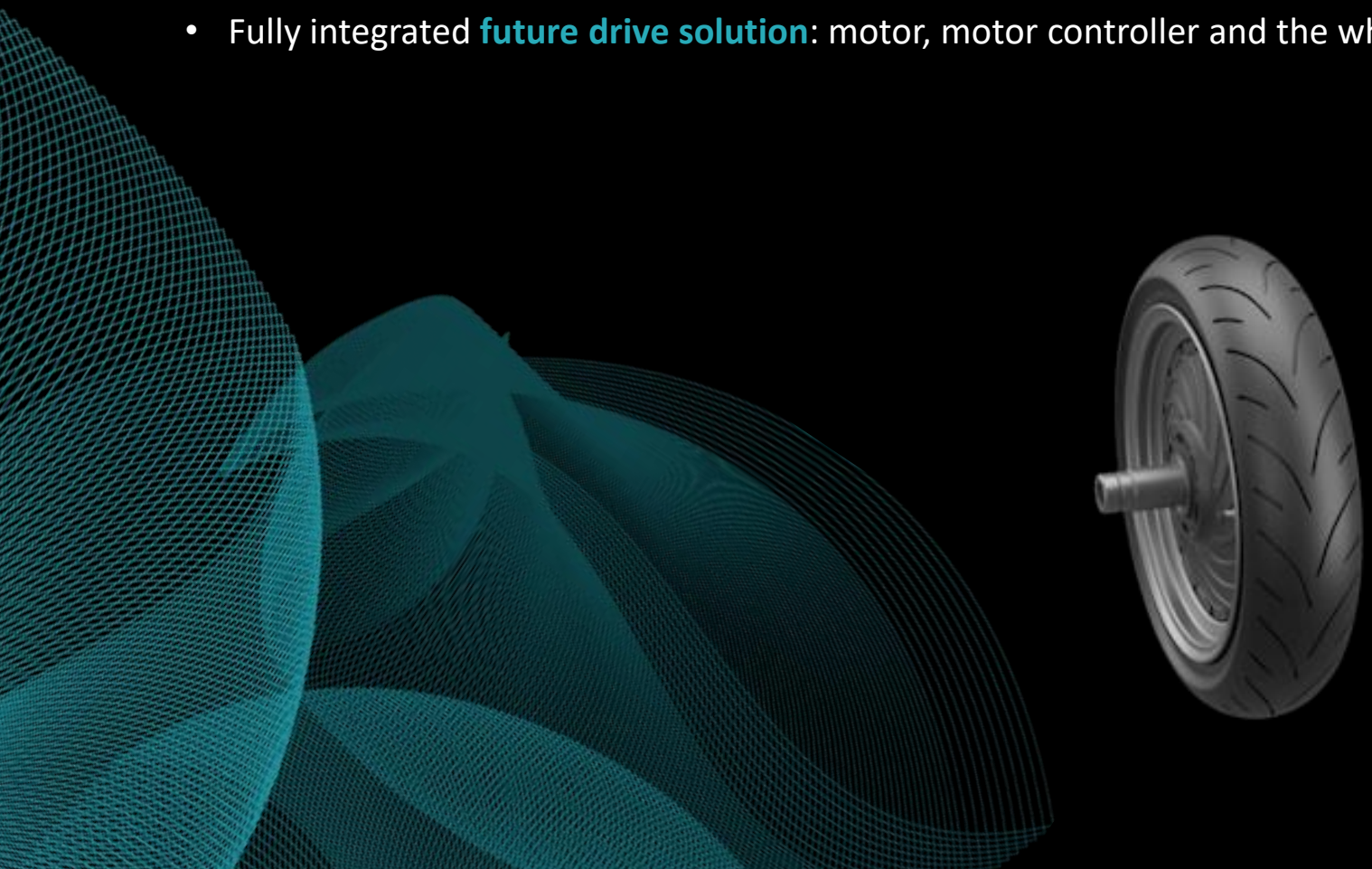
(54) Title: MODULAR MULTI-PHASE ELECTRIC MACHINE



