Russian Hydrogen and Fuel cell Program (country update)

12 Joint IPHE Implementation and Liaison

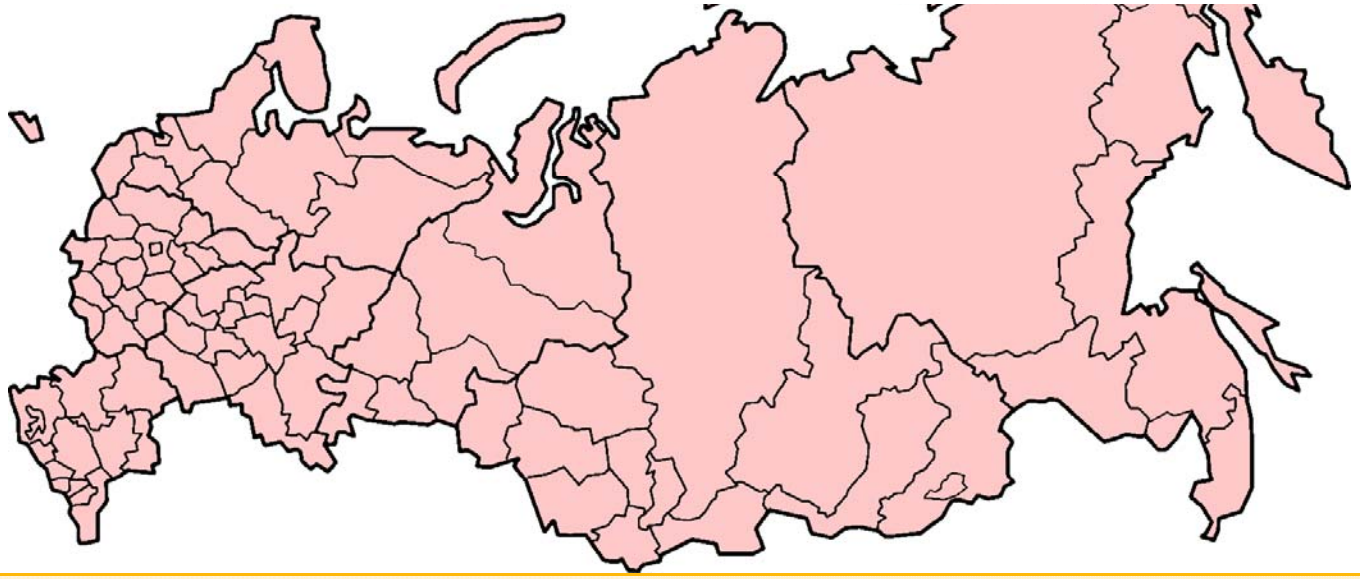
& Steering Committee Meeting

December 1-3, 2009

Washington (DC), USA

Energy Strategy 2030 targets: power production in Russia

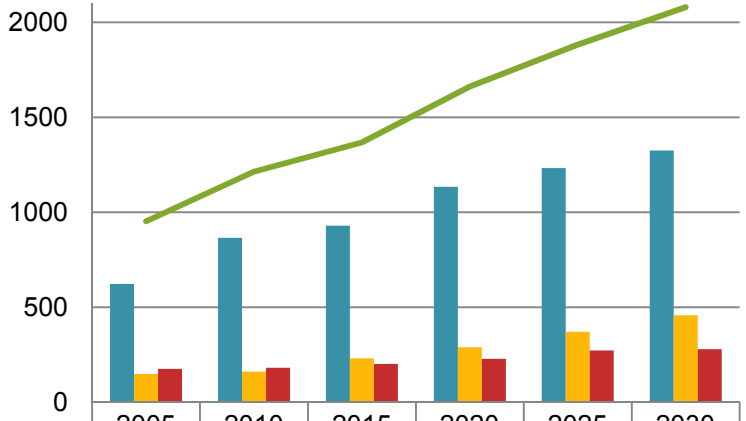
Priorities in H2\FC technologies are determined by the main targets of long-term social and economic development of the Russian Federation



Annual gross domestic product	30 000 – 35 000 USD (2000) per capita
Energy consumption	0.32-0.34 tce/1000 USD GDP
Electricity consumption	0.35-0.37 kW h/USD GDP
Annual electricity production	2000 bln. kW h
Energy saving	0.4 bln. tce

