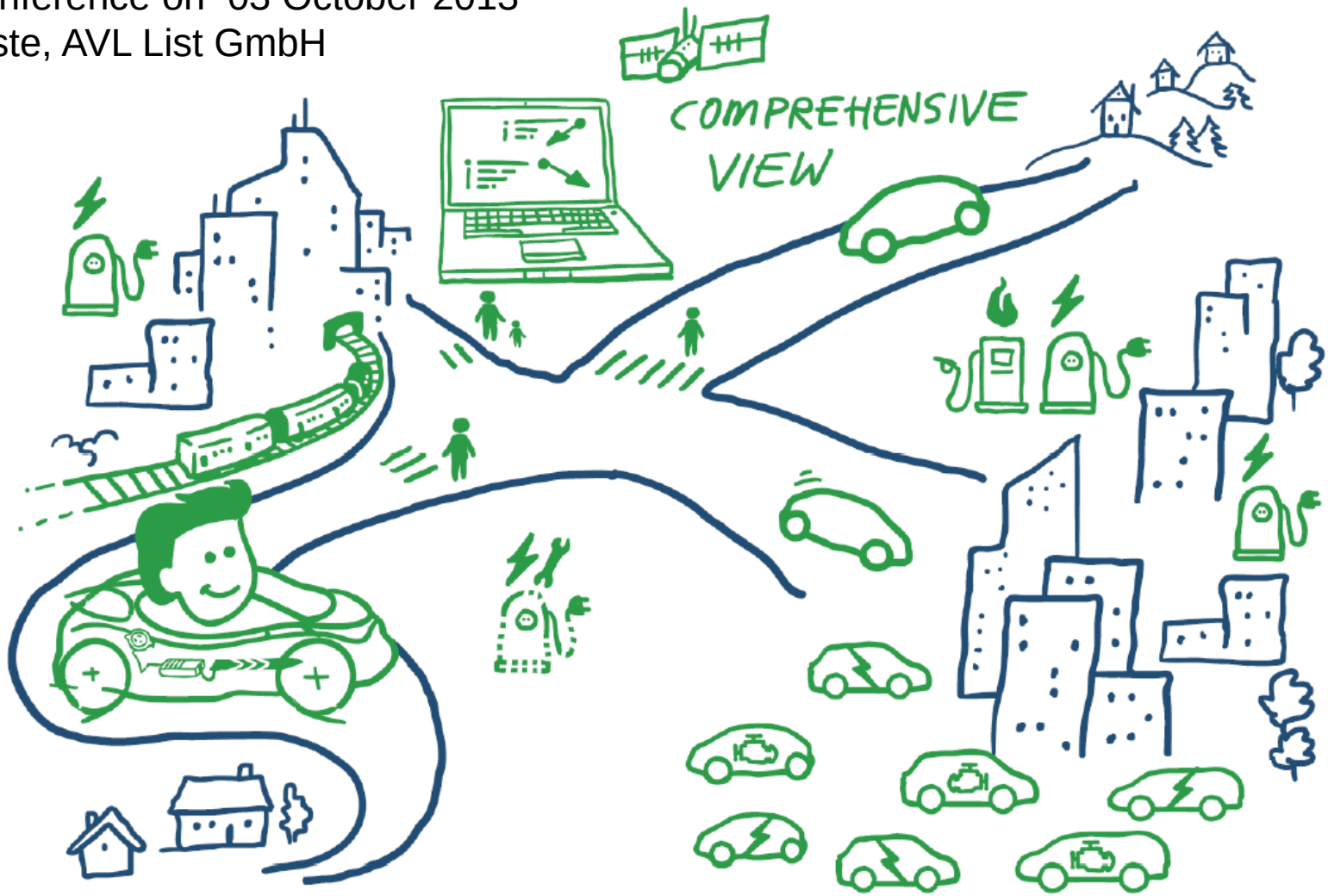
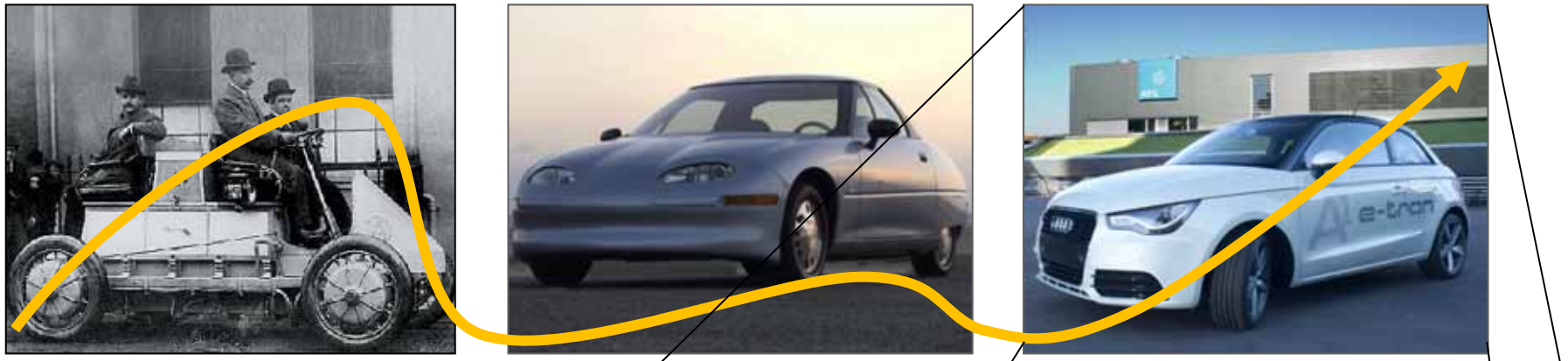
VECEPT Presentation of Technical Results

