E-mobility: powered by renewable and sustainable energy

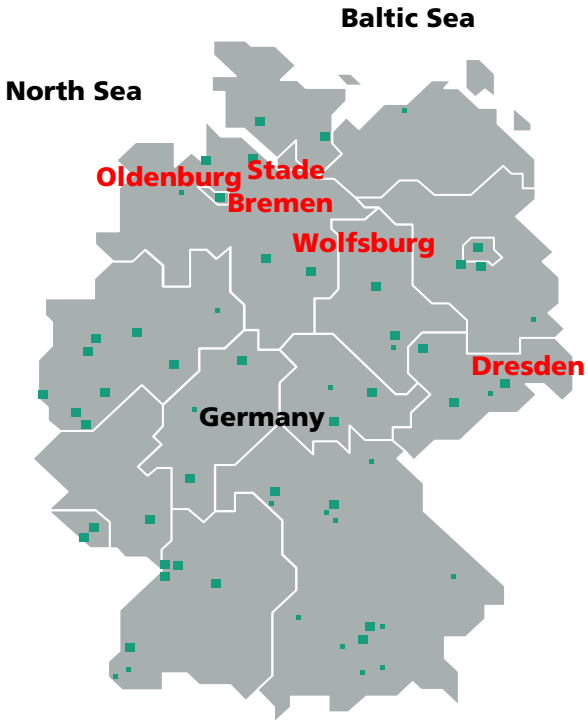
Prof. Dr.-Ing. Matthias Busse

Fraunhofer IFAM

Overview Fraunhofer and Fraunhofer IFAM

Fraunhofer

- 67 institutes and research units
- 23,000 employees
- annual research volume of € 2 billion (2013)
  - more than 70 % derives from contracts with industry and from publicly financed projects



Fraunhofer IFAM

- one of Europe's largest independent R&D centers for Shaping and Functional materials and Adhesive Bonding and Surfaces
- 583 employees
- total budget 2013: € 46.1 million
- branches in Bremen and Dresden
- project groups in Stade and Oldenburg

Fraunhofer-Institute for Manufacturing Technology and Advanced Materials (IFAM)

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Fraunhofer lighthouse projects

- Health and Environment
- Safety and Security
- Mobility and Transportation
- Energy and Resources
- Production and Services
- Communication and Information

Cell-free bioproduction

- Synthesis of customized proteins on an industrial scale

Electromobility II – Transfer

- Transfer of various research findings into market-relevant products

Rare earth metals

- Up to 50% reduction of rare earth metals needed for permanent magnets

66 Dy
60 Nd

E³ production

- New production technology to gain maximum value with minimum resources

E1
E²
E³
E3

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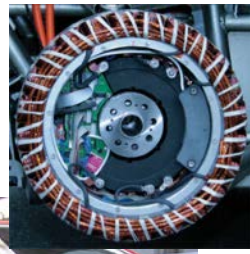
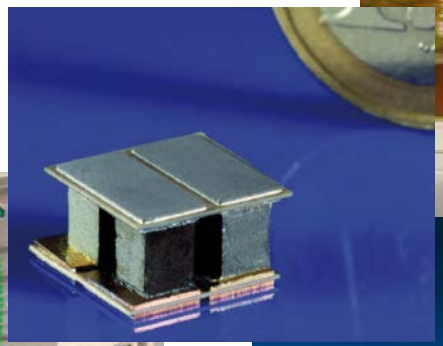
Business fields IFAM

- Automotive
- Aerospace
- Energy and Environment
- Medical Technologies and Life Sciences





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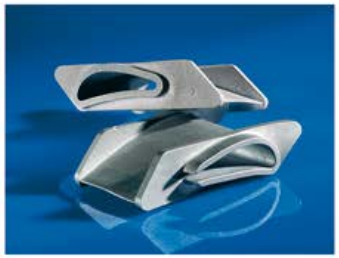
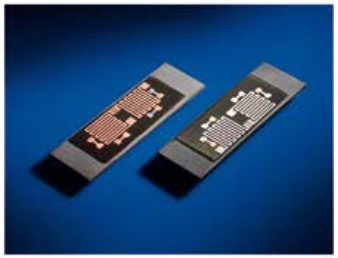
From Material to Reliable Application

MATERIAL	SHAPING	FUNCTION	TESTING	APPLICATION
				
· Metals · Ceramics · Polymers · Structural materials · Functional materials · Composite materials	· Powder Metallurgy · Casting · Freeform fabrication · Nano- and microstructuring	Integrating functionalization into manufacturing process · Sensors · Actuators · Functional coatings · Energy storage	· Material analysis · Mechanical testing · Performance tests · System validation · Expert reports	· Automotive · Electromobility · Energy and environmental technologies · Aerospace · Medical technology · Microsystems technology · Machine and equipment construction

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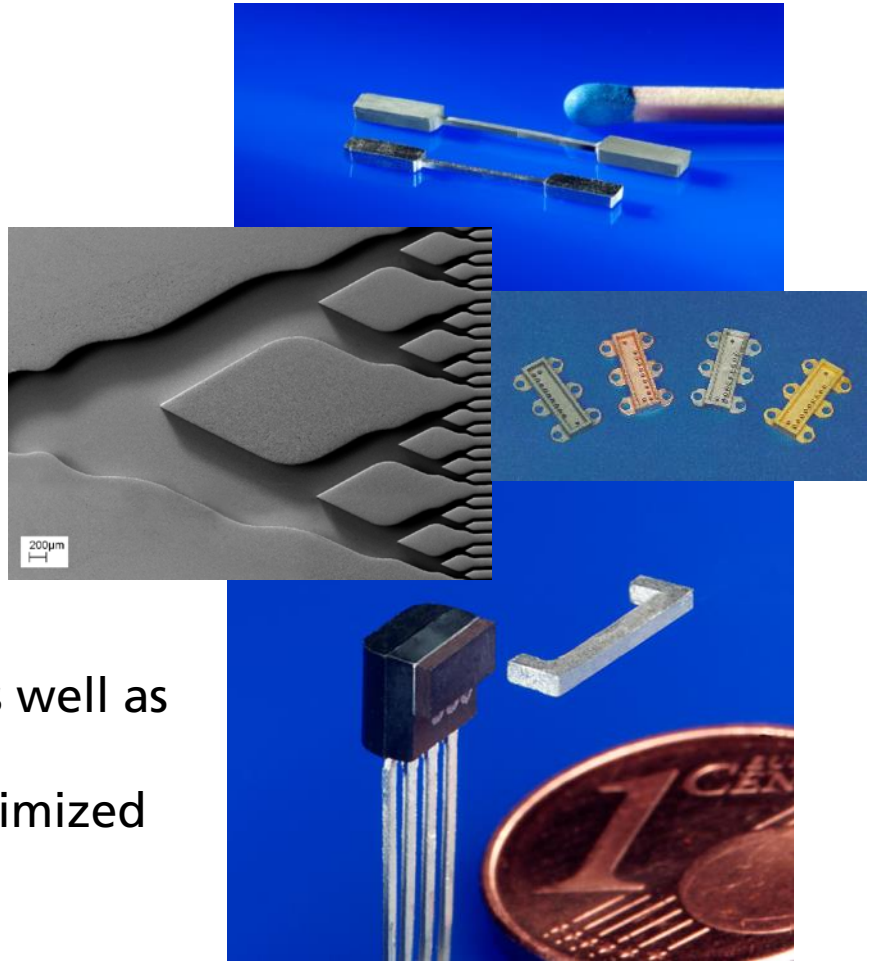
IFAM‘s current research topics in MIM

