READY FOR HYDROGEN!

TAG GmbH

Table of contents

The way to achieve climate neutrality by 2040

- The Austrian federal government has set itself the goal of achieving climate neutrality by 2040.
- Hydrogen plays an important role to reach this objective, especially for the decarbonization of industry.
- Particularly regarding security of supply and maintaining international competitiveness, building up a functioning hydrogen infrastructure is essential.
- H_2 infrastructure is the link to connect areas with competitive hydrogen production costs with demand centers and ensures the development of a cost-efficient and competitive internal energy supply.
- A rapid and well-coordinated ramp-up of the hydrogen economy is required to achieve the decarbonization targets without de-industrialization,
- The long-term storage capability enables the decarbonisation of the electricity supply whilst ensuring security of supply. It provides the vital system flexibility across space and time that is essential for a resilient renewable energy supply.
- The high-capacity, cost-effective H_2 transmission infrastructure can bridge long and avoid bottlenecks in the flow of energy.

Regulatory framework for Hydrogen

H2 market ramp-up

- The H_2 market ramp-up requires fast and reliable energy policy development and implementation at national and European level.
- To bridge the gap whilst FDR (Financing and De-Risking) options are being finalised, the project is being taken forward at TAG GmbHs own expense – with support from CEF co-funding – to ensure rapid implementation.
- The timely planning and implementation of a forward-looking infrastructure that meets expected needs are the cornerstone for the development of an H_2 market.
- As a prerequisite for the H_2 market ramp-up, the H_2 network infrastructure must reliably connect production and demand areas (import and transit of hydrogen) as well as the storage facilities, embedded in a European Hydrogen Backbone.
- To facilitate the H_2 market ramp-up, the regulated network operators – who are bound on strict rules and can not act as free market players – have developed an option for a regulatory model that uses the currently available instruments of the EU gas and hydrogen package, targeting three goals:
  - 1. Competitive and predictable hydrogen transport costs from the beginning
  - 2. Sharing of costs and hedging ramp-up risk
  - 3. Creation of framework conditions that enable the necessary investments

H2 network infrastructure: Flexible phase model for efficient market ramp-up (1)

- In preparation for implementation of a hydrogen network, the network operators have developed detailed plans and concepts to improve the existing natural gas infrastructure and minimize the costs for the H_2 network infrastructure.
- At the same time, the transmission system operators have created the conditions for accessing FDR options by gaining Projects of Common Interest (PCI) status.
- Together with Snam, GCA and bayernets the SoutH2 Corridor – a 3,300 km dedicated hydrogen pipeline corridor connecting North Africa, Italy, Austria and Germany – was initiated to provide access to particularly promising import opportunities and to enable Austria to participate actively in this European infrastructure.

H2 network infrastructure: Flexible phase model for efficient market ramp-up (2)

- The network infrastructure required for a successful ramp-up of the hydrogen market shall be defined in a two-stage process:

  - 1. Legally defined H_2 start network:

    As part of the European import corridors, this forms the backbone of the future hydrogen network and at the same time serves the rapid development of regional hydrogen valleys.

  - 2. Needs-based expansion of the start network (core network):

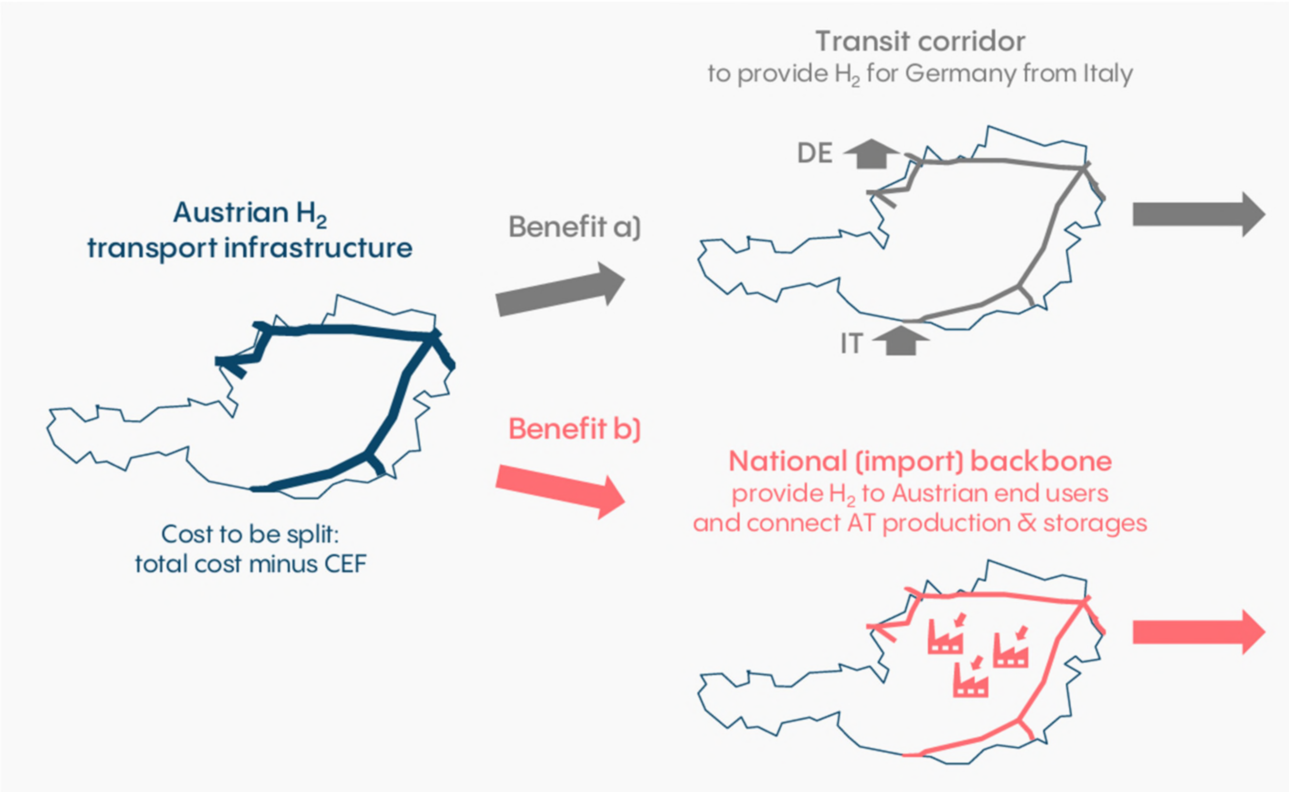
    Expansion measures that can be implemented in the short term will be carried out as part of the network development planning and are based on clearly defined demand thresholds.
    At the same time, this sequential approach enables efficient dimensioning, timely, needs-based implementation of the H_2 network infrastructure and a uniform tariff.