For A3PS Conference on 03 October 2013

Dr. Frank Beste, AVL List GmbH



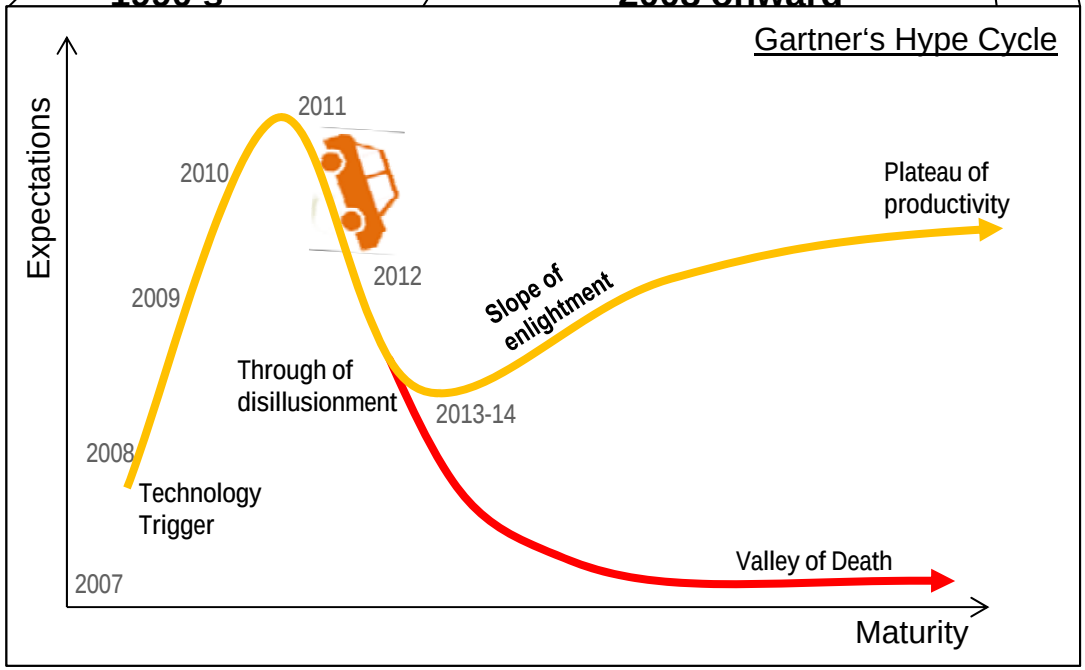
FIRST AGE | **SECOND AGE** | **THIRD AGE**



1840 – 1920‘s | **1990‘s** | **2008 onward**

Facilitate „Slope of Enlightment“:

- advance innovation to push intelligent ICE / EV synergy for target cost and new customer benefits
  - EV with RE → the „real EV“
  - PlugIn Hybrid → all purpose hybrid



D. Beeton, Urban Foresight

Challenges for the VECEPT Program….

- ✓ “Best in Class” PHEV regarding FC
- ✓ Competitive constant velocity FC
- ✓ “Best in Class” add-on costs for PHEV drivetrain
- ✓ Infrastructure need for PHEV different from that of BEV fleets

VECEPT funded by Klima and Energiefond, Project start Oct 2012

VECEPT - Vehicle with Cost-Efficient Power Train

Targets:

VECEPT focuses on the development and testing of a PHEV demonstrator as a volume concept for the global market and a potential SOP target in 2017. The engineer target especially focuses on all-purpose ability of the vehicle, competitive performance and production cost. The demonstrator vehicle is intended to be equipped with a newly developed drivetrain system and battery which support a minimum AER of 30km and highest efficiency in all operation modes. Besides the use of PHEVs in mixed fleets also the use patterns of various user groups regarding potential differences between PHEV and BEV will be investigated.

