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Comprehensive Energy Management—Eco Routing & Velocity Profiles

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Contents

Introduction

Bernhard Brandstätter[1] and Daniel Watzenig[1] on Behalf of the Cluster of 4th Generation Electric Vehicles

This book is organized in two volumes (the contents of both volumes are listed at the end of this introduction):

- Volume 1: "Comprehensive Energy Management—Eco Routing & Velocity Profiles"
- Volume 2: "Comprehensive Energy Management—Safe Adaption, Predictive Control and Thermal Management"

Comprehensive Energy Management

Energy management plays a central part in today's vehicles, especially for battery electric vehicles, where a limited number of charging possibilities and time-consuming charging processes lead to range anxiety of the users. This can be considered as an important factor (apart from the increased cost of electrical vehicles compared to conventional ones) that prevents larger number of fully electric vehicles on the road.

Thus comprehensively treating energy and controlling it is of uttermost importance.

This book provides findings of recent European projects in FP-7 grouped in a cluster named "Cluster of 4th Generation Electric Vehicles" but also gives insight into results from ongoing H2020 projects related to energy management.

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Since fuel cell technologies are gaining more attraction again, the last section of the book gives an overview of the state of the art in this field what PEM[2] fuel cells is concerned.

Cluster of 4th Generation Electric Vehicles

The Cluster "4th Generation EV" was set up late 2013 by the European projects INCOBAT, iCOMPOSE and eDAS, with the purpose to synchronize and cojointly promote the R&D topics on electric vehicles. By growing to a total of six projects with the FP7 projects Batteries2020, IMPROVE and SafeAdapt, the cluster also enlarges its networks and range of influence on the European electric vehicle community (Fig. 1).

The projects within the cluster are focusing on the following goals:

- Batteries 2020+: improve performance, lifetime and total cost of ownership of batteries for EVs
- eDAS: Holistic energy management for 3rd and 4th generation EVs.
- iCOMPOSE: Integrated Control of Multiple-Motor and Multiple-Storage Fully Electric Vehicles.
- INCOBAT: Innovative Cost Efficient Management System for Next Generation High Voltage Batteries.
- IMPROVE: Integration and Management of Performance and Road Efficiency of Electric Vehicle electronics.
- SAFEADAPT: enrich networked embedded systems in e-vehicles.

Uniting more than 40 partners from 12 countries all over Europe, including 7 OEMs, with an overall budget of more than 36 million Euros, the impact of the cluster on the next generation of electric vehicles keeps on growing.

The "4th Generation EV" cluster is organized around the three following working groups:

- Comprehensive energy management
- Central computing platform
- Potential of electrification

[2]Proton exchange membrane

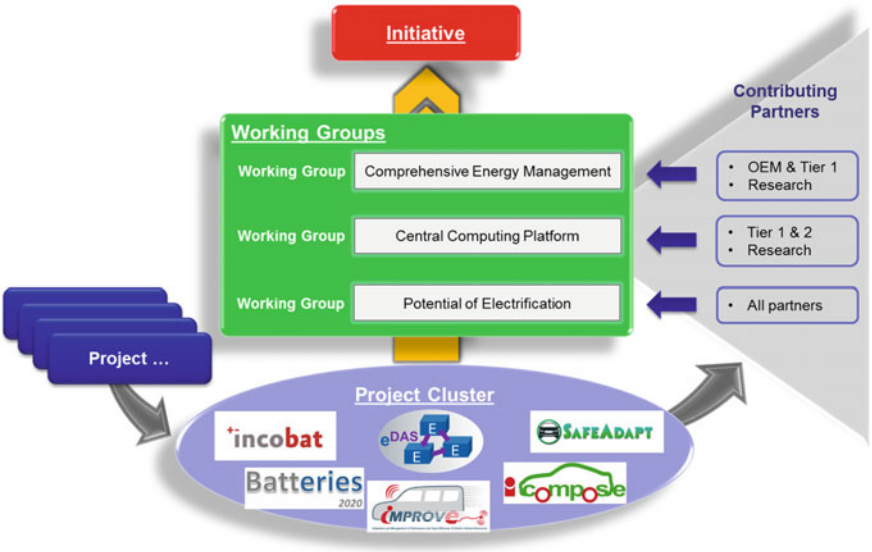

Fig. 1 Cluster of 4th Generation Electric Vehicles

Some of the cluster projects will end in 2016 but bridging to H2020 projects has already begun. As an example the H2020 project OPTEMUS can be mentioned, where the comprehensive energy aspect is widened by new technologies like heating panels and energy harvesting technologies with strong focus on thermal comfort sensation inside the cabin (which plays a very important role in overall energy consumption).

Organization of this Book

The chapters of this book are organized under five different groups: ECO driving and ECO routing covers different approaches for optimal speed profiles for a given route (mostly interconnecting with cloud data); model-based functional safety and fault-tolerant E/E architectures; advanced control making use of external information (from a cloud) as well; thermal management as a central part for energy optimization and finally some aspects on fuel cells.

These subject areas with their chapters (chapter titles in italic) are listed below:
Volume 1:

- ECO Driving and ECO Routing
  - *Aspects for Velocity Profile Optimization for Fleet Operated Vehicles*: on-board and off-board optimization including cloud communication

- *Semi-Autonomous Driving Based on Optimized Speed Profile*: different controllers including model predictive control
- *Design of Vehicle Speed Profile for Semi-Autonomous Driving: energy consumption optimization for different driving conditions*
- *Energy-Efficient Driving in a Dynamic Environment*: considers energy optimal velocity profiles in the presence of other traffic participants and overtaking possibility
- *Model-Based Eco-Routing Strategy for Electric Vehicles in Large Urban Networks*: energy consumption model that considers accelerations and road infrastructure

Volume 2:

- Safety Aspects
  Addressing fault-tolerant approaches of automotive energy-efficient E/E architectures and model-based functional safety engineering in
  - *Safe Adaptation for reliable and Energy-Efficient E/E Architectures*
  - *Model-based functional safety engineering*
- Advanced Control
  - *Model predictive control of highly efficient dual mode energy storage systems including DC/DC converter*
  - *Predictive energy management on multi-core systems*: first approach to solve a reference speed tracking problem on a multi-core platform in real time
- Thermal Management
  - *Holistic thermal management strategies for electric vehicles*: including some rudimentary cabin comfort issues
  - *Heat pump air conditioning systems for optimized energy demand of electric vehicles*
- Fuel Cells
  - *Thermal management of PEM fuel cells in electric vehicles*

The aspects within the field of comprehensive energy management are too numerous that all of them could have been addressed in this book (aerodynamics and adaptive control of aerodynamic features could be mentioned in this context as an example). We think, however, that important key enabling elements for optimal energy management taking the environment and context into account have been collected in this book.

We cordially acknowledge all authors and co-authors for their efforts and looking forward to next steps in future projects.

Graz, Austria
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