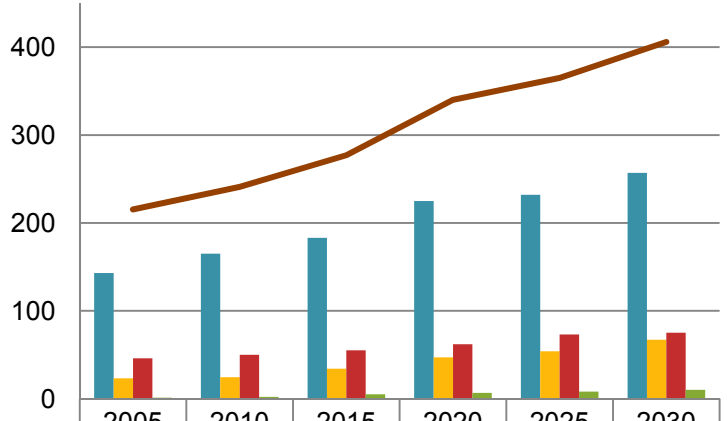
Structure of the Russian power production sector for 2030

Generation of electricity, bln. kW h



	2005	2010	2015	2020	2025	2030
Thermal	623	866	930	1134	1233	1325
Nuclear	149.5	162	232	290	371	458
Hydro	176	182	202	229	273	280
Total	953	1214	1368	1662	1882	2079

Power generation, GW



	2005	2010	2015	2020	2025	2030
Thermal	143	165	183	225	232	257
Nuclear	23.2	24.5	34	47	54	67
Hydro, incl.	46	50	55	62	73	75
- PS Hydro	1.2	2	5	6.5	8	10
Total	215.4	241	277	340	365	406

New power units for 2030		
Thermal	250 GW	Coal (110 GW) and NG (150 GW)
Nuclear	67 GW	New (44 GW) and Upgraded (23 GW)
Hydro	66 GW	New (20 GW) and Upgraded (46 GW)
Maneuverable	9 GW	Hydro Pumped and Hydrogen
Distributed and back-up	20-30 GW	Incl. Renewables(10-20 GW)

Objectives:

To increase energy efficiency and environmental safety of power production and utilization of primary energy sources through use of hydrogen technologies

To increase the share renewables in the country's energy mix	• High pressure electrolyzers; Co-generation systems; Hydrogen storage; Fuel cells
Improve system's load management for nuclear and coal power stations in the European part of Russia	• High pressure electrolyzers; Hydrogen-oxygen steam generators; High temperature fuel cells (SOFC and MCFC)
Combined power and heat supply for distributed customers	• Fuel processors; Purification and compression; Co-generation systems; Fuel Cells; Storage systems
To use hydrogen containing by-product gases for autonomous power supply in industry	• Separation and storage technologies; Turbines; Hydrogen combustors, Fuel Cells
To increase environmental safety and efficiency of power plants	• Purification and compression; Electrolyzers; H_2/O_2 steam generators; Storage; Hydrogen cooling for turbogenerators
Portable and back-up power supply	• Fuel processors; Low temperature fuel cells; Reversible and regenerable hydrogen storage
Hydrogen for chemical industry, metallurgy, oil processing, etc.	• Fuel processors with CO_2 sequestration; High pressure electrolyzers; Separation and storage technologies
Hydrogen for advanced technology in food, glass, electronic, pharmaceutical industries	• High purity hydrogen supply equipment;
Clean hydrogen and hybrid vehicles	• On-board storage and fuel processing; Fuel cells
Aerospace industry	• Advanced liquid hydrogen technologies; Rocket engines; Supersonic Combustion RAMJET

Hydrogen production

	2008-2012	2013-2020	2021-2030
Electrolyzers **Low temperature** **High pressure (15 MPa)**	Components design; Catalysts; <4.2 kW h/m^3 10 m^3/h	Prototypes and Demonstration (up to 100 m^3/h);	<4 kW h/m^3, 100 m^3/h <3000 €/(m^3/h); Infrastructure integration
Fuel processors and microprocessors	Catalysts; 10 m^3/h experimental devices; microprocessor prototypes	Prototypes; Demonstration; Small-scale production	eff. 80%, 100 m^3/h CO_2 sequestration; Infrastructure integration
Advanced liquefaction	Components design; experimental devices; Delivery facilities	Prototypes; Delivery facilities	14-15 kW h/kg 7000 -10 000 €/t; Infrastructure integration