- Timing: 02.07.2012 – 01.07.2015
- Lead: AVL List GmbH
- Partner: AIT GmbH, ecoplus GmbH, Fluidtime Data Service GmbH, IESTA, Infineon AG, IVD GmbH, Magna Steyr Battery Systems GmbH & Co OG, Verbund AG, VIF mbH, Samariterbund Wien GmbH, Uni Wien

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VECEPT - Vehicle with Cost-Efficient Power Train

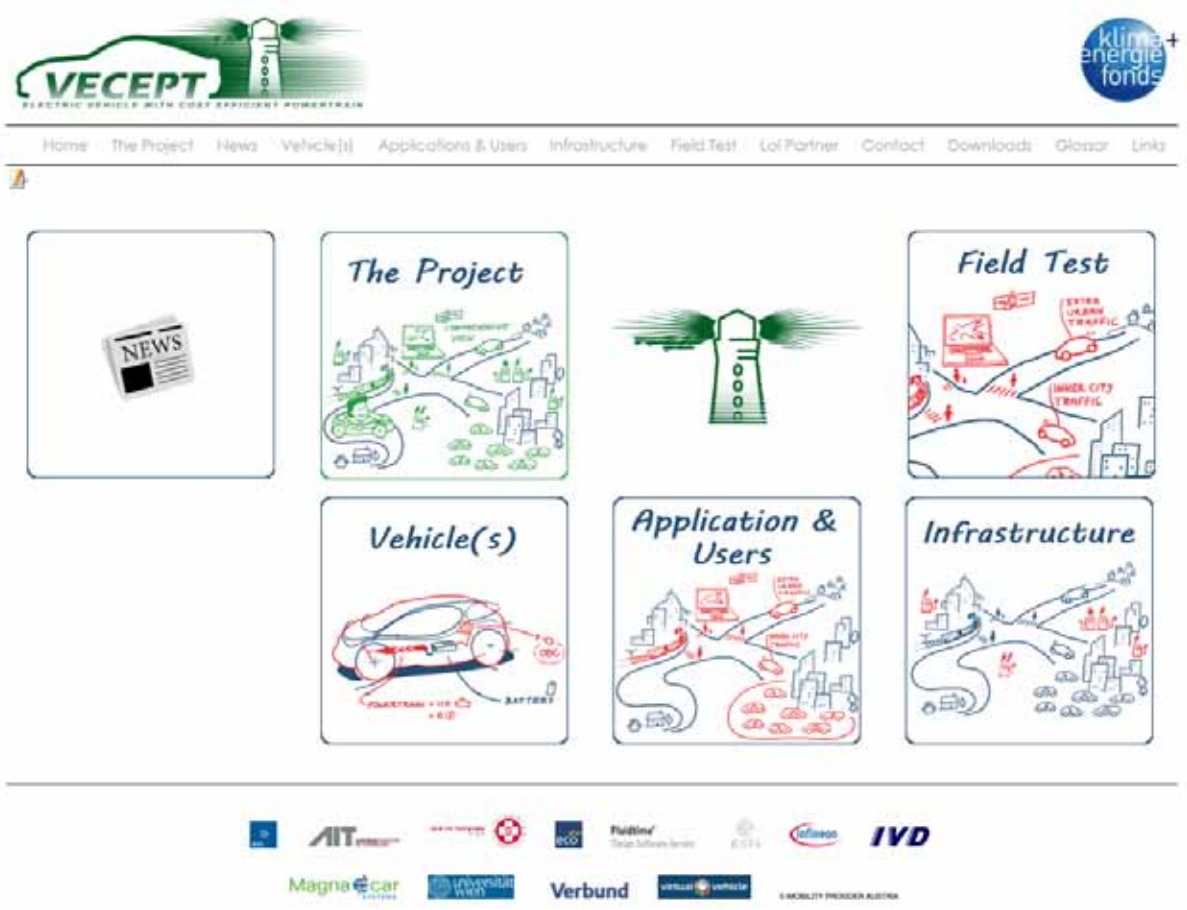
Work Packages:

- **AP1:** Development of vehicle drivetrain components and their geometric and functional integration into a demonstrator (AVL List GmbH)
- **AP2:** Increase of energy efficiency and vehicle safety, integrated thermal- and energy management, optimized HV-battery (Magna Steyr Battery Systems GmbH & Co OG)
- **AP3:** Vehicle application, user behavior, strategic planning SW-framework for the management of mixed fleets (AIT GmbH)
- **AP4:** Infrastructur – Installation and operation of charging systems and analysis of user behavior (Verbund AG)
- **AP0.3:** Evaluation and quality managements – holistic evaluation approach for AP1-4 in real conditions (VIF mbH)

