Analyzing Water Demand for Sustainable Hydrogen Production in Central Asia

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Building Resilient Energy Systems


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

<table>
<thead>
<tr>
<th>Input</th>
<th>Process</th>
<th>Output</th>
<th>Life Cycle Emissions [kg CO₂ eq/ kg Hz]</th>
<th>Cost [$/kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas &amp; steam reforming</td>
<td>Steam reforming hydrocarbons into hydrogen and carbon monoxide</td>
<td>H₂</td>
<td>9.0-11.0</td>
<td>0.7 - 2.1</td>
</tr>
<tr>
<td>Natural gas &amp; partial oxidation</td>
<td>Methane reacts with limited amount of oxygen</td>
<td>H₂</td>
<td>9.0-11.0</td>
<td>0.7 - 2.1</td>
</tr>
<tr>
<td>Natural gas &amp; steam reforming with CCS</td>
<td>Steam reforming hydrocarbons into hydrogen and carbon monoxide</td>
<td>H₂ (stored)</td>
<td>3.0-7.0</td>
<td>1.2 - 2.3</td>
</tr>
<tr>
<td>Natural gas &amp; partial oxidation with CCS</td>
<td>High temperature reaction between coal and oxygen</td>
<td>H₂ (stored), Other species</td>
<td>3.0-7.0</td>
<td>1.2 - 2.3</td>
</tr>
<tr>
<td>Coal gasification</td>
<td>High temperature reaction between coal and oxygen</td>
<td>H₂ (stored), Other species</td>
<td>16.0-20.0</td>
<td>1.3 - 2.5</td>
</tr>
<tr>
<td>Coal gasification with CCS</td>
<td>High temperature reaction between coal and oxygen</td>
<td>H₂ (stored), Other species</td>
<td>11.8</td>
<td>1.6 - 2.6</td>
</tr>
<tr>
<td>Methane pyrolysis</td>
<td>Splitting natural gas into hydrogen and solid carbon</td>
<td>H₂, Solid carbon/graphites</td>
<td>1.9-4.8</td>
<td>1.6 - 3.4</td>
</tr>
</tbody>
</table>

## Fossil-Fuel Based Hydrogen

## Renewable Energy-Based Hydrogen

- Electricity from renewable energy
- Biomass gasification with CCS
- Biomass & pyrolysis

## Nuclear Power-Based Hydrogen

- Electricity from nuclear power
- Heat from nuclear power

## CCS

- Carbon Capture and Storage
Assessment of Readiness Level across UNECE Region
Levels of actions taken towards the integration of hydrogen into energy systems

Scandinavia
Extensive investments alongside varied pilot projects make Scandinavia a strong act to follow. Sweden’s recent production of emission-free steel could be the start of transformative change across international industry.

Baltic
The region shares long-term EU commitments and is expected to develop further national hydrogen strategies to support widespread use of hydrogen in transport and other key sectors with high potential.

Western Europe
Western European nations including Austria, France, Germany, the Netherlands and the UK are among the global leaders in implementing large-scale hydrogen projects. Commercial scale projects are being announced alongside specific targets in hard-to-decarbonise industries.

Central Europe
The integration of hydrogen into national strategies is directly supporting the creation of regulatory frameworks. EU support for projects such as Slovenia’s renewable hydrogen project is a welcome addition to the region.

North America
There is high potential for scaling up hydrogen across the North American region. However, there is a need for a more comprehensive regional approach towards hydrogen project implementation to complement existing research and development.

Southern Europe
Universal agreement that hydrogen is a viable future technology with complementary national strategies is supporting the introduction of public and private partnerships. Nations including Italy and Spain have the potential to become a leading source of clean hydrogen generated from renewable energy.

Western Balkans
Wider inter-regional EU projects can support clean hydrogen production and usage. Increased support from international partners can make bold action a reality in the region.

Russia
Hydrogen inclusion in the national long-term, alongside strong political statements in a standalone national hydrogen roadmap can support the nation to ramp up hydrogen production.

Central Asia
Existing knowledge in natural gas and renewable energy provides a strong case for Central Asia to expand clean hydrogen production. Support from the wider international community could support decarbonisation through financing and regulatory frameworks.

Caucasus
The blending of hydrogen into natural gas pipelines in Azerbaijan could facilitate further nations to follow suit. Georgia has also recently sought funds from international partners to make the first steps in producing green hydrogen.
Water Requirements for Production of 1 kg of Hydrogen

- Electrolysis using RE (Solar and Wind): 27 kg
- Electrolysis using Hydropower: 19 kg
- SMR + CCUS: 22 kg
- Electrolysis using Nuclear Energy: 288 kg

Sources: Energy Post, mdpi.com
Kazakhstan

Potential of Hydrogen Production by 2040

**Estimated Water Requirements**

- **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**
Potential of Hydrogen Production by 2040

Minimum Scenario

Maximum Scenario

![Hydrogen by water electrolysis using small hydropower electricity, thousand tons per annum](image1)
![Hydrogen by water electrolysis using large hydropower electricity, thousand tons per annum](image2)

Estimated Water Requirements

Minimum Scenario

Maximum Scenario

![Water Electrolysis using small hydropower](image3)
![Water Electrolysis using large hydropower](image4)
Potential of Hydrogen Production by 2040

- **Minimum Scenario**
- **Maximum Scenario**

Estimated Water Requirements

- **Min Scenario**
- **Max Scenario**

- Hydrogen by water electrolysis using renewable electricity, thousand tons per annum

Water required (thousand tons per annum)
Potential of Hydrogen Production by 2040

- Minimum Scenario
- Maximum Scenario

Estimated Water Requirements

- Hydrogen by water electrolysis using renewable electricity, thousand tons per annum
- Hydrogen by SMR + CCUS, thousand tons per annum

Turkmenistan
Potential of Hydrogen Production by 2040

Minimum Scenario

Maximum Scenario

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

Water requirement (thousand tons per annum)
Water Stress Index in Central Asia

Source: ScienceDirect

<table>
<thead>
<tr>
<th>Country</th>
<th>Water Stress Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kazakhstan</td>
<td>0.2</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>0.34</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>0.53</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>1.04</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>1.15</td>
</tr>
</tbody>
</table>

Threshold of WSI

- <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
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.
Thank you for your attention!

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