Hydrogen Production: PEM electrolyzers

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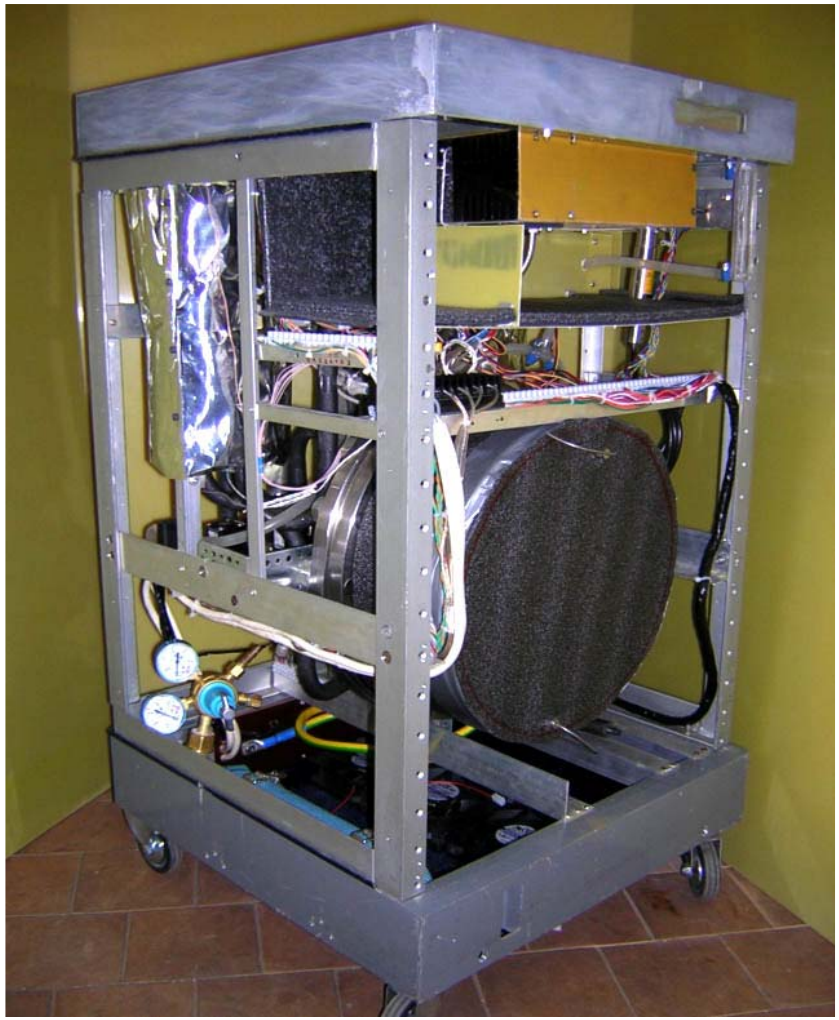
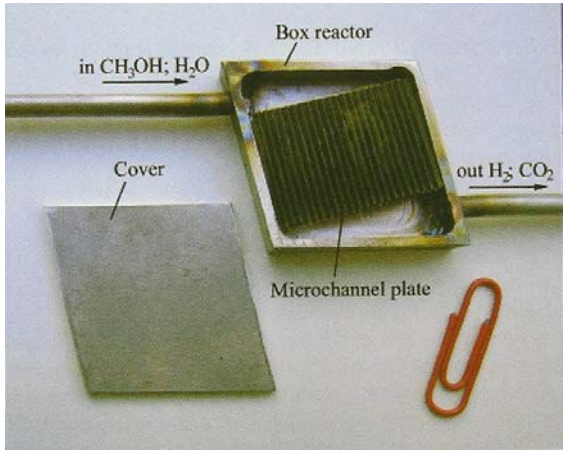


New generation of electrolysis system based on PEM for high purity hydrogen production at high pressure (up to 130 bar)

Hydrogen Production: fuel processors

FP based on an integrated reformer unit for steam reforming of natural gas in a 5 kW_e SOFC plant

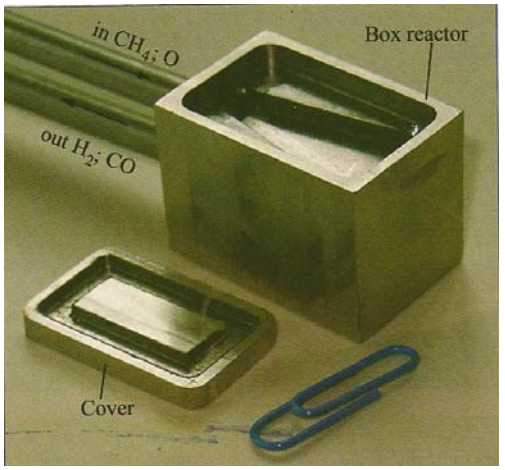


Microreactor for production of hydrogen in catalytic methanol steam reforming

28 l/h at 400 °C
10 l/h at 260 °C

Microreactor for production of hydrogen in catalytic methane partial oxidations

380 l/h at 850°C and 80% methane conversion



Aluminium-Hydrogen Technologies

Self-contained power sources or chargers for supply of: intercommunication and telecommunications systems and equipment: radio, satellite and mobile connection, monitoring, safety and data transfer system in the absence of external power supply or in emergency situation, as well as various consumer applications for potable equipment

Laptop power source
Output power 30 W,
Energy output ≥ (4*15 W-h).