- Titanium, titanium alloys
- Hard and soft magnetic materials
- Thermal management materials

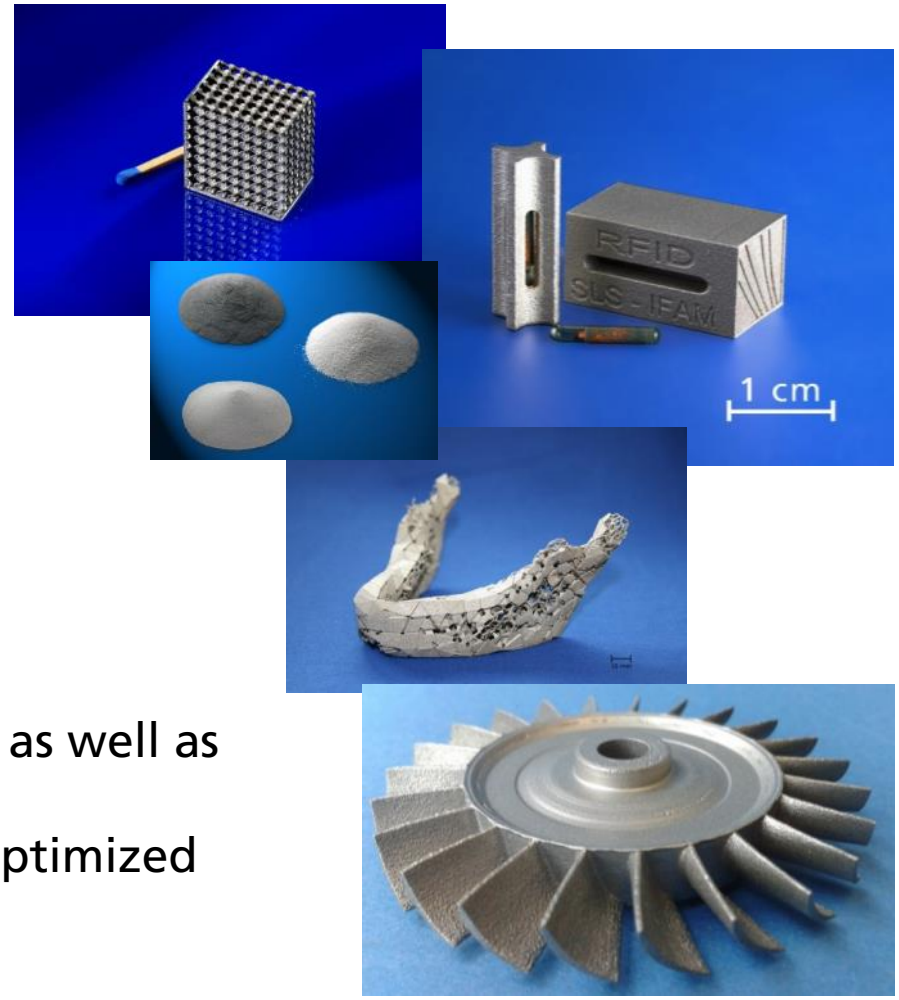
- Quality control of feedstock systems
- Tolerances
- 2-component injection molding
- Micro injection molding



In strictly confidential bilateral projects as well as in publicly funded consortium projects, all aspects of MIM are developed and optimized for our customer‘s benefit.

IFAM's current research topics in Additive Manufacturing

- Material/Parameter development
- Functionalisation of parts by
  - Realisation of complex internal structures
  - Integration of RFID tags
- Quality control strategies for metal powders for Laser Melting



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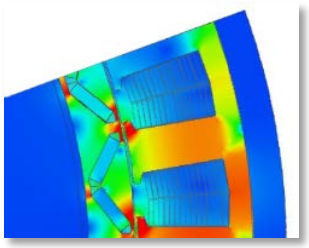
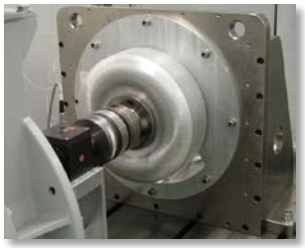
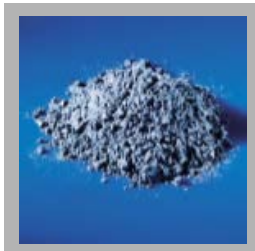
Example: Electric drivetrain at IFAM





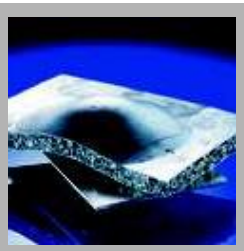
DEVELOPMENT	PRODUCTION	TESTING	APPLICATION
• Elektromagnetische und thermische Auslegung / Simulation elektrischer Maschinen • Mechanische Auslegung und Konstruktion von Antriebssystemen • Softwareentwicklung Fahrzeugsteuerung, Steuergeräte & Umrichter	• Gießtechnische Herstellung von Spulen • Fertigung gegossener Gehäusekomponenten • Prototypenfertigung • Komponentenfertigung Antriebsstrang / Fahrwerk • Entwicklung von weich- und hartmagnetischen Komponenten	• Leistungsprüfung elektrischer Maschinen • Funktionale Sicherheit von Steuergeräten • Fehlertoleranz von Antriebssystemen • Erprobung von Gesamtsystemen	• Fahrzeugintegration von Komponenten • Aufbau von Erprobungs-trägern und Demonstratorfahrzeugen • Inhaltliche Ausgestaltung von Weiterbildungs-angeboten Elektromobilität

