ANO «Hydrogen technology solutions»®

Centre for research and scientific development

CERTIFICATE

ANO "Hydrogen Technology Solutions" is a member of the Russian Union of Industrialists and Entrepreneurs

CERTIFICATE

In the state register of trademarks and service marks of the Russian Federation, an entry was made on the registration of the trademark of the ANO "Hydrogen Technology Solutions" and a Trademark Certificate was obtained.

DIPLOMA

Received a diploma of the nominee of the national award in the field of environmental technologies "ECOTECH-LEADER 2022" for the project "Use of liquefied natural gas and "green" hydrogen when burning a mixture of natural gas and hydrogen in a boiler room"

THE ACTIVITY OF ANO “HYDROGEN TECHNOLOGY SOLUTIONS” IS RELATED TO :

- The study of promising developments and trends in the field of hydrogen energy;
- Conducting "R&D";
- Work with promising young people and assistance in realizing creative potential.

We conducted the following scientific research:

Experimental study of the composition of exhaust gases and condensate during combustion in a condensing boiler of natural gas and a mixture of gases.

As part of the experiment, an experiment was conducted jointly with the NRU MPEI, in which a schematic diagram was developed and gas and hydraulic circuits were installed to conduct experiments using a CALDANIA MURALE CIAO GREEN 25 C.S.I. gas boiler.

STUDENT DESIGN BUREAU OF “HYDROGEN ENERGY” AT THE NRU"MPEI"

SDB "Hydrogen Energy" was created as part of the implementation of the strategic academic leadership program "Priority-2030". The objectives of the creation of the SDB "Hydrogen Energy" are – popularization of research and innovation activities among young people, its integration into the scientific and educational process of the institute, the development of team and project work skills aimed at obtaining the final result.

STUDENT DESIGN BUREAU OF “HYDROGEN ENERGY” AT THE NRU"MPEI"

Tasks of the SDB "Hydrogen Energy":

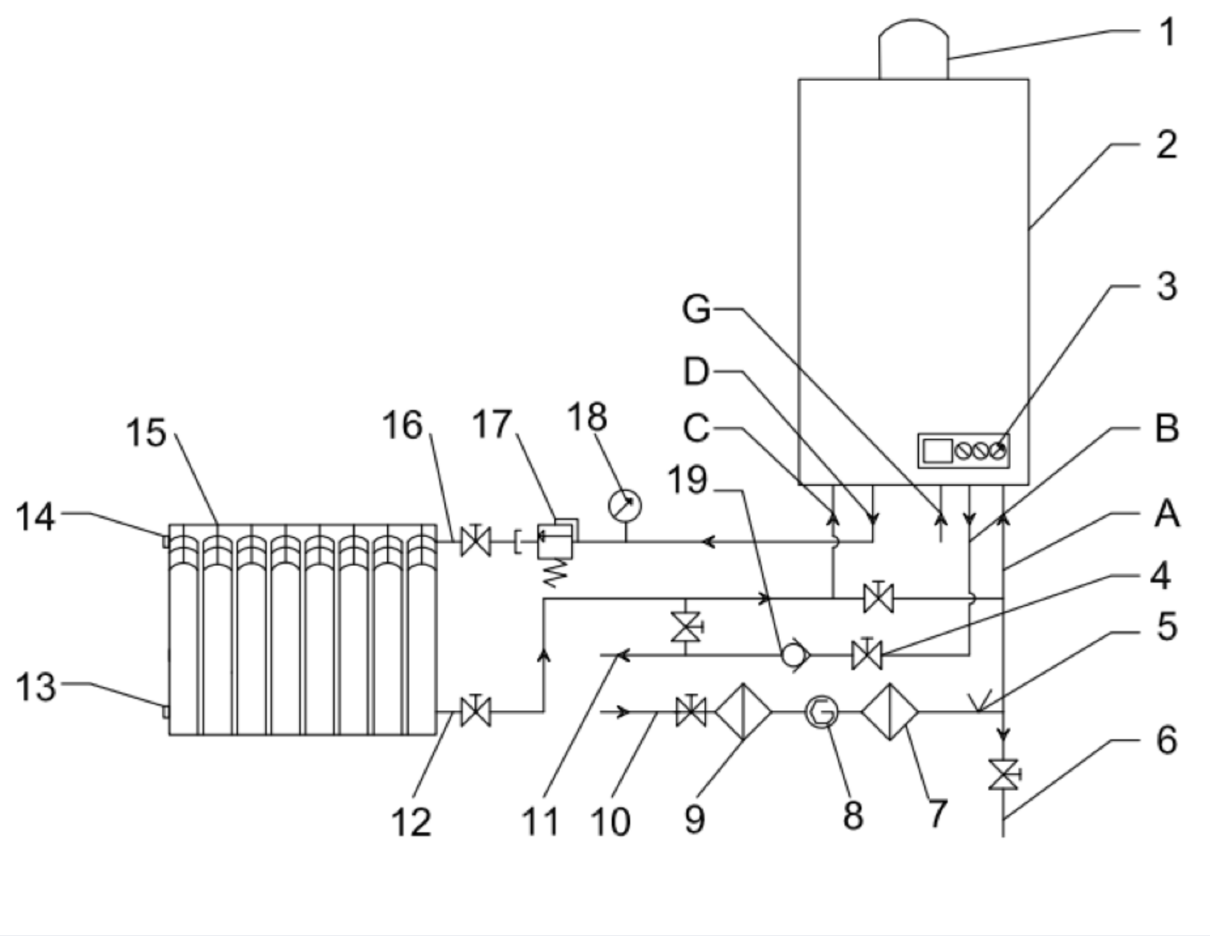
- implementation of practice-oriented training;
- achieving maximum involvement of students in the scientific and educational process;
- creating conditions for scientific creativity of young people;
- creation of teams of a wide profile by attracting students of various fields of training and specialties;
- training of highly qualified personnel with real experience in various scientific, innovative and technical projects;

At the moment, 4 students work in the SDB "Hydrogen Energy" in the following areas:

- Burner devices;
- Heat exchangers-heat exchangers;
- Mathematical model of the boiler/instrumentation/automated control system;
- Carbon regulation.

STAND IMPLEMENTED AS PART OF THE R&D OF ANO "HTS"

A – Cold water inlet from the water pipe
B – Hot water outlet to the hot water circuit
C – Return pipeline of the heating circuit
D – Direct pipeline of the heating circuit
G – Gas inlet
1 – Flue gas pipe
2 – Wall-mounted condensing boiler
3 – Control Panel
4 – Ball valve
5 – Thermocouple type XA
6 – Water discharge line
7 – Polyphosphate filter
8 – Flow meter
9 – Mechanical filter
10 – Cold water pipeline
11 – Heated water discharge line
12 – Heating waste water line
13 – Plug
14 – Mayevsky Crane
15 – Heating radiator
16 – Untreated heating water line
17 – Safety valve
18 – Pressure gauge
19 – Check valve



How promising is the use of hydrogen in the energy?

Hydrogen is a secondary energy carrier, that is, an energy carrier that does not exist on Earth in its pure form.

Hydrogen can be produced by various methods, such as electrolysis of water, pyrolysis of methane and steam conversion of methane.

It should be noted that only during the electrolysis of water, organic fuel is not used to produce hydrogen.

How reasonable is it to use natural gas to produce hydrogen if natural gas itself is an excellent fuel?