GEM IN-WHEEL DRIVE

GEMmotors

- **Unique** modular multiphase motor technology
- Global **patented** innovation
- Advanced motor technology: **efficient**, **simple** and **compact**.
- Fully integrated **future drive solution**: motor, motor controller and the wheel



MOTOR TECHNOLOGY: COMPARISON

GEMmotors

	Standard in-runner electric motor with transmission	Standard in-wheel (hub) motor with external controller	Advanced GEM in-wheel drive with integrated controller
			
Simple solution	X	?	Y
High system efficiency	X	?	Y
Fully integrated	X	X	Y
Economical solution	?	Y	Y

ADVANTAGES

GEMmotors

ADVANCED DRIVE

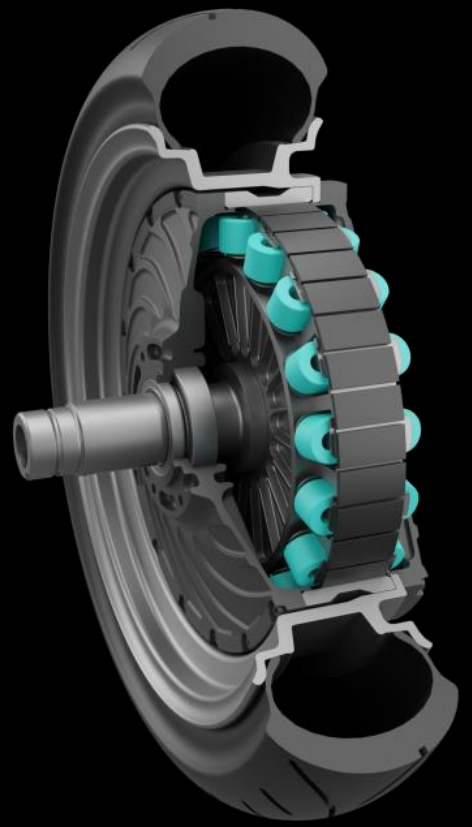
- Fully **integrated** in-wheel drive with integrated controller – the future trend solution
- Advanced **modular** design and increased redundancy
- Unique and global **patented** solution
- Safe and **reliable** solution (low voltage)

SMART DESIGN

- Low number of parts and simple design
- The most **space optimized** solution
- **Regenerative** braking and increased driving range
- Excellent cooling
- Flexible design for **different applications**

