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HYDROGEN ENERGY IN THE RUSSIAN FEDERATION

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Hydrogen – vital element for neutral carbon economy

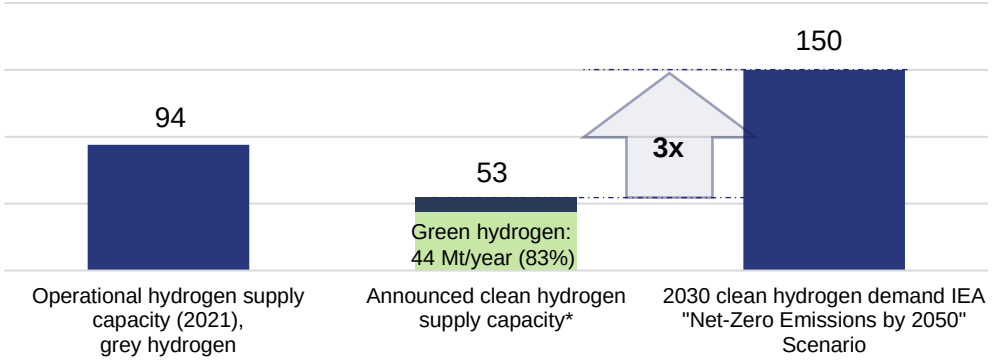
*«…hydrogen and its derivatives will contribute **10%** of total emissions reductions by 2050…and **12%** of final energy demand»*

IRENA World Energy Transition Outlook 2022

*«…hydrogen and hydrogen based fuels (enable) to avoid up to **60 Gt CO2** emissions in 2021-2050 in the Net zero Emissions Scenario»*

IEA Global Hydrogen Review 2021

Global operational and announced clean hydrogen supply capacity (August 22) vs. expected demand (Mt / year)



Source: IEA World Energy Outlook 2022, IEA "Net-Zero Emissions by 2050" Scenario, Deloitte Energy Transition Monitor

Barriers

Administrative
- lack of uniform standards
- legislation restrictions
- protectionism policy

Technological
- low TRL on critical technologies
- complicated delivery (lack of carriers, pipelines, ammonia production capacity)
- electrolysers capacity shortage
- safe use conditions

Economical
- LCOH is still very high to compete with conventional sources of energy

Climate
- Additional leaks of methane and hydrogen can negate the effect of reducing GHG emissions

** Includes ambitions that are in a very early stage (i.e. projects with an ambition set, but without specific plans – high uncertainly), planned projects that are pre-FID and planned projects that are post-FID*

A list of priority hydrogen technologies

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Production

9 1.Steam methane reforming	9 11.Chemical absorption of CO2 by alkanolamines
9 2.Autothermal reforming of methane	5 12.Adsorption separation
6 3.Carbon dioxide methane reforming	5 13.Membrane separation
7 4. Decomposition of methane (catalytic)	8 14.Cryogenic separation
7 5. Decomposition of methane (plasma-assisted)	9 15.Alkaline Electrolyzer
9 6.Coal gasification	9 16.PEM Electrolyser
4 7.Gasification of veg. raw materials and solid waste	5 17.AEM Electrolyser
6 8.Processing of veg. raw materials and solid waste	7 18.SO Electrolyser
4 9. Thermochemical cycles	5 19.DO Electrolyser
4 10.Thermoelectrochemical cycles	4 20.Photolytic decomposition of water

Storage and transportation

9 21.Compression H_2 (CGH_2)	
9 22.Liquefaction H_2 (LH_2)	9 26.Containers for LH2 transportation
7 23.Hydrogenation/ dehydrogenation (LOHC)	9 27.Capacities for LOHC
5 24.Ammonia technologies (decomposition of ammonia)	9 28.Containers for NH3
9 25.Methanol technologies for H2 storage	9 29.Containers for methanol
7 30.Metal hydride storage of H2	
5 31. Inorganic hydrogen carriers	
5 32.Geological storage facilities	
9 33.Low pressure vessels	9 34. Hydrogen pipelines

Application

9 35.Alkaline fuel cells (AFC)
9 36.Proton exchange membrane fuel cell (PEMFC)
7 37.Phosphoric acid fuel cell (PAFC)
9 38. Solid oxide fuel cell (SOFC)
8 39.Molten carbonate fuel cell (MCFC)
7 40. Direct-methanol fuel cell (DMFC)
5 41. Direct Ammonia Fuel Cell (DAFC)
6 42. GTCC on methane-hydrogen mixture
7 43.Gas burners and boilers on methane-hydrogen mixture
9 44.Ammonia technologies (synthesis of ammonia)
7 45. Obtaining hot-briquetted iron (HBI)
7 46.Methanol technologies (CO2-based syntheses)

Scale of technological readiness levels (TRL)

TRL in the world in 2022

1 Name of the technology

CO2 capture technologies

Priority technology

High technology roadmap
“Development of hydrogen energy” until 2030

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1 **Responsible:** Deputy Chairman of the Government of the Russian Federation