The efficiency of fuel cells is about 50%, therefore, when generating electricity in a fuel cell (FC), the recovery coefficient will be **0.33**.

It should be noted that water vapor is formed at the outlet of the FC, the energy of which can be used to produce thermal energy.

In addition to electrical and thermal energy, it is possible to obtain water vapor condensate in the thermal power plant, which can be used to produce hydrogen.

It is important to note that very pure hydrogen is required for the production of electrical energy using fuel cells, and the "drying" of hydrogen increases its cost.

Hydrogen obtained from natural gas by pyrolysis is called "turquoise" according to the international classification.

During pyrolysis, methane (CH_4) molecules break down into carbon (C) and hydrogen (H_2) molecules.

The following main types of pyrolysis are distinguished:

Plasma. Electricity is used to produce plasma. The temperature in the reactor is 2000 ° C. The pressure is atmospheric.

In the fluidized bed at a temperature of 900 ° C. The pressure is atmospheric.

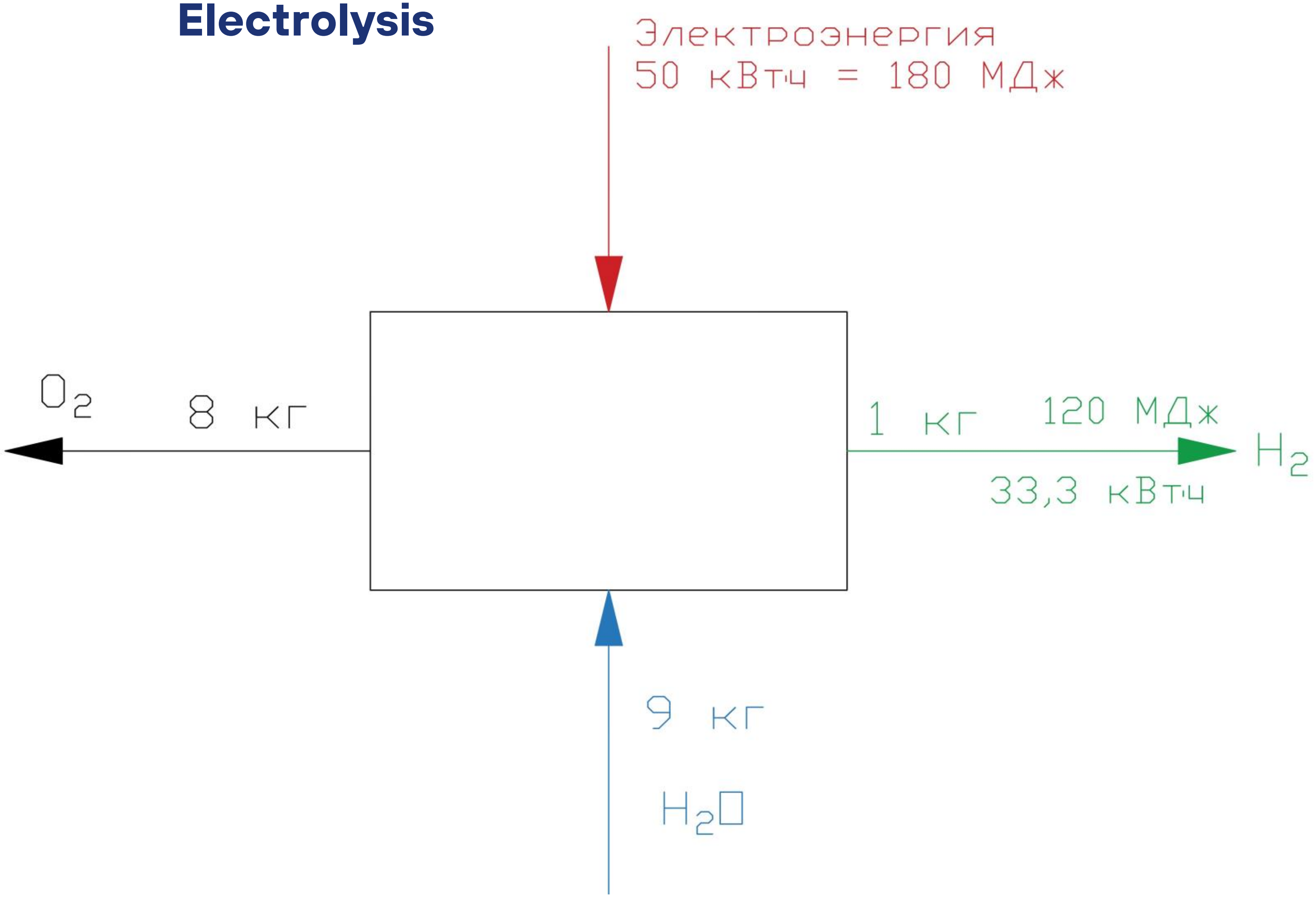
In molten metal or salt. The temperature in the reactor is **650 / 1100 ° C**. Pressure – up to **5** bar.

Pulsed methane combustion (PMP). The temperature in the reactor is **1200 / 1500 ° C**. Pressure – up to **20** bar.

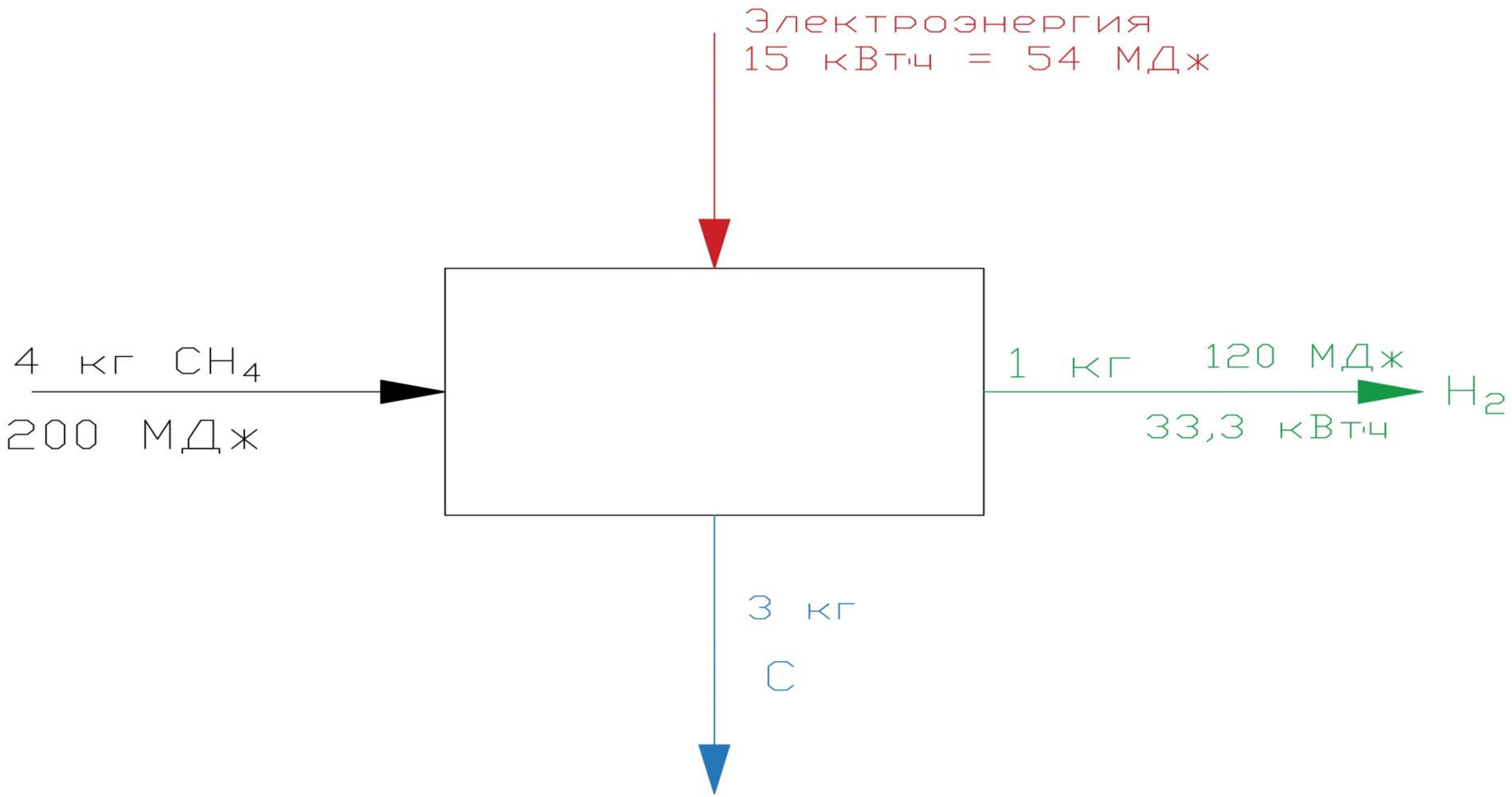
It takes four kilograms of methane (CH_4) to produce one kilogram of hydrogen (H_2). The lowest heat of combustion of one kilogram of hydrogen is 120 MJ (33.3 kWh). The lowest heat of combustion of 4 kg of methane is 200 MJ (55.6 kWh). That is, the energy value of the hydrogen obtained by pyrolysis is 60% of the energy value of the feedstock.