Mobile phone charger
Output power - 3 W,
energy output - 3 W-h.

High temperature hydrogen generator based on

hydrothermal aluminium oxidation

4 м^3/h of H_2 (0.36 kg/h – 12kWh) and 6 kg/h of nanocrystalline AlOOH

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Hydrogen Production:

PLASMA TECHNOLOGY of HYDROCARBON CONVERSION into HYDROGEN (SYN-GAS)

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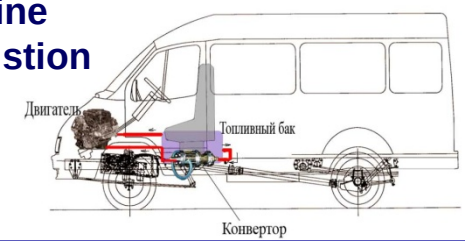
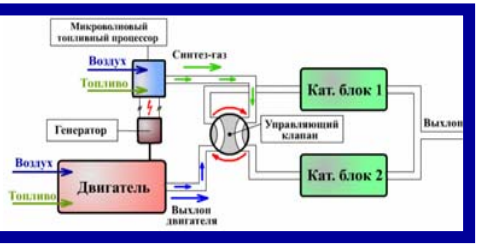
COMPACT PLASMA CONVERTER

Mixed hydrogen-gasoline fuel for internal combustion engines



DIESEL exhaust gases purification from nitrogen oxides



On-board hydrogen generator for fuel cells vehicles (future)

Designed for providing zero and low emission transport with hydrogen using conventional gasoline stations infrastructure

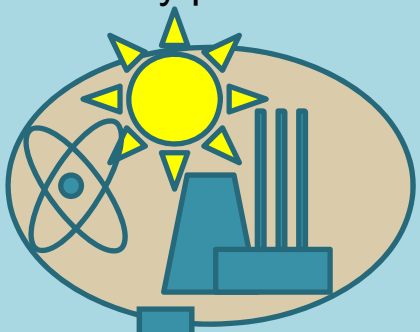
Hydrogen storage

	2008-2012	2013-2020	2021-2030
On-board storage for hybrid vehicles	New materials (up to 4-5% wt/); Composite (50 MPa) vessels; Experimental tanks	Prototypes 1-1.5 kg H_2	Demonstration projects 2.5 kg H_2
On-board storage for FC vehicles (Irreversible and regenerable)	Experimental systems; Composite (50 MPa) vessels;	Prototypes integrated with FC;	Demonstration projects up to 5 kg H_2
Reversible for stationary applications	New materials; Experimental systems for 10 m^3/h and 10 kg H_2;	Prototypes integrated with FC (5-100 kW); Commercialization back-up power	Commercialization autonomous power supply;
Irreversible systems for stationary and portable applications	Catalysts; New materials; Experimental systems for 10 kW; Prototypes of portable systems	Prototypes and Demonstration for 100 kW power units; Regeneration technologies; Commercialization of portable systems	Commercialization autonomous power supply;

Hydrogen Storage and Purification

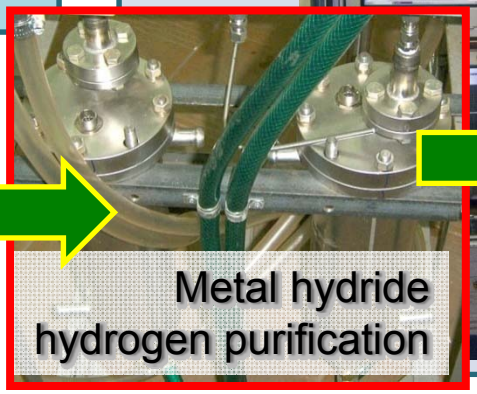
Joint Institute for High Temperatures, Russian Academy of Sciences