SUPERIOR PERFORMANCE

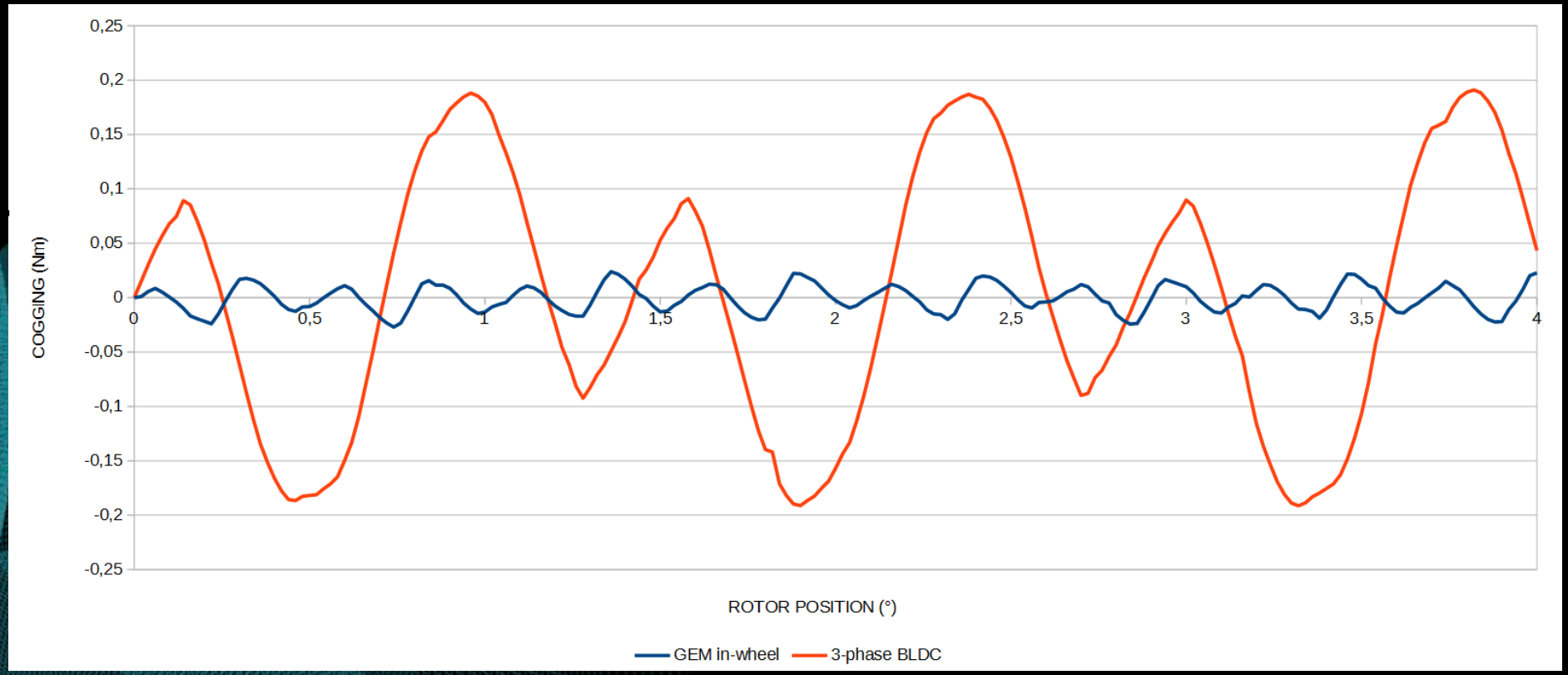
- Small **cogging** (less than 0.1%) and ripple torque (FOC control)
- High **efficiency** (up to 92%) and longer driving range (up to 20%)
- High **torque** and better acceleration (lower phase current)
- **Low EM emission** due to integrated controller (90% less)



SUPERIOR PERFORMANCE

LOW COGGING AND RIPPLE TORQUE

- Very small cogging (**10 times less**) and very smooth free-wheeling
- Low ripple torque and very quite operation due to **FOC control**