Virtual OEM: The VECEPT partner consortium comprises leading companies and institutions from Austrian automotive industry, infrastructure technology, the public sector and science and form a virtual OEM to cover all aspects regarding the development and the deployment of PHEVs

WP 0.2 – IESTA:
Project website implemented

- Project Homepage www.vecept.at



WP 1 – AVL List GmbH: Deliverable Concept PHEV

Work on system-level:

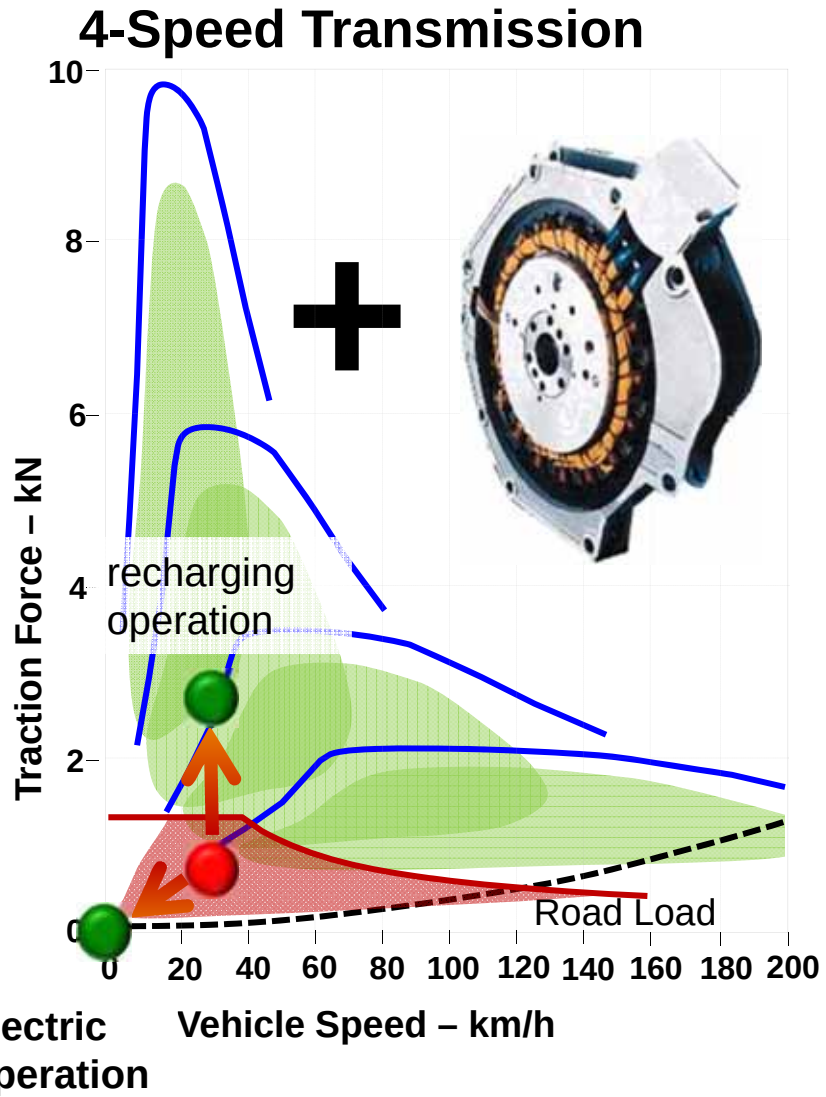
- Requirements for VECEPT demonstrator vehicle
- Powertrain requirements developed
- Powertrain architecture developed
- Base requirements for components developed
- Simulation models EXCEL/Cruise/AMESIM implemented
- Shifting analysis for AVL transmission conducted and ongoing
- Draft design for components (transmission, engine, vehicle package)
- NVH benchmark analysis of comparable state-of-art hybrid vehicles

Work on component-level:

