

# Stationary Fuel Cell Systems for the Residential Market

Dipl.-Ing. K. U. Birnbaum  
Germany

OPEN WORKSHOP  
Fuel cells: Why is Austria not taking off?  
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# The German Market for Fuel Cell technology I

At the beginning of the Fuel Cell research and development in Germany, that was in the late 1980s, we saw two mass markets:

- the **Transportation** sector with thousands of new cars per year and
- the **Residential** sector with a large stock and thousands of new buildings per year.

Additional we expected an application in the sector **Commerce, Trade and Services**.

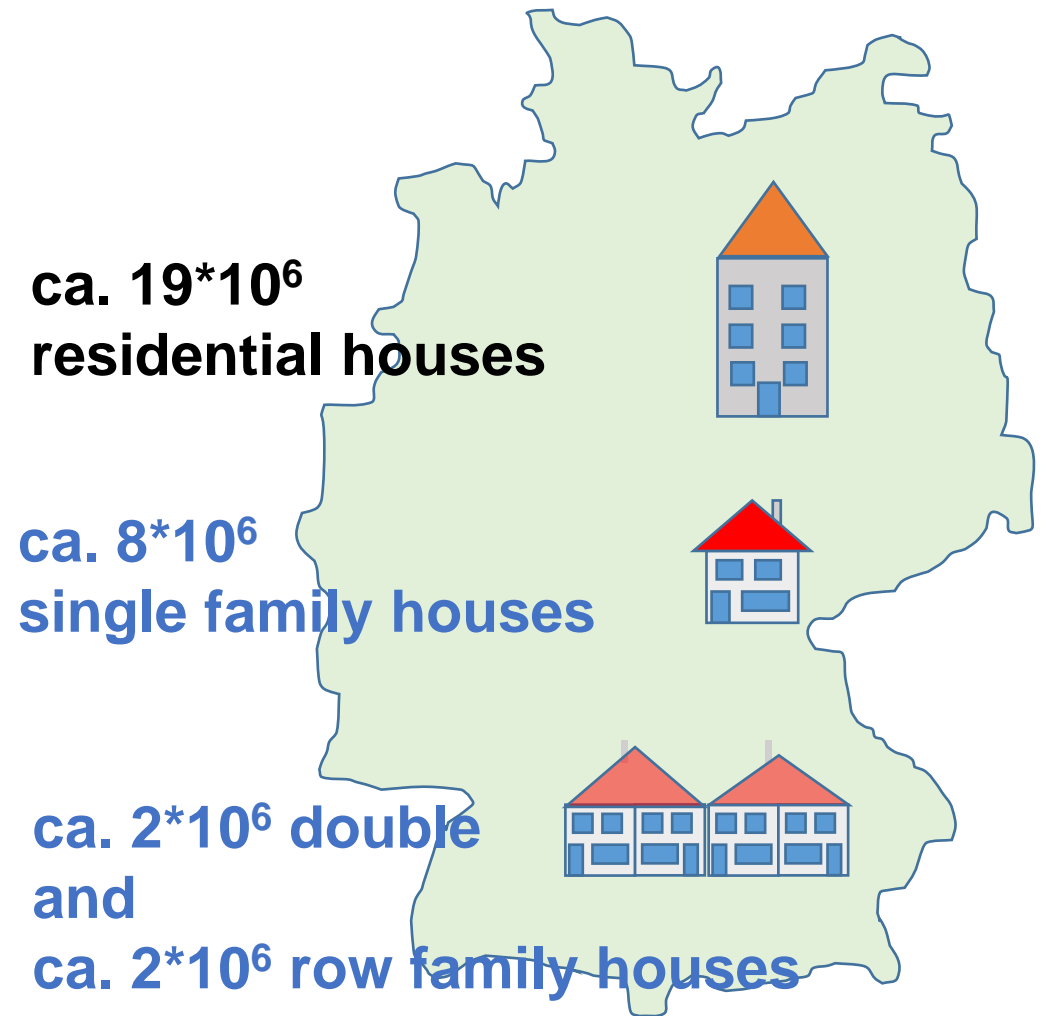
We had no doubt, that the innovation power of the car manufacturers Daimler, Opel, Volkswagen, BMW and/or Ford would stimulate the development.

As it was difficult to manage the technical difficulties, **except Daimler all others stopped their fc-activities.**

# The German Stock of residential houses

The theoretical potential for FC house energy devices results from the stock of  $19 \cdot 10^6$  residential houses (2009) and the knowing, that the yearly building activities are relatively high because of the low interests on credits.