Primary power sources

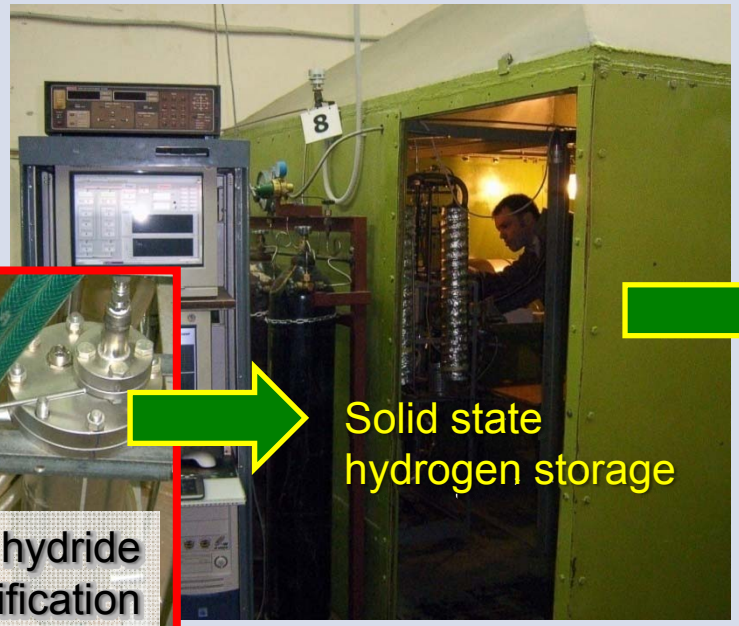


Impure hydrogen

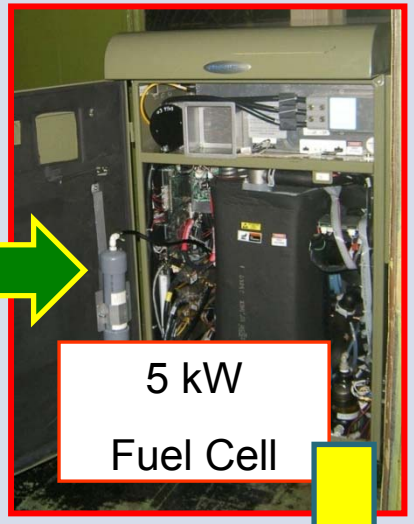
Experimental hydrogen storage and purification system integrated with PEM Fuel Cell



Metal hydride hydrogen purification



Solid state hydrogen storage



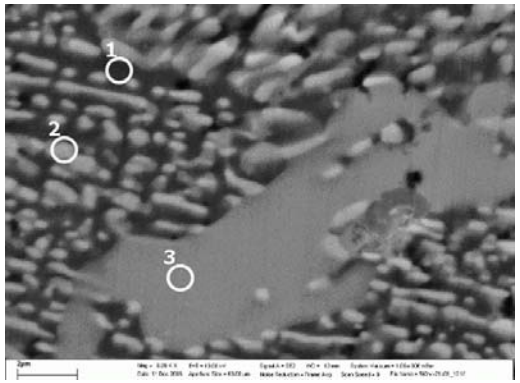
5 kW Fuel Cell

Systems for autonomous and uninterruptible power supply of telecommunication nodes, clinics, data-centers, etc.

5 kW model load

Hydrogen Storage

Institute of Problems of Chemical Physics of RAS



New nanostructured alloys and composites on the base of Al and Mg

Metal hydride storage system

Fuel Cells

	2008-2012	2013-2020	2021-2030
Alkaline FC and co-generation units (H_2/Air)	Prototypes FC 25 kW CG 10 kW durability 10 000 h	Demonstration, incl. renewable systems	Commercialization, 5 – 350 kW eff. >50% durability 40 000 h
PEM FC and co-generation units	Components; Prototypes 10 kW, durability 10 000 h	Demonstration 5-250 kW eff. >50% durability 20 000 h	Commercialization
High temperature FC	Experimental SOFC and MCFC 5-50 kW	Prototypes SOFC and MCFC, 300 kW Integrated with fuel processors	Demonstration up to 10 MW; System integration; Commercialization

Fuel Cells

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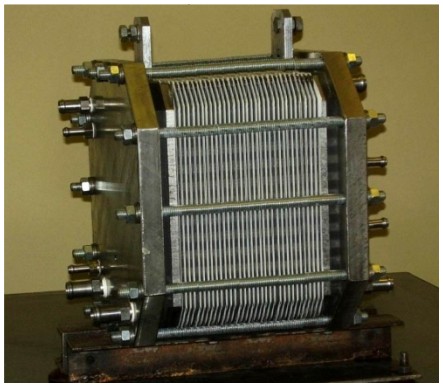
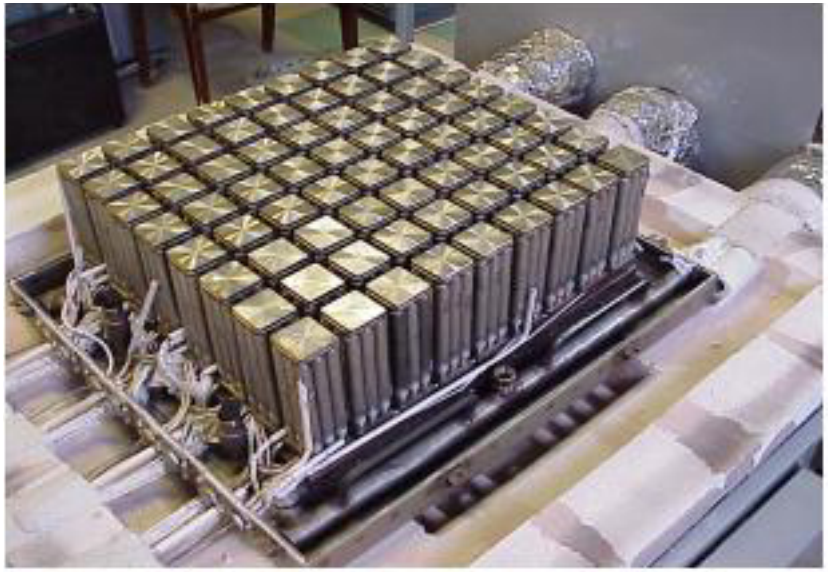
Energy systems based on solid polymer electrolyte (PEM) fuel cells (10 kW module).