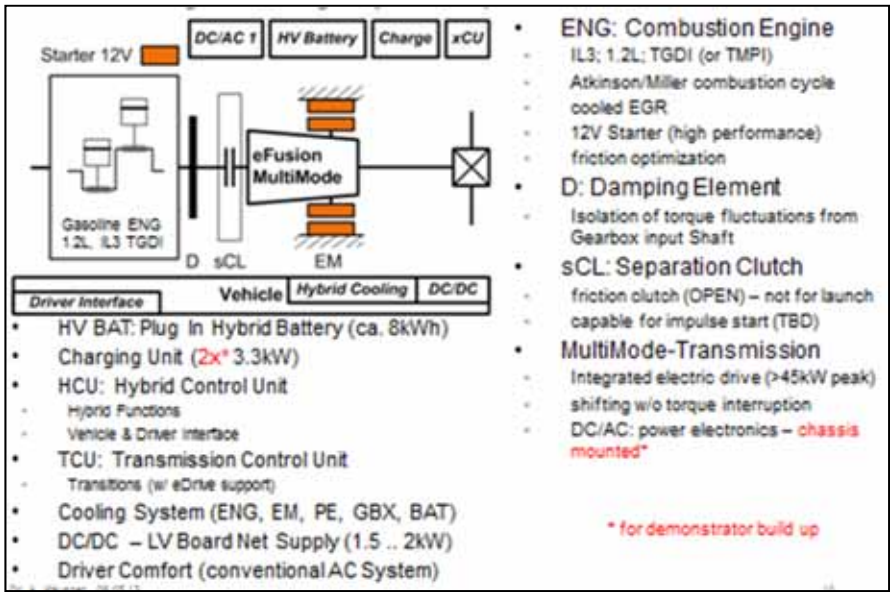
- Definition of thermal requirements, based on selected baseline-vehicle in close cooperation with WP2

Limited Transmission gear number with e-Motor

Electrification with dedicated combustion engine layout allows significant reduction of transmission gear number