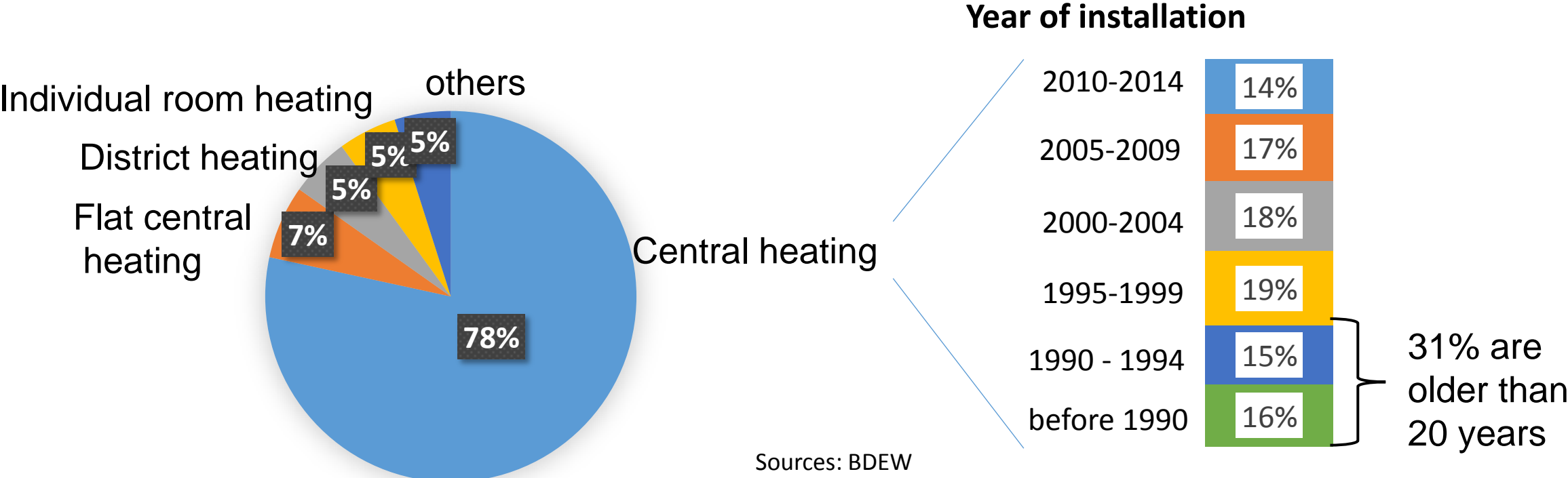
The **Federal Statistic Office** classified in 2014  
ca.  $8 \cdot 10^6$  single family houses,  
ca.  $2 \cdot 10^6$  double family houses and  
ca.  $2 \cdot 10^6$  row family houses.



Sources: BDEW and Federal Statistic Office

# House heating systems

Ca. 78% or  $15 \cdot 10^6$  of the living houses are equipped with a central heating system.



Sources: BDEW

# **Callux**, the German step towards commercialisation

The German **Federal Ministry for Transport and Digital Infrastructure** initiated **CALLUX**, a field and praxis test for fuel cell based house energy supply devices.

There was the target to support/trigger R&D activities to make fc devices marketable.

They shall contribute to a reduction of the CO<sub>2</sub>-emissions of the residential sector, which has a share of 10% of the total German CO<sub>2</sub>-emissions.