Fraunhofer IFAM – overview expertise in E-mobility

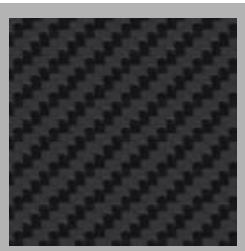


Material development

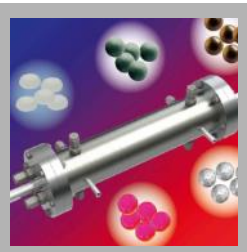
Technical Training eMobility



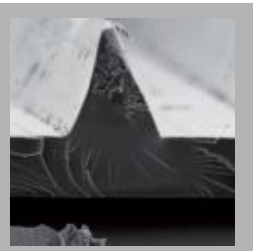
Lightweight materials



Fabrication of crp components

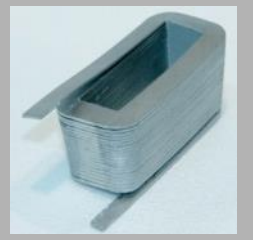


Energy management



Paint and Lacquer technology

Electric vehicle fleet



Casting technology

Engine test bench

Adhesive bonding technology

Energy storage

Component development

Printing technology

Rapid Prototyping

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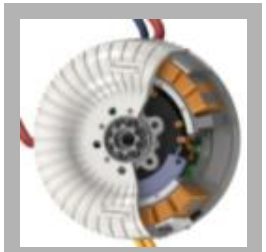
Fraunhofer Wheel Hub Drive
Drive Concept



Component development

- permanent magnet synchronous machine with outer rotor
- power electronics (IGBTs) with dc-link capacitor and control unit placed inside the stator case
- case integrated fluid cooling for stator windings and power electronics
- increased fault tolerance by changes in the converter-drive topology
- CAN-Bus connection to vehicle control unit

Fig.: sectional view of the wheel hub motor

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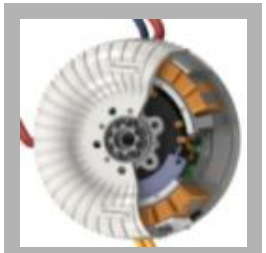
Fraunhofer Wheel Hub Drive
Drive Concept - specifications

Description	Value
Rated Power	55 kW
Peak Power	72 kW
Rated Torque	700 Nm
Peak Torque	900 Nm
Max. Speed	1500 rpm
Rated DC-Voltage	400 V
Max. Efficiency	93.4 %
Mass (incl. Bearings)	42 kg
Outer diameter	364 mm
Length	105 mm



Component development

Fraunhofer E- Concept Car Type 0

Based on Fraunhofer components, like:

- 2 wheel hub motors with integrated power electronic
- vehicle control unit
- Li-ion battery system
- DC and AC charging unit

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Demonstrator vehicles Frecc0 1.0 and Frecc0 2.0

Frecc0 S

based on prototype parts, such as

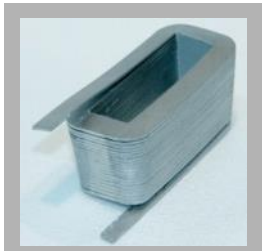
- two electric drive motors
  (rated power approx. 70 kW each, Fa. Wittenstein)
- Li-ion battery system
  (37,6 kWh, 192 kW rated power, Fa. Akasol)
- vehicle control unit (Fraunhofer ESK)
- auxiliary components (DCDC-converter, heater, vacuum pump for power brake usw.)

Frecc0 R

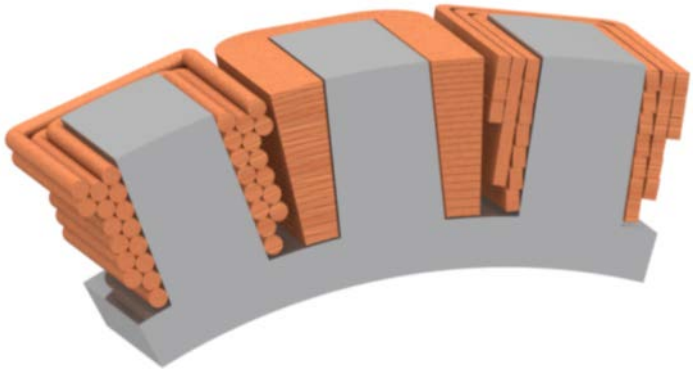
based on Fraunhofer components developed within FSEM, such as

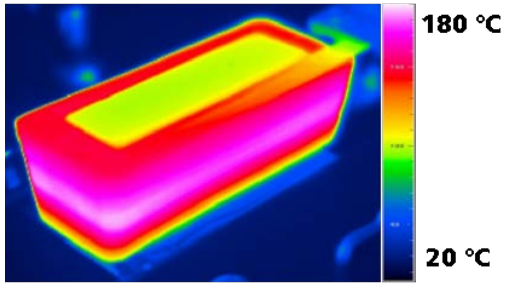
- Two wheel hub motors with integrated converter
  (55 kW rated power, 700 Nm rated torque)
- vehicle control unit
- DC and AC charging unit
- Li-ion battery system

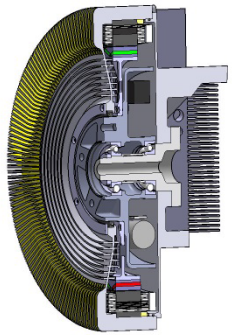
Casting technology - coils

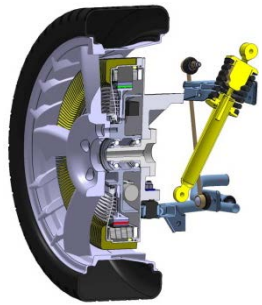

Casting technology

- Using casting technolgy for fabrication of coils
- Advantages compare to usual fabrication methods:
  - coil geometry is adapted to the component geometry
  - change of width and height within the coil possible
  - increase of magnetic flux density and higher coil filling factor









