

Fuel Cell Technology – HyTRAN Project

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ABSTRACT

HyTRAN – Hydrogen and Fuel Cell Technologies for Road Transport, a project under the auspices of the European Commission's Sixth Framework Program for Sustainable Development, should advance the fuel cell technology towards commercially viable solutions by developing components and systems and to integrate the subsystems into innovative, fully integrated and compact Fuel Cell Systems.

The project is divided into two technical platforms:

- 80 kW Direct Hydrogen PEM Fuel Cell system for propulsion of passenger cars
- 5 kW Diesel Reformate PEM Fuel Cell Auxiliary Power Unit (APU) for truck on-board power supply

TENNECO is playing a central role in this project. One of TENNECO's key tasks is the full system integration of the Fuel Cell APU. In a first step the system was integrated virtually with help of CATIA V5. In a second step, TENNECO is building the prototype, based on the results gained from the virtual integration work. Beside this important contribution, TENNECO is also active on a component level (e.g. sulphur trap, self-actuated pressure control valves) and on a subsystem level (e.g. diesel and water supply system testing, acoustic measurements).

INTRODUCTION

Fuel cell systems have great potential to play a key role in our everyday life. Especially in mobile applications, fuel cells will help to increase system efficiencies, to avoid the release of greenhouse gases and to move to a future sustainable mobility. While fuel cell propulsion

systems offer great mid- and long-term perspectives, Fuel Cell Auxiliary Power Units (APU) have a real chance to reduce fuel consumptions and pollution by avoiding the necessity of truck idling within the next few years. One of the most promising technologies for APUs are diesel reformat PEM (Proton Exchange Membrane) fuel cell systems. This technology is supported by the European Commission's Sixth Framework Program for Sustainable Development. Part of this program is the HyTRAN project. 19 partners under the lead of the VOLVO Technology Corporation are developing two innovative, fully integrated and compact fuel cell systems. TENNECO, one of the largest Tier 1 suppliers for emission and ride control systems, is one of the companies that were selected by the European Commission to participate in the HyTRAN consortium to develop fuel cell systems for a future environmentally friendly mobility. TENNECO's main responsibility is the full system integration of the auxiliary power unit, first virtually and in a second step physically. Therefore, TENNECO applies its expertise from the development, manufacturing and assembling of exhaust systems.

TENNECO'S MOTIVATION AND CAPABILITIES TO DEVELOP AND SUPPLY FUEL CELL SYSTEMS

MOTIVATION

Each year, U.S. trucks consume more than one billion gallons of diesel fuel - without even moving. Truckers idle their engines while they rest for a variety of reasons, including heating or cooling, preventing start-up problems or to operate electrical equipment. Studies have shown that a typical long-haul tractor-trailer idles approximately 1,830 hours per year. Reducing the idling time of heavy-duty trucks reduces fuel consumption, fuel costs, engine wear and maintenance costs, diesel

emissions and noise. According to EPA studies, truck idling annually emits more than 11 million tons of carbon dioxide and more than 180,000 tons of nitrogen oxides, as well as fine particulate matter and other harmful air toxics. Approximately 15 states and dozens of local counties have already promulgated laws that restrict the amount of time that a vehicle can idle its main engine. Additional and more stringent laws will follow. [1]

TENNECO carried out a benchmark study [8] on different idling alternatives. In this study, Fuel Cell APUs have been compared with the competing technologies listed below. As requirements, these systems must be able to provide 1.5kW average power for a 6.6 hours resting time. The power requirement has been defined by the HyTRAN OEM partners.

- ICE APUs: Small ICE engines drive an alternator that produces electricity. Some ICE APUs are also providing cooling and/or heating, by using additional accessory components, e.g. by running an electric heater or cooler, by recycling heat from the APU engine or the exhaust gases, or by employing some of the truck's subsystems as for example the cooling loop. ICE APUs are the biggest competitor to Fuel Cell APUs. However, upcoming emission regulations make ICE APUs heavier and larger.
- Batteries: Trucks can be equipped with additional batteries that are being loaded during driving and that provide electricity during resting. Common batteries are too heavy. Li-Ion and Li-Polymer batteries have safety issues that make them unusable for this application.
- Electrification Stations: A truck driver, resting on such a special parking place has the possibility to connect his truck to a stationary service module or a pedestal that offers services like providing electricity, internet access, TV, heating and cooling. There are different systems becoming available on the market offering different ranges of services. These electrification stations are not viewed as a stand-alone solution, as it will be nearly impossible to establish a widely available infrastructure. Consequently, there is definitely a need for mobile systems that are not bounded to specific parking places.

Beside the technology benchmark, TENNECO also worked on a market survey [9] covering Europe and the US, to investigate the market needs and to align TENNECO's work with the strategies of the OEMs.

From the technology benchmark and the market survey, TENNECO drew the following conclusions: In the 2008 to 2012 timeframe, idling alternatives like those being listed above will be used, as there is no better alternative available right now. However, there is the consensus that the above technologies are only interim solutions and that Fuel Cell APUs have great potential to become the

preferred solution beyond 2012. Beside efficient energy generation, Fuel Cell APUs are also able to offer several add-on functionalities that make them very attractive:

- Producing extra hydrogen that can be used for exhaust gas aftertreatment purposes
- Providing heat for auxiliary heating and for engine preheating
- Replacement of alternator (long-term)
- Replacement of belt-driven cooling pump and A/C compressor by electrical ones (long-term)

However, to be competitive to established technologies, Fuel Cell APUs need to offer the same or even better performance data, i.e. durability, weight, volume, efficiency, costs and acoustics.