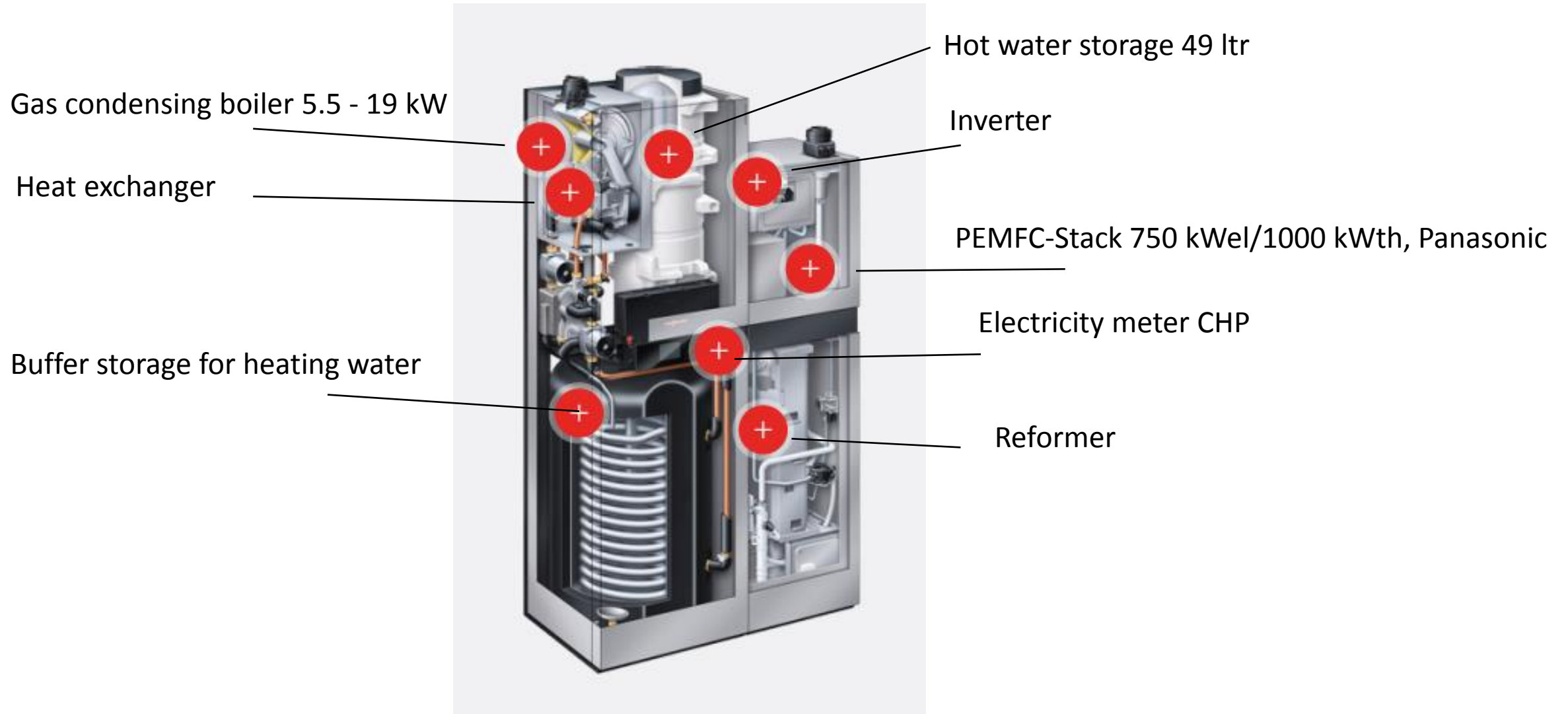
The project itself started in 2008 and ended in November 2015.

- **474 devices were installed under CALLUX,**
- **the average lifespan of the devices increased to 2 – 3 years,**
- **the stack lifespan enhanced to more than 20,000 hours and**
- **totally  $5 \times 10^6$  operation hours are reached and  $> 3 \times 10^6$  kWh<sub>el</sub> power generated.**

# The Outcome of Callux: Eight FC-appliances are at the market

	Company	name	Fuel Cell		condensing boiler	Price (tax inclusive) €	funding €
			capacity kWh	capacity kWh			
Bosch Thermo-technik	Buderus (Aisin Seiki Kyocera)	LOGAPOWER BZH192IT	SOFC	700/1200	25		8,850
	Junkers (Aisin Seiki Kyocera)	Cerapower FC10	SOFC	700/1200	25		8,850
Viessmann	Hexis (Viessmann)	Galileo 1000N	SOFC	1000/1800	from 7 to 21	22,600	10,200
	Viessmann (Panasonic)	Vitovalor 300P	PEM-FC	750/1000	from 5.5 to 19	19,860	9,300
SOLIDpower	SOLIDpower	Bluegen	SOFC	1500/1500			12,450
	SOLIDpower	Engen 2500	SOFC	2500/2000			
BDR Thermea	Senertec (Baxi Toshiba)	Dachs Innogen	PEM-FC	250-700/950	from 4,8 to 20		8,850
Elcore	Elcore	Elcore 2400 Max	HT-PEM	305/700	21	18,000/22,000	7,500
Vaillant	Vaillant (IKTS Sunfire)	FC 5. generation	SOFC	700/1300			

# Cross Section of the Viessmann **Vitocalor 300-P**



<http://www.viessmann.de/de/wohngebaeude/kraft-waerme-kopplung/mikro-kwk-brennstoffzelle/vitocalor-300-p.html>

# Do fuel cell systems thrive on their own?

No, they don't. The breakthrough could not yet be initiated, despite a couple of financial incentives, by federal and/or regional governmental institutions as well as by utilities.

The high selling price is one of the barriers.

To give now a jumpstart, the Federal Government has set up a new funding programme. It is called “**Energy Efficient Construction and Rehabilitation** “ and started at 01.08.2016.

The notifications for a funding have to be submitted to the **Credit Institute for Reconstruction (KfW)** .