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Engine test bench

Engine test bench

- Engine test bench in combination with battery testing equipment

- Parallel testing of two electric motors and real battery pack up to 500 kg possible
- Temperature tests of the battery pack from -40 to +120 °C

- Real time simulation (HIL) possible

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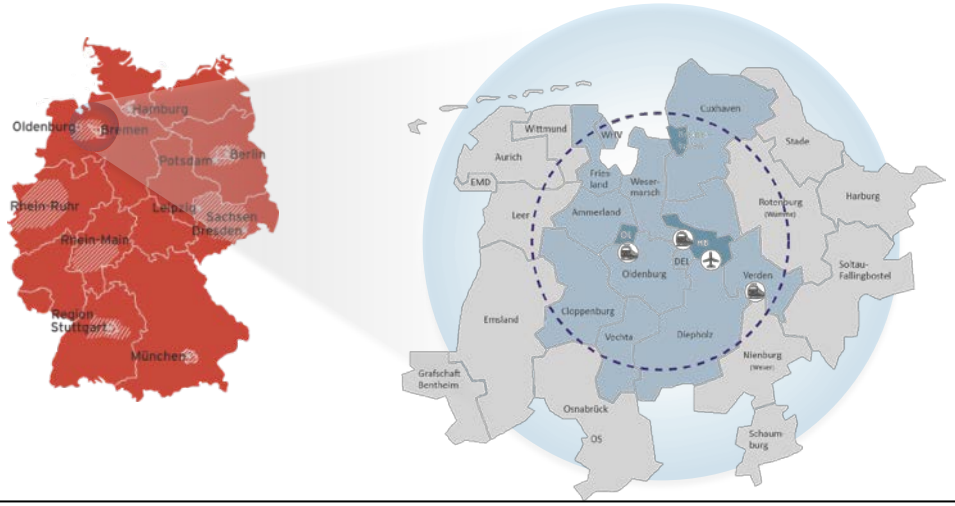
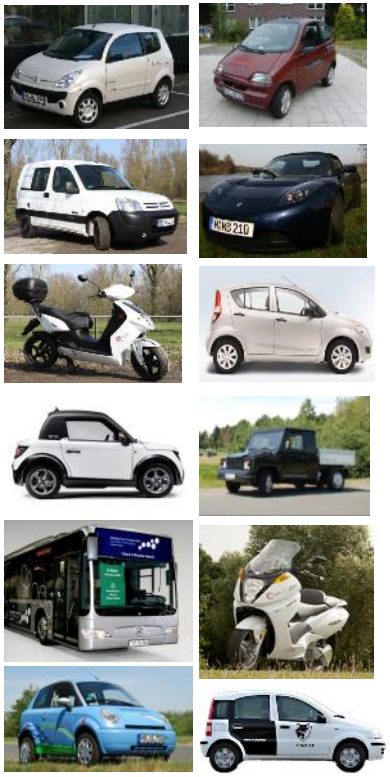
Pilot region Bremen-Oldenburg


Electric vehicle fleet





➢ More than 100 charging stations and 200 electric vehicles are available in the Pilot Region Bremen/Oldenburg

Objectives:

- fleet test with electric vehicles (implementation, evaluation, analysis)
- Development and testing of new concepts for electric vehicles

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Energy storage


Energy storage

- Improvement of actual battery systems by optimising existing cell chemistries ⇨ ≈ 250 Wh/kg
- Development of future systems (next generation) Li/S, Na/S ⇨ ≈ 500 Wh/kg
- Staff: 20
- located in Bremen and Oldenburg

Cell chemistry and materials

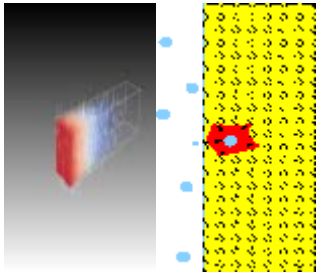
Manufact. and processing

Test methods and charact.

Simulation and modeling

System integration

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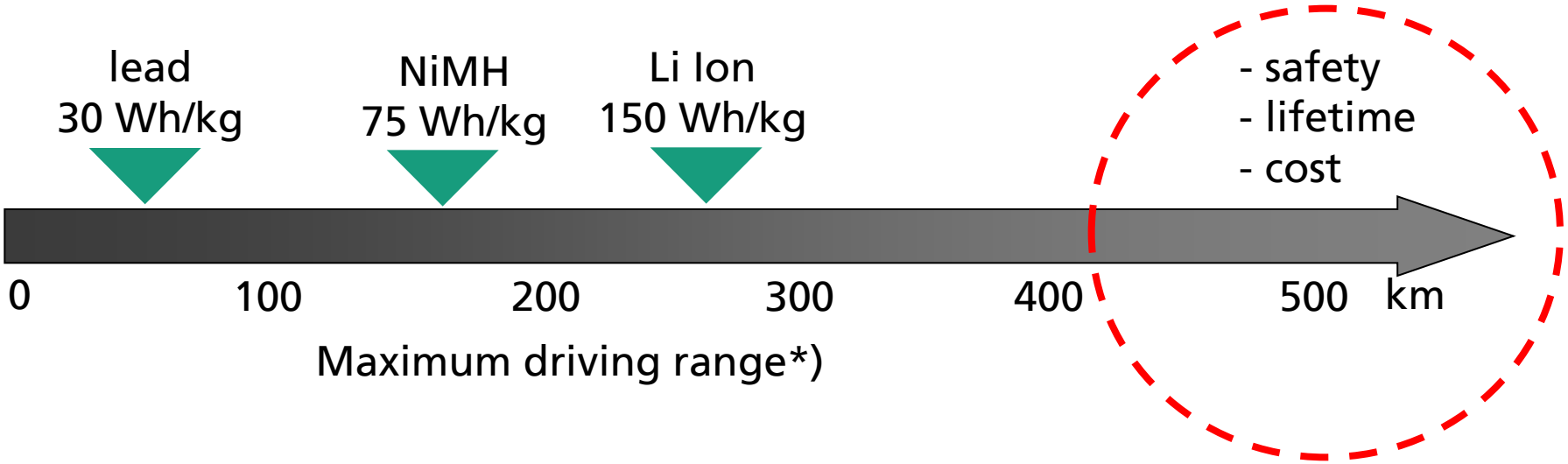
Batteries for electric mobility – what are the needs?

- Power rating similar to combustion engine
- extended lifetime (10y)
- high driving range
- reliable and safe



*) assumption: 220 Wh/kg, 400 kg battery system

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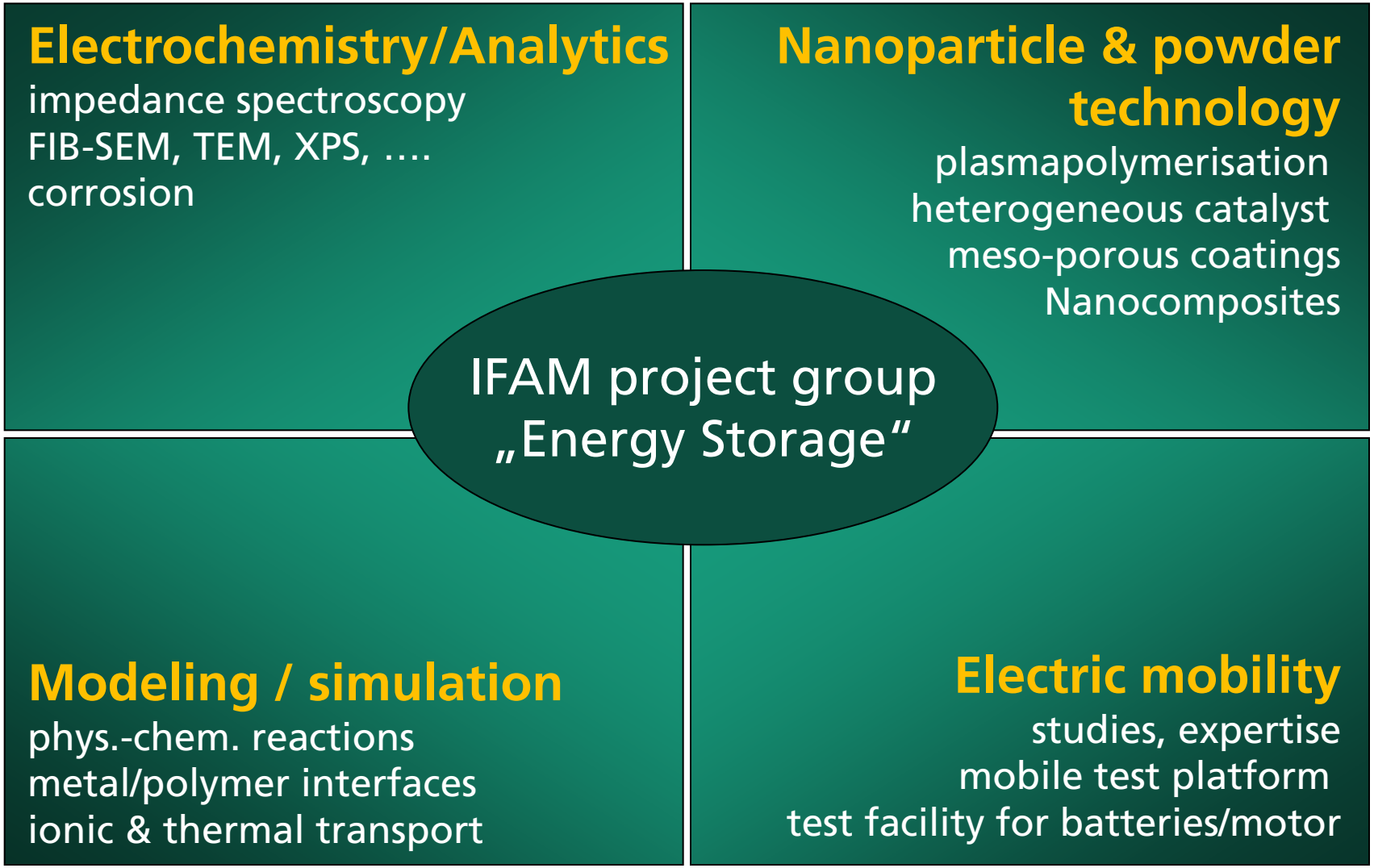
Battery-related competences and resources at IFAM