About 15 kWh of electricity is required to produce 1 kg of hydrogen by flame pyrolysis. Consequently, the energy value of one kilogram of hydrogen produced by plasma pyrolysis will be 47% of the sum of the values of the heat of combustion of 4 kg of methane and the electrical energy spent on hydrogen production.

Electrolysis



Plasma pyrolysis



Basing by the above analysis, hydrogen obtained by electrolysis of water has a higher energy value than hydrogen obtained by plasma pyrolysis.

Question: What is the point of converting high-quality electricity into hydrogen with a negative energy result?

Answer: it makes sense to obtain hydrogen only with the use of currently unclaimed electricity produced through renewable energy sources (RES).The use of hydrogen for energy generation is promising in regions where expensive imported fuel is used for energy production.

The more expensive the imported fuel, the better the economy of using hydrogen.

It is important to note that it is proposed not to replace hydrocarbon fuel with hydrogen, but to co-burn hydrogen, which should be produced at the place of its consumption, and imported fuel.

Not instead, but together with organic fuels!

In this case, the combustion of hydrogen will reduce the consumption of expensive imported fuel.

An important technical issue is the determination of the permissible proportion of hydrogen in the total fuel consumption in specific power plants, such as gas turbine units (GTU), gas piston units (GPU), hot water and steam boilers.

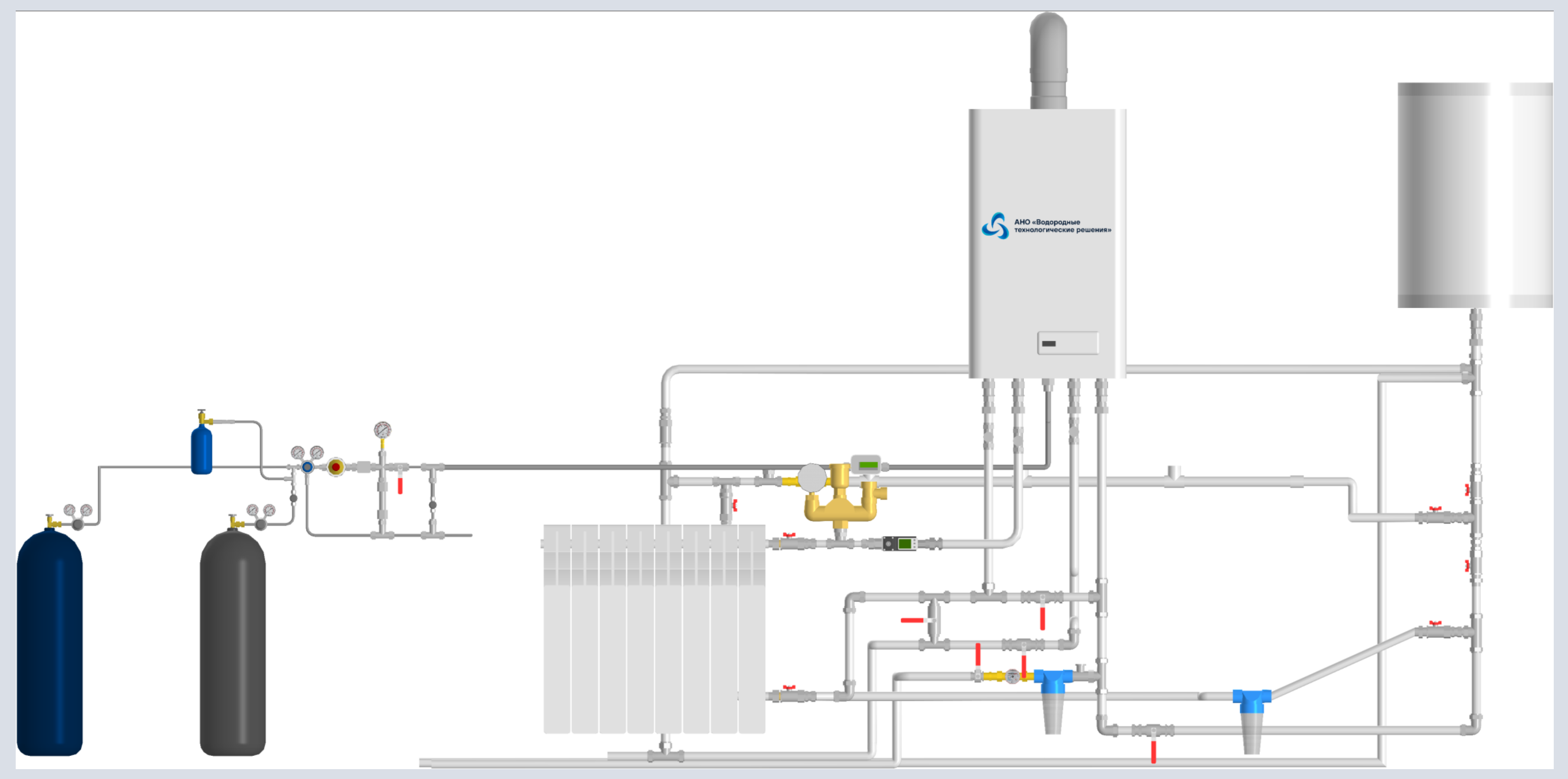
Hydrogen energy sources could become one of the promising solutions to the problem of energy supply to isolated territories and territories for which special environmental requirements have been established, in particular, in the Arctic zone of the Russian Federation.