Preparation for serial manufacturing.



Fuel Cells

Russian Federal Nuclear Center – All-Russia Research Institute of Technical Physics (RFNC – VNIITF)

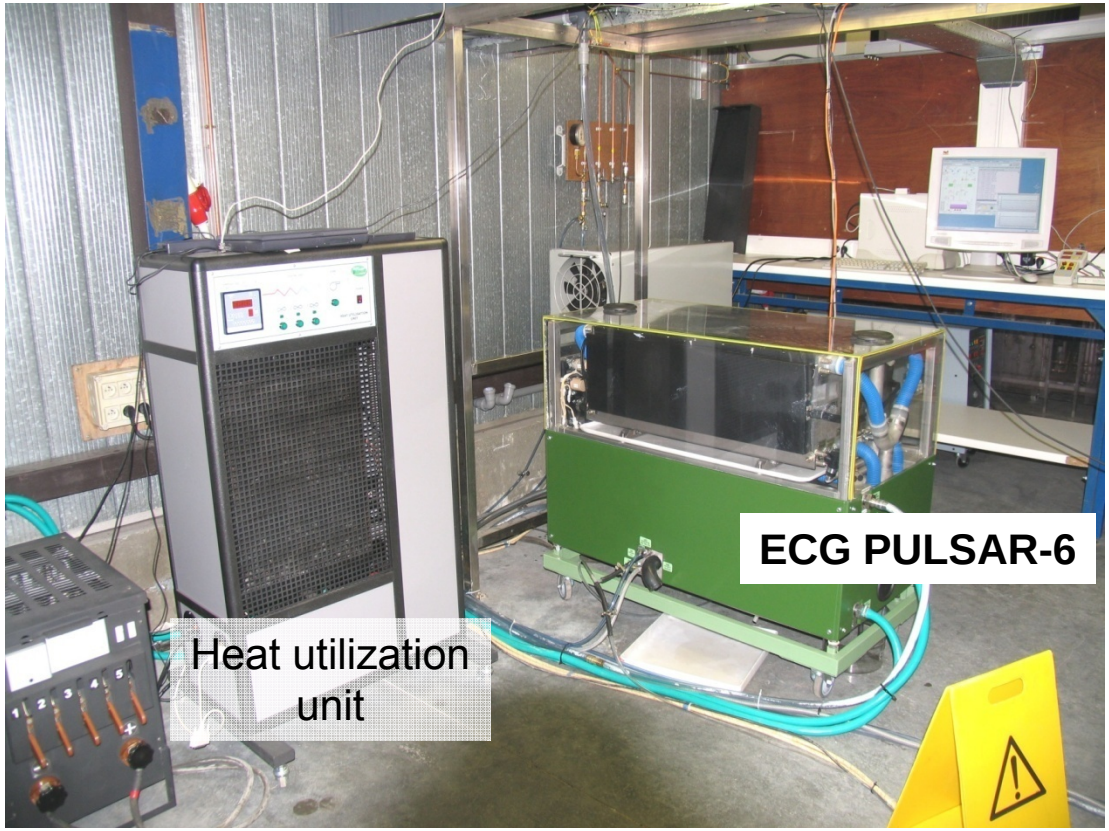


Solid Oxide Fuel Cell

Power 2,5 kW

Voltage 43,2 V

Fuel Cells



Hydrogen-air 5 kW AFC
PULSAR-6 CO-GENERATOR

Hydrogen combustion technologies

	2008-2012	2013-2020	2021-2030
H_2/O_2 steam generators	Experimental devices 25 MW, 7 MPa, 1200 K	Prototypes and Demonstration 100 MW, 10 MPa, 1500 K	Demonstration load management system; Commercialization
High temperature steam turbines and power units	Components; Experimental systems 5 MW;	Prototypes and Demonstration 10 MW;	Commercialization 10 MW autonomous power units
Hybrid high temperature power units	Experimental H_2/Air - gas turbine units, 10 MW	Experimental FC - turbine units 1-10 MW, eff. 60%	Prototypes and Demonstration 10 MW

