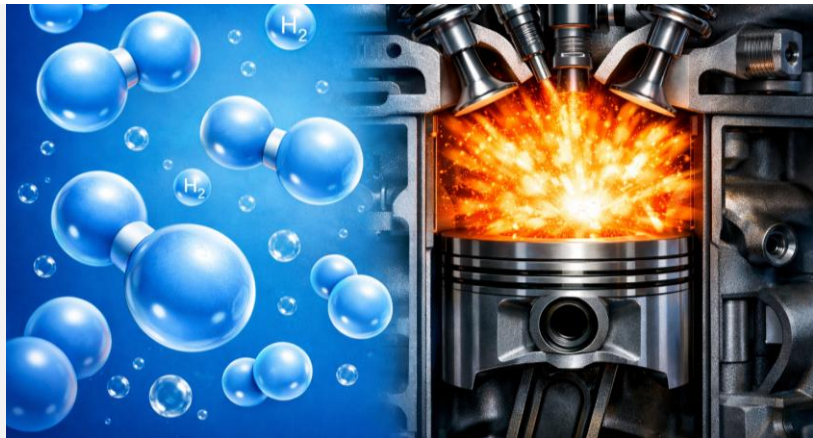


LEC GETS
LEC Green Energy and
Transportation Systems

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Center (K1)

Type of project: mixed
 Short title: LEC GETS
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IN-DEPTH UNDERSTANDING OF HYDROGEN COMBUSTION ANOMALIES THROUGH OPTICAL INVESTIGATIONS

ADVANCED OPTICAL INSTRUMENTATION ON ONE OF LEC’S RESEARCH ENGINES SERVES TO BETTER UNDERSTAND THE POTENTIAL ROOT CAUSES OF HYDROGEN PRE-IGNITION AS A BASIS FOR DEVELOPING HIGH-POWER H₂-FUELED ENGINES

Global warming is one of the greatest challenges the world faces in the 21st century. The key element to achieving ambitious CO₂ reduction targets is a global transition from a fossil fuel-based energy system to a system that is built on renewable energy sources. Internal combustion engines are well suited to serve as climate-neutral, zero environmental impact sources of mechanical energy if the transition from fossil to renewable fuels can be achieved. Hydrogen (H₂) is easily produced from renewable energy sources via electrolysis during times of an oversupply of electricity and may be used for propulsion or power generation in internal combustion engines when electricity demand exceeds the supply (Figure 1, left side). Currently, a key limitation to achieving very high power levels with H₂-fueled engines is the occurrence of combustion anomalies, in particular the so-called phenomenon of “pre-ignition”. It refers to self-ignition of the combustible mixture inside the engine in an uncontrolled way and at an unwanted timing, leading to malfunction and severe damage of the engine.

To develop mitigation measures in a target-oriented way, research must focus on understanding the origins and the potential root causes of pre-ignition events inside an engine’s combustion chambers.

Optical investigation of H₂ pre-ignition at LEC

To obtain in-depth insights into pre-ignition phenomena in hydrogen-fueled operation, a sophisticated experimental methodology was developed at the Large Engines Competence Center (LEC) in Graz. A research engine was instrumented with optical sensors which allow to determine the spatial and temporal origins of pre-ignition phenomena inside the engine (Figure 1, right side). With help of the optical measurement data, e.g., the lubricant oil was identified as playing a key role in the occurrence of pre-ignition, while other potential root causes could be explicitly excluded. Consequently, the design of specific key components of the engine must be optimized for hydrogen operation to avoid pre-ignition phenomena in the future.

SUCCESS STORY

The results obtained using the optical measurement method are substantial in guiding such engine design optimization work.

Impact on production engines using H₂ as fuel

The elimination of pre-ignition is key to establishing hydrogen-fueled internal combustion engines as high power, highly efficient, robust, affordable and zero environmental impact energy converters in real-world applications such as transportation of goods and people, machinery and power generation. The optical research methodology developed at LEC for understanding pre-ignition phenomena in detail sig-

nificantly supports this goal. Target-oriented optimization of hydrogen engines and key components thereof will have a positive impact on fostering their market penetration and thus provide a specific benefit for relevant national and international company partners (e.g., engine manufacturers and related component suppliers) in the COMET K1 Green Energy and Transportation Systems (GETS) consortium. Based on the developed optical methodology and the transfer of the results to series engine applications, the LEC has further strengthened its position as an internationally active and renowned COMET K1 center that carries out high-quality research work in the field of large engine technology.

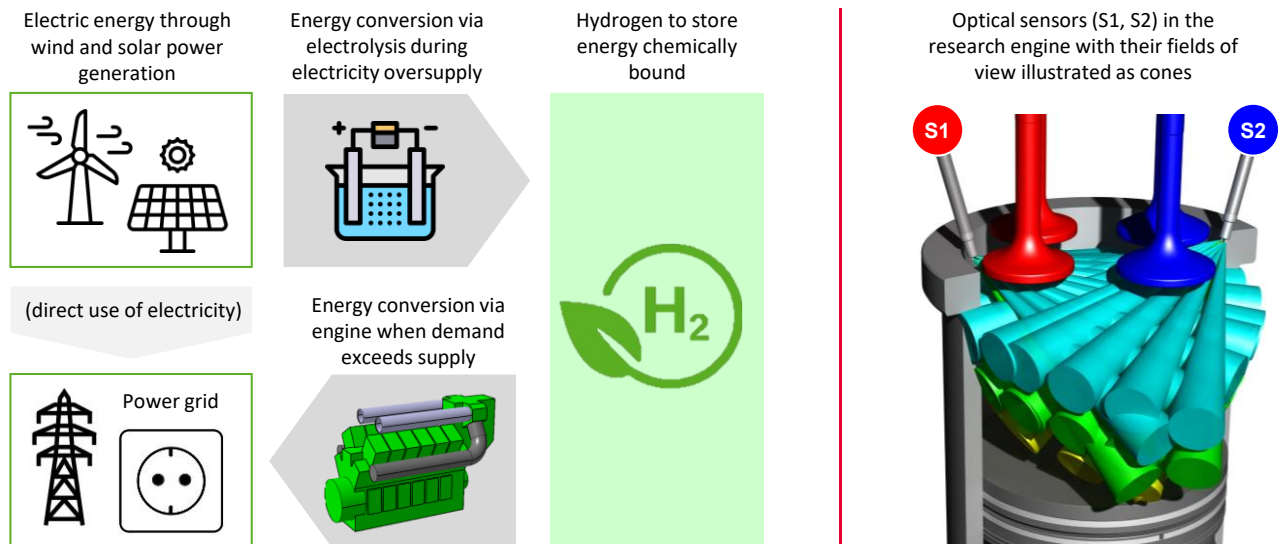


Figure 1: Energy system based on hydrogen as renewable fuel with internal combustion engine as energy converter (left) and instrumentation of the research engine at LEC with two optical sensors to obtain in-depth understanding of pre-ignition (right). © LEC GmbH

The optical investigations of H₂ pre-ignition were published in detail in the [Intern. Journal of Engine research](#).

Project coordination

Univ.-Prof. Dr.-Ing. Nicole Wermuth
 Scientific Director
 LEC GmbH
 T +43 (0) 316 873 30087
 nicole.wermuth@lec.tugraz.at

K1 COMET Center LEC GETS

LEC GmbH
 Inffeldgasse 19/2
 8010 Graz
 T +43 (0) 316 873 30101
 office@lec.at – <https://www.lec.at>

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