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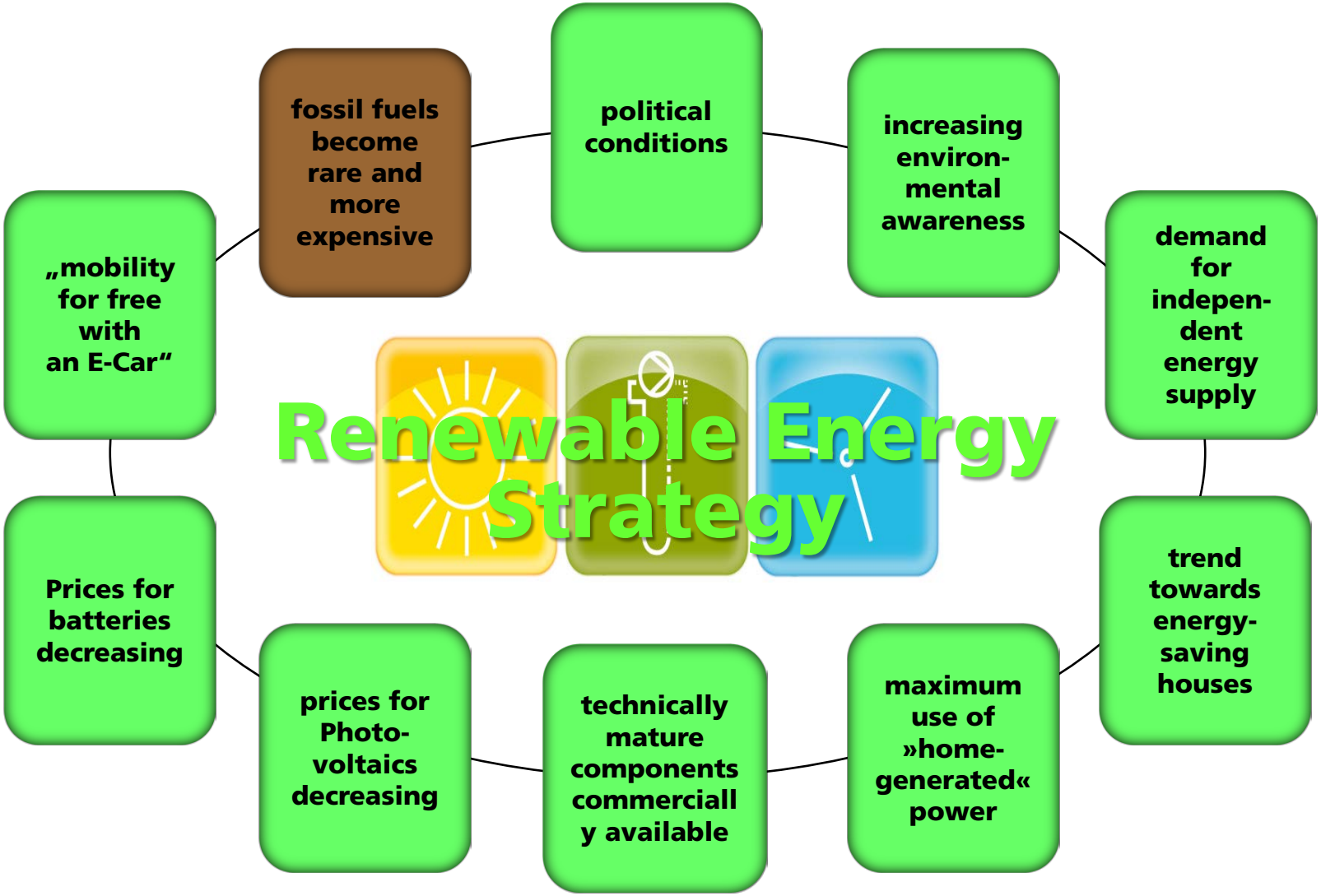
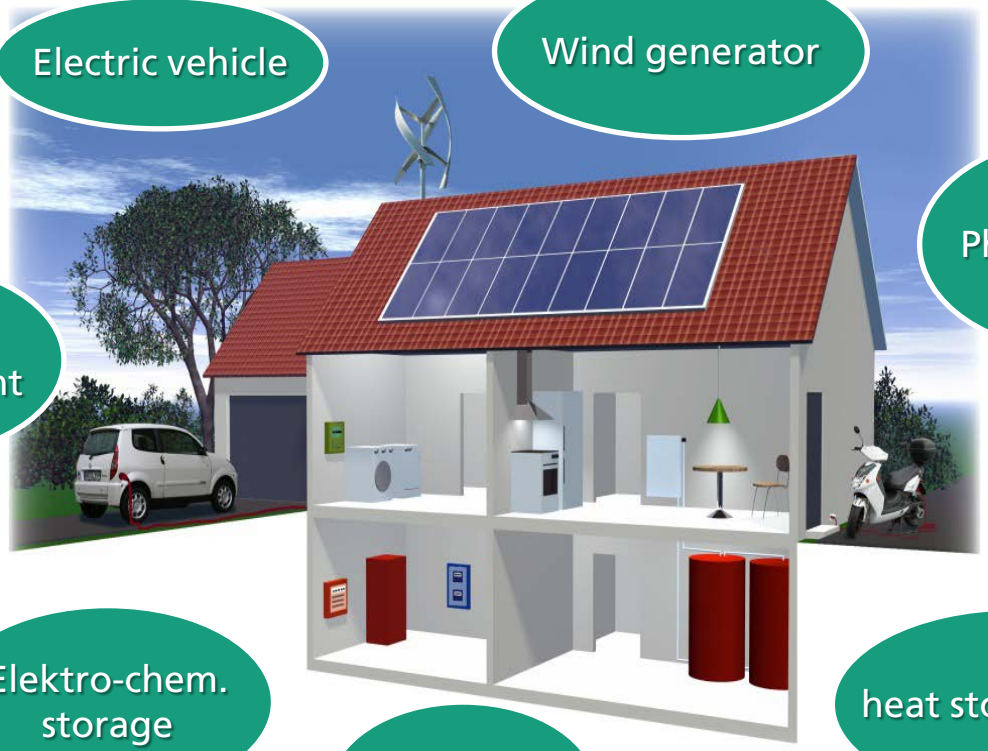
Where should the energy for E-mobility come from?



Approach: enertarc® recommends a Fraunhofer IFAM-tested complete system (tests with real components)



