

# Hydrogen Expansion Engine for energy recovery and efficiency enhancement in fuel cell electric vehicles

## Summary

Profile type	Company's country	POD reference
<b>Technology request</b>	<b>Germany</b>	<b>TRDE20230808011</b>
Profile status	Type of partnership	Targeted countries
<b>PUBLISHED</b>	<b>Research and development cooperation agreement</b>	<b>• World</b>
Contact Person	Term of validity	Last update
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## General Information

### Short summary

A German institute focusing on the use of hydrogen in vehicles has developed a hydrogen expansion engine system combining an expansion engine with an electric generator which increases the efficiency of fuel cell systems. It can also be applied in other sectors like natural gas-based energy supply. To bring the technology to market maturity and adapt it to further applications, the institute is looking for industrial partners to build a prototype under a R&D or technical cooperation agreement.

### Full description

A German research institute is working on research topics for new vehicle concepts and technologies. Their activities range from conceptual considerations to simulation and design to prototypical construction of selected technologies and the construction of research vehicles. The focus is on the use of hydrogen as a future energy carrier and the provision of electrical energy through fuel cells at the vehicle level. They are currently looking for industrial companies with expertise in the compression and expansion of hydrogen to build a first demonstrator for their innovative concept based on a hydrogen expansion. This prototype will serve as experimental validation of the already successfully performed theoretical calculations and simulations they performed.

**Background and challenge:** In fuel cell electric vehicles, the gaseous hydrogen is stored in pressure tanks at up to 700 bar while in the fuel cell stack pressures of only 1-3 bar are required. Current vehicles use simple pressure

reducers with cross-section changes to reduce the pressure level. A disadvantage of this solution is that a huge amount of energy released by this expansion process is being lost while it could be used to power the vehicle. There are solutions like expansion engines associated with generator which can be implemented in hydrogen powertrain to address this challenge. Their implementation can improve both, the well-to-wheel efficiency of the fuel cell vehicle and the system efficiency of the powertrain.

The institute's innovative concept: They work on a new concept combining an expansion engine with an electric generator. It functions as follows: the expansion engine converts the depressurisation energy of hydrogen into kinetic energy. It is accompanied by a generator that converts the kinetic energy into electrical energy. Connected power electronics with a voltage converter ensure the supply of electrical energy to the battery or electric motor. They performed extensive calculations and simulations to assess the efficiency increase achieved by using the expansion engine in different vehicle platforms (cars, trucks, trains and ships) and under various driving or load profiles. These simulations also take into account energy losses that occur during the expansion process.

The market potential of the technology in the hydrogen vehicle sector can be estimated by analysing the number of fuel cell systems with pressurized hydrogen tanks to be sold in the coming years. They assume that each of these systems could feature a hydrogen expansion engine system in future. Projections indicate that by 2035, there could be nearly 400,000 fuel cell vehicles sold worldwide, all of which could potentially be equipped with the described invention. This estimation does not yet consider the additional applications in both hydrogen and natural gas-based mobile and stationary systems with combustion engines, which would further increase the market potential significantly.

The institute is looking for partners experienced in compression and expansion of hydrogen to build a prototype and bring it to market maturity. Within the frame of the cooperation the expansion engine will also be optimized and adapted to further applications. Cooperation can be under a research and development agreement or a technical cooperation agreement.

### Advantages and innovations

With the use of the hydrogen expansion engine system, the efficiency of the overall system, which integrates the fuel cell, hydrogen, or natural gas combustion engine, is increased. This results in more energy being utilized from the same amount of stored gas, leading to either an increased vehicle range or reduced fuel consumption. Consequently, this technology promotes resource-efficient operation. Additionally, the hydrogen expansion engine has the potential to significantly enhance the well-to-wheel efficiency by recovering energy from the pressure difference between the tank pressure and the operating pressure of the fuel cell system. This technology not only improves the efficiency of fuel cell, hydrogen, and natural gas-based energy supply, but can also be applied in stationary applications and other sectors such as building or decentralized energy supply.

### Technical specification or expertise sought

In an extensive preliminary investigation, reciprocating or linear piston machines were identified as suitable technologies for the expansion engine since they are able to handle high pressure ranges at relatively low mass flows. Streaming machines, such as turbines, would be subjected to unrealistically high speeds even with multi-stage expansion, making them unsuitable for the given conditions. However, turbines become highly relevant for the process engineering aspect of air compressor applications. By implementing a bypass with an upstream pressure reducer, lower pressures can be utilized and employed for air compression purposes. Therefore, depending on the specific application, both reciprocating and flow machines are viable options.

The institute is looking for industrial companies with expertise in the compression and expansion of hydrogen in reciprocating and/or streaming machines to build a first demonstrator to serve as experimental validation of the already successfully performed theoretical calculations and simulations. The goal is to further develop the technology through a joint research and development cooperation agreement until it is market ready. The sought company should have the manufacturing equipment to build a physical demonstrator, and know-how to select suitable materials for the operating conditions of the expansion engine. Through the technical cooperation agreement, the expansion engine will be continuously optimized and adapted for further applications, such as the compression of fuel cell's cathode air. The development of the technology aims to be highly application-oriented and flexible. The collaboration is expected to be established through internationally funded projects but can also take place through bilateral agreements.

### Stage of development

#### **Under development**

IPR Status

#### **IPR applied but not yet granted**

### Sustainable Development goals

#### **• Goal 7: Affordable and Clean Energy**

## Partner Sought

### Expected role of the partner

-Type of partner sought: Industry

-Specific area of activity of the partner: Industrial partner with competences and know-how in the production of hydrogen compressors and expansion engines, which in cooperation with the research institute in the first step builds

up a demonstrator to experimentally investigate and further develop the technology. Subsequently, the technology is to be advanced to market maturity in a collaborative manner.

#### Type of partnership

**Research and development cooperation agreement**

#### Type and size of the partner

- **SME 11-49**
- **Big company**
- **SME <=10**
- **SME 50 - 249**

## Dissemination

#### Technology keywords

- **02009026 - Energy supply system**
- **04002005 - Generators, electric engines and power converters**
- **004002008 - Turbines, fluid machinery, combined heat and power**
- **02009024 - Powertrain and chassis**
- **004006001 - Energy management**

#### Targeted countries

- **World**

#### Market keywords

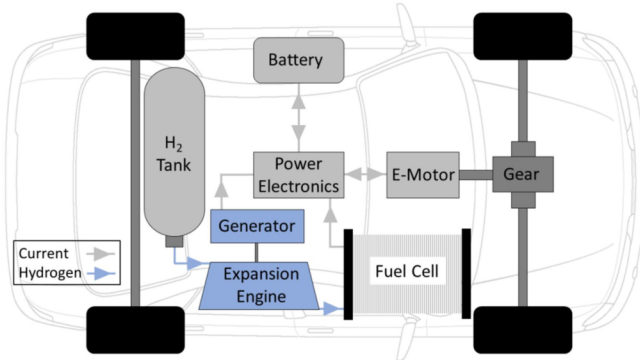
- **006005006 - Co-generation**
- **08002001 - Energy management**
- **08003006 - Power transmission equipment (including generators & motors)**
- **09008003 - Gas transmission and distribution**
- **006005007 - Other alternative energy (including nuclear energy)**

#### Sector groups involved

- **Mobility - Transport - Automotive**

## Media

#### Images



[Hydrogen Expansion Engine in a FCEV.JPG](#)