Sustainable Hydrogen Production in the UNECE region: findings for Turkmenistan and next steps

ENERGY

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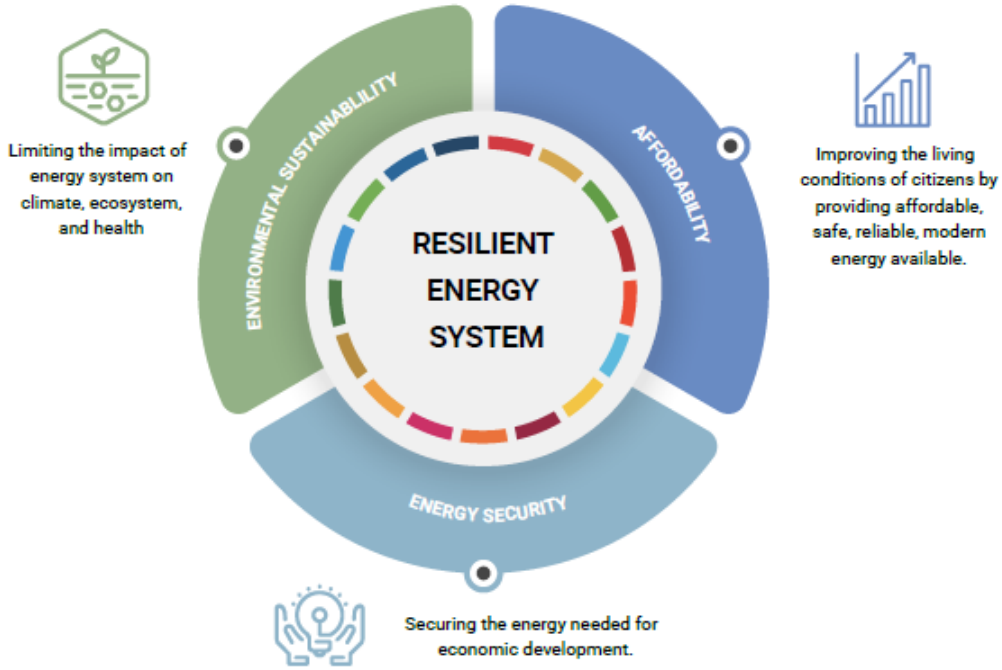
Building Resilient Energy Systems

Technical Considerations and Actions for Achieving Energy Security, Affordability, and Sustainability Net-Zero for Europe, North American and Central Asia

What is a resilient energy system?

- A **resilient energy system** ensures that energy makes an optimal contribution to a country's **social, economic, and environmental** development.
- **Energy security** strengthens energy independence through interconnectivity and trade.
- **Affordability** reduces costs of electricity, heating, cooling, and transport.
- **Environmental sustainability** lowers the carbon footprint and enhances efficiency across the energy supply chain.



Hydrogen Production Routes

		INPUT	PROCESS	OUTPUT	LIFE CYCLE EMISSIONS [kg CO_2. eq/ kg H_2]	COST [$/kg]
FOSSIL-FUEL BASED HYDROGEN	Natural gas & steam reforming		Steam reforming hydrocarbons into hydrogen and carbon monoxide	H_2 CO_2	9.0-11.0	0.7 - 2.1
	Natural gas & partial oxidation	O_2	Methane reacts with limited amount of oxygen	H_2 CO	9.0-11.0	0.7 - 2.1
	Natural gas & steam reforming with CCS	CCS	Steam reforming hydrocarbons into hydrogen and carbon monoxide	H_2 CO_2 (stored)	3.0-7.0	1.2 - 2.3
	Natural gas & partial oxidation with CCS	O_2 CCS	High temperature reaction between coal and oxygen	H_2 CO_2 (stored) Other species	3.0-7.0	1.2 - 2.3
	Coal gasification		High temperature reaction between coal and oxygen	H_2 CO_2 Other species	18.0-20.0	1.3 – 2.5
	Coal gasification with CCS	CCS	High temperature reaction between coal and oxygen	H_2 CO_2 (stored) Other species	11.8	1.6 – 2.6
	Methane pyrolysis		Splitting natural gas into hydrogen and solid carbon	H_2 C Solid carbon/ graphite	1.9-4.8	1.6 – 3.4
RENEWABLE ENERGY-BASED HYDROGEN	Electricity from renewable energy		Electrolysis - splitting water into hydrogen	H_2 O_2	0.7-2.8	2.6 – 23.0
	Biomass gasification with CCS	CCS	High temperature reaction between oxygen and biomass (e.g., wood logs)	H_2 CO_2 (stored) Other species	-14.6-0.4	1.9-8.4
	Biomass & pyrolysis	(without O_2)	High temperature reaction of biomass (e.g., wood logs) with no oxygen	H_2 Other species	-14.6-0.4	1.3-2.2
NUCLEAR POWER-BASED HYDROGEN	Electricity from nuclear power		Electrolysis – splitting water into hydrogen	H_2 O_2	0.3-0.6	4.2 - 7.0
	Heat from nuclear power		Heat from nuclear power and water through thermochemical process. Heat for Steam reforming hydrocarbons	H_2 O_2	~0.1	2.2–2.6

HYDROGEN VALUE CHAIN

Hydrogen, an innovative solution for achieving carbon neutrality

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PRODUCTION

FUEL-BASED PRODUCTION

Natural gas
Steam methane reforming/ autothermal Reforming with or without CCS

Coal
Gasification of coal with or without CCS

Biomass
Gasification of biomass with or without CCS

Steam reforming and gasification with CCS

ELECTRICITY SYSTEM

Renewable energy
Electricity from wind, solar, hydro or geothermal power

Nuclear
Electricity and heat from nuclear power

Water electrolysis

CONVERSION, PROCESSING & TRANSPORTATION

H_2

PURE H_2

PROCESSING

- Liquification and regasification of H_2
- H_2 gas compressed

CONVERSION

- **Haber-Bosch process**
  H_2 & N_2 → ammonia;
  standard shipping modes
- **Methanization**
  $H_2 + CO_2 \rightarrow CH_4 + H_2O$
  or $H_2 + CO \rightarrow CH_3OH$ (methanol)
  (synthetic or substitute natural gas)

STORAGE

Liquified H_2 in storage tanks

Geological storage in underground salt caverns

USE

TRANSPORT

- Hydrogen into **fuel cells** for trucks, passanger vehicles
- **Synthetic fuels** for shipping and aviation

INDUSTRY

- Hydrogen as **feedstock** in refining, steel production, chemicals production
- Hydrogen for **heat generation** for industrial processes

BUILDINGS

- Hydrogen for **heating**
- Hydrogen for onsite **power** through fuel cells

POWER

- Fuel cell **electricity**, H_2 turbines and H_2 CHP
- **Energy storage** and system buffer

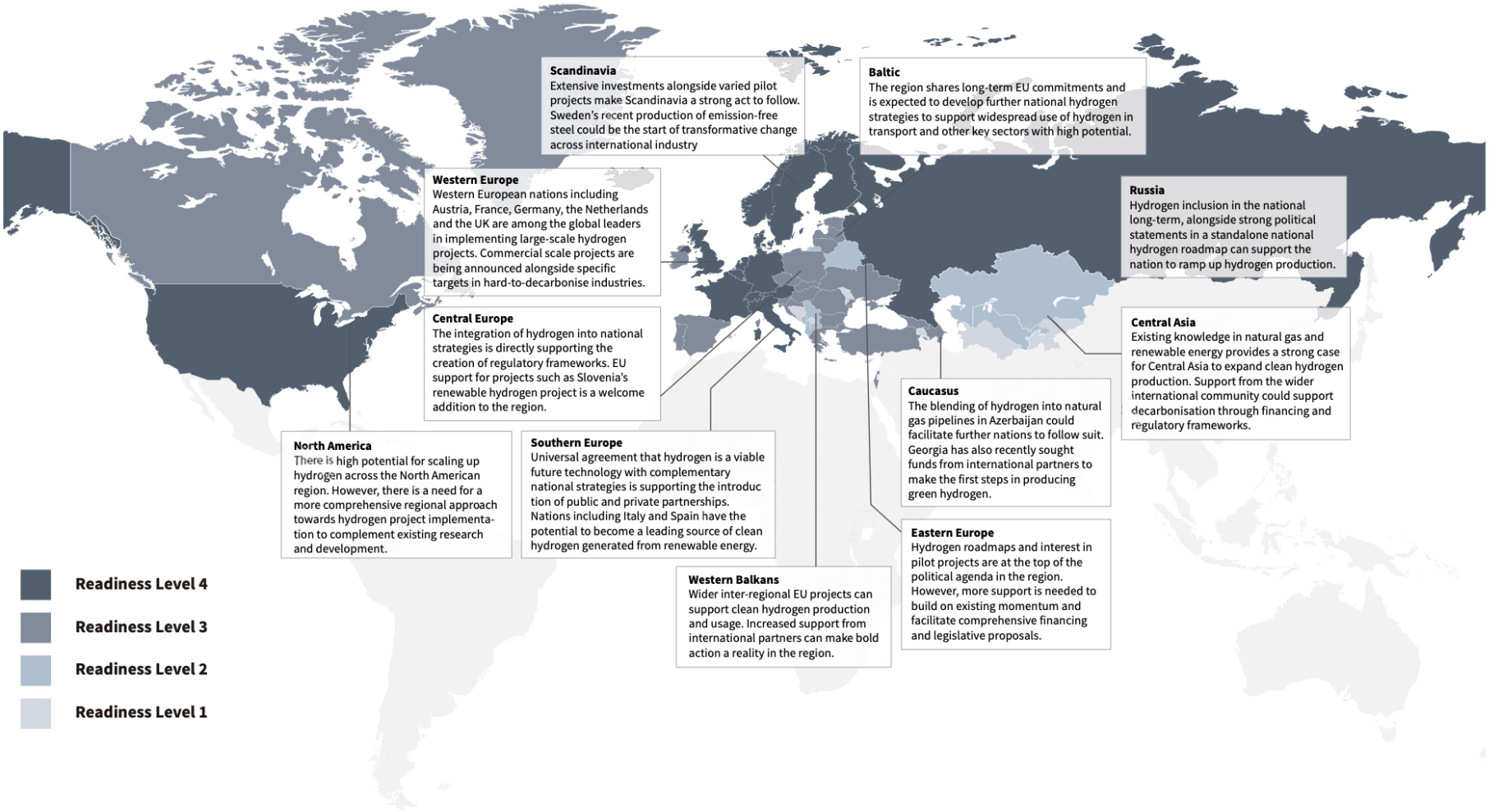
Awareness
Recognise hydrogen as a viable climate mitigation option

Acceptance
Develop and integrate policies to jumpstart hydrogen economy

Finance
Direct public and private investment into clean hydrogen projects

Assessment of Readiness Level across UNECE Region

Levels of actions taken towards the integration of hydrogen into energy systems



Project on Sustainable Hydrogen Production Pathways

Analysis of national potentials to contribute to development of a hydrogen ecosystem and global energy transitions, including the supply of energy to energy-deficient regions of the world

Analysis of priority areas for the development of national hydrogen potential

Analysis of hydrogen production potential across CIS countries

Analysis of the opportunities for hydrogen export and possible applications in the domestic market

Peer-to-peer dialogue on best practices and lessons learned in developing national hydrogen strategies

Subregional assessment of cost and technical performance of hydrogen production from fossil fuels, low-carbon energy, and renewable energy across beneficiary countries

Refining of existing data and assumptions related to sustainable hydrogen production for the energy model.

Directions for the implementation of pilot projects for the supply of sustainable hydrogen for export

Recommendations for pilot projects in international cooperation in sustainable hydrogen technologies

Policy dialogue to identify and overcome existing barriers to development of a hydrogen ecosystem

Final seminar for representatives of governments, industry, and academia to present and discuss recommendations and discuss how they can be incorporated into draft National Action Plans to meet SDG 7

Towards the Hydrogen Economy Development in Turkmenistan

By 2040, Turkmenistan may have resources for hydrogen production by:

- **Water electrolysis using electricity from renewables** (if renewable energy develops in the country)
- **Steam methane reforming with CCUS** (if the CCUS industry develops)

The resource potential of hydrogen production is determined by:

- Technical and economic potential for wind, solar and another RE development;
- Share of renewable electricity that would be appropriate to use for H2 production instead of being used directly in Turkmenistan power sector or exported to neighboring countries;
- Natural gas production potential;
- Share of natural gas that would be economically feasible to use for H2 production instead of direct use of gas in economy or its export;
- CCUS potential for long-term storage of carbon dioxide produced during hydrogen production from natural gas.

Towards the Hydrogen Economy Development in Turkmenistan

Resource potential of hydrogen production in Turkmenistan by 2040

	MINIMUM SCENARIO	MAXIMUM SCENARIO
Renewable electricity for hydrogen, GWh per year	306.6	17630
Natural gas for hydrogen, bcm per annum	9.609	28.827
Hydrogen by water electrolysis using solar and wind electricity, thousand tons per annum	6	321
Hydrogen from methane by SMR + CCUS, thousand tons per annum	1813	5439
Hydrogen total, thousand tons per annum	**1819**	**5760**
Required capacity of CCUS systems, $MtCO_2$ per annum	18	54

Towards the Hydrogen Economy Development in Turkmenistan

In the shorter term: domestic hydrogen consumption → to start in the transport sector, which accounts for 25% of the country's energy consumption.

The first steps:

- Launch of pilot hydrogen fuel cell electric buses,
- Phased development of a hydrogen refueling infrastructure around hydrogen-producing enterprises.

In the long term: transporting hydrogen using the existing gas transport infrastructure, esp. in the direction of China.

A **national hydrogen strategy** is needed to get a clearer picture of the prospects for hydrogen economy.

Way forward

The hydrogen economy deployment pace will be determined by:

- Strategic focus on low-carbon development
- Building an appropriate regulatory framework
- Expanding market
- Technological development
- International cooperation
- Projects implementation
- Export strategy

Thank you for your attention!

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