Responsible ministries: The Ministry of Energy and the Ministry of Industry and Trade

2 **Leading companies:** Gazprom PJSC and Rosatom State Corporation

Responsible executor: more than 40 companies

3 **Technological map**

List of the most significant and promising technologies

4 **Targets and Action plans**

In two sub-directions of hydrogen energy development and decarbonization of industry and transport:

1. based on natural gas
2. based on nuclear industry technologies

5 **General action plan**

improvement of industrial safety during the exploitation of hydrogen equipment and transport

regulation of requirements for hydrogen industrial products, its standardization and certification

- elaboration of the necessary regulatory framework to support and stimulate the development of hydrogen projects
- development of hydrogen infrastructure, training and international cooperation

ПРАВИТЕЛЬСТВО РОССИЙСКОЙ ФЕДЕРАЦИИ

РАСПОРЯЖЕНИЕ

от 16 января 2023 г. № 40-р

МОСКВА

1. Принять предложение Минэнерго России, согласованное с Минэкономразвития России, о подписании соглашений о намерениях между Правительством Российской Федерации и заинтересованными организациями в целях развития высокотехнологичного направления "Развитие водородной энергетики" (далее - соглашения).

2. Определить:

Заместителя Председателя Правительства Российской Федерации Новака А.В. ответственным лицом в соответствии с установленным распределением полномочий, осуществляющим курирование (контроль) вопросов развития высокотехнологичного направления "Развитие водородной энергетики" и реализации соглашений;

межведомственную рабочую группу по развитию в Российской Федерации водородной энергетики профильным координационным органом для координации развития в Российской Федерации высокотехнологичного направления "Развитие водородной энергетики";

Минэнерго России федеральным органом исполнительной власти, ответственным за развитие высокотехнологичного направления "Развитие водородной энергетики";

"дорожную карту" развития высокотехнологичного направления "Развитие водородной энергетики" на период до 2030 года, утвержденную решением межведомственной рабочей группы по развитию в Российской Федерации водородной энергетики, основным механизмом реализации соглашений.

3. Предоставить Заместителю Председателя Правительства Российской Федерации Новаку А.В. право подписания, изменения и расторжения соглашений, подготовленных в соответствии с типовой

Hydrogen projects

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Production	Storage and transportation	Application

SMR+CCS facility
Sakhalin Region

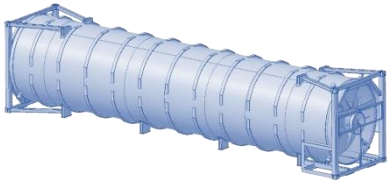
Operator: Rosatom

Production and supply of low-carbon “blue” hydrogen
carbon capture and storage (CCS) facility
planned capacity >100 000 t/year of hydrogen

Process Equipment of Cryogenic Complexes
Moscow region

Operator: H2 Invest

Large-tonnage liquefaction units
Liquid hydrogen storage tanks and tank-containers

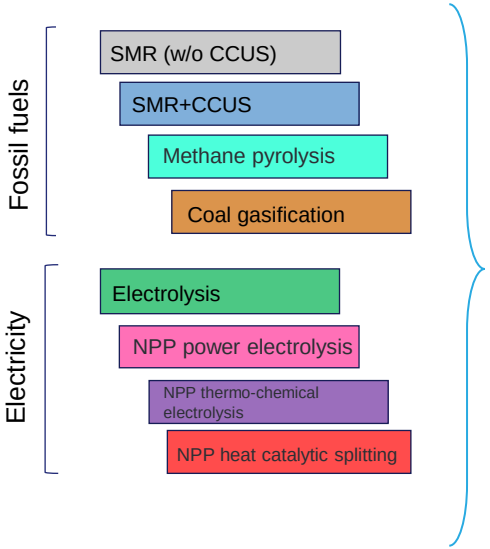


Transport applications: (KAMAZ, Russian Railways, TMH)

Snowflake International Arctic Station
Moscow Institute of Physics and Technology (MIPT)

100% ecological fully-autonomous hydrogen energy solutions for the future environmental life-support technologies in remote areas in the Arctic.

Certification & standardization



Carbon footprint regulatory standards without restrictions on source or technology

Many countries developed their own clean hydrogen standards without distinguishing between production technologies

UK, Low Carbon Hydrogen Standard Policy < 2.4 kg CO2-eq/kg

EU, EC Delegated regulation act (07 Feb.23) <3.38 kg CO2-eq/kg H2, 70% lower than predefined fossil fuel comparator

US, DOE Clean Hydrogen Production Standard <4.0 kgCO2e/kgH2

China, Standard and Assessment for Low-carbon Hydrogen, Clean Hydrogen and Renewable Hydrogen Energy <4.9 kgCO2e/kgH2

It is necessary to define common approaches to the classification of "low-carbon" hydrogen based on a single methodology for calculating the carbon footprint

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Thank you!