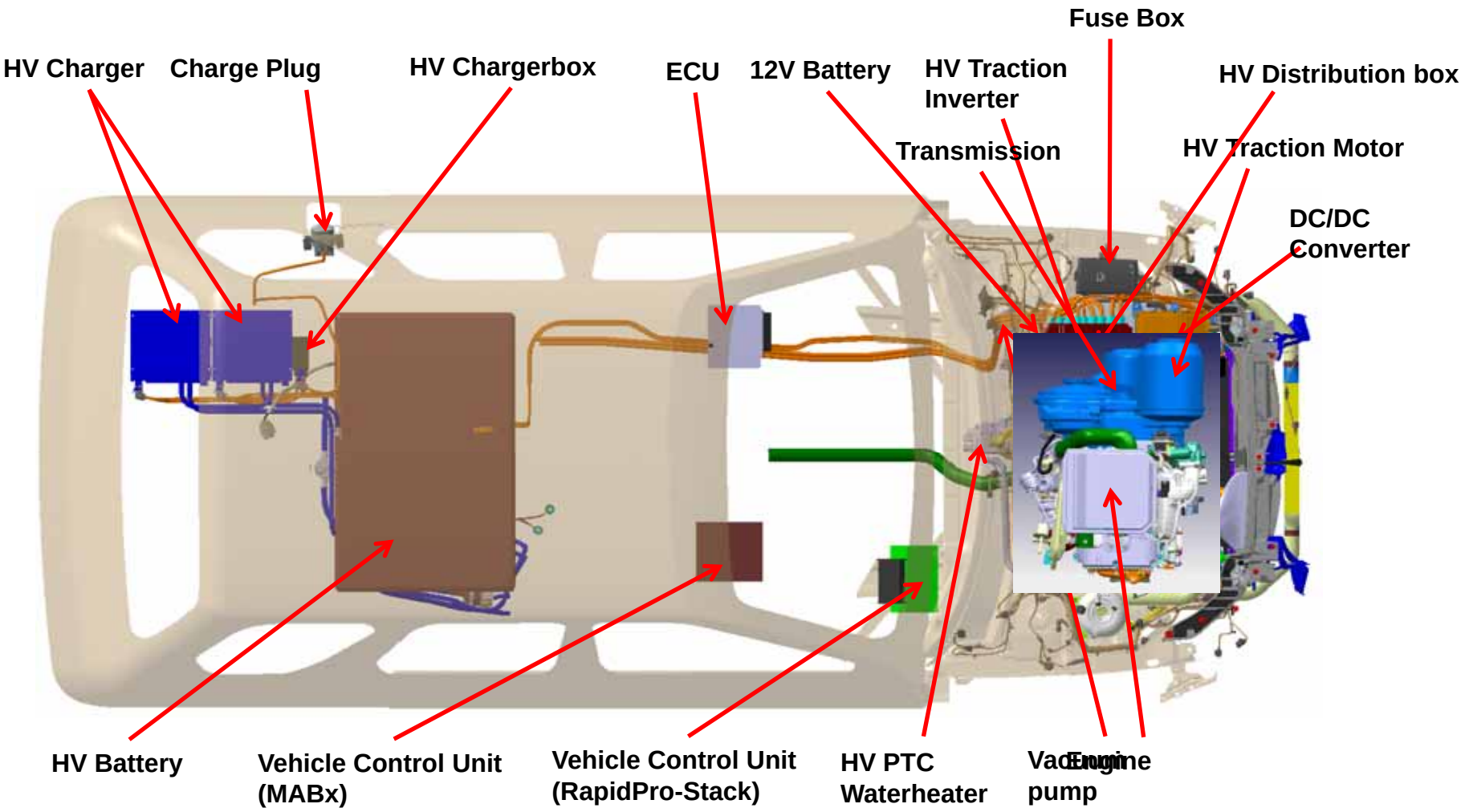
Drivetrain Quick View



<u>Key concept features are as follows:</u>

- Single electric motor integrated in transmission:
  - provide torque for the drive-train system
  - take over actuator functionality within transmission system
- Transmission with:
  - eCVT mode to operate combustion engine also at minimum vehicle speed and provide charge power for the electric system
  - 2 electric gears for reduced e-motor torque demand and best efficiency
  - 3 combustion engine gears
- Best fuel consumption and reduced complexity combustion engine optimized for hybrid drive-train requirements
- Integrated system design for compact packaging and good NVH
- Small battery optimized for AER requirements, no backup charge required, low auxiliary power demand

Vehicle integration

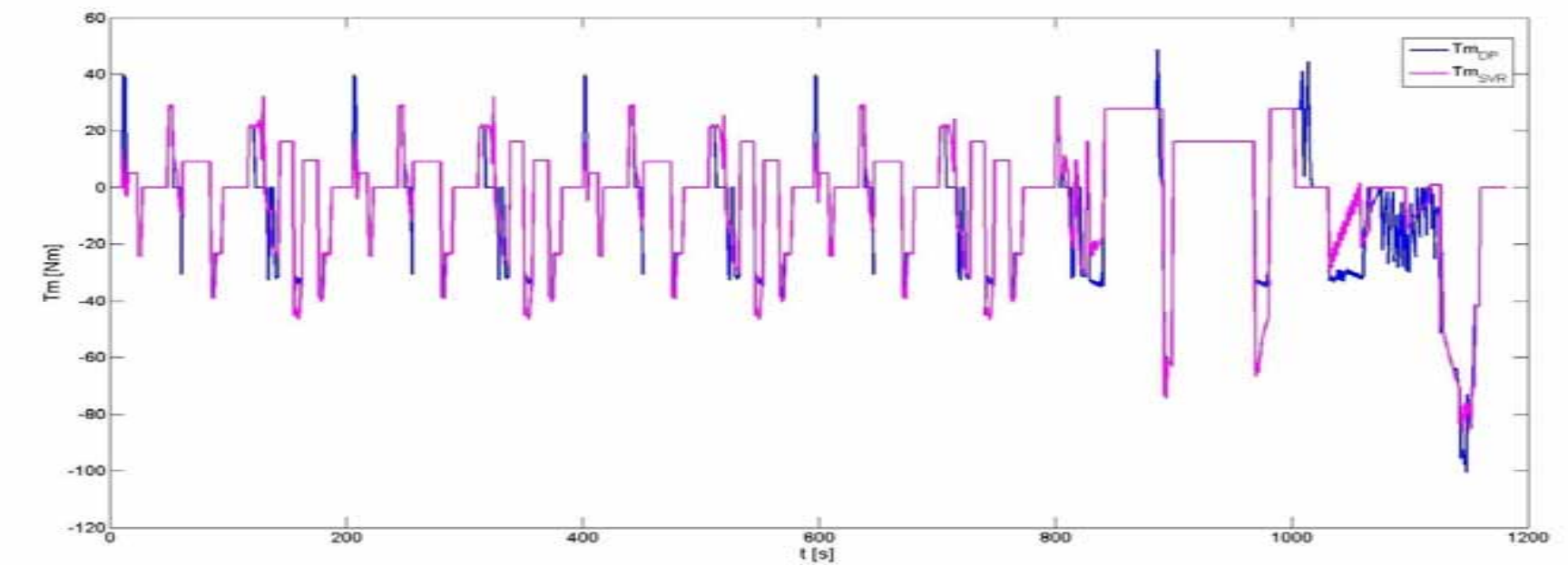


WP 2 – Magna Steyr Battery Systems GmbH & Co OG: Requirement Optimization and Operating Strategy

Work for Requirement Optimization and Operating Strategy:

- Analyze of energy consumption in PHEV
- Simulation of different cooling concepts basing on the requirements of VECEPT demonstrator vehicle and drive train (combustion engine and electric drive), the power electronics, the battery and the HVAC system (heating, ventilating and air conditioning)
- Concept for cooling circuit with benchmark simulations for the most promising cooling concepts
- Concept for HVAC system with an electric compressor and a chiller for battery cooling with benchmark simulations for the most promising HVAC system design
- Development of the control strategy for the designed HVAC system