CLIMATE	ECOLOGY
GREENHOUSE GASES	HARMFUL EMISSIONS
H_2O – water vapor	NO_x – nitric oxide
CO_2 – carbon dioxide	CO – carbon monoxide
CH_4 - methane	SO_2 – sulfur dioxide

It is necessary to separate the substances that are formed during the combustion of organic fuels into greenhouse gases that affect climate change and harmful substances from the point of view of ecology.

The table shows the main gases that can be formed during the combustion of gaseous fuels.

STAND IMPLEMENTED AS PART OF THE R&D OF ANO “HTS”



RESULTS OF MEASUREMENTS OF NOx AND CO CONCENTRATIONS IN FLUE GASES.

Gas composition	100% CH_4	11% H_2 + 89% CH_4	22% H_2 + 78% CH_4
Outdoor air temperature, °C	10	14,2	15,1
Exhaust gas temperature, °C	67,8	63,3	62,9
Concentration CO_2, %	8,6	8,9	8,5
Concentration NO_x, ppmv	12	11	7
Reduced concentration NO_x, %	-	8,3	41,7
Concentration CO, ppmv	118	111	70
Reduced concentration CO, %	-	5,9	40,7
Concentration O_2, %	5,0	5,1	5,9

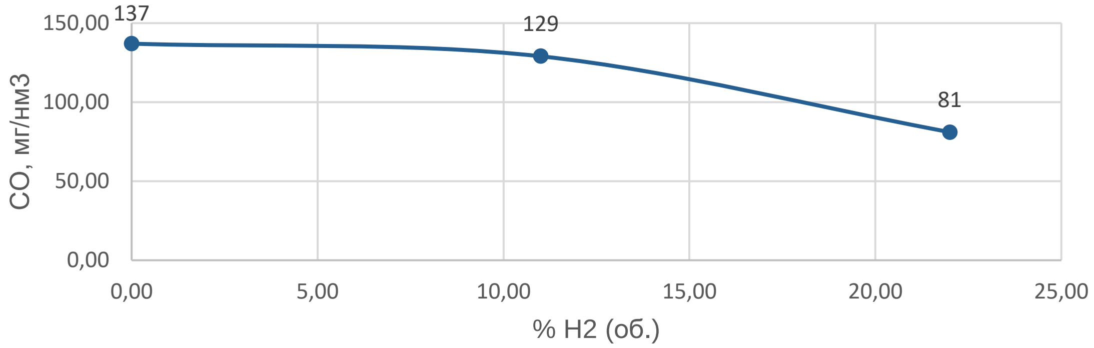
RESULTS OF MEASUREMENTS OF CONDENSATE CHARACTERISTICS

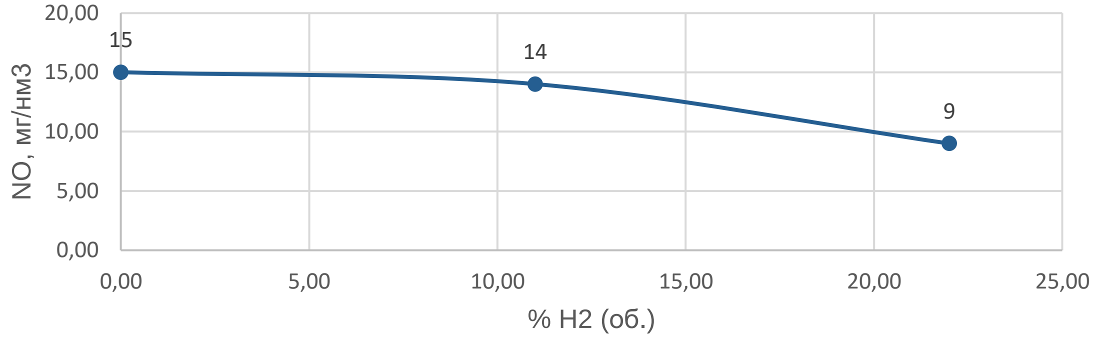
Condensate analysis	100% CH_4	11% H_2 + 89% CH_4	22% H_2 + 78% CH_4
pH, pcs.	7,59	7,64	7,24
Eh (Redox potential), mV	211	304	323
Total salinity, mg/l	484	653	553

CHARACTERISTICS OF THE FUEL GAS.

Specifications	Natural gas	Methane 100% CH_4	11% H2 + 89% CH4	22% H2 + 78% CH4
Density under normal conditions, kg/nm³	0,746	0,717	0,674	0,600
Volumetric lower heat of combustion under normal conditions, MJ/nm³	36,6	35,88	33,76	30,92
Volumetric lowest Wobbe number under normal conditions (WI), MJ/nm³	48,00	48,18	46,76	45,40