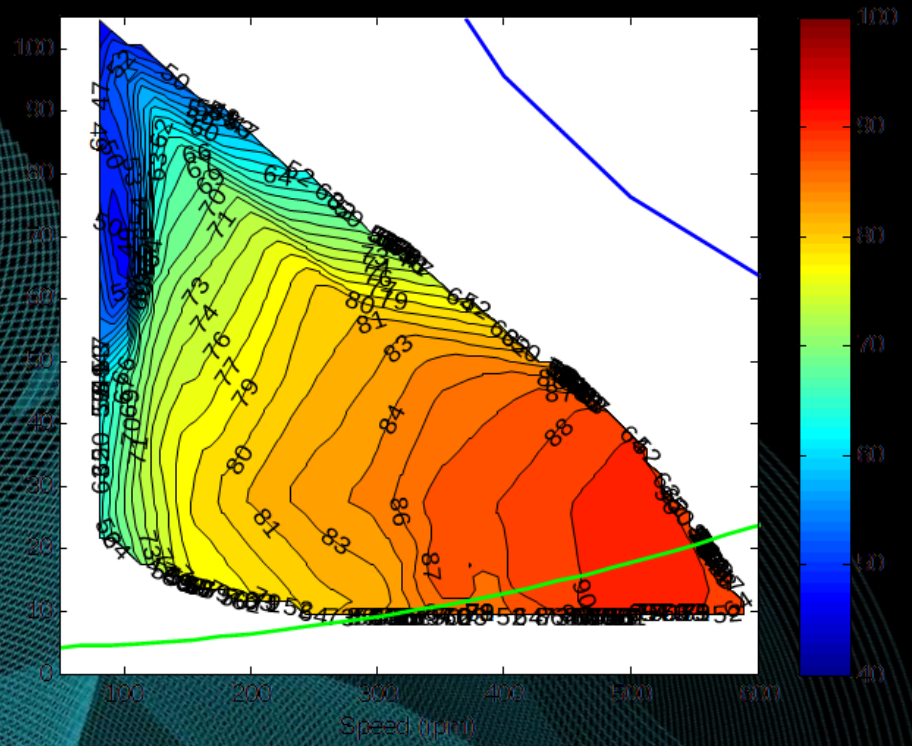


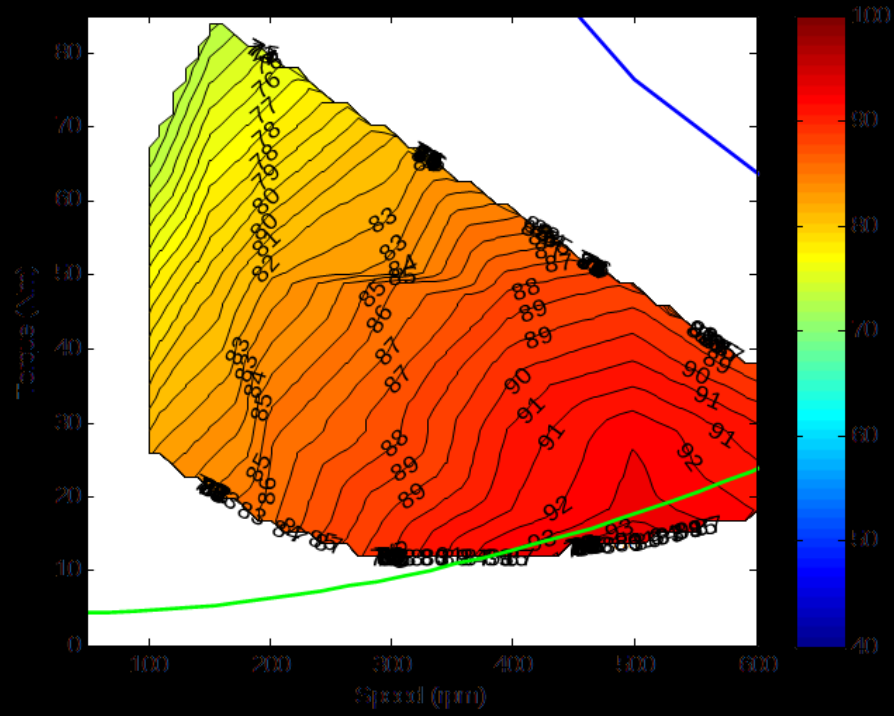
SUPERIOR PERFORMANCE

GEMmotors

HIGH EFFICIENCY

- One of the highest **system efficiency up to 92%**
- **Lower battery consumption** due to lower losses
- Increased **driving range up to 20%**





PRODUCT PORFOLIO

GEMmotors

	G0	G1.1	G1.3	G2.4	G2.6	G3
						
Nominal power	800 W	1,5 kW	3 kW	4 kW	6 / 7,5 kW	7,5 - 15 kW
Peak power	1000 W	3 kW	6 kW	9 kW	15 kW	30 kW
Voltage level	24 - 75 V	24 - 75 V	24 - 75 V	48 - 75 V	48 - 75 V	48 - 100 V
Rim size	D200mm typical	min 10″	min 10″	min 13″	min 13″	min 14″
Total motor weight	12 kg	8 kg	11 kg	19 kg	25 kg	30 kg
Speed	100 - 400 RPM	200 - 700 RPM	200 - 1000 RPM	300 - 1000 RPM	300 - 1300 RPM	500 - 1000 RPM
Torque	80Nm	120 Nm	160 Nm	240 Nm	350 Nm	500 Nm
Motor controller	Fully integrated	Fully integrated	Fully integrated	Fully integrated	Fully integrated	Fully integrated
Cooling	Air	Air	Air	Air	Air	Forced air
Status	Samples	Preproduction	Preproduction	Production	Production	Developement
Application	AVG, industrial utility, vehicles, trolleys, carts, etc.	Scooter and 2-wheeler			Motorbike, commercial vehicle	
		Bicycle		3-wheeler, micro car, other 4-wheeler		

APPLICATIONS

GEMmotors

2-WHEELER





3-WHEELER





4-WHEELER









ROBOTIC and OTHER