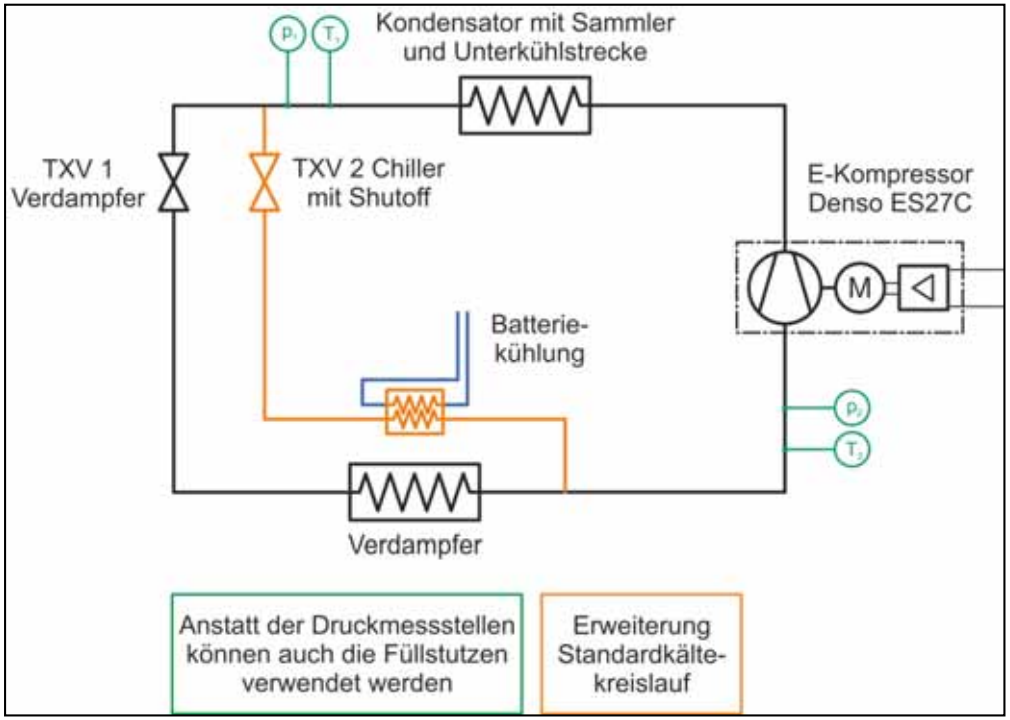
Integrated Operation strategy & Optimization potentials



Integrated operation strategy:

- strategy for minimal fuel consumption in development (function based on SOC and vehicle velocity) by dynamic programming for different cycles
  - optimal torque split factor for speed and acceleration profile
  - optimal gear for current situation
- solution quality by comparing dynamic programming and approximated solution by support vectro functions

Energy-, thermal management on component level



Concept of the planned HVAC system in VECEPT

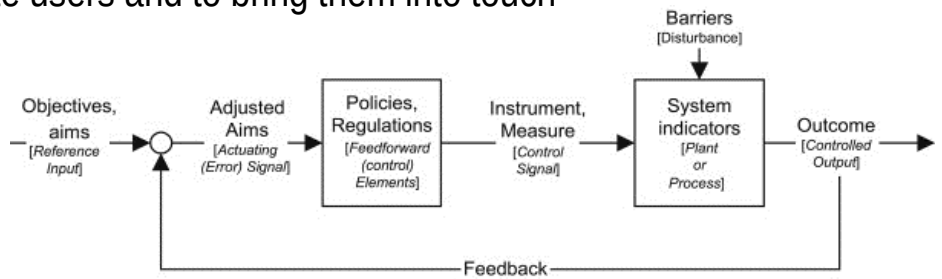
<u>Energy- thermal management (ongoing):</u>

- optimize a thermal management to fulfill requirements of the drivetrain (combustion engine, electric drive, power electronics, battery HVAC system)
- implementation of simulation models for alterantive cooling concepts:
  - system layout for demonstrator
  - efficiency for different driving cycles
- design HVAC system for passenger cabin and the conditioning of the battery in case of warm ambient condition (chiller)

WP 3 – AIT GmbH:
Deliverable Combined Mobility Service

Management of mixed fleets to quickly address a large number of users: Business and public fleets offer a favorable access to a high number and variety of people for testing and providing feedback to the developers. They serve as a multiplier to address private users and to bring them into touch

Framework is developed to specify and implement methods and algorithms for mixed fleet management optimizations



Concepts for combined mobility services

The conceptual framework has been developed from a holistic perspective, taking into account all the needs of fleets operated by the private and public sector, integrating mobility requirements from the choice of the appropriate.