TAG

Stable financing of the H2 network infrastructure

- Investments in the H_2 start-up and core networks are financed by the H_2 network operators – analogous to the electricity and natural gas sectors. European FDR mechanisms are used in the best possible way to reduce the costs and limit the risk of the H_2 infrastructure development.
- The investments shall be implemented gradually according to the step-by-step model described before.
- The basis for this is the relevant provisions of the Austrian Gas Act (GWG) as well as the respective regulatory approved network development plans.
- These plans are based on policy objectives at national and European level and ensure that the expansion of the H_2 infrastructure is legally secured, coordinated with the political targets and prioritized according to need.

Financing of H2 ramp-up



Cross-Border commitment

National financing

Market-driven pricing in ramp-up phase

- In order to enable market-oriented transport tariffs right from the start and thus to allow for an H_2 market ramp-up, the EU Gas and Hydrogen Package provides for the instrument of intertemporal cost allocation supplemented by state guarantees.
- The market-oriented ramp-up tariffs in the initial phase are significantly lower than the ones that would result from the actual costs and transports.
- The cost recovery for the H_2 network infrastructure is planned over a long-term calculation period and shall be mapped via a ramp-up account.
- This ramp-up account is to cover the approved costs of the H_2 networks on the expenditure side and aimed at financing itself on long-term calculated, market-driven ramp-up tariffs.
- The proposal of the TSOs foresees that the temporary gap between H_2 network costs and revenues from ramp-up tariffs is to be covered by a ramp-up account.
- To finance the temporary gap on the ramp-up account on the capital market and to provide the lowest possible (interest) costs, the borrowing is to be secured by a state guarantee.
- Through any adjustment of the term of the ramp-up account and permissible cost allocations it can be reacted to changing market conditions if necessary.

H2 Concept Development Program (H2CDP) – Hydrogen @ TAG 2025

TAG H2 Project in the European context

EHB: Five main import corridors to Central Europe

Repower EU: TAG's pipeline system lies in the Adriatic H2 corridor and at the intersection of the southeastern H2 corridor and the eastern corridor.

SoutH2Corridor

sunsHyne CORRIDOR

- Main sources Hydrogen: **North Africa**
- 2 TSO Groups for:
  - Needs-based infrastructure development
  - Coordinated infrastructure
- Import potential from NA corresponds to 40% of REPowerEU-Target (10 Mt p.a.)
- Import potential to Austria up to 1,5 Mt H2 p.a.

Source: Hydrogen Infrastructure Map: https://www.h2inframap.eu/

www.south2corridor.net
www.sunshynecorridor.eu

Co-funded by the European Union

SoutH$_2$ Corridor

SoutH2Corridor

The **SouthH$_2$ Corridor** is **a 3.300 km long pipeline network**, dedicated exclusively to the transport of hydrogen, connecting **North Africa, Italy, Austria and Germany**; it will make a significant contribution to **security of supply** and to achieving the EU's **decarbonization targets**.

The **South H2 Corridor** is based on the collaboration of four TSOs. Every project up to the connection to North Africa has achieved PCI/PMI status.