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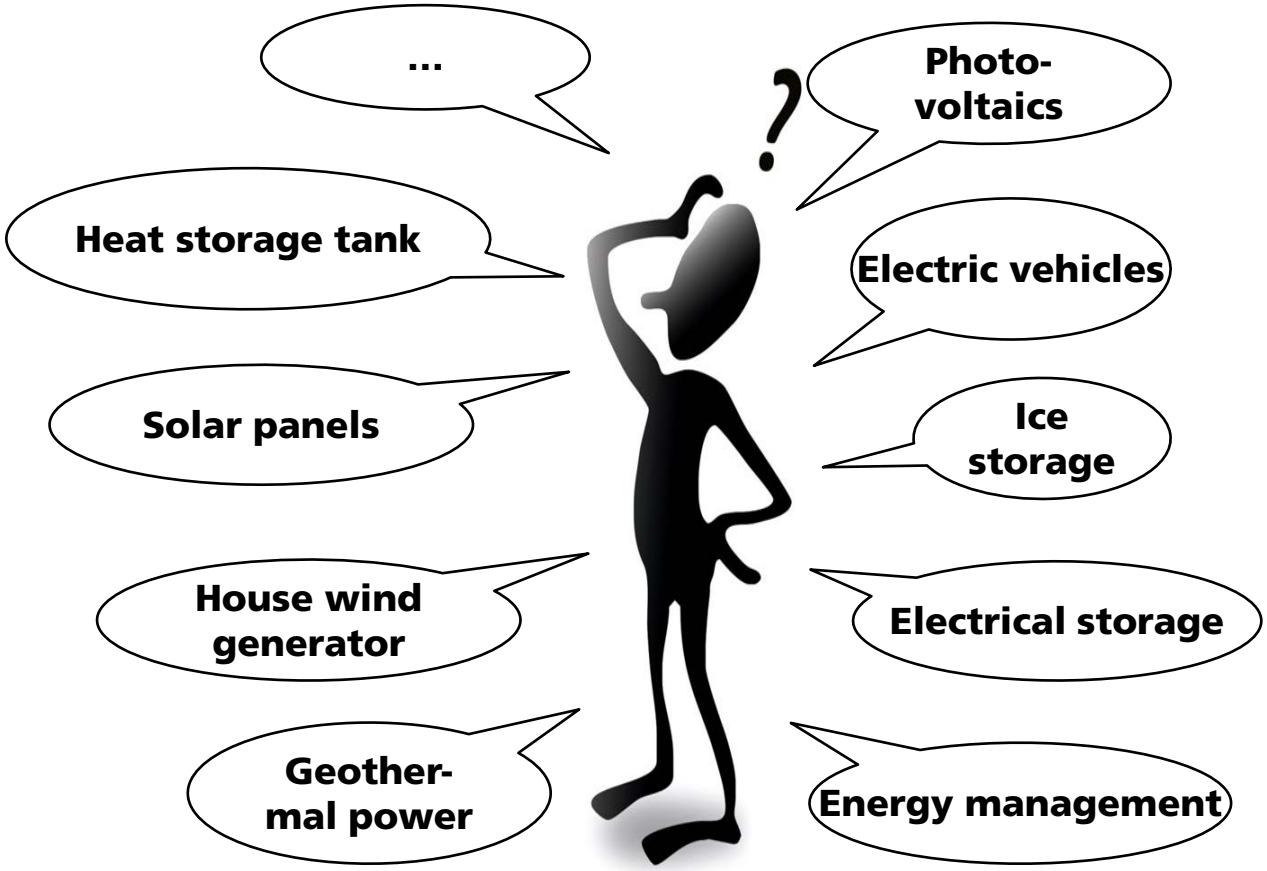
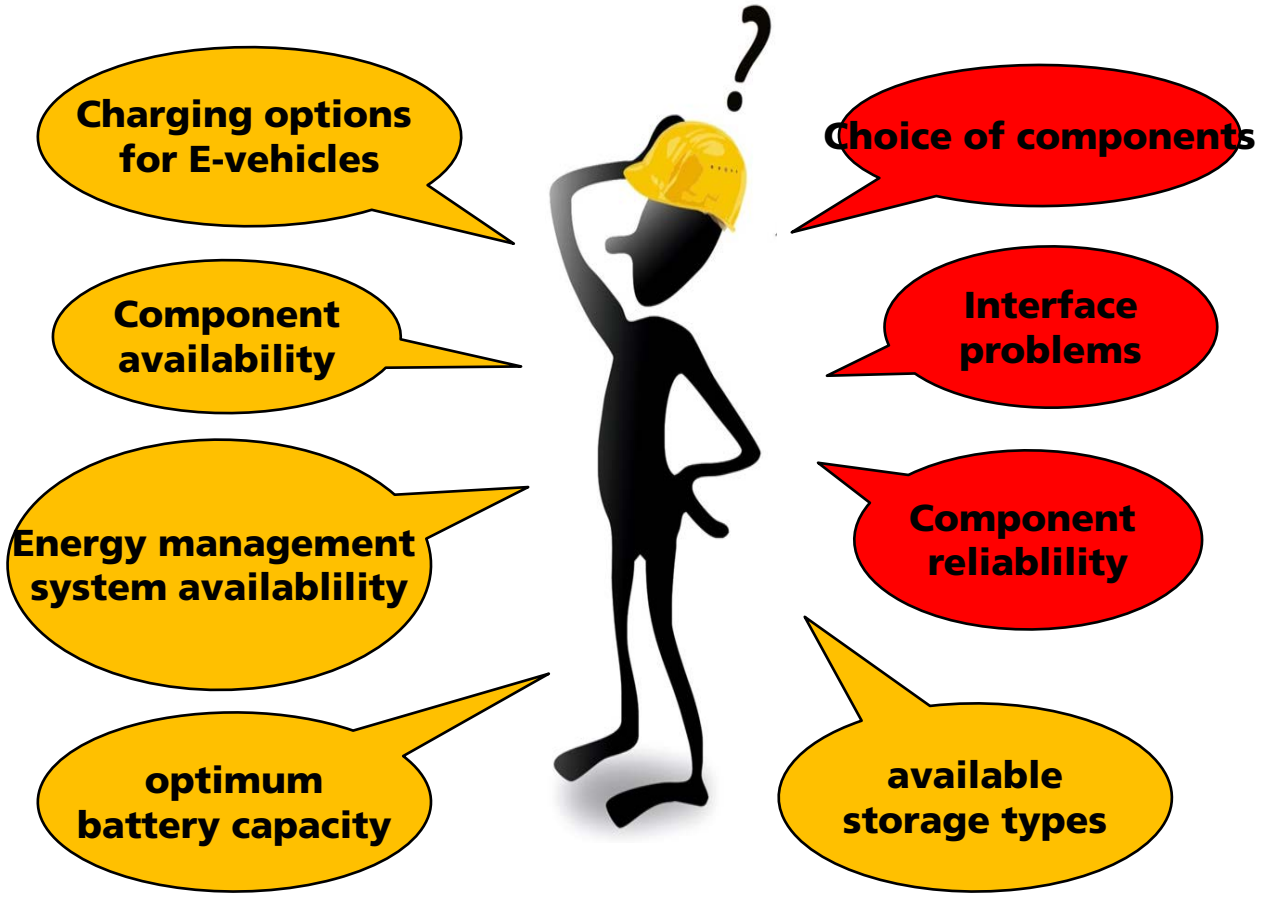
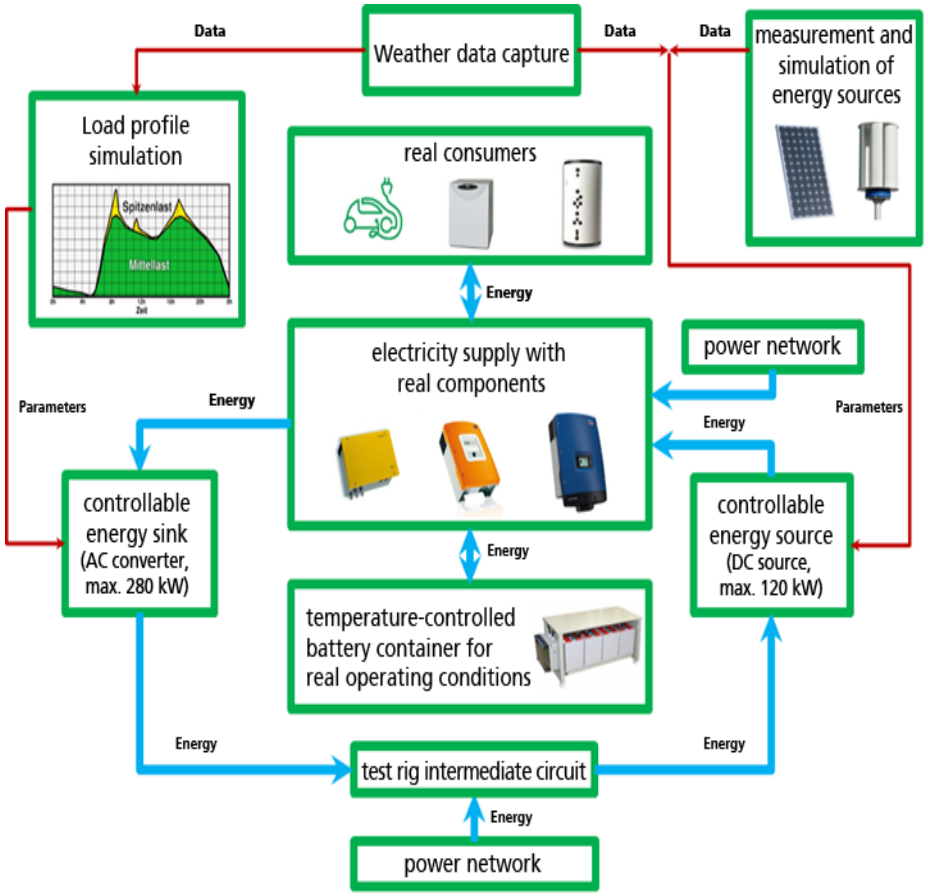
Private house owners: system complexity ?