Power Units: H2/O2 steam generators

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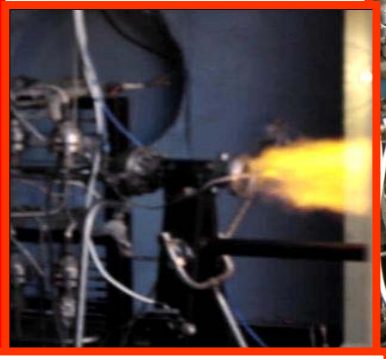
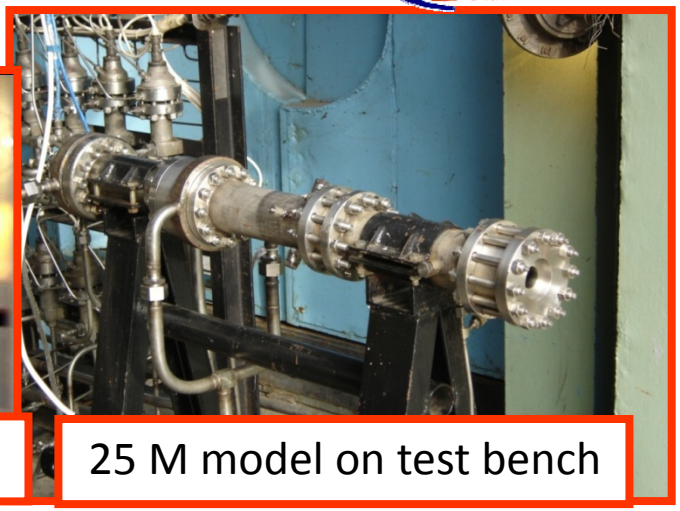
Chemical Automatics Design Bureau

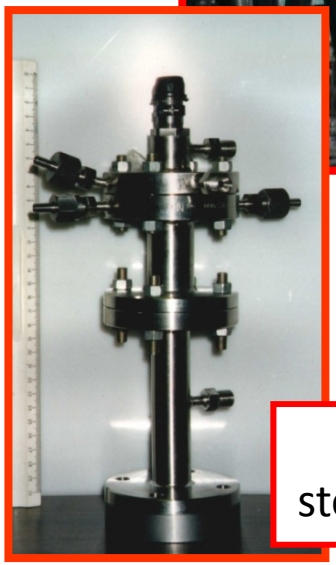
Fire tests



Ignition system test



25 M model on test bench



150 kW
steam generator

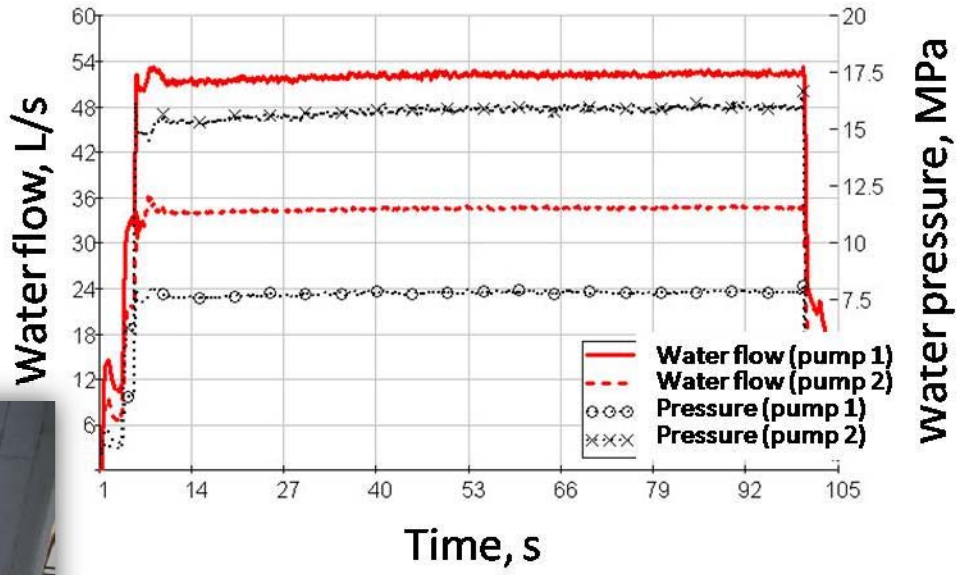
Parameters of experimental units

Model	Thermal power	Steam parameters	
		T, K	*P*, MPa
20 K	20-100 kW	1100	0,5
100 K	100-150 kW	1000	4
10 M	10-20 MW	1200	7
25 M	25-30 MW	1200	10