- **Snam** - Italian H2 Backbone
- **TAG** - H2 Readiness of the TAG pipeline system
- **GCA** - H2 Backbone WAG + Penta-West
- **bayernets** - HyPipe Bavaria – The Hydrogen Hub

3.300 km Length of the network

>65% Share of repurposed network

Supporting partners[1]

Verbund, TotalEnergies H$_2$, ENERTRAG, voestalpine, WACKER, OMV, VNG, RWE, SEFE, bayernoil, TUNUR, ABO WIND, WIEN ENERGIE, SEAWIND, ChemDelta Bavaria, RAG Austria AG, RHI MAGNESITA, Westlake Vinnolit, GETEC, IV Industriellenvereinigung Steiermark

All supporters: https://www.south2corridor.net/support-us

TAG

Co-funded by the European Union

Project “H2 Readiness of the TAG Pipeline System”

Delivery point TAG - GCA

- Cooperation **„SoutH2 Corridor“ (PCI)**
- Connection to the WAG system for supplying the Upper Austrian industrial area and Southeast Germany

Delivery point AT - SK

- Cooperation **„SunsHyne Corridor“**
- Connection to EUSTREAM in SK to supply SK, CZ and Germany
- Possible imports from Eastern/Southeastern Europe

Delivery point IT - AT (SNAM - TAG)

- Cooperation **“South H2 Corridor” (PCI)**: SNAM/TAG/GCA/Bayernets
- Cooperation **„SunsHyne Corridor“:** SNAM/TAG/EUSTREAM/NET4GAS/OGE
- Link to main source: North Africa via Italy to Austria
- Enables the supply of competitive, green hydrogen to Austria and neighboring countries, including southern Germany.

The TAG Project

- **Conversion** of one of the three existing 380 km long pipelines for 100% H2
- Installation of **H2 compressors** along the pipeline
- Construction of **Metering stations**
- Injection and withdrawal points for **local demand/supply**
- Connections to neighboring countries and to the WAG
- **Main flow direction: South - North** ~168 (IT/AT) → 142 (AT/SK) GWh/day*
- **Bidirectional operation possible**
- Comprehensive **internal TAG “H2 Program”** with **challenges: de-risking & technical standards**
- **Planned commissioning: 2032**

* possible changes as the project progresses

TAG

Integration into national and international planning

- Included in the **National Network Development Plan (KNEP)** as a planning project
- Part of the **AGGM H2 Roadmap**
- Part of the Integrated Austrian Network Development Plan (**ÖNIP**) of the Federal Ministry for Economic Affairs and Energy (**BMWET**)
- Included in the International Network Development Plans **TYNDP '24 & TYNDP '26**
- **Positive** Cost-Benefit Analysis (**CBA**)
- **PCI status EU Global Gateway Project**
- Studies **co-financed by** the European Energy Fund (**CEF Energy**)
- **Presented as one of the EU's eight Energy Highways with the following objectives***:
  - Targeted support for Member States and project promoters
  - Mobilization of funding and
  - Measures to further streamline and accelerate permitting processes

TYNDP: Ten Year Network Development Plan
* Global Gateway: Global Gateway - International Partnerships - European Commission

Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52025DC1005
* Fragen und Antworten zum Europäischen Netzpaket und zur Initiative „Energieautobahnen“

Broad support and cooperation

- **AT: HYPA & HIAA**
- **DE: HIBB**
- **IT: H2IT**
- **Support** from potential **H2 producers** and **consumers**
- TAG is a founding member of **ENNOH**
- Political **support and letters of intent** at the **trilateral** (DE, AT, IT) and **pentalateral** (DE, AT, IT, TN, DZ) levels
- **Cooperation** and regular **exchange** between the **EC, ministries, regulators, project developers, and financial institutions**

TYNDP: Ten Year Network Development Plan; NDP: National Development Plan; JDOI: Joint Declaration of Political Intent; HYPA: Hydrogen Partnership Austria; HIAA: Hydrogen Import Alliance Austria; HIBB: H2 Importbundnis Bayern; ECH2A: European Clean Hydrogen Alliance; ENNOH: European Network of Network Operators for Hydrogen; EHB: European Hydrogen Backbone

CEF application 2024 – main project data

CEF 2024	
Date of submission	22. October 2024
Status	Grant Agreement signed on 06. May 2025
Start of CEF project	11. November 2024
Starting event	Kick-off meeting
Finishing date	31. March 2027
Finishing event	Concept for business establishment and asset conversion selected
Scope of Work	
WP1	**Project Management** *(Ensuring project achievements by effective project management and coordination of project activities)*
WP2	**Conceptual Engineering** *(Development of a concept based on the previous investigations of the technically and operationally best possibility for transportation of H_2 by repurposing the existing TAG pipeline system)*
WP3	**Permitting Conception** *(Development of a permitting concept for the asset conversion)*
WP4	**Conversion Planning** *(Development of an implementation plan for business establishment and asset conversion)*
WP5	**FEED Preparation** *(Conduction of a tender for FEED contractor based on determined conversion plan)*