Building contractors: dimensioning / compatibility / reliability?



Solution: enertarc® recommends a Fraunhofer IFAM-tested complete system (Test with real components)



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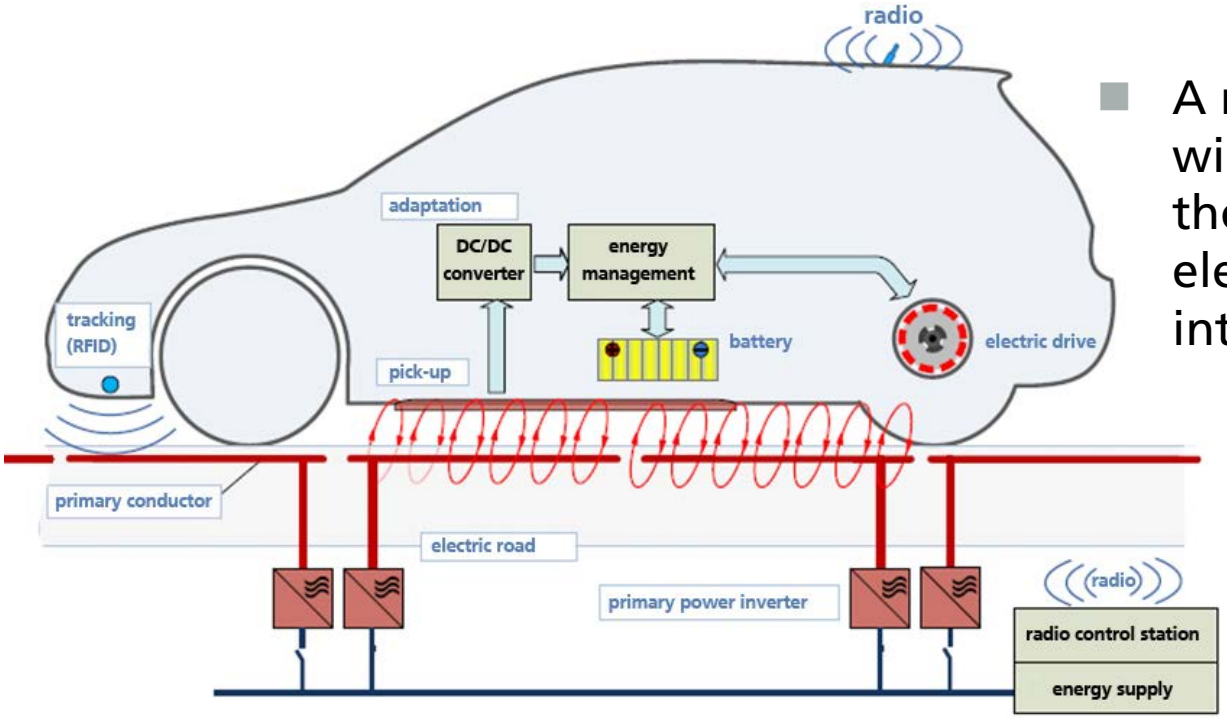
Dynamic inductive charging from renewable energy (parking AND driving!)

Induction coils providing traction power via electromagnetic fields are inserted into the road: 60 KW@ 80 km/h (!)



- A receptive coil (pick-up) will be mounted beneath the vehicle, converting the electromagnetic power into electricity.

Source: INTIS GmbH

Training E-Mobility

Technical Training
eMobility

- ✓ Our trainings show latest R&D activities
- ✓ Our trainer are experts from Fraunhofer
- ✓ Our seminars combine theory and practice
- ✓ Our seminars contain the following topics:

Energy storage

Electric drives

Mobility

Vehicle concepts

Security

Technical didactics

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Overview learning lab

- practical work in a learning lab → every training day combines theory and practice

source: http://www.lucas-nuelle.de/custom/3dlab/kfz/deu/lab.html

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Seminars in Europe, China and South Africa

Technical Training eMobility

- **Electromobility Technologies**
  - 2-day seminar
  - Comprehensive overview of electromobility technologies
  - Language: English/Chinese
  - Location: Beijing/ Shanghai
- **Electromobility for the Future**
  - 1-day seminar
  - Overview of trends and new developments in electromobility
  - Language: English/Chinese
  - Location: Beijing/ Shanghai/Johannesburg

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Thank you for your attention!

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