THE RESULTS OF MEASUREMENTS OF THE CONCENTRATION OF NO AND CO IN FLUE GASES

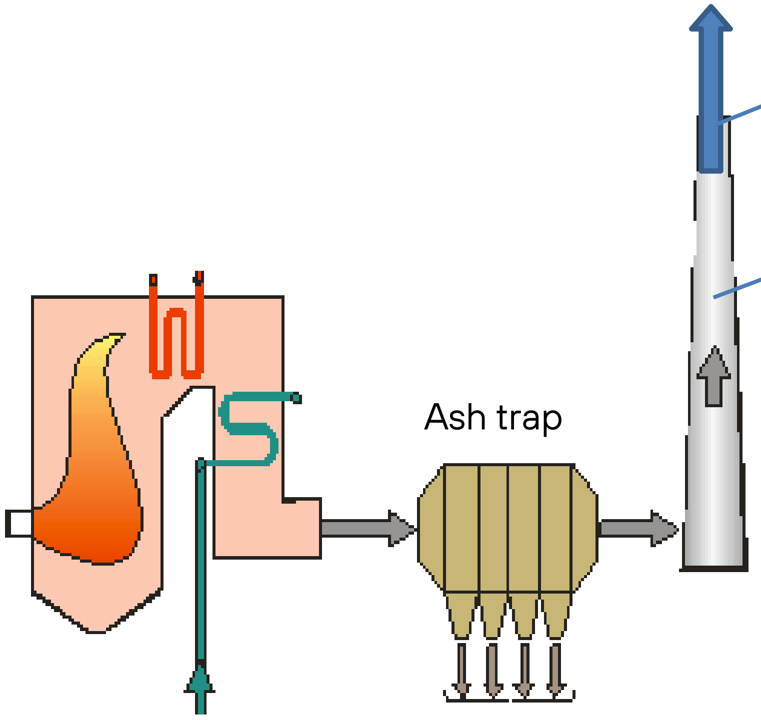


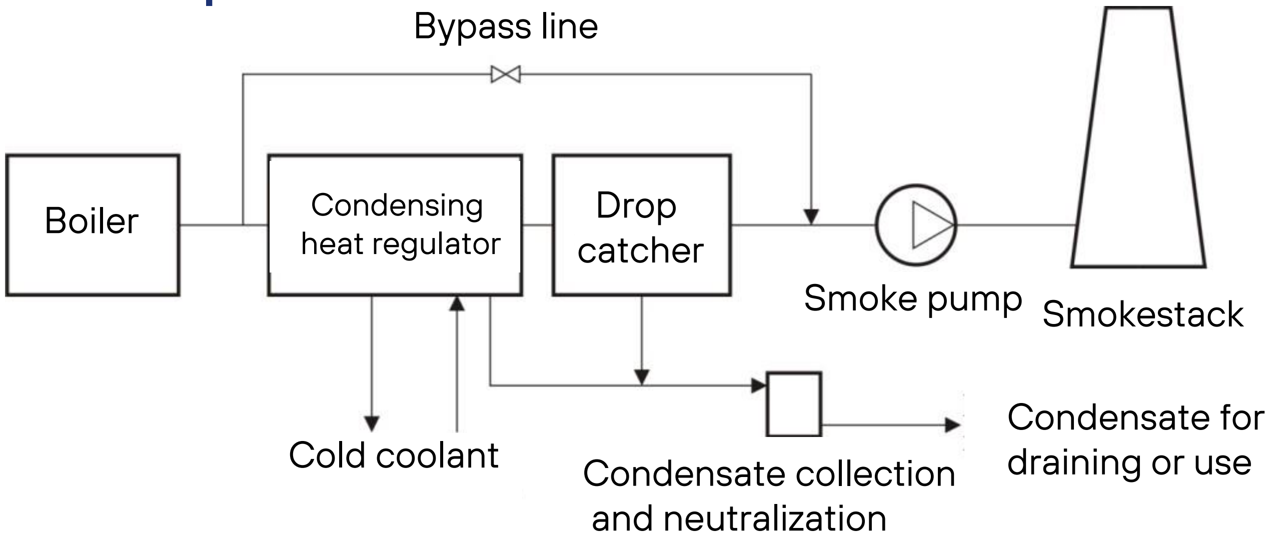


The values of concentrations of carbon monoxide (CO) and nitrogen oxides in the flue gases of the boiler are given with an excess air coefficient equal to one.

Losses 2500 kJ/kg

120 - 150°C > t_P



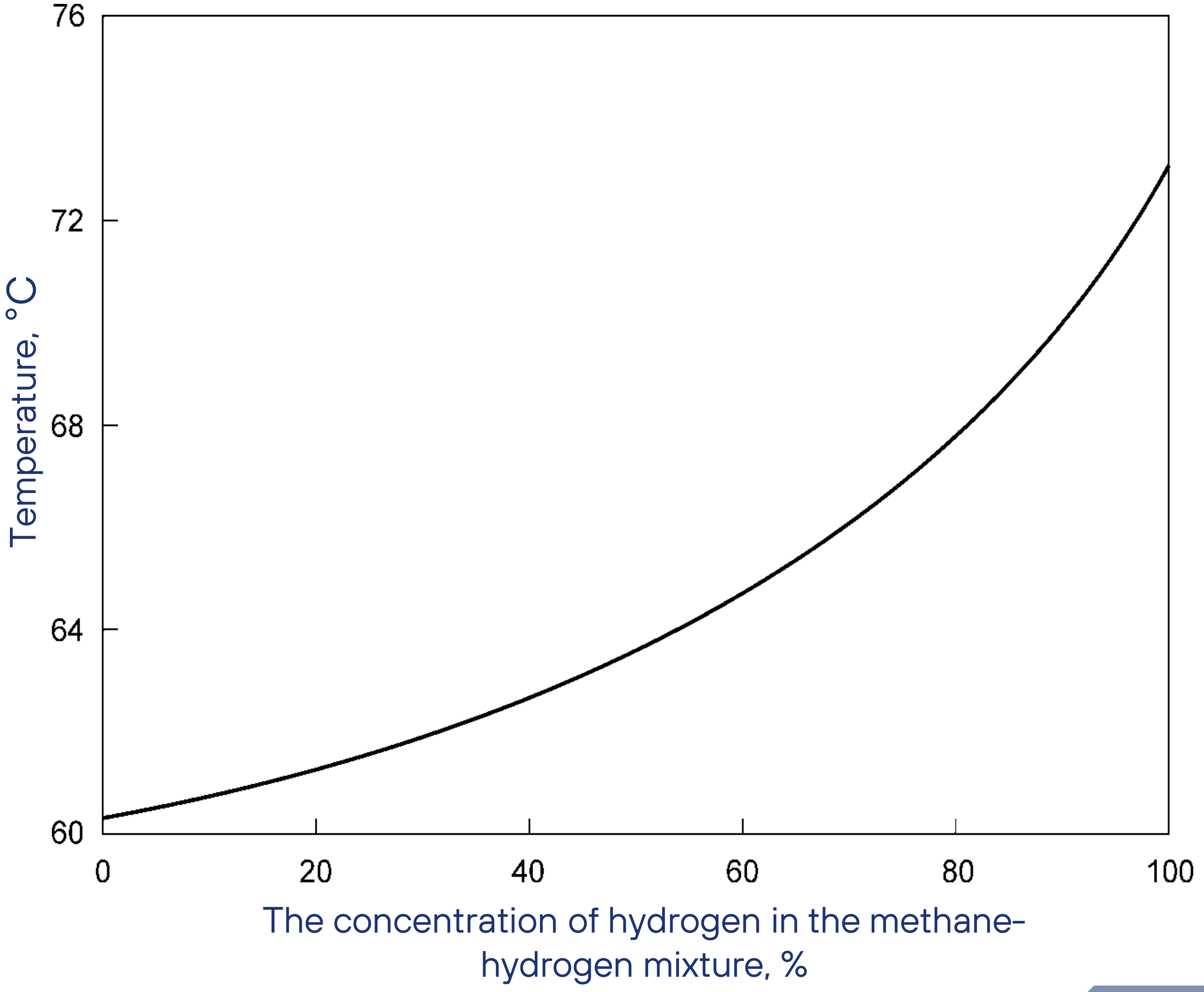


Water vapor, like carbon dioxide, is a greenhouse gas. Reducing its emissions into the atmosphere is also an urgent task. Simultaneous reduction of water vapor and carbon dioxide emissions into the atmosphere during natural gas combustion is possible due to condensation of flue gas water vapor before their release into the atmospheric air.

For natural gas Q_B - Q_H ≈ 10% from Q_H; 18,5 % - for hydrogen

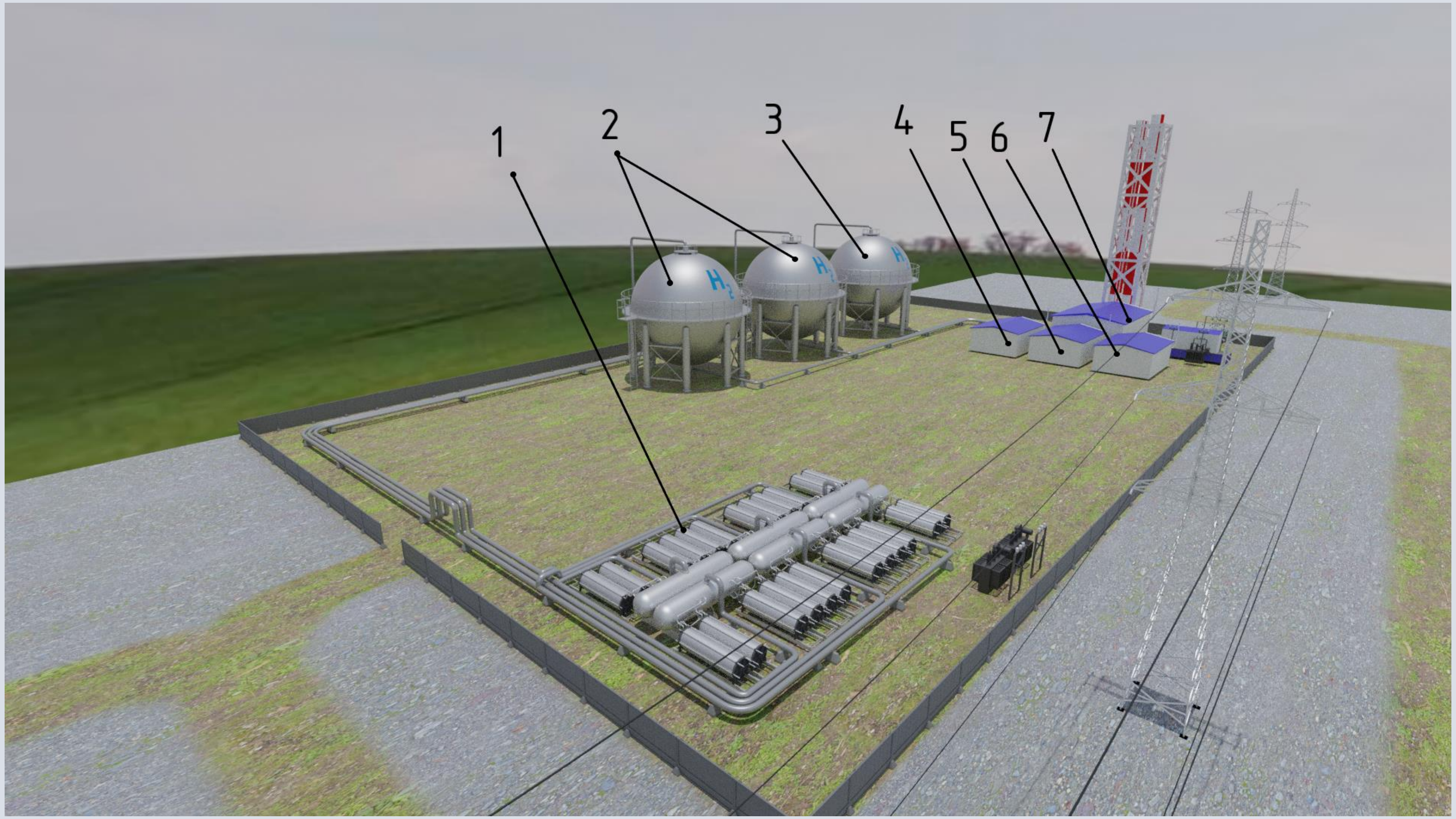
An increase in the proportion of hydrogen in the VSG increases the water vapor content in the combustion products and leads to a noticeable increase in the dew point temperature.

As a result, the efficiency of using KTU increases.



SCHEME OF THE PROJECT IMPLEMENTATION USING LNG AND GREEN"HYDROGEN AND BURNING A MIXTURE OF NATURAL GAS AND HYDROGEN IN A BOILER ROOM

Designations:
1. – Electrolysis plants
2. – Hydrogen Receivers
3. – Receivers for a mixture of Natural gas CH4 (80%) and Hydrogen H2 (20%)
4. – Heat exchange system
5. – Boiler room
6. – Pumping group
7. – Condenser



PROCESS DESCRIPTION:

1. From the LNG storage, liquefied gas enters the regasification plant. After that, natural gas is supplied through the heat exchange system (4) to the boiler room (5) for water heating.
2. In condenser (7), condensate of water vapor from flue gases and additional thermal energy is formed. The condensate can be used both to recharge the heating system and to produce hydrogen.
3. Hydrogen obtained in the electrolysis plant (1) by water electrolysis enters the hydrogen receiver (2).
4. From the receiver, hydrogen is supplied to the storage receiver of a mixture of methane and hydrogen (3).
5. Methane-hydrogen mixture, burned in a hot water boiler (boilers) (5).

This concept is implemented for island settlements for uninterrupted supply of consumers with thermal energy.

DESCRIPTION OF ELECTRIC AND HEAT SUPPLY SCHEMES FOR CONSUMERS USING METHANE HYDROGEN MIXTURES:

The following slides show the main components of the equipment used for the production, storage and use of hydrogen, which is produced by electrolysis from water.

Sources of electric energy are:

- Solar power plant (SPP);
- Gas piston unit (GPU).

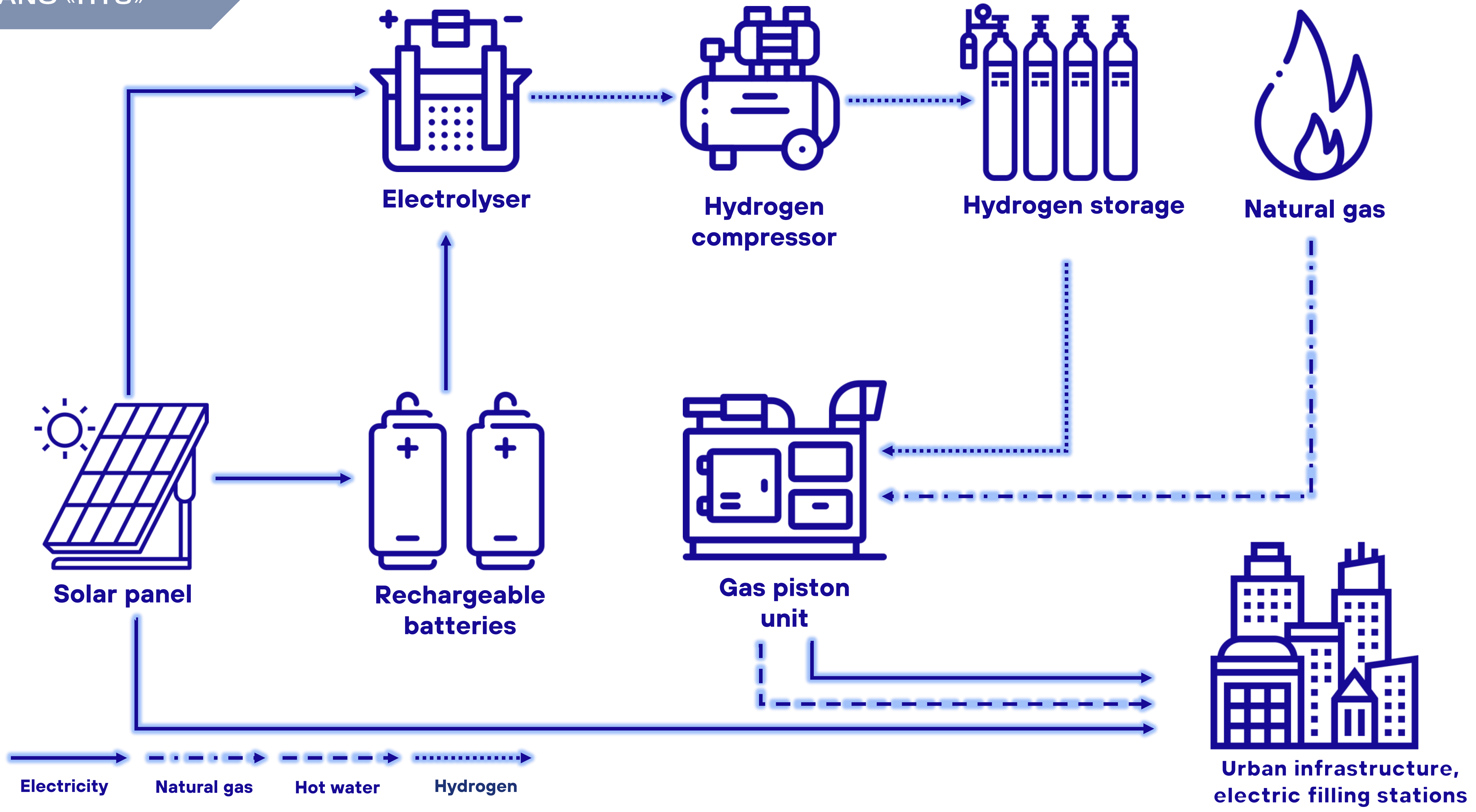
The sources of heat energy are:

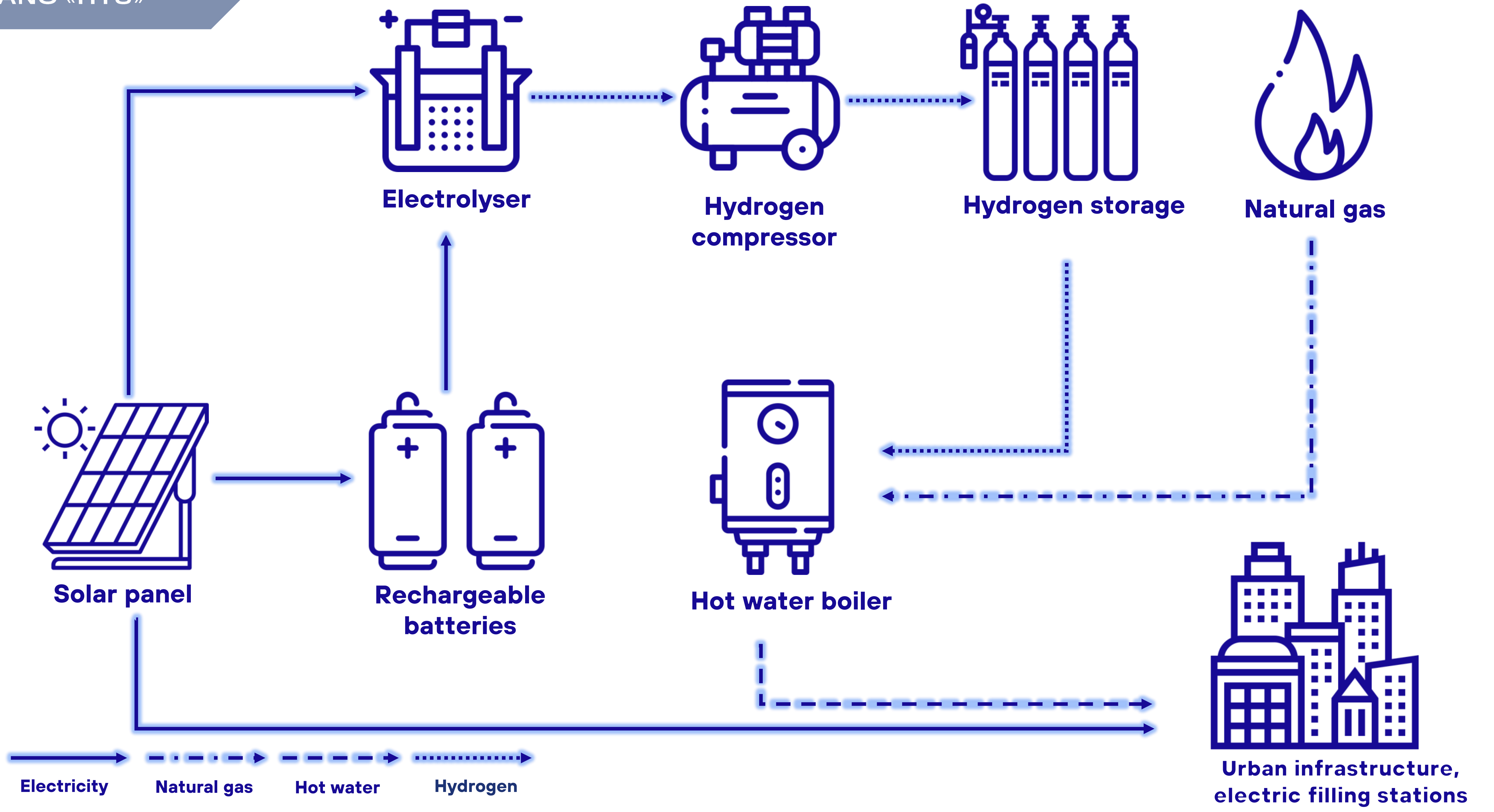
- Gas piston unit (GPU);
- Hot water boiler.

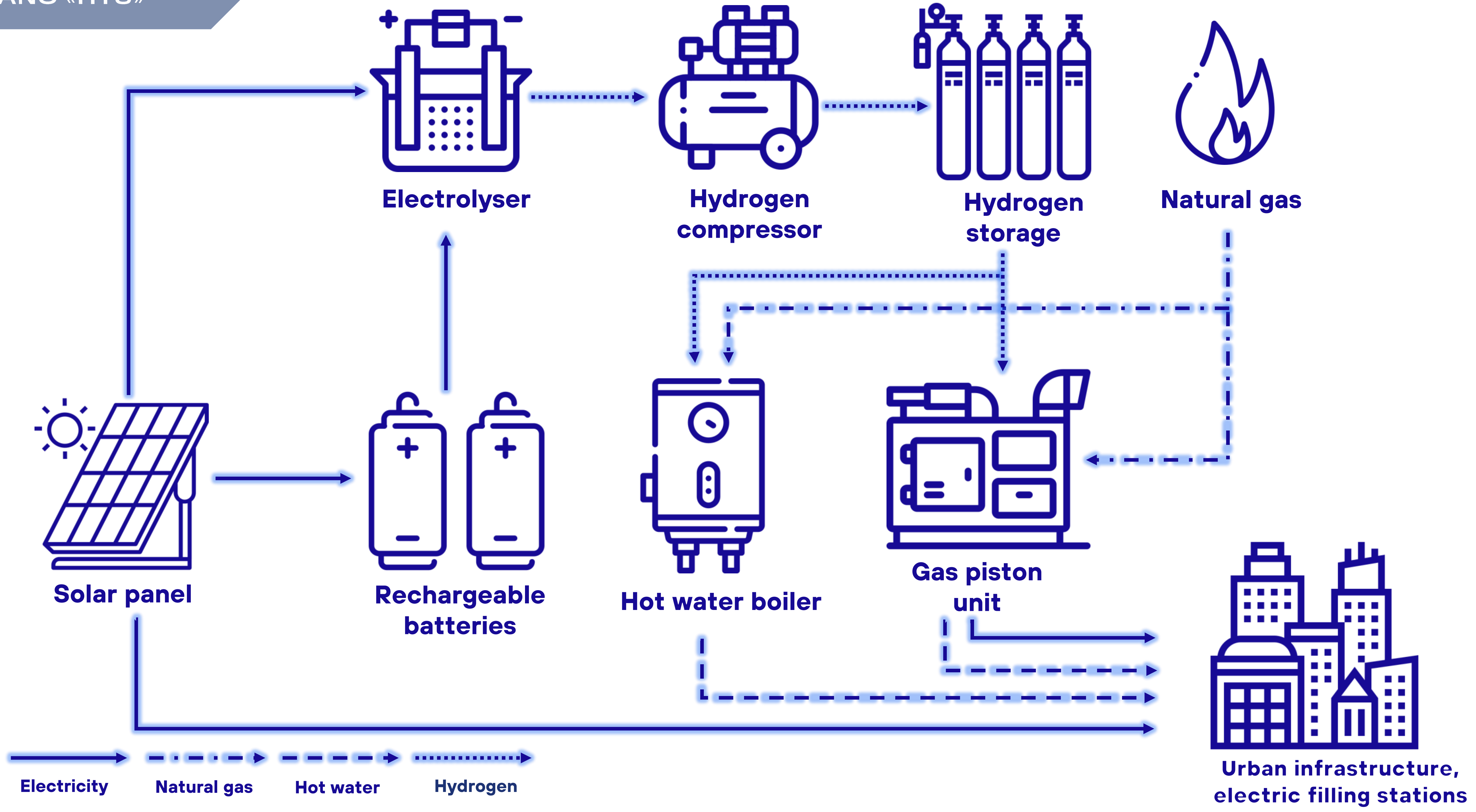
Hydrogen is produced by electrolysis of water in an electrolysis plant and accumulates in hydrogen receivers under pressure.

The pressure in the receiver is created by a hydrogen compressor.

Before burning hydrogen in a GPU and/or a hot-water boiler, it is mixed with natural gas to form a methane-hydrogen mixture (MHM).


Electrolyser
Hydrogen compressor
Hydrogen storage
Natural gas
Solar panel
Rechargeable batteries
Gas piston unit
Urban infrastructure, electric filling stations
Electricity
Natural gas
Hot water
Hydrogen


Electrolyser
Hydrogen compressor
Hydrogen storage
Natural gas
Solar panel
Rechargeable batteries
Hot water boiler
Urban infrastructure, electric filling stations
Electricity
Natural gas
Hot water
Hydrogen


Electrolyser
Hydrogen compressor
Hydrogen storage
Natural gas
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Hot water boiler
Gas piston unit
Urban infrastructure, electric filling stations
Electricity
Natural gas
Hot water
Hydrogen

DESCRIPTION OF ELECTRIC AND HEAT SUPPLY SCHEMES FOR CONSUMERS USING METHANE HYDROGEN MIXTURES:

The first diagram shows a method for obtaining electrical and thermal energy using a gas piston unit (GPU) operating on a methane-hydrogen mixture (MHM).

The second diagram shows a method for obtaining thermal energy using a hot water boiler in which the MHM is burned.

The third diagram shows a method for obtaining electrical and thermal energy using a gas piston unit (GPU) and a hot water boiler running on a methane-hydrogen mixture (MHM).

DESCRIPTION OF ELECTRIC AND HEAT SUPPLY SCHEMES FOR CONSUMERS USING METHANE HYDROGEN MIXTURES:

The principle of operation of the system is as follows:

In the presence of the sun, electric energy is produced in the SPP, which is supplied to the consumer.

If the power of the electric power consumer is less than the power generated by the SPP, then the excess energy enters the electrolyzer in which hydrogen is produced, which is accumulated in the receiver or cylinders.

In the absence of solar energy, a GPU running on the MHM is launched.

The accumulated hydrogen can be burned as part of a mixture with fuel gas, both in a GPU for generating electric energy and in a boiler for producing thermal energy.

Specific parameters of the system, such as the installed capacity of the SPP, the performance of the electrolyzer, the volume of hydrogen storage, the power of the GPU and the power of the boiler are optimized depending on the schedule of consumption of electrical and thermal energy by the Consumer.

The following options are possible in the attached diagrams:

1) A wind generator(s) can be used instead of a SPP or in addition to a SPP.
2) Along with using a conventional boiler, a condensing boiler can be used. At the same time, the resulting water condensate after its purification can be used to produce hydrogen in an electrolysis plant.
3) Instead of a receiver or cylinders for storing hydrogen, a reactor with metal hydrides can be used. In this case, a hydrogen compressor is not required.

CONCLUSION

The transfer of thermal power plants and boiler houses from coal to natural gas combustion certainly significantly reduces carbon dioxide emissions and is currently the simplest from a practical point of view.

- In the future, a more effective measure to reduce carbon dioxide emissions is the combustion of natural gas mixed with hydrogen. The addition of hydrogen to natural gas leads not only to a reduction in natural gas consumption, but also to a reduction in emissions of greenhouse gases and harmful substances into the atmosphere!

- When designing promising power plants, it makes sense to work out technical solutions right now that will allow the use of hydrogen-containing gas (HCG) as fuel in the future.

- Modernization of boilers for conversion to the combustion of VSG will definitely lead to an increase in emissions with flue gases of water vapor.

CONCLUSION

- To reduce emissions of water vapor into the atmosphere, the use of condensing heat exchangers (CTU) is promising, which allows reducing fuel consumption while maintaining thermal power and at the same time reducing emissions of the main greenhouse gases into the atmosphere: carbon dioxide and water vapor, as well as increasing the efficiency of the boiler.

- Reducing the flue gas temperature will reduce the thermal pollution of the air basin.

- Considering the declared prospective volume of hydrogen production, the issue of obtaining water for hydrogen production will become very acute. The condensate of water vapor from flue gases can be used to produce hydrogen by electrolysis.

PUBLICATIONS OF ANO “HTS”

Name of the publication	Publication resource	Date of publication
The use of hydrogen in energy: environmental issues	Turbines and diesels	January - February 2021
Reduction of CO2 emissions from combustion of gaseous fuels in boilers	Website of ANO “HTS"	24.04.2021
Prospects for reducing greenhouse gas emissions in the energy sector of the Russian Federation	Website of ANO “HTS"	24.04.2021
Combustion of hydrogen-containing gases in gas turbine installations	Turbines and diesels	March – April 2021
Combustion of hydrogen-containing gas in hydrogen and steam boilers	Website of ANO “HTS"	16.05.2021
The effect of fuel composition on greenhouse gas emissions	Energy and industry of Russia	15.06.2021
The relationship between humidity and temperature	Website of ANO “HTS"	30.06.2021
Reduction of greenhouse gas emissions in hot water and steam boilers	Energy and industry of Russia	15.09.2021
The main ways to reduce CO2 emissions into the atmosphere in the energy sector of the Russian Federation	Website of ANO “HTS"	29.10.2021
Decarbonization: Is this the way we are going?	Energy and industry of Russia	10.02.2022

*To follow the link to read, click on the title of the article

PUBLICATIONS OF ANO “HTS”

Name of the publication	Publication resource	Date of publication
Global energy transition and domestic solutions	Academy of Energy of the Russian Federation	23.03.2022
Combining regions: how to create effective generation in remote areas	Energy and industry of Russia	10.10.2022
Publication in the catalog "Russian Hydrogen Industry competencies"	Catalog of the Ministry of Industry and Trade	08.06.2022
Energy from hydrogen for remote areas. Prospects for the use of hydrogen-containing gases for energy production in isolated areas	Energy and industry of Russia	10.10.2022
Assessment of the possibilities of reducing greenhouse gas emissions from fuel combustion in boilers of thermal power plants and boiler houses	eLIBRARY	24.11.2022
The use of renewable energy and hydrogen in isolated areas in order to reduce fuel consumption and emissions of harmful substances into the atmosphere	Regional energy and energy conservation	05.12.2022
Investigation of the composition of exhaust gases and condensate during combustion in a condensing boiler of natural gas and methane-hydrogen mixtures	Website of ANO “HTS"	22.03.2023

*To follow the link to read, click on the title of the article

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