Context of the H2CDP for 2025

1. TAG together with three other TSOs – SNAM, GCA, and bayernets – is forming the SoutH2 Corridor which is part of the European Hydrogen Backbone. With its 3.300 km cross-border infrastructure, North Africa, Italy, Austria, and Germany are linked by repurposing existing natural gas infrastructure for transporting Hydrogen from the production centers in the south to the industry centers in Southern and Central Eastern Europe.
2. In 2022, a strategic study was conducted, based on which a feasibility study was commissioned in 2023. This study was completed at the end of 2024 but must be refined, with a particular focus on selecting the most suitable business structure and appropriate facilities and summarizing these in a concept.
3. Since April 2024, TAG's conversion project is designated as PCI under the TEN-E regulations. The first stage involves the conversion of one of the three TAG pipelines for H_2 transport of up to 168 GWh/d at Entry Arnoldstein and 142 GWh/d at Exit Baumgarten. Intake and offtake points along the pipeline support the national supply.
4. The refinement study mentioned above is embedded in a dedicated concept development program (H2CDP) covering several topics. Besides technical aspects, it includes market and business development, statutory and regulatory issues, organizational matters, and financing and funding options. In addition, aspects of gas flow control are also being examined. The aim is to develop a concept that covers all identified necessary topics, which will then be further developed in the subsequent phases until it is mature enough for its implementation.