# KfW programme 433, Fuel Cell Funding I

**What is funded:** The installation of a stationary FC-appliance with a capacity of min  $P_{el}=0.25 \text{ kW}_{el}$  to max  $P_{el}=5.0 \text{ kW}_{el}$  in new or existing buildings.

**Who can get a funding:** Private persons, for single and two family houses, but it is necessary to involve an authorised energy-expert. The application must be submitted before project start.

**The amount of funding:** The subsidy is composed by two parts, the basic amount of 5,700 € and the capacity based amount of 450 € per every started 100  $\text{kW}_{el}$ . It is paid out after the installation is finished.

Example for Vitovalor: basic 5,700 € plus capacity  $8 \times 450 \text{ €} = 3,600 \text{ €}$ , in total 9,300 €,

Example for Galileo: basic 5,700 € plus capacity  $10 \times 450 \text{ €} = 4,500 \text{ €}$ , in total 10,200 €.

# KfW – 433, Fuel Cell Funding II

## **Requirements** to get funding:

- The FC must be integrated into the heat and power supply of the house.
- With the installation of the FC a hydraulic balancing must be done and documented.
- The installation must be done by a certified enterprise.
- After installation, the electrical efficiency must be min 32% and the over all efficiency min 82%.
- A 10 years full maintenance contract must be signed, which guarantees an electrical efficiency of not less than 26%.

# Insulation standards, energy demand, funding

Because of the regulatory requirements the insulation standards of new built living houses are relatively high and if the energy demand of a new house corresponds to the KfW Energy Efficiency House standards 55, 40 or 40<sub>plus</sub> the owner can get funding for the financing of the house by the **Creditbank for Reconstruction (KfW)** . The level depends from the reached standard.

Within the framework of the programme „**Heating with Renewables**“ the **Federal Office for Economic Affairs and Export Control (BAFA)** supports the **shift from an existing fossil system to a renewable one** . The installation of an environmental friendly system like solarthermal systems, biomass or heat pumps in new houses is funded too.

# Example for the decision of a house builder

The house is under construction and will have ca 180qm living area:

- Calculated room heating demand: 12,525 kWh/a
- Calculated heat demand for hot water: 3,517 kWh/a
- The ordered heating system consists of a gas condensing boiler (max 20 kW<sub>th</sub>) plus a solar thermal collector of 11.5 m<sup>2</sup> and a 800 ltr hot water storage.
- The costs of all materials for this system are 12,000 €.
- The manufacturer guarantees 5 years, the expected lifespan is 20 years.

By the BAFA programme “**Heating with Renewables**“ the solar system and its integration is funded with **2.000 €**, so that the costs are reduced to **10,000 €**.

# Competitors at the house energy supply market

Conventional competitors are gas and oil condensing boilers with integrated solar thermal systems. Based on renewables pellet and heat pump systems are the competitors.

Type	price range €	funding €	remaining costs €
Gas condensing boiler plus solar thermal	5,000 - 12,000	ca 2,000	<b>ca 3,000 - 10,000</b>
Oil condensing boiler plus solar thermal	6,000 - 9,000	ca 2,000	<b>ca 4,000 - 7,000</b>
Pellet system plus solar thermal	10,000 - 13,000	ca 3,500 + 2,000	<b>ca 4,500 - 7,500</b>
Heat pumps (air/water)	10,000 - 18,000	1,300	<b>ca 8,700 - 16,700</b>
Fuel Cell energy supply system	19,000 - 22,000	up to 11,000	<b>ca 8,000 - 11,000</b>

# Summary

- The fuel cell house energy systems are not really known to house owners and installers.
- Only less installers can offer/install that new and complicate technique.
- The heat demand in houses reduces continuously, since 2003 in average by 18%.
- A 10 years maintenance contract has to be signed.

- The competitors have high reliability and low maintenance costs, maintenance contracts are not necessary. The lifespan of condensing boilers is long. All that makes them attractive for end users.

# The National Innovation Programme for Hydrogen and Fuel Cell Technology, Phase II

- In **September 2016** the **Federal Cabinet** decided the cross-ministries **Innovation Programme for Hydrogen and Fuel Cell Technology** phase II (NIP).
- It shall ensure the continuation of the R&D for individual components of the fuel cell as well as for other components of the systems. Additional market incentives will be provided from the financial resources of the **Technology Introduction Programme**.
- The **Ministry for Transport and Digital Infrastructure** will invest up to 2019 additional **250x10<sup>6</sup> €** for H<sub>2</sub> and FC R&D, while the **Ministry for Economical Affairs and Energy** will invest **25x10<sup>6</sup> € per year** for applied R&D in the context of the **6. Energy Research Programme**.

