

## Certificate Course Mobility: Technology of Hybrid & Electric Vehicles

As of January 2017, over 12 million hybrid electric vehicles and over 2 million battery electric vehicles have been sold worldwide. China and the United States are market leaders in battery electric vehicles and Japan is market leader in hybrid electric vehicles with 1.5 million hybrids being delivered in Europe since 2000. The performance of the electric power train has been substantially increased in the last two decades compared to electric motors for industrial applications with conventional designs. The certificate course **Technology of Hybrid & Electric Vehicles** provides insights on this interdisciplinary and rapidly progressing field of technology.

### Course Benefits & Take Away for Participants

The participants will

- gain a detailed knowledge of all drive train topologies for electric and hybrid electric vehicles and their benefits and shortcomings in specific applications (types of vehicles);
- have a detailed understanding of the technical function and construction alternatives of all components required for electric drive trains, namely electric machines, power electronics and energy storage systems. This includes the underlying physical and technical principles as well as practical implementations in current electric vehicles;
- be enabled to specify appropriate drive train topologies and components for electric vehicles based on a detailed analysis of the energy and power demand for a given use-case (driving profile).



### Overview Course Agenda

The structure of the course is leading from the general technical requirements of hybrid and electric drive trains, to details on available technical solutions and finally to the components (motor, power electronics and energy storage systems).

	Day 1	Day 2	Day 3
8:30 - 12 am	Lecture	Lecture	Lecture
	Lunch Break		
1 - 4:30 pm	Lecture	Lecture	Excursion & Farewell (Exams optional)

- Hybrid Drive Trains
- Electrical Drive Trains
- Energy Demand of Cars
- Energy Storage Systems
- Basics of Rotating Electric Machines
- Induction Machines
- Synchronous Machines
- Power Electronics
- Charging
- Excursion

Exemplary Schedule of a 3-day Certificate Course

## Agenda in Detail

Day 1:	Day 2	Day 3
<p><b>Introduction</b></p> <p><b>Session 1: Hybrid Drive Trains</b> Variants of hybrid drivetrains   Serial, parallel &amp; power split hybrid drives   Complex structures &amp; practical examples</p> <p><b>Session 2: Electrical Drive Trains</b> Electric motor variants   Torque-speed performance of electric motors   Electric motors &amp; gearboxes   Performance comparison of electric motors &amp; combustion engines   Design rules &amp; power-to-weight-ratio   Electric drive trains (shaft, wheel, and wheel hub drives)</p> <p><b>Session 3: Energy Demand of Cars</b> Driving resistances   Auxiliary components   Energy flow   Driving cycles</p> <p><b>Session 4: Energy Storage Systems I</b> Characteristics of electric batteries</p>	<p><b>Session 5: Energy Storage Systems II</b> Lithium ion batteries   Fuel cells</p> <p><b>Session 6: Basics of Electrical Machines</b> Rotating fields   Calculation MMF curve   Calculation force &amp; torque   Mechanical design &amp; construction   Materials (copper, aluminum, soft magnetic material, hard magnetic material)   Losses in electric machines</p> <p><b>Session 7 &amp; 8 : Induction Machines/ Synchronous Machines</b> Operating principle   Modelling (equivalent circuit diagrams)   Performance (torque-speed-characteristics)   Losses</p>	<p><b>Session 9: Power Electronics</b> Components (diode, thyristor, power transistors, MOSFET, IGBT)   Topology of power electronics in electric cars   DC/DC-converter   DC/AC-converter</p> <p><b>Session 10: Charging</b> Tethered &amp; contactless charging</p> <p><b>Company Visit</b></p>

## Registration & Organizational Details

Duration	3 days
Price	2.495 € per participant
Group Size	max. 15 participants
Certificate	Certificate of the HECTOR School of Engineering & Management, Technology Business School of the Karlsruhe Institute of Technology (KIT)
Requirements	<p>First University Degree (Bachelor or equivalent)</p> <p>A minimum of 5 years of professional experience in the specific field of the course is recommended.</p> <p>The course can be held in German or in English – appropriate skills in the respective language are required. For international companies translators can be hired.</p>
Registration	<p>Register online via:</p> <p><a href="http://www.ectorschool.kit.edu/certificate_courses.php">www.ectorschool.kit.edu/certificate_courses.php</a></p>



For consultancy or company arrangements please contact:

### Program Consultancy

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## Course Instructor



### Prof. Dr.-Ing. Martin Doppelbauer

Professorship Hybrid Electric Vehicles (HEV) at the Karlsruhe Institute of Technology (KIT)

Prof. Dr.-Ing. Martin Doppelbauer was appointed with the professorship at HEV at the KIT in 2011.

At HECTOR School he combines his scientific expertise with more than 15 years of industry experience: From 2002 - 2011 he signed responsible as *Head of Electric Motor Development* for SEW Eurodrive and previously from 1995 - 2011 as *Head of Development* at the Danfoss Bauer GmbH.