H2CDP 2025

Development setup and organization

Goals and scope of work of the H2CDP program

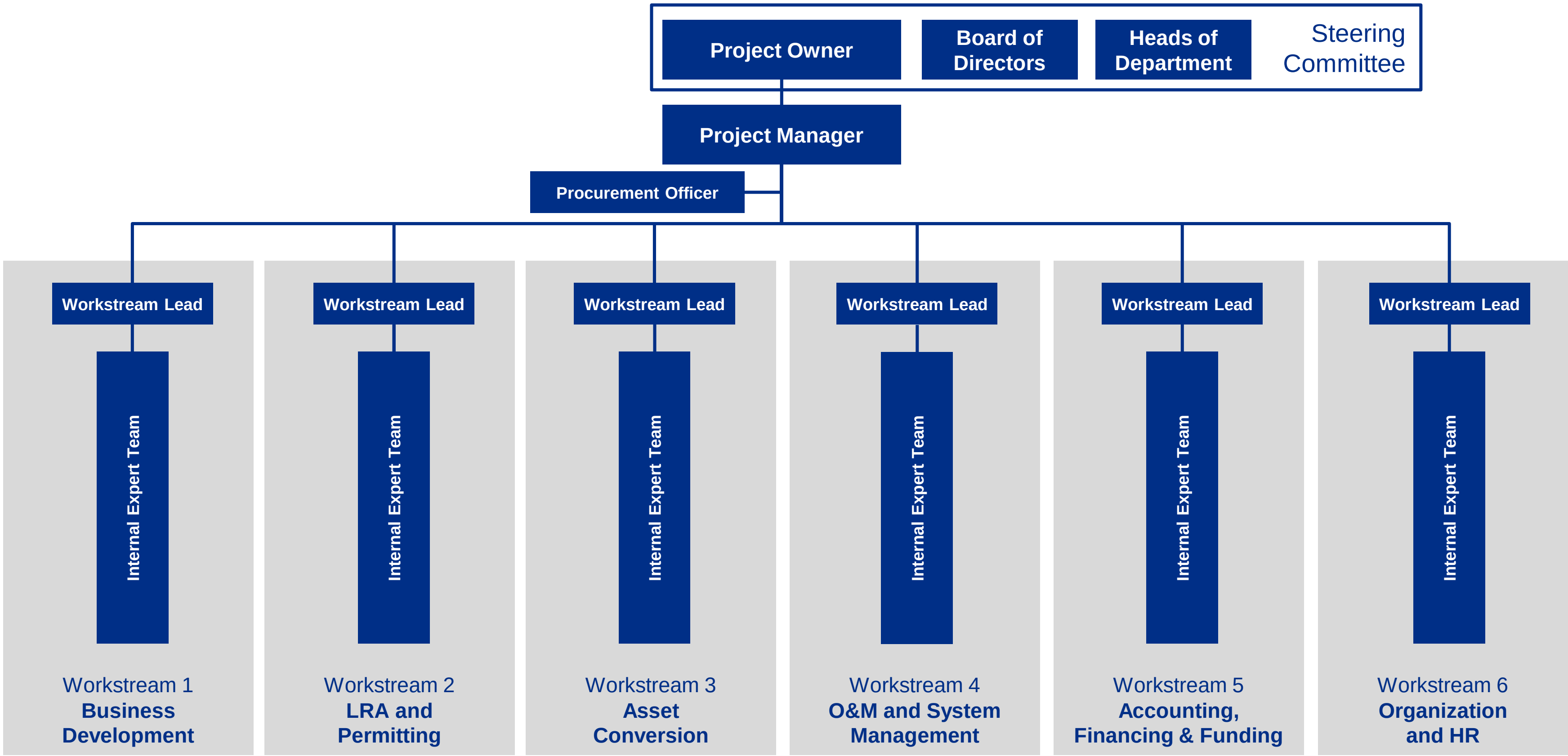
Program Goals

- Developing and selecting the best concept for establishing an H_2 transport business within TAG, covering all business relevant topics based on predefined selection criteria.
- The concept determines the solution itself, and the related development process based on regulated business framework. The concept development covers analysis of the all three pipelines, intending to convert the system step by step with 168 GWh/d for the first pipeline at the Entry Arnoldstein.
- The infrastructure conversion can be carried out as a whole or in steps based on predefined modules (pipeline as such, compressor station, metering station) and a related implementation strategy using synergies between all three pipelines.
- Based on the selected concept, the FEED phase is to be planned, and a FEED partner is to be determined by a respective tender.
- Furthermore, the general determinations and structural elements for the new H_2 business must be defined in accordance with the expected regulatory framework.
- To this end, market development hypotheses and the associated market potentials must be assessed in a way that the money at risk remains as low as possible.

Scope of Work

- Elaborating on the development topics and summarizing results according to the predefined scope.
- Building up internal know-how and, if necessary, identifying the need for external expertise, obtaining appropriate offers, and subsequent commissioning while considering CEF funding requirements as thoroughly as possible.
- Defining the first conversion step based on the overall concept developed.
- Assessing the market conditions based on available studies (e.g., public multi-client studies) associated with expected market developments.
- Monitoring and assessing the development of technical standardization and developments in the regulatory framework.
- Deriving implications and defining the further processing strategy, with a primary focus on the first conversion step.
- Conducting a tender process to select one or more FEED partners and preparing the best bidder proposal suitable for possible contract awards.
- Defining an organization structure that assures the sustainable operation of the H_2 business, considering all applicable legal and regulatory requirements.
- Outlining a financing and funding concept, giving an overview, especially of funding possibilities on the EU and national levels.

H2CDP Program Organization – Holistic approach with six workstreams



H2CDP 2025

Demand and asset utilization estimates

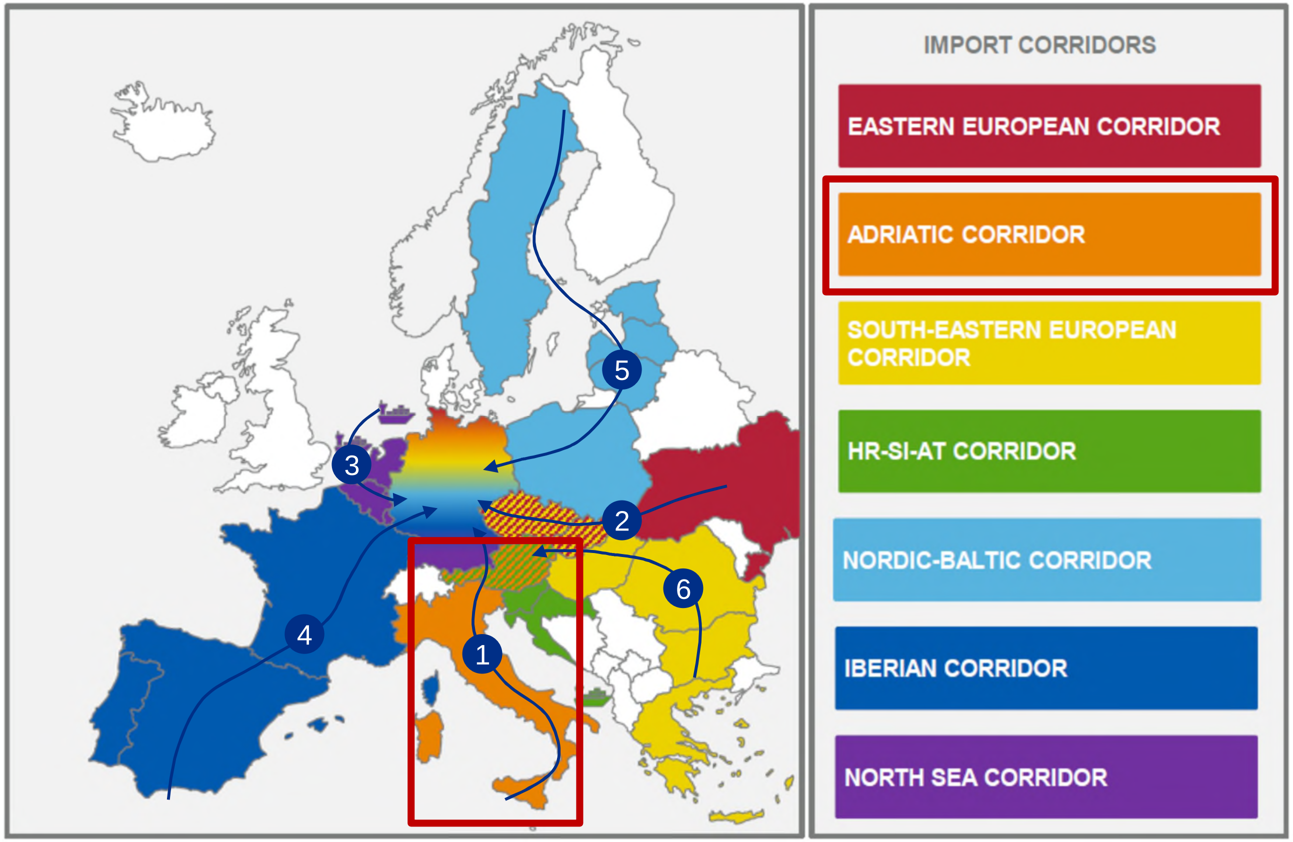
Approach for estimates of business design data

