



# HOLICE: A holistic approach to the integration of combustion engines and electric machinery in heavy hybrid electric vehicles

## SHC Theme 2

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## Summary

To realize major improvements in terms of energy efficiency of the propulsion system in heavy hybrids, a truly holistic approach is needed. This is a long-term goal of the HOLICE project established within the Scania and KTH strategic collaboration platform (ASP). The overall goal of this project is to estimate potential efficiency improvements in different heavy-hybrid applications (heavy/light, long haulage/distribution) enabled by a more holistic approach than what is used today.

In this project, which has been carried out between November 2014 and today, a general survey of today's state of the art was first carried out. A number of meetings with personnel from Scania, KTH/Division of Mechatronics, KTH/Division of internal combustion engines and KTH/Dept. Electrical energy conversion have also been held. As a key outcome of these discussions, a list of potential ideas for realizing improvements in heavy hybrid-electric drivetrains has been identified. Several of these proposals identify possible potentials for improvement through unconventional use of electrification to mitigate limitations of the combustion engine. Most of these proposals must be considered as high-risk nature and in a planned continuation during autumn 2015, a selection of these proposals will be identified for further analysis in the form of master theses project works, representing more detailed pre-studies of the proposals, which are planned for execution during spring 2016.

## Background

A truly holistic integration of combustion engines and electric machinery is believed to have the potential of providing significant improvements in terms of energy efficiency compared with today's most sophisticated drivelines. The purpose of this project is to establish the state of art hybrid drivelines and to identify important research questions that need to be addressed in order to achieve this big improvement.

This above represents a long-term goal of the HOLICE project established within the Scania and KTH strategic collaboration platform (ASP) and the project received funding (630 kSEK) from SHC for the period 2014-10-01 to 2015-03-31 with Oskar Wallmark (KTH/Dept. Electrical energy conversion) as project leader.

## General project description

The project is multidisciplinary in nature and aims at increasing the collaboration within different units at KTH in the field of heavy hybrid electric drivetrains.

## Achieved results

Until now, key results include:

- A mapping of different research initiatives and funding bodies with focus on hybrid electric drivetrains and combustion engines has been compiled (see [1]).
- A list of suggestions suitable for coming pre-studies in the form of master thesis project works has been compiled (see [1]).

Additionally, one of the suggestions for a coming pre-study, comprising of a novel hybrid driveline configuration, has been experimentally implemented as a small scale hybrid electric vehicle built by approximately 20 students at KTH and competing in the 2015 Shell Eco marathon competition which was held in Rotterdam, May 21-24, 2015 (see Figure 1). Also, a waste-heat recovery system was installed in the vehicle.



Figure 1 – Down-scaled experimental prototype of the hybrid-electric driveline configuration suggested in [1].

## Contribution to hybrid vehicle technology

The identified concepts proposed for coming pre studies can potentially lead to results that can be of direct interest to the Swedish automotive industry.

## Uniqueness and news value

The review of present state of art and the mapping of Swedish research initiatives on hybrid electric drivetrains and combustion engines cannot be considered as research activities but rather as a compilation of knowledge of interest to the different project actors. At this stage, it is not clear which exact potential the concept proposals will have for the Swedish automotive industry.

## Timing and finance

From October 1<sup>st</sup> 2014 until June 30<sup>th</sup> 2015, the project budget has been 630 kSEK provided by SHC.

## Executors and collaboration

Within the project, an internal group was formed at KTH/Dept. of Electrical energy conversion consisting of Oskar Wallmark, Mats Leksell and Jan Boivie (enrolled for the project). The main body of the work, including the authoring of the final report [1], was, however, carried out by Jan Boivie together with Mikael Hellgren from KTH/Div. Mechatronics.

Two meetings were held at Scania and three meetings at KTH with the additional participating persons

- Andreas Cronhjort, KTH/Div. Internal combustion engines.
- Jonas Holmborn, KTH/Manager CCGEx competence center
- Elna Holmberg, SHC/Manager
- Anders Hultqvist, KTH/Div. Internal combustion engines.
- Johan Lindström, Scania.
- Jonas Mårtensson, KTH/Dept. Automatic control.
- Nils-Gunnar Vågstedt, Scania.

## Dissemination of Results

The final project report [1] has been finished and will be disseminated to the SHC member companies through the SHC web forum. The project was presented at the cross-thematic SHC meeting held in Hallsberg on March 11-12, 2015.

## Papers and publications

1. J. Boivie and M. Hellgren, and O. Wallmark (ed.), "A holistic approach to the integration of combustion engines and electric machinery (HOLICE) for heavy hybrid electric vehicles," Technical report, KTH Royal Institute of Technology, June, 2015.

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