Integration of hydrogen and steam turbine technology

EXPERIMENTAL HYDROGEN-OXYGEN STEAM-TURBINE POWER PLANT UP TO 5 MW ON THE TEST BENCH

Experimental test with 2 water pumps

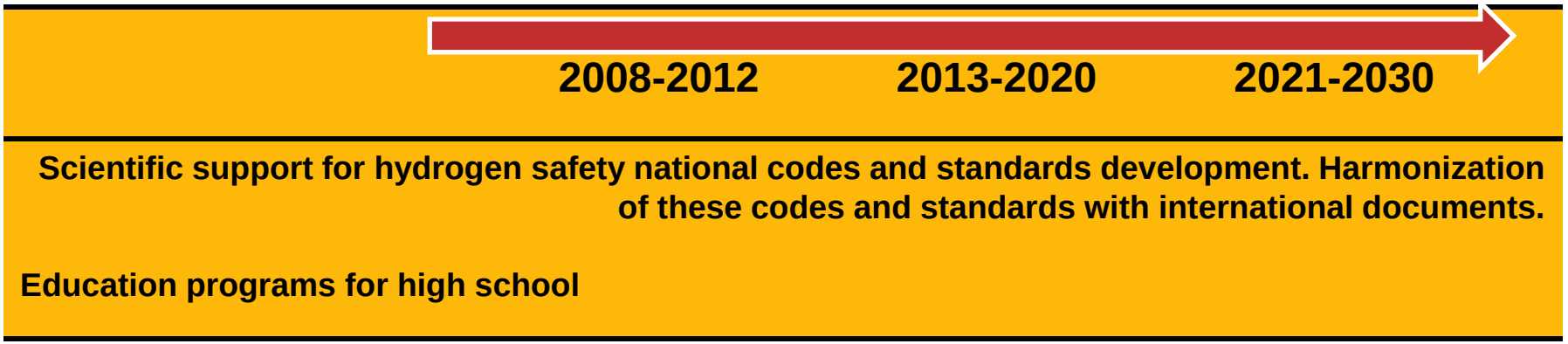


Main parameters:

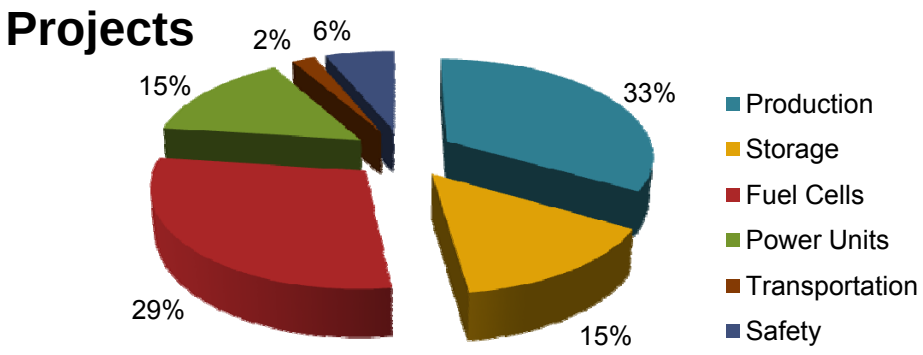
- Time out on the main mode of less than 10 seconds
- The specific power of 32 kW/kg.
- Promising efficiency of more than 40%.

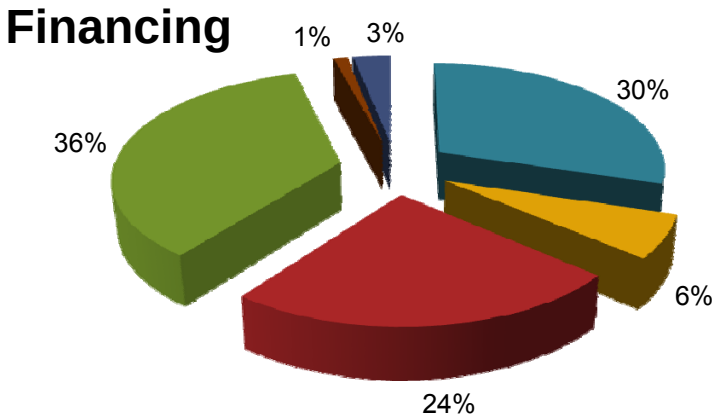
Safety, codes, standards, education

National hydrogen technical regulations – under consideration



GOVERNMENTAL FUNDING





1 BLN ROUBLES

Thank you
for your attention!

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