The Hydrogen Value Chain

From production to applications
Fichtner is working in all areas of the hydrogen value chain and is actively contributing to the sector’s development

Fichtner competencies

- **Business Models**: Hydrogen business model development e.g. for a company in the natural gas industry

- **System Planning**: System modelling to integrate power-to-x technologies (from plant to country level)

- **Hydrogen Plant Design**: Three decades engineering experience for installations with hydrogen

- **Hydrogen Infrastructure**: Hydrogen-readiness of natural gas assets and grid calculation of networks

- **Hydrogen Mobility**: Integrated concepts for hydrogen production and mobility infrastructure

- **Green Chemicals**: Process engineering know-how and experience in the chemical and refinery sector

- **Sector Development**: Fichtner Forum Hydrogen 2019 with over 60 participants from 16 countries
Why are people talking about hydrogen?
Current interest in hydrogen as an energy source and commodity is dominated by four main drivers

**Background**

- **Mobility & Industry**
- **Electricity & Gas**
- **Storage of fluctuating (excess) electricity**
- **Pressure to reduce emissions from mobility and industry**
- **Existing infrastructure of pipeline systems and storages**
- **Large costs of infrastructure for high e-mobility shares**
What will a hydrogen value chain look like?
Hydrogen can be produced using different energy sources. It has a variety of applications in mobility, industry and energy.
Hydrogen as electricity storage is very expensive. Therefore, it can only be considered as an option in the far future or under special circumstances.

Value chain 1: Hydrogen as electricity storage

- Fixed Costs Electrolysis (per MWh H₂)
- Fixed Costs Electrolysis (per MWh Electricity)
- Fixed Costs Electrolysis + Fuel Cell (per MWh Electricity)

Example: 2000 h/a

Fixed Cost of Electricity from Power-to-Gas to Power With Input Electricity Price 0 €/MWh

1.5 MWh el → 1.0 MWh H₂
0€ → 110€

1.8 MWh H₂ → 1.0 MWh el
200€ → 350€
Curtailed green energy is currently limited to specific grid sections. Even there, annual availability of curtailed power is low.

Value chain 2: Hydrogen from excess electricity

„Element Eins“
100 MW electrolysis project

„Hybridge“
100 MW electrolysis project
Large parts of the European energy system can only be decarbonized through the import of green chemicals

Value chain 3: Hydrogen as a commodity

Source: calculations by Fichtner based on Final Energy Consumption EU-27, Eurostat 2017
A global supply chain for hydrogen is forming. Large players are already positioning themselves to deliver hydrogen to consumers.

Value chain 3: Hydrogen as a commodity - global developments
Hydrogen produced as a commodity with a dedicated value chain is the only option to deploy it in at scale in mobility and industry

Hydrogen value chains - summary

<table>
<thead>
<tr>
<th>Option</th>
<th>Applications</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value Chain 1</strong></td>
<td></td>
<td></td>
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</tbody>
</table>
| Hydrogen as electricity storage | Energy (electricity sector) | High cost
|                     |                               | Decarbonization of electricity sector only                      |
| **Value Chain 2**   |                               |                                                                 |
| Hydrogen from excess electricity | Mainly energy (heat and electricity sector) | High cost even at low electricity prices
|                     |                               | Limited potential due to availability of excess electricity
|                     |                               | Only viable under specific circumstances                        |
| **Value Chain 3**   |                               |                                                                 |
| Hydrogen as a commodity | Energy                  | Lowest cost alternative                                         |
|                     | Mobility                     | Largest market potential                                         |
|                     | Green chemicals              | Production mix of large-scale centralized and smaller de-centralized plants possible
|                     |                               | Import enables large-scale decarbonization of European energy sector |
What are Europe’s main success factors for developing hydrogen?
In order to be successful, Europe must develop an integrated strategy covering the entire hydrogen value chain: production, infrastructure and applications

Success factors for hydrogen in Europe

Developing applications where hydrogen provides added value

Creating a hydrogen infrastructure using local synergies

Finding a good mix of de-centralized and centralized production as well as imports

Sources: steam reforming from CCS by Equinor, others: sample calculations by Fichtner