- The business design data includes…
  - … capacity data for the design of the technical infrastructure
  - … temporal development of H_2 flows
    - … in a Central-European context and
    - … for Austria
- The design basis for the H_2 network refer to …
  - … aligned cross border capacities based on international demands
  - … the domestic consumption based on data from AGGM – AGGM provides a temporal development of the flows for this purpose.
- There are various studies on H_2 development at the European level, which, due to different methodologies, come to widely differencing conclusions, so that only qualitative statements can be derived at this point in time.
- TAG has assigned a meta-study, in which the H_2 development at the European level is presented on the basis of three existing multi-client studies with a focus on midstream.

ENERVIS Flow Study – Used studies

	TYNDP (ENTSO-G)	**Kountouris** (Denmark 2024)	**Fraunhofer** (Germany 2025)
Focus	*Occurrence of bottlenecks and related reinforcements being needed*	*Production and transport of hydrogen for minimum costs*	*Reshaping of different pathways concerning flows, storage and infrastructure*
Infrastructure	• Showing where reinforcement of infrastructure will be necessary without reflecting the cost-optimal system • Reflecting political objectives	• Identifying the cost-efficient H_2 backbone and import corridors • Reflecting purely economic considerations, no political or technical constraints	• Showing the backbone scales with increasing H_2 demand • Reflecting only economic aspects, no political or technical constraints
Regulation	Reflecting the political requirements for production, consumption and transport	Neglecting political and regulatory requirements for production, consumption, and transport	Considering the political and regulatory requirements only for consumption, neglecting those for production and transport

ENERVIS Flow Study – Import corridors and their relevance for Austria's role in the H_2 system



European import routes

- Six major import routes for hydrogen to Central Europe have been identified.
- This mainly includes deliveries via pipelines, although deliveries via ship/derivatives, particularly for north-western Europe, are also considered.
- Project consortia have been identified for all import routes, most of which plan to transport H_2 by repurposing natural gas pipelines.

Corridor assessment and ranking

1. **SoutH2 / Adriatic Corridor – strategically highly relevant for Austria and CE despite economic uncertainty**
2. Central European Hydrogen Corridor – most balanced and economically robust
3. North Sea Corridor – cost-efficient, indirectly relevant for Austria
4. Iberian Corridor – system-relevant but limited direct relevance for Austria
5. Nordic-Baltic Corridor – long-term diversification option
6. SEEHyC – early-stage corridor with high uncertainty

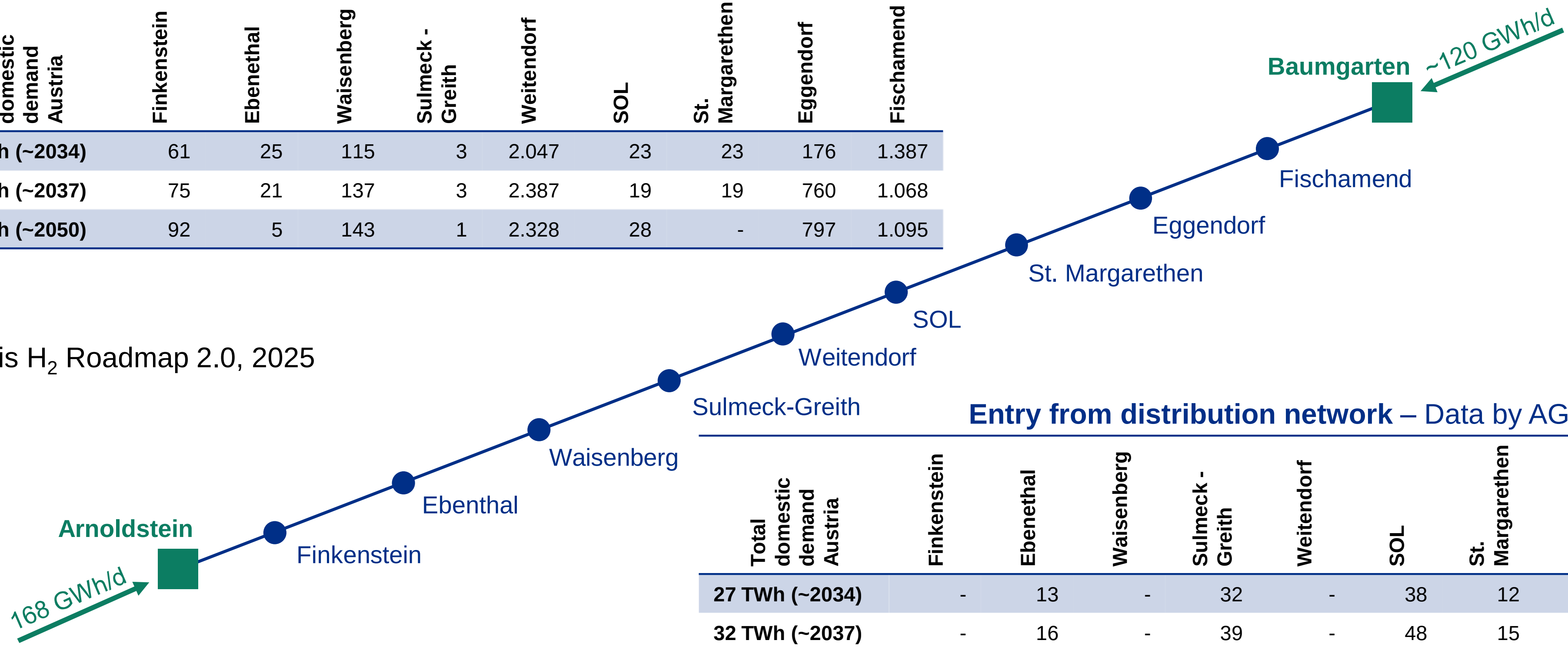
Across nearly all studies, the **SoutH2 / Adriatic Corridor** (North Africa → Italy → Austria → Germany) emerges as one of the most relevant routes.