Sources: [http://www.bmvi.de/SharedDocs/DE/Anlage/VerkehrUndMobilitaet/nip-regierungsprogramm.pdf?\\_\\_blob=publicationFile](http://www.bmvi.de/SharedDocs/DE/Anlage/VerkehrUndMobilitaet/nip-regierungsprogramm.pdf?__blob=publicationFile)  
<https://www.now-gmbh.de/de/aktuelles/presse/bundeskabinett-verabschiedet-nip-ii>

# Molten Carbonate Fuel Cells in Germany I

Typically the electrical capacity of Molten Carbonate Fuel Cells is in the range of more than 200 kWel, so that they are predestinated for the energy consumption sector

**Commerce, Trade, Services** as well as for the sector **Industry**.

Ca 20 years ago the company **MTU/CFC-Solutions** used the **Fuel Cell Energy** concept and developed the **Hot Module**. A couple of units were installed, supported by federal R&D programmes. It was tried to combine the MCFC with gasturbine and others and also to use it in ships. But because of missing success, **CFC Solutions GmbH** closed its activities. The Know How and the production site in Ottobrunn near Munich was overtaken by **Fraunhofer IKTS** in Dresden and its subsidiary **FuelCell Energy Solutions**.



# Molten Carbonate Fuel Cell in Germany II

After some years of R&D, at September 19th a 1.4 MWel MCFC-plant could be launched.



[http://www.friatec.de/content/friatec/de/Allgemeines/News/index.html?lan\\_given\\_content=friatec/gen/news/de/dmethods/News290/](http://www.friatec.de/content/friatec/de/Allgemeines/News/index.html?lan_given_content=friatec/gen/news/de/dmethods/News290/)

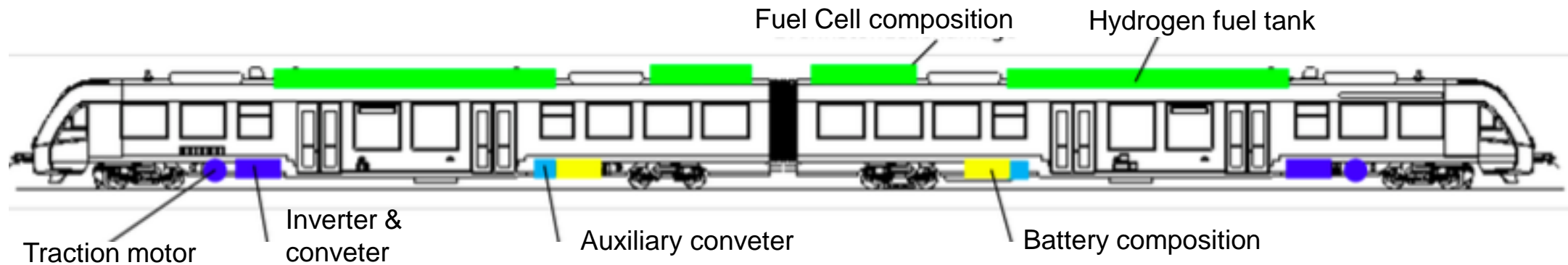
It is a joint project of FCE-Solutions and the utility E.ON. The plant is installed at Friatec AG in Mannheim, a specialist for products of wearless and noncorrosive materials.

Friatec expects to avoid 3,000 tons of CO<sub>2</sub> per year by using this Fuel Cell plant.

# Another Highlight is the Alstom Fuel Cell Train

Alstom presented the first fuel cell train at the InnoTrans in Berlin at September 20<sup>th</sup> 2016

The Coradia **iLint** train is powered by the Ballard PEMFC Velocity-9SSL and fueled by H<sub>2</sub>.



The iLint is the emission free version of the regional train Coradia and shall replace the diesel traction on non-electrified railway lines.



<http://www.alstom.com/Global/Transport/Resources/Documents/brochure2014/Coradia%20iLint%20-%20Product%20sheet%20-%20English.pdf?epslanguage=en-GB>

# The next brand new application is the **HY4 fuel cell aircraft**



**September 29th**,  
**first flight of the  
HY4 in Stuttgart,  
for 10 minutes**



[http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151\\_read-19469/#/gallery/24481](http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-19469/#/gallery/24481)

The **DLR-Institute of Engineering Thermodynamics** and the partners **Hydrogenics**, **Pipistrel**, **H2FLY**, **University Ulm** and **Stuttgart Airport** realised the 4 persons plane. It is operated by a PEMFC of Hydrogenics and a high-capacity battery, which is used as storage and for starting.