Objectives to analysis of mobility requirements:

1. Feedback system
2. Hierarchical system
3. Combined in a matrix

	QUALITATIVE		QUANTITATIVE	
SYSTEM HIERARCHY OF	THE CONTROL CYCLE			
	Objectives	*Policies*	*Instruments*	*Indicators*
MACRO LEVEL 1	Objective 1,1	Policy 1,1	Measure 1,1	Indicator 1,1
	…	…	…	…
	Objective 1,n	Policy 1,n	Measure 1,n	Indicator 1,n
LEVEL 2	Objective 2,2	Policy 2,2	Measure 2,2	Indicator 2,2
	…	…	…	…
	Objective 2,n	Policy 2,n	Measure 2,n	Indicator 2,n
MICRO LEVEL N	Objective n,n	Policy n,n	Measure n,n	Indicator n,n
	…	…	…	…
	Objective n,n	Policy n,n	Measure n,n	Indicator n,n

WP 4 – Verbund AG: Concept for PHEV/BEV charging

The methodology for deliverables can described in following bullets:

- building on BEV charging concepts established in EMPORA
- research on BEV/PHEV models coming to market
- research on micro economics of drivers of PHEVs
- preliminary concept for PHEV charging

PHEV user micro economics analysis

- Main Assumptions: Drivers for electrification will intensify
  - Diesel and Gas prices for customers will increase
  - Cities will implement Green Zones and Policies
  - Green electricity prices will increase slower than fossil energy prices
- Effects of REX or PHEV: Low-CO2 Mobility with Flexibility
  - Barrier of limited range effectively removed
  - Economic benefits for maximizing electric range
  - Smaller Battery than with most BEV models (focused on daily AER need)

Concept for PHEV/BEV charging

Conclusion on preliminary concept for PHEV charging – three use cases:

1. Home / Slow Charging:
   - PHEV/REX drivers will predominately charge at home / work
   - Identical Use Case as BEV: Normal Charging, 3.7 – 11kW
2. Opportunity Charging:
   - Identical Use Case as BEV: Accelerated Charging ~ 22 kW
   - New Use Case for curb-side parking drivers
3. Fast charging during trips:
   - Difference compared to BEV users; fast charging not crucial for PHEV
   - Use Case merge with opportunity charging during trips: Fast charging 22kW – 50kW

Conclusion for charging technology:

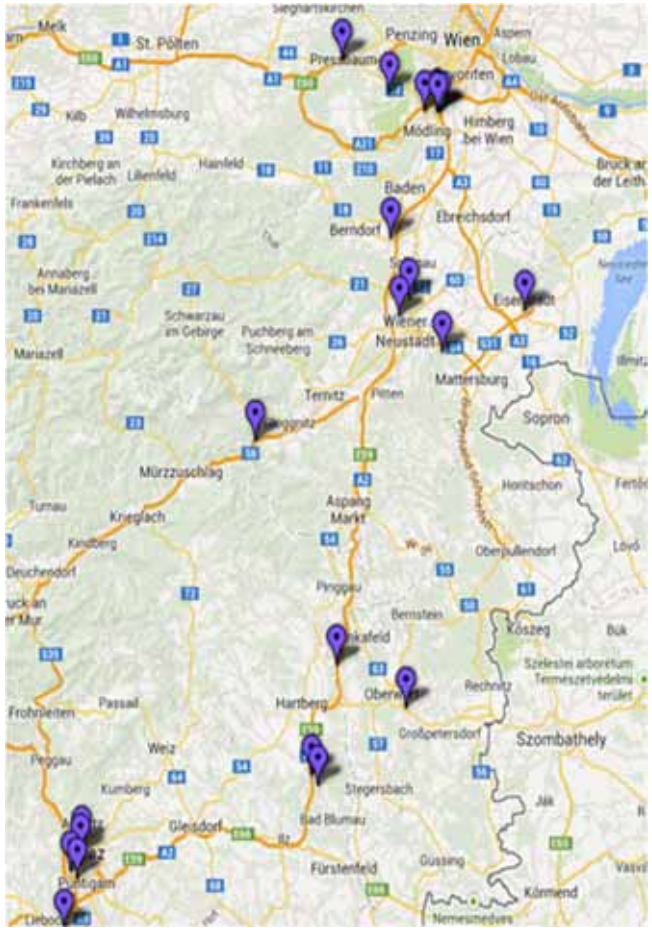
1. Current vehicle models mainly fit for slow/opportunity charging
2. Some next generation models growingly fit for DC fast charging

Milestone Charging Sites selected

Infrastructure for PHEVs and for BEVs is expected to provide the feeling of safety and comfort to drive everywhere anytime. It has to properly deal with the range anxiety of the users and the general anxiety regarding new technologies

As results from this phase the following achievements could be reached:

- Catalogue of site selection criteria
- Traffic data analysis for selected are-as within the relevant region
- Pool of about 30 site candidates in the relevant region (→ see figure)
- Advanced site contract negotiations for 6 of these locations



For further information please visit our homepage

www.vecept.at

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