Capacity assumptions for the design of TAG's H_2 network

Exit to distribution network – Data by AGGM in [MW]

Total domestic demand Austria	Finkenstein	Ebenethal	Waisenberg	Sulmeck - Greith	Weitendorf	SOL	St. Margarethen	Eggendorf	Fischamend
27 TWh (~2034)	61	25	115	3	2.047	23	23	176	1.387
32 TWh (~2037)	75	21	137	3	2.387	19	19	760	1.068
43 TWh (~2050)	92	5	143	1	2.328	28	-	797	1.095

Basis H_2 Roadmap 2.0, 2025



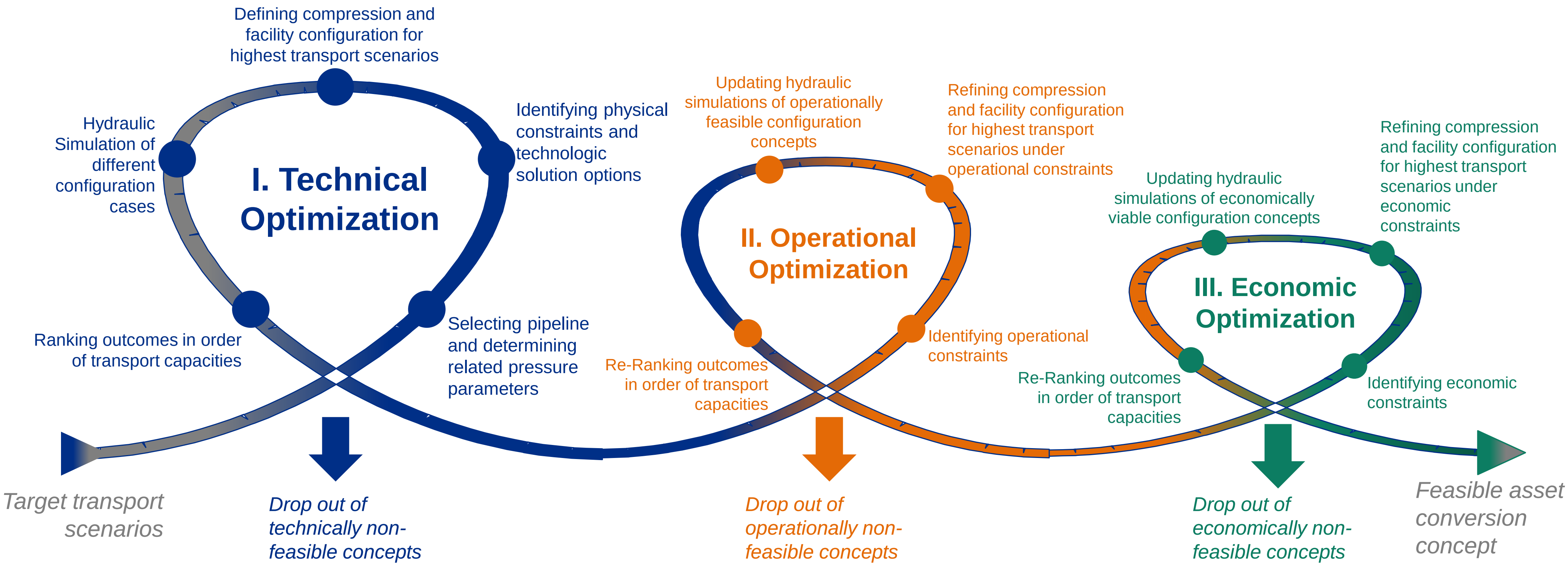
Entry from distribution network – Data by AGGM in [MW]

Total domestic demand Austria	Finkenstein	Ebenethal	Waisenberg	Sulmeck - Greith	Weitendorf	SOL	St. Margarethen	Eggendorf	Fischamend
27 TWh (~2034)	-	13	-	32	-	38	12	-	158
32 TWh (~2037)	-	16	-	39	-	48	15	-	-
43 TWh (~2050)	-	23	-	42	-	53	19	-	-

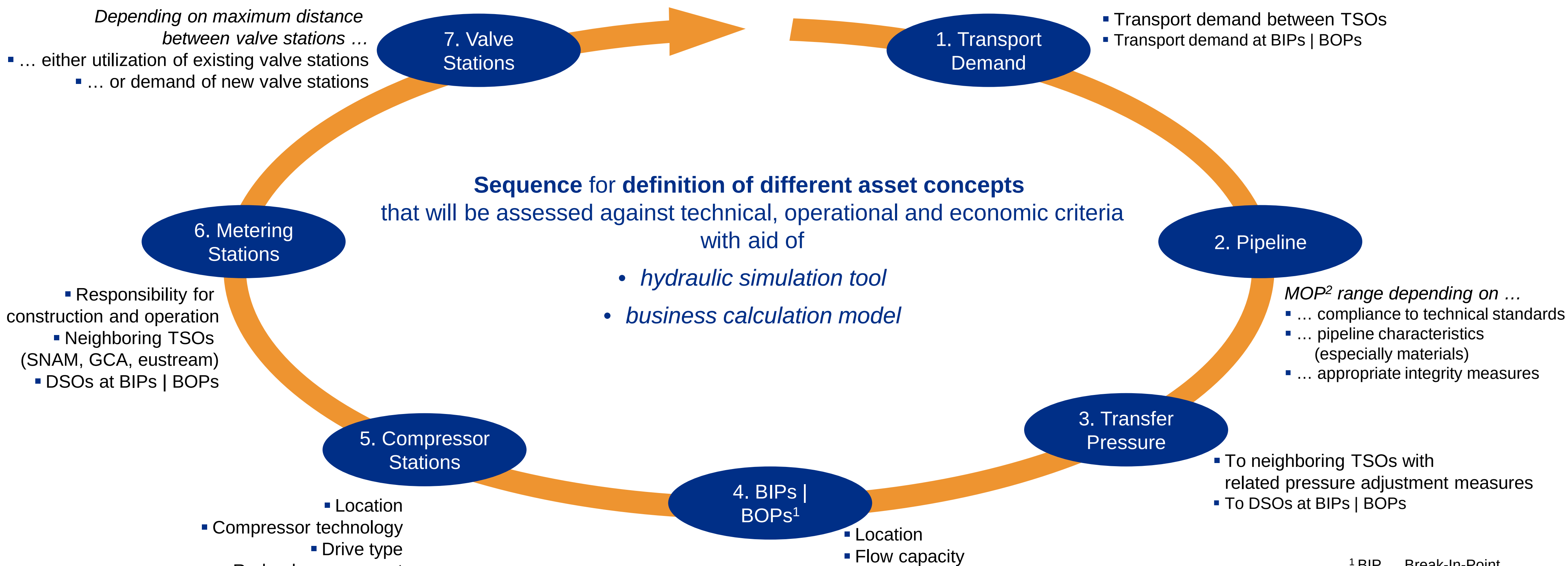
H2CDP 2025

Updated technical overview

Step-wise processing approach for selecting the best H2CDP conversion concept



Determination loop for assessment of best H2CDP asset concept



[1] BIP … Break-In-Point
BOPs … Break-Out-Points
[2] MOP … Maximum Operating Pressure

Converting a pipeline system to H2 transport

De-/Commissioning Steps

- Decommissioning
- Restructuring measures
- Commissioning with H_2
- Outlook for H_2 operations

The way to go

- **Objective:**
  - Outlining the approach for the sectional conversion of a natural gas pipeline to hydrogen (H_2)

- **Main areas:**
  - Decommissioning and disconnection from the existing natural gas transmission system (interconnectors, metering and compressor stations)
  - Implementation of conversion measures and repairs
  - Put into operation with hydrogen

- **Methodology:**
  - General research of underlying regulations (ÖVGW & DVGW regulations, EIGA) and literature (research reports)
  - Experience from German TSOs

General steps of a pipeline transition to H2

1. Technical examination with regard to the hydrogen compatibility of the natural gas pipeline to be converted
2. Planning preparation for the implementation of technical and organizational measures
3. Decommissioning
4. Implementation of technical measures to prepare the pipeline for hydrogen operation
5. Recommissioning of the pipeline with hydrogen

The steps in detail (1)

1. Technical examination with regard to the hydrogen compatibility of the natural gas pipeline