First products will be stand-alone systems with low installation effort. Such systems will be encapsulated in a box, which can be integrated on the truck very easily via a few interfaces, i.e. mechanical connection to the chassis, connection to the diesel tank and to the electric system. Short- and mid-term, such stand-alone system might use PEM (Polymer Electrolyte Membrane) fuel cells, as the competing technology, SOFC (Solid Oxide Fuel Cell) systems, are still more expensive than PEM systems and as they are sensitive to vibrations and to repeated start-ups and shutdowns.

Mid- and long-term, highly integrated systems will be preferred for original equipment trucks. Long-term, Fuel Cell APUs might become available that are also able to power trucks during driving. In this way, the internal combustion engine will only be used for propelling the truck and the APU will take over the energy supply for all electrical systems and accessories. Such an APU will then run during resting and during driving and will consequently only be shut down maybe once a week. Such operation conditions could help SOFC systems to enter the market.

In the field of fuel cell systems, TENNECO is actually mainly involved in the development of auxiliary power units. The reasons for this are listed below:

- TENNECO, as Tier 1 supplier for exhaust systems, already has key capabilities to develop and manufacture components for APU systems
- TENNECO has first experiences with fuel cell systems, due to involvement in appropriate R&D projects
- Political framework forces truck operators to stop idling and to look for alternative energy sources
- More than 2 million class 8 diesel trucks are on the U.S. aftermarket [2], at least 460,000 are candidates for auxiliary power units
- Between 140,000 and 280,000 new class 8 trucks in the U.S. per year (see Figure 1)
- Strategic investments in tomorrow's technology
- Early market within the next 2 to 4 years, due to political framework

- Knowledge transfer: on-board hydrogen production for exhaust aftertreatment (e.g. H₂-SCR)
- Reduction of energy consumption and pollution

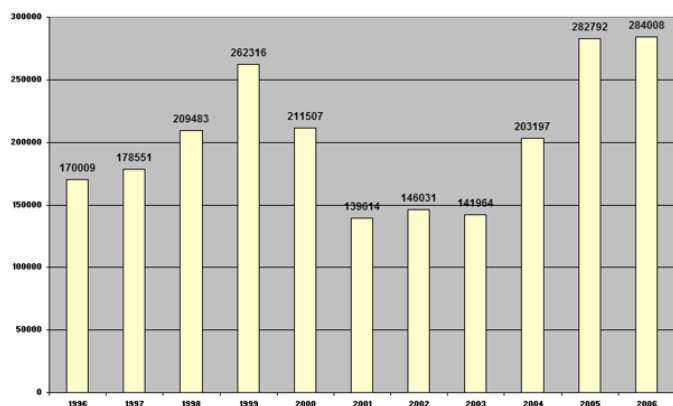


Figure 1: Class 8 U.S. Truck Sales [3]

Mid- and long-term, TENNECO is also interested in getting more involved in fuel cell systems for propelling vehicles. If fuel cell propulsion systems become the future system of choice and capture the vehicle market, the demand for conventional exhaust systems, as we have them today, will be regressive. An early involvement in potential future markets and new innovative products is an important step for TENNECO's long-term business. These new propulsion systems will not have a significant impact on TENNECO's ride control business.

CAPABILITIES

TENNECO has excellent capabilities to manufacture and supply fuel cell systems. As a Tier 1 supplier for passenger cars, motorcycles, light- and heavy-duty vehicles, TENNECO has well-established contacts to OEMs all over the world and is part of the every day course of business. This makes TENNECO a valuable partner for the vehicle industry. The experience in manufacturing, e.g. bending, welding, forming and deep drawing, is a basic precondition for supplying components for fuel cell systems. Moreover, TENNECO has the ability to do partial and full system integrations. Fuel Cell APU components that have been identified as potential products are listed below:

- Steam Reformers (STR), Auto-thermal Reformers (ATR)
- Sulphur-Traps
- Water Gas Shift (WGS) Reactors
- Preferential Oxidation (PrOx) Reactors
- Heat Exchangers
- Tubing
- Valves (self-actuated pressure control device)
- Housings
- Decoupling elements
- Space frames
- Noise reducing devices
- Fuel Cell Stack Components

TENNECO's partnerships with OEM customers in exhaust component design and full system integration require experience in managing flows, heat transfer and material compatibility. Therefore, simulation tools and testing competencies for acoustics, durability, flow and heat management are available. Applying this expertise to developing hydrogen fuel cell systems is a logical next step for TENNECO.

Good contacts to TENNECO's HyTRAN partners and experiences with fuel cell systems, due to TENNECO's central role in HyTRAN and the participation in the Initiative Fuel Cell Rhineland-Palatinate project, form a very good base for future activities and cooperation in this field of technology.

THE HYTRAN PROJECT

OBJECTIVES

HyTRAN – Hydrogen and Fuel Cell Technologies for Road Transport (www.hytran.org), a project under the auspices of the European Commission's Sixth Framework Program for Sustainable Development (FP-6), should advance the fuel cell technology towards commercially viable solutions by developing components and systems and to integrate the subsystems into innovative fully integrated and compact Fuel Cell Systems.

The main objective of the European Commission's transportation research is to develop systems that offer near zero emissions and safe operation. Research in the FP-6 program is conducted in the areas of reducing congestion, intelligent transport systems, new vehicle concepts and fuels. The research aims to identify diverse and environmentally friendly sources of energy, and enable a move away from unsustainable solutions with an objective of reducing greenhouse gases, ensuring the security of energy supplies and having a competitive internal market for energy within the European Union. Long-term issues will include new sources of energy such as hydrogen, fuel cells, the transport and storage of energy, biomass and cleaner fossil fuel systems.

GENERAL INFORMATION

The HyTRAN consortium is led by Dr. Per Ekdunge from Sweden's Volvo Technology Corporation and includes 19 European vehicle manufacturers, component suppliers and research institutions. The project partners are listed below: