Analyzing Water Demand for Sustainable Hydrogen Production in Central Asia

ENERGY

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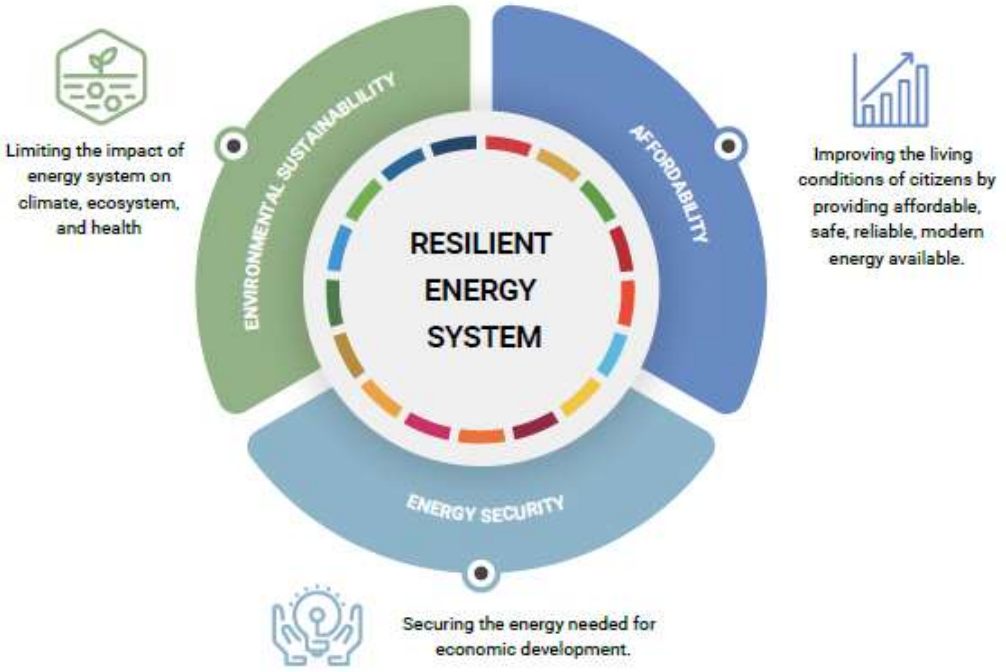
Building Resilient Energy Systems

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		Methane reacts with limited amount of oxygen	H_2 CO	9.0-11.0	0.7 - 2.1
	Natural gas & steam reforming with 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		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		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		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

UNECE

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

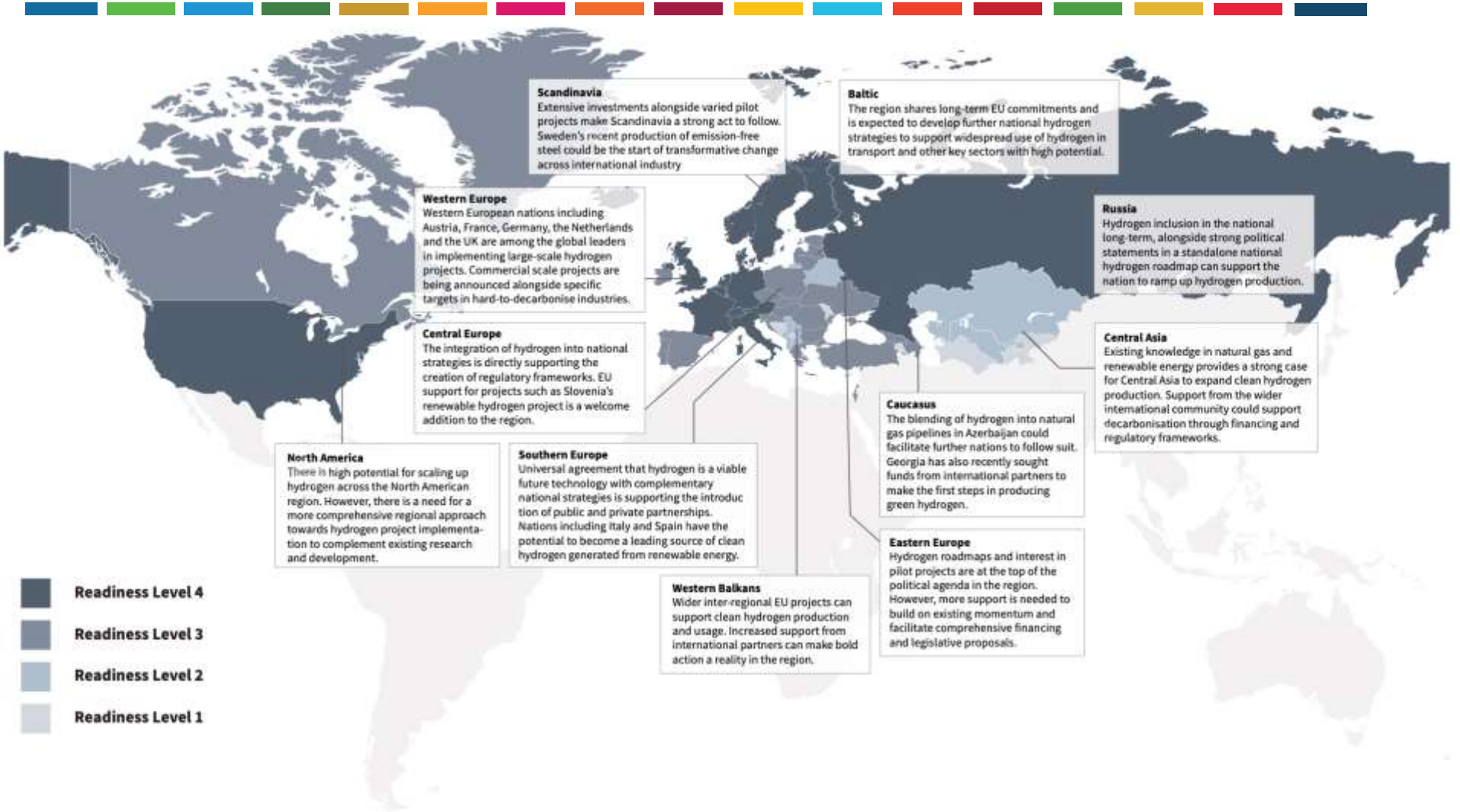
Awareness
Recognise hydrogen as a viable climate mitigation option

Acceptance
Develop and integrate policies to jumpstart hydrogen economy

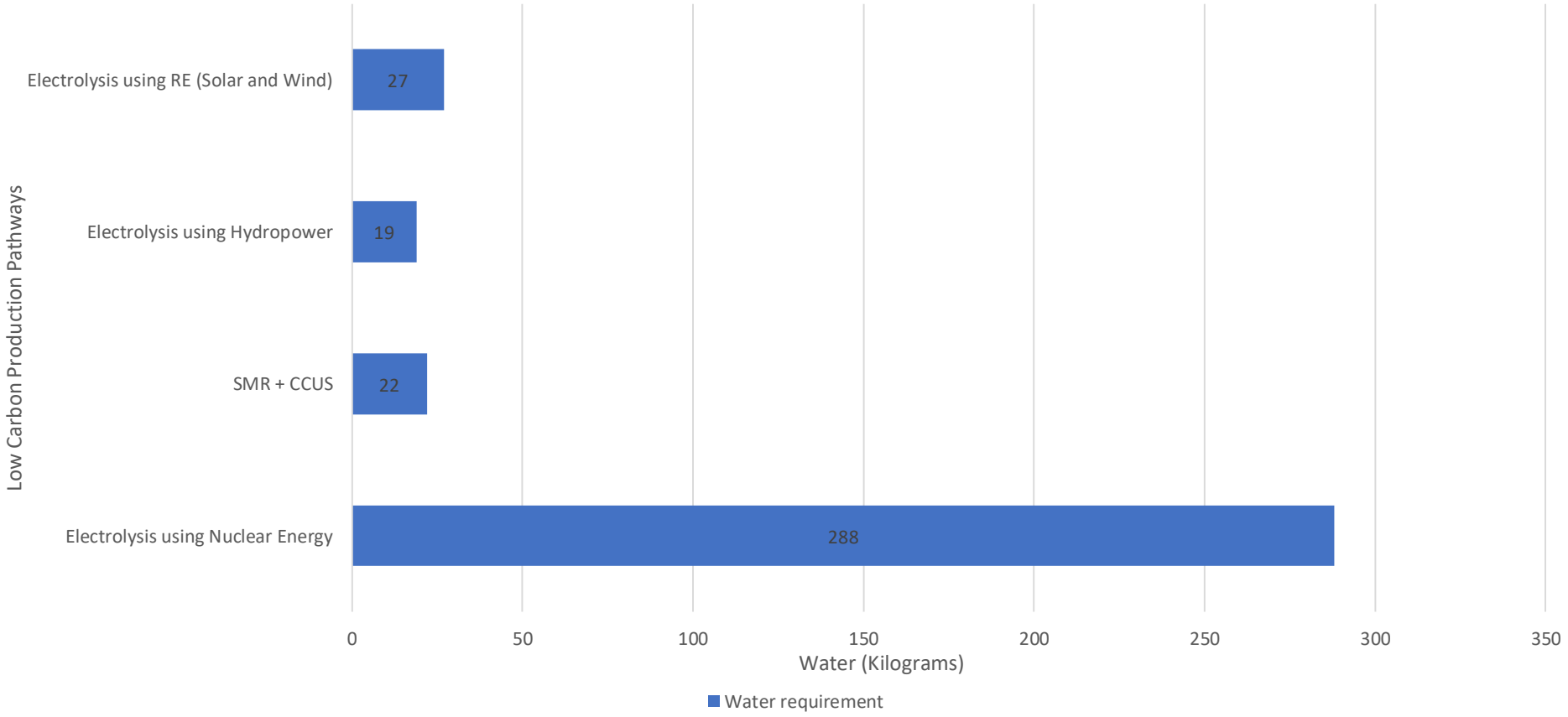
Finance
Direct public and private investment into clean hydrogen projects

Assessment of Readiness Level across UNECE Region

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



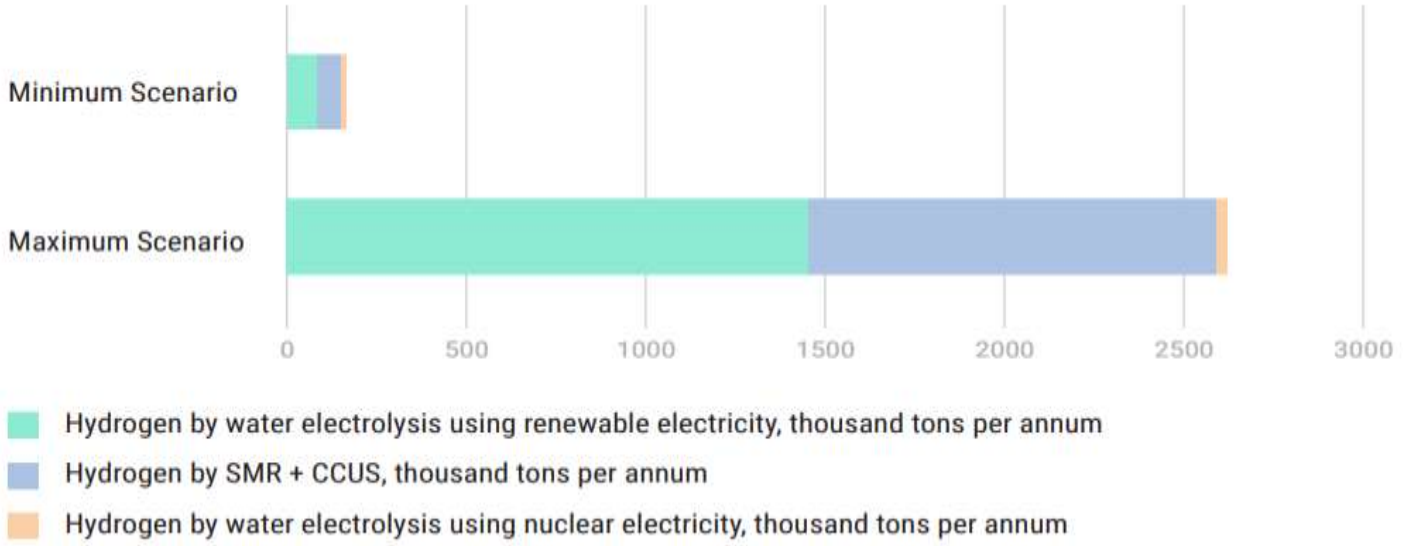
Water Requirements for Production of 1 kg of Hydrogen



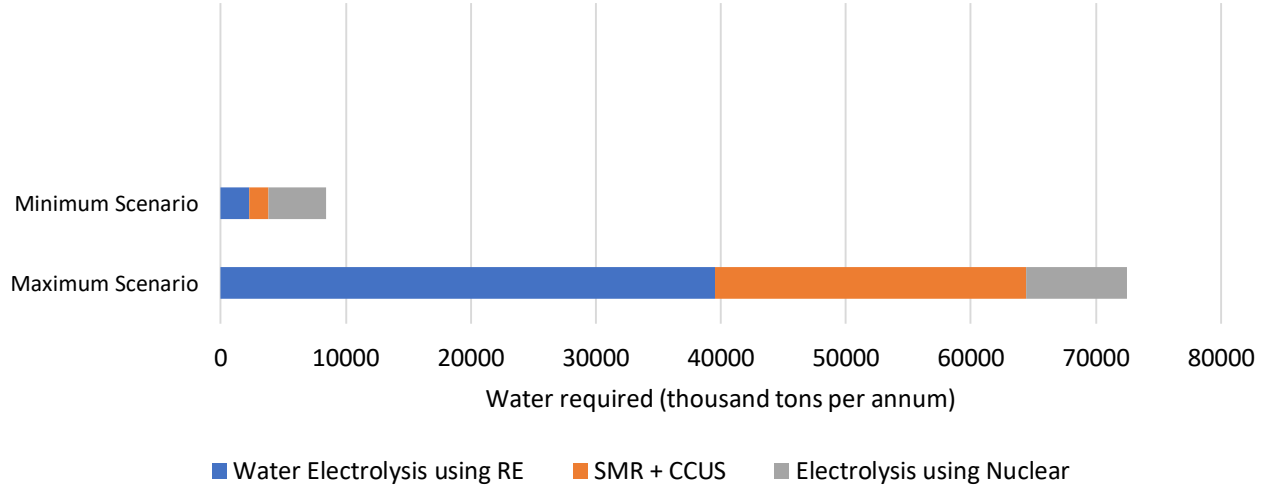
Sources: Energy Post, mdpi.com

Kazakhstan

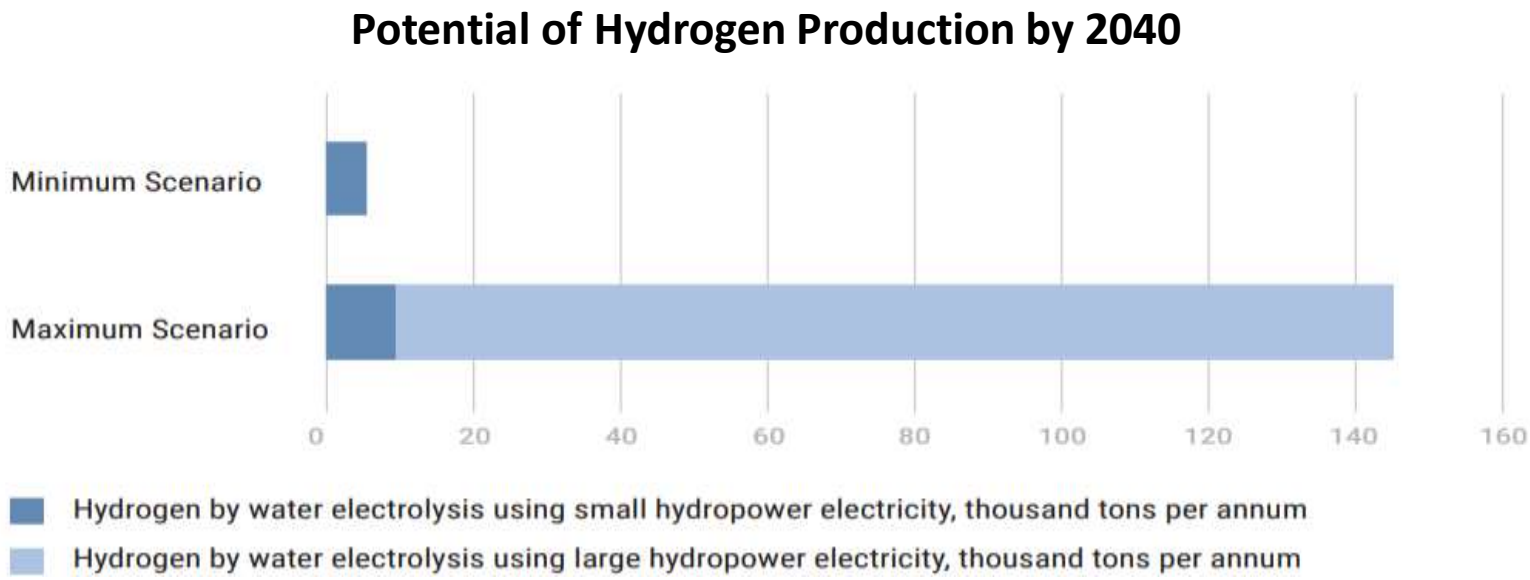
Potential of Hydrogen Production by 2040

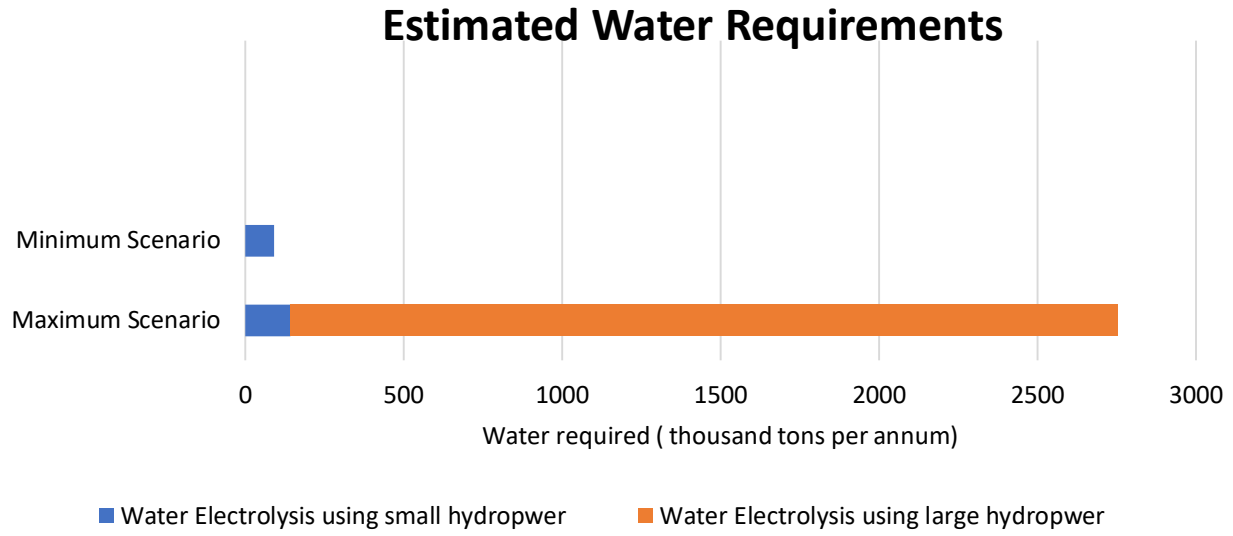


Estimated Water Requirements



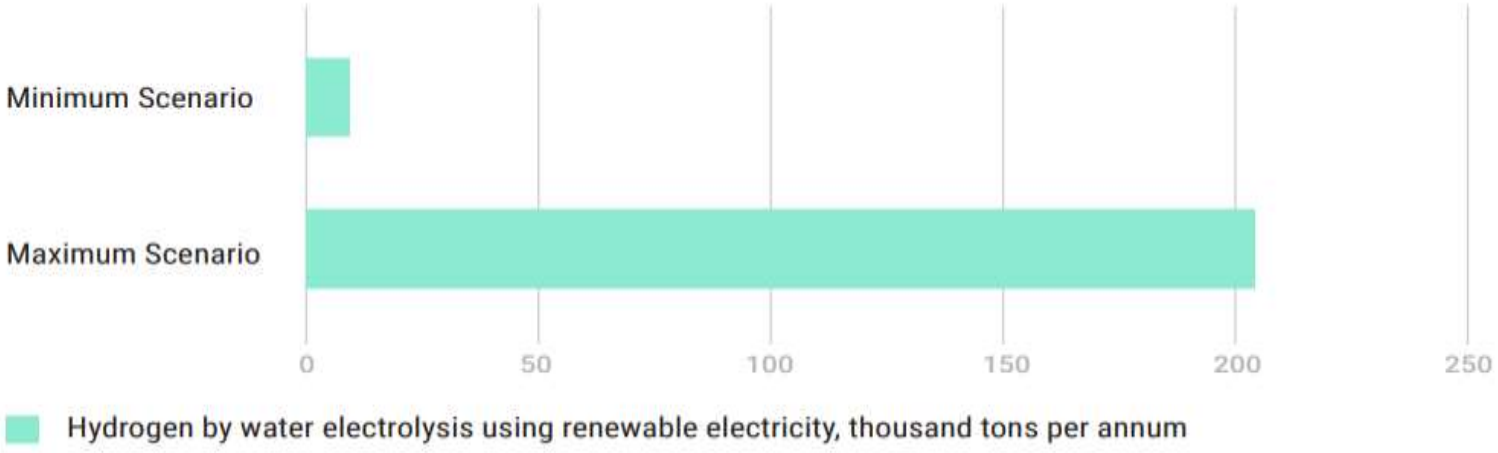
Kyrgyzstan


Potential of Hydrogen Production by 2040
Minimum Scenario
Maximum Scenario
0
20
40
60
80
100
120
140
160
Hydrogen by water electrolysis using small hydropower electricity, thousand tons per annum
Hydrogen by water electrolysis using large hydropower electricity, thousand tons per annum

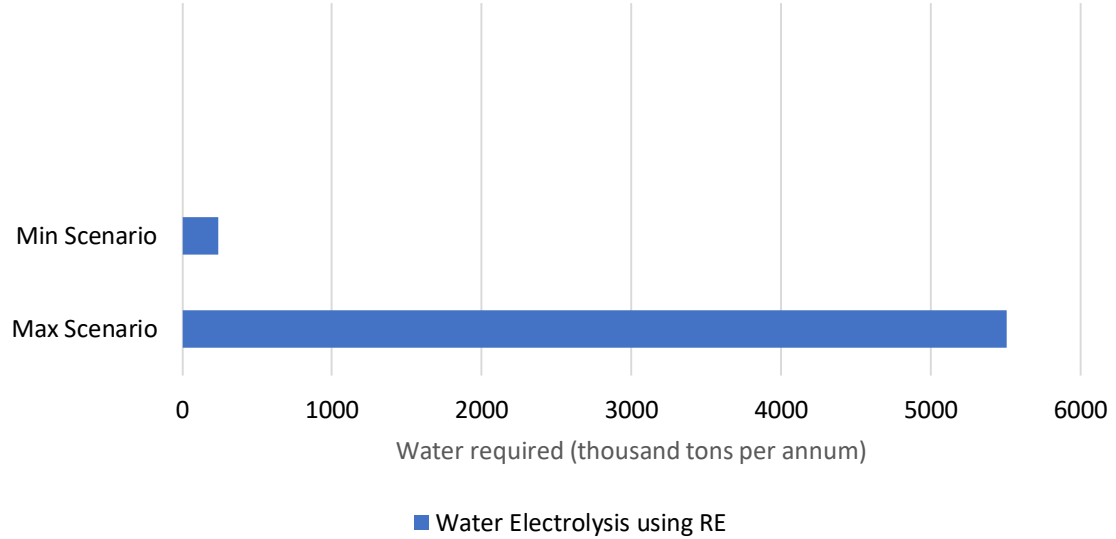

Estimated Water Requirements
Minimum Scenario
Maximum Scenario
0
500
1000
1500
2000
2500
3000
Water required (thousand tons per annum)
Water Electrolysis using small hydropwer
Water Electrolysis using large hydropwer

Tajikistan

Potential of Hydrogen Production by 2040

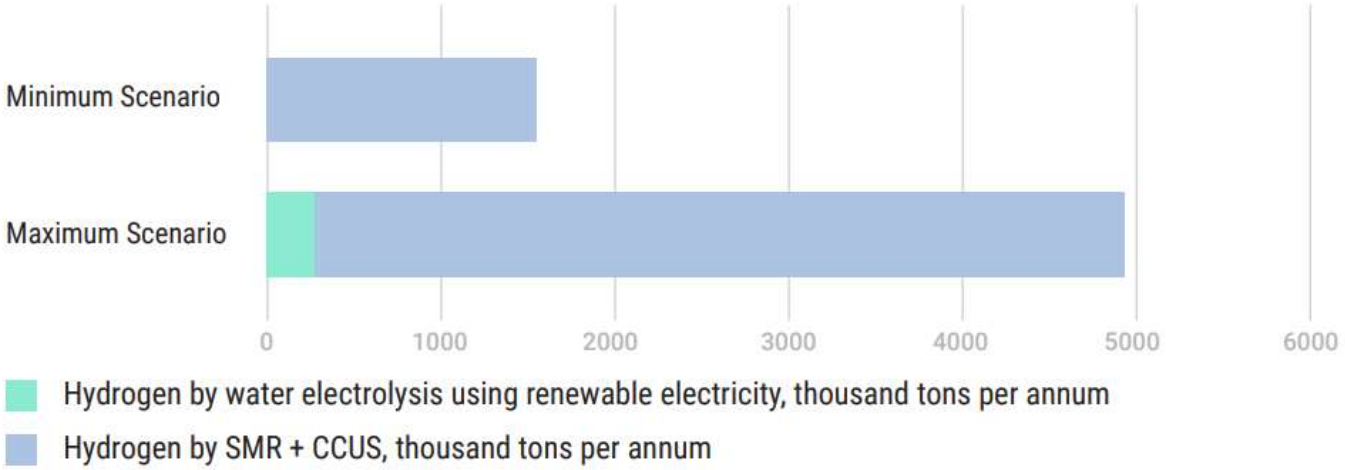


Estimated Water Requirements

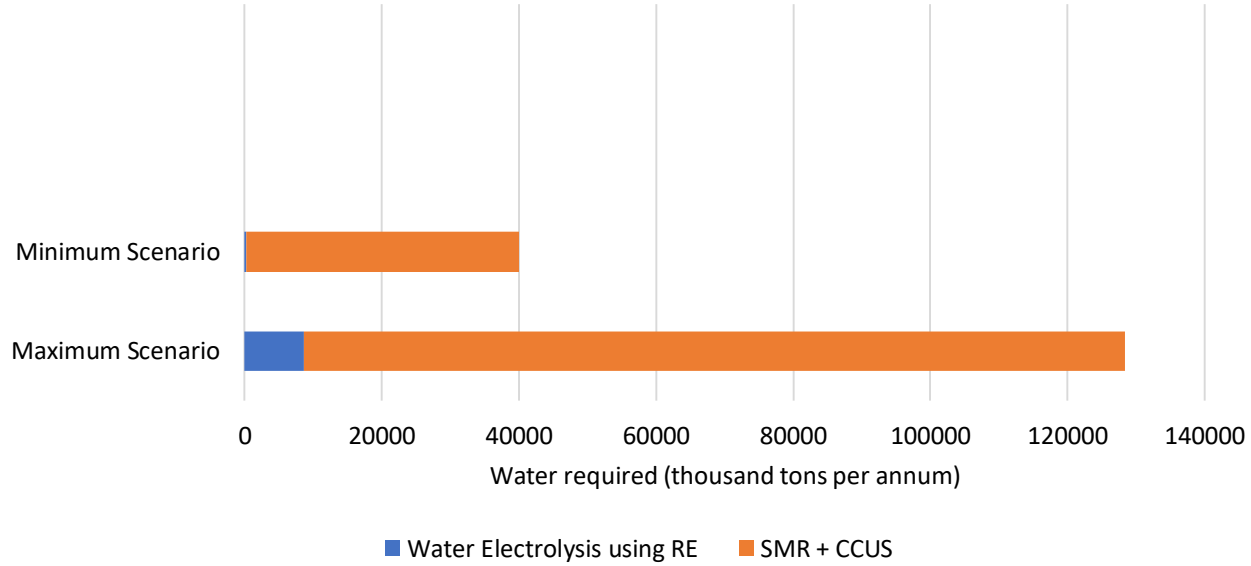


Turkmenistan

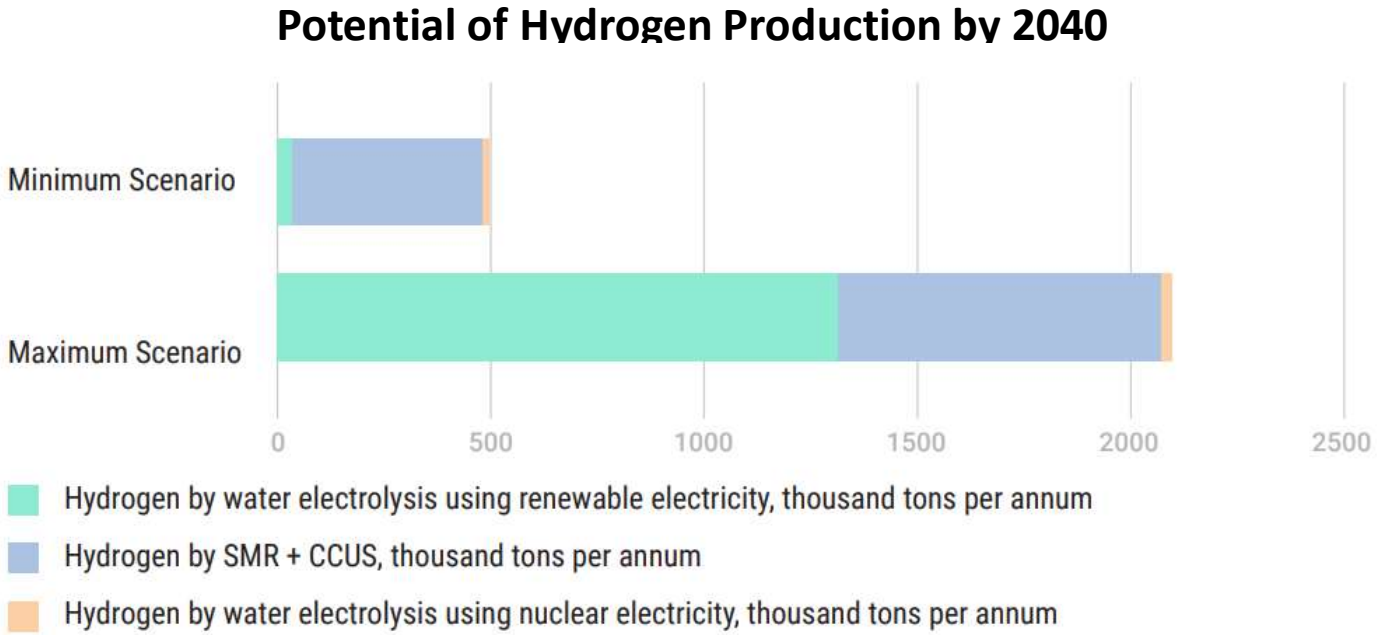
Potential of Hydrogen Production by 2040

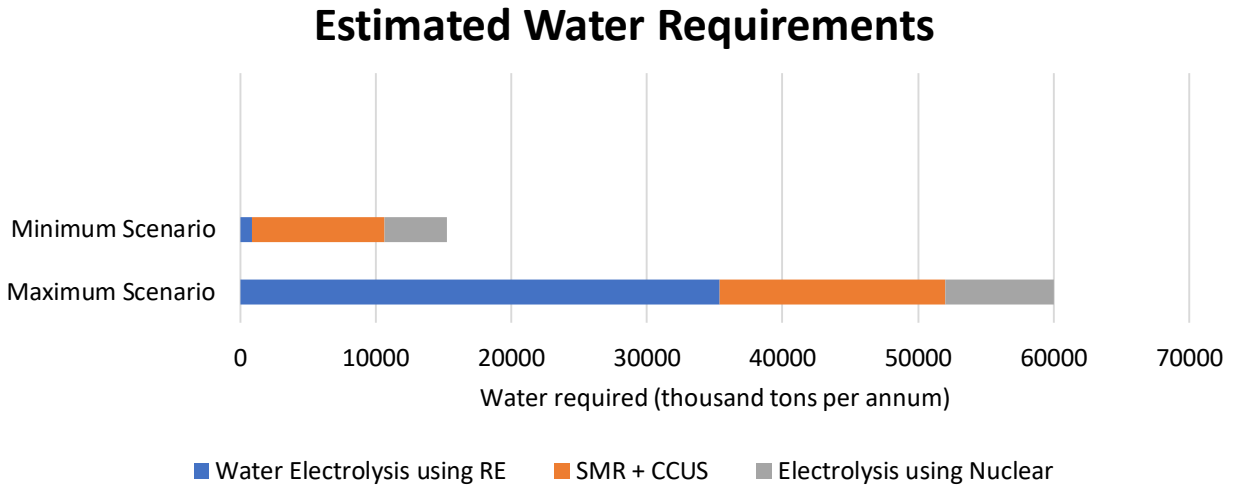


Estimated Water Requirements

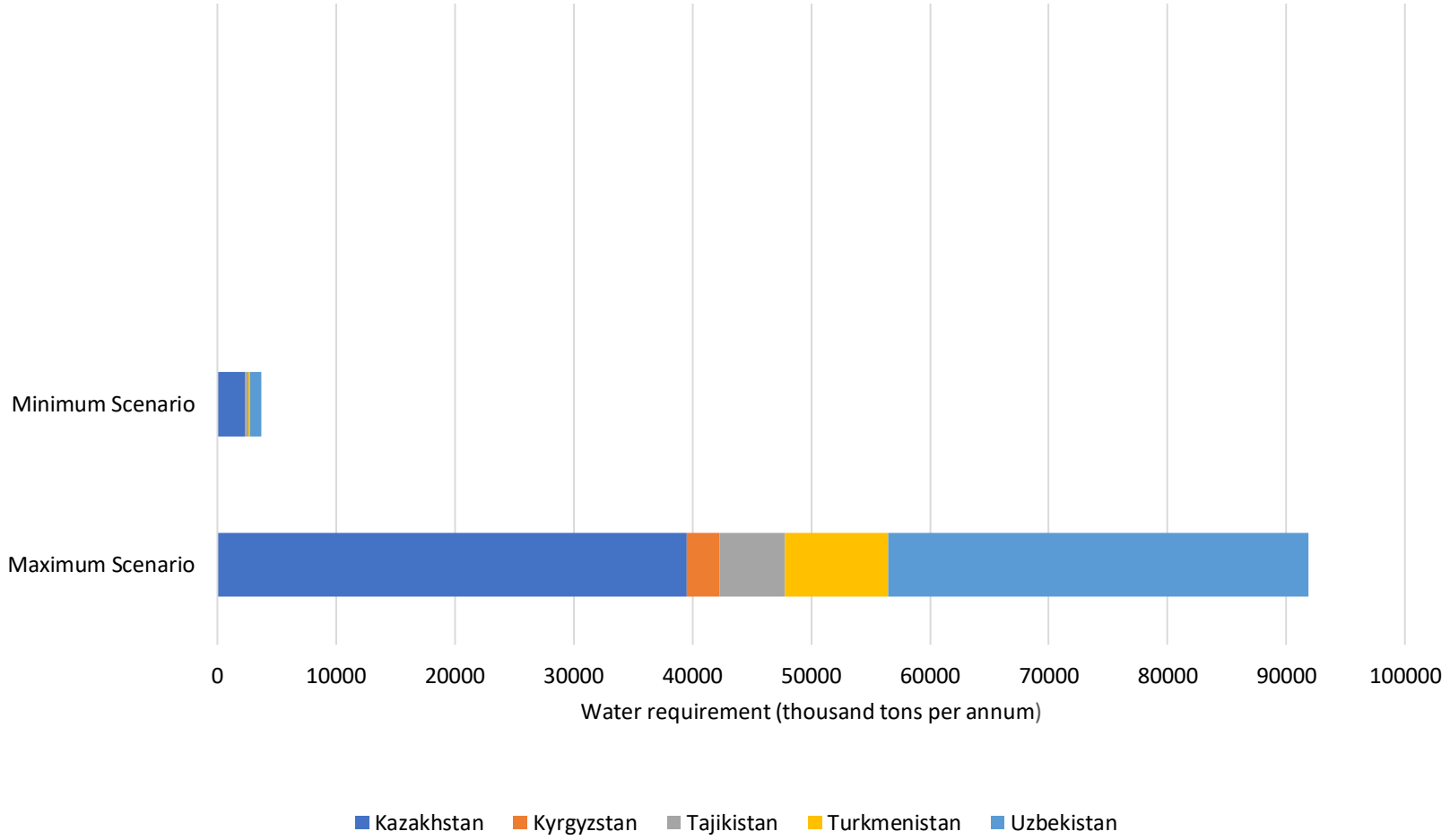


Uzbekistan

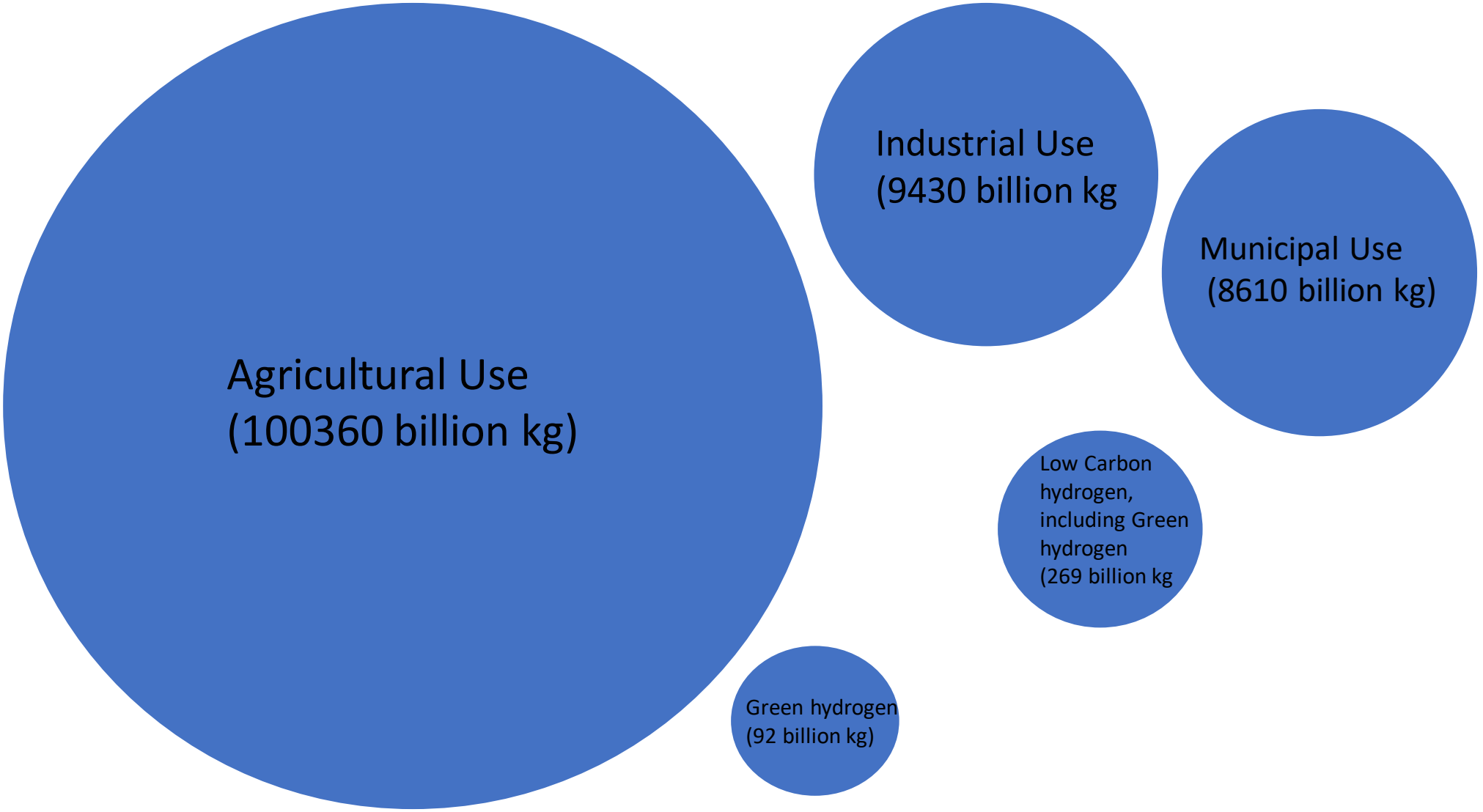

Potential of Hydrogen Production by 2040
Minimum Scenario
Maximum Scenario
0
500
1000
1500
2000
2500
Hydrogen by water electrolysis using renewable electricity, thousand tons per annum
Hydrogen by SMR + CCUS, thousand tons per annum
Hydrogen by water electrolysis using nuclear electricity, thousand tons per annum


Estimated Water Requirements
Minimum Scenario
Maximum Scenario
0
10000
20000
30000
40000
50000
60000
70000
Water required (thousand tons per annum)
Water Electrolysis using RE
SMR + CCUS
Electrolysis using Nuclear

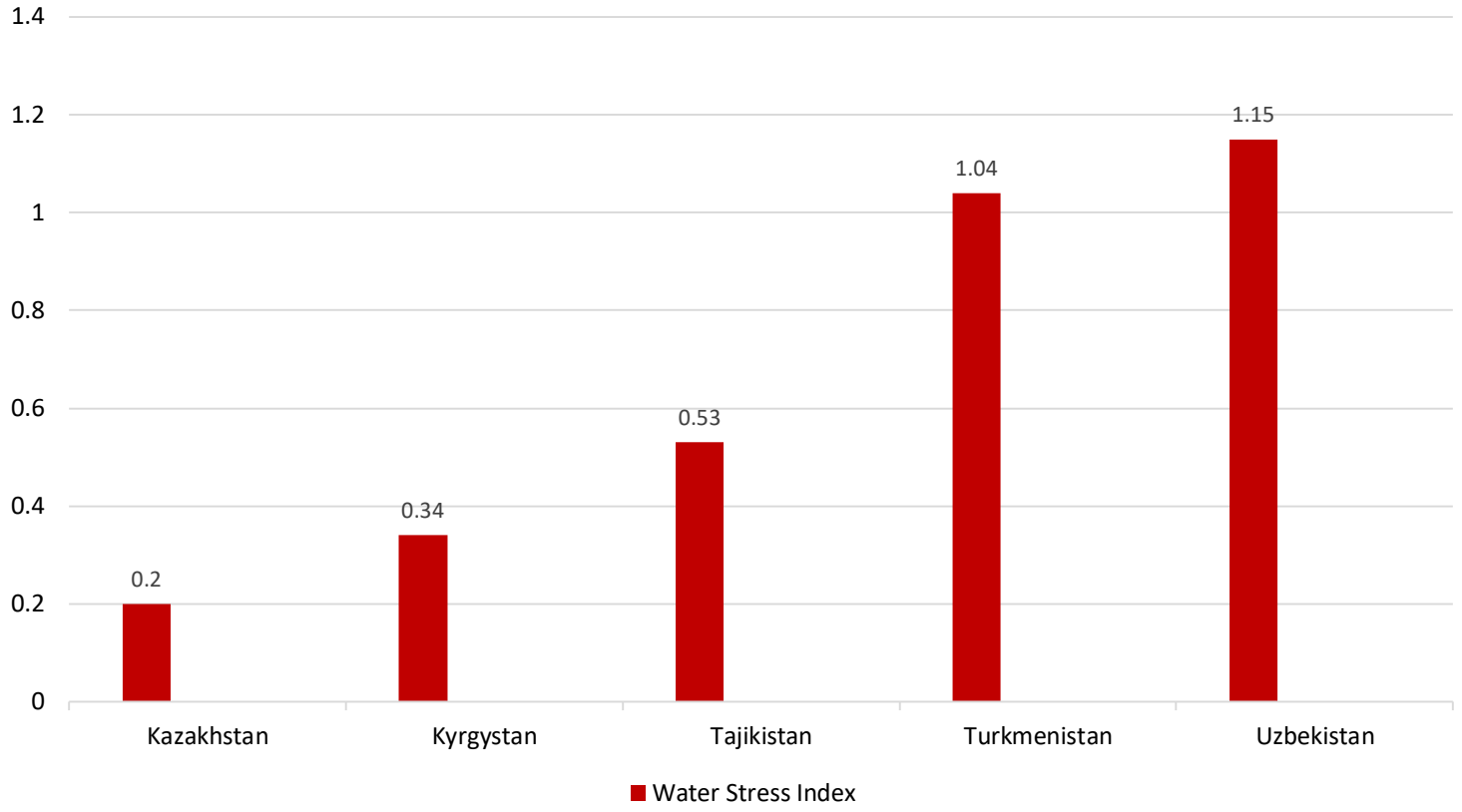
Estimated Water Requirements for Green Hydrogen Production by 2040 in Central Asia



Comparative Water Consumption



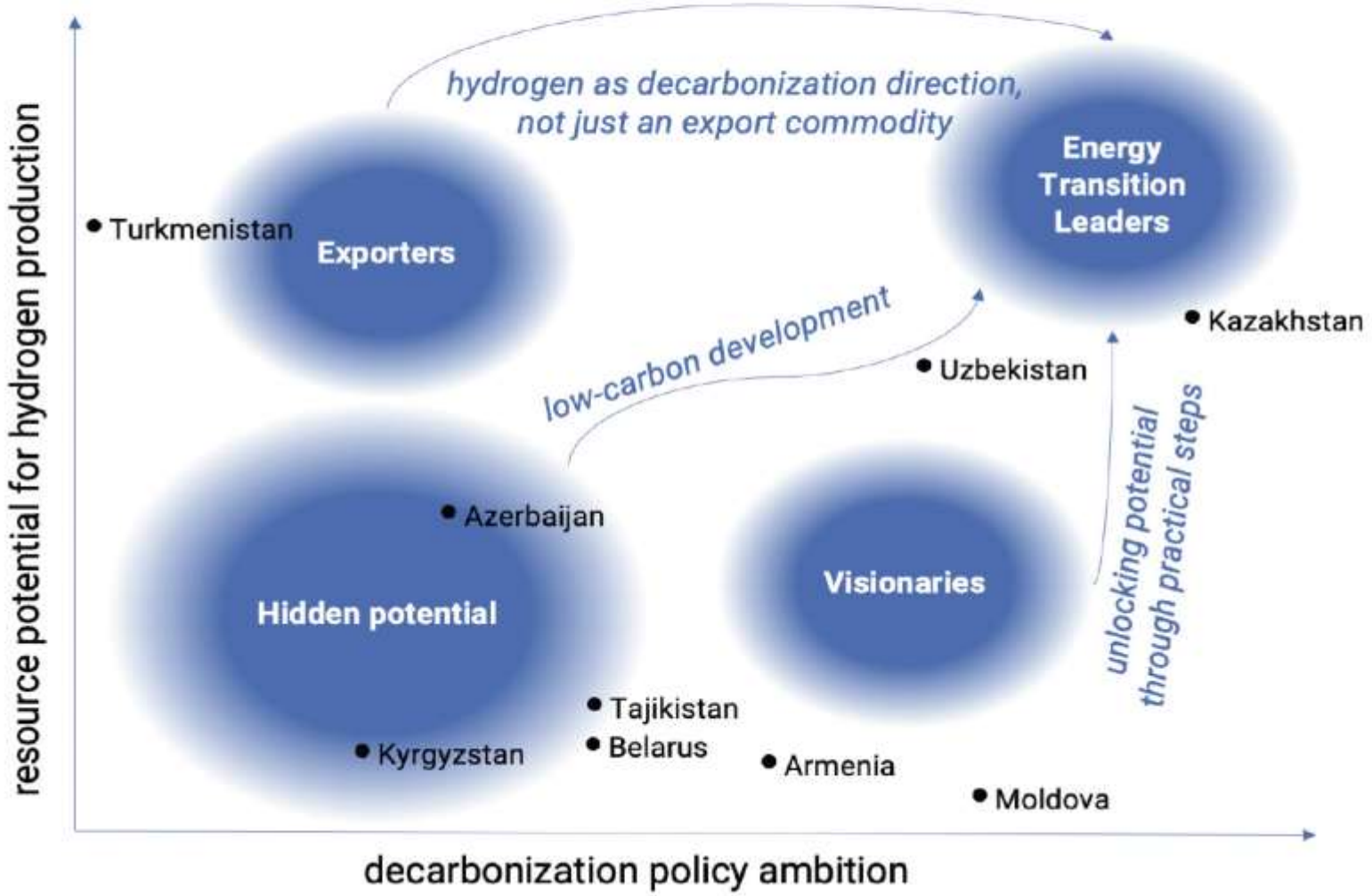
Water Stress Index in Central Asia



Threshold of WSI	Division
<0.1	No water stress
0.1–0.2	Low water stress
0.2–0.4	Moderate water stress
0.4–1	High water stress
>1	Severe water stress

Source: ScienceDirect

Possible typical scenario models for hydrogen economy establishment and deployment in the countries covered by the study, depending on their decarbonization policy ambition and resource potential for low-carbon hydrogen production



Source: UNECE

Thank you for your attention!

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