Short version profile plan for Sustainable Vehicle Technologies 2015–2019

Vision

The research within this profile should contribute to sustainable and energy efficient vehicle design and operation. Our vision is a highly energy efficient transport system, that uses renewable energy sources, and have no net emissions of greenhouse gases. The role of the profile is to support the development of vehicle technologies aiming in this direction as well as to assess and guide towards overall sustainability. The role of the profile is also to facilitate collaboration between Chalmers different research competence centres as well as research groups from different research disciplines.

Background and context

Passenger and freight transportation contributes globally to about one fifth of the energy use and of the energy related CO_2 emissions. Many projections indicate that energy use and CO_2 emissions from transport could rise sharply in the future. To address this challenge EU states that by 2050 all transport related greenhouse gas emissions must be reduced by 60 % compared to 1990.

The ambitions of the Swedish Government are zero net emissions of greenhouse gases for Sweden in 2050 and a vehicle fleet for road-based transport independent of fossil fuels already in 2030. Following these two ambitions, a governmental investigation shows the necessity of:

(1) a substantial reduction in the amount of vehicle kilometre driven and the amount of energy used per kilometre,
(2) the expansion of electricity as an energy carrier in the transportation sector, and
(3) large amounts of biofuels available for use in Sweden in 2030–2050.

Chalmers has broad expertise to address these multi-disciplinary problems on different systems levels.

Active fields

Sustainable Vehicle Technologies is a profile shared between the Energy Area of Advance and the Transport Area of Advance. It has four active research fields:

- Combustion Engine Research,
- Electric and Hybrid Vehicles,
- Vehicle Concepts and Design, and
- Vehicle Environmental Impact.

Although the research within the active fields applies to all modes of transport, vehicle technologies for road transport are dominating.

Combustion Engine Research

Research in this field encompasses *internal combustion engines* and *after-treatment systems*. Regarding internal combustion engines, the main focus lies on generation of new knowledge, development of advanced research tools, and investigation of new technological solutions and concepts that aim at increasing the energy efficiency and reduce exhaust emissions. An area of increasing importance is new concepts associated with alternative and renewable fuels, in all steps from fuelling to exhausts as well as combustion engines adjusted for hybrid electric vehicles. Research connected to after-treatment systems has the aim to abate emissions from vehicles primarily through catalyst-based technologies. Both experimental and theoretical methods are used to address the main focus areas: catalytic activity at low temperatures, reduction of nitrogen oxides in oxygen excess, catalyst deactivation, and sulphur scrubbing.

Electric and Hybrid Vehicles

Within this active field we have identified three subareas: *hybrid powertrain design and control*, *electric motors and converters*, and *energy storage systems*. Electrification of vehicle powertrains sparks research on both system and component level. On a powertrain system level, the goal is to exploit the increased flexibility to reach high cost-effectiveness and energy-efficient operation. Regarding electric motors and converters, a prioritised activity is to tailor-make electrical car propulsion e-motors for various vehicle applications and sizes as well as to take a grip of the total energy consumption in an electrical vehicle.
In the area of energy storage systems focus lies on improved safety, e.g. by understanding the degradation mechanisms, of Li-ion batteries and on the development of next generation storage systems for vehicle applications.

Vehicle Concepts and Design

Within this active field we have identified four subareas: *reduced resistance, noise reduction, advanced structure and materials,* and *maintenance, durability, and robustness.* In reduced resistance, the focus is to improve the fluid flow around all kinds of vehicles. Main priorities within noise reduction are to understand noise and vibration sources, minimise generation, control propagation, and minimise impact of noise, both inside and outside the vehicle. Research on advanced structure and materials for vehicle applications includes how to influence and predict dynamic forces and stresses, evaluate influence of modified materials, quantify increased operational demands as well as improve, ensure and validate structural integrity. In maintenance, durability and robustness activities are connected to estimate and control operational loads, establish reliability and safety as well as risk criteria for different operations.

Vehicle Environmental Impact

Within this active field we have identified five subareas: *systems analysis, policy analysis and market formation, recycling of vehicle batteries, emission measurement and impact,* and *eco-operation.* Energy systems analyses are conducted to guide cost-effective vehicle technology choices and selection of future fuels. Policy analysis and studies of market formation are being conducted in several areas, e.g. on the introduction of electrified vehicles and vehicle recycling and reuse of components. Regarding recycling of vehicle batteries, system studies are conducted and recycling technology is developed. The marine eco-operation activities concerns human factors in order to achieve energy efficient driving of ships

Planned activities 2015–2019

One important aim for this research profile is to **facilitate collaboration** between Chalmers' different research competence centres and departments within the topic of sustainable vehicle technologies, e.g. by sharing postdocs. The profile also aim for facilitating research exchange with other universities as well as industry, through e.g. partly funded visits to and from Chalmers, partly funded conferences, workshops, seminars when topics applies to a broad part of the profile, supporting emerging research topics in the form of pre-studies and activities in order to strengthen the internal research community, such as all-researchers-workshops twice a year.

The profile has initiated several research work packages, the majority as parts of the large interdisciplinary effort to improve scientific knowledge regarding next generation hybrid electric vehicles. The topics of these research work packages are:

- **Optimized engine control for hybrid drive lines (2016–2017)**
  Hybrid electric vehicles studied from the combustion perspective where the electric motor is used to smooth the transients in the combustion engine.
- **Active cell balancing (2016)**
  Analysis of how active cell balancing decides different properties of the hybrid powertrain.
- **Enhanced total energy efficiency in electric motors and converters (2016–2017)**
  Analysis of challenges connected to total energy consumption in an electric vehicle.
- **Li-sulphur technology in energy storage systems (2016–2017)**
  Improved Li-sulphur technology with higher power densities and long cycle life as electrical energy storage in hybrid vehicles.
- **The Swedish car movement database (2016)**
  Analysis of car movement data for improved knowledge on e.g. battery size.
- **Active flow control for reduced resistance (2016–2017)**
  Analysis of the shape of the vehicle with focus on active flow control.
- **Environmental assessments (2016–2017)**
  Systems analysis focusing on the role of hybrid electric vehicles.
- **Control system design for hybrid vehicles (2015-2016)**
  Development of control strategies for the thermal variations of the combustion engine and aftertreatment system in a hybrid vehicle.
- **Internal Combustion engines for hybrid vehicles (2015-2016)**
  Development of models for design of the aftertreatment system focussing on cold-start behavior.
- **Catalysis for emission control for hybrid vehicles (2015-2016)**
  Analysis of various types of emission catalysts with the special boundary conditions that applies for hybrid electric vehicles.
- **Emission cleaning from methane engines (2015-2016)**
  Analysis of methane oxidation catalysts to understand the surface mechanisms during reactions in complex gas mixes.
- **Fuels for the shipping sector: the role of electrofuels (2015-2016)**
  Systems analysis of future role of fuels produced from carbon dioxide and water with electricity as the main source,
- **Optical remote sensing of ship plumes (2015-2016)**
  Method development for optical remote sensing to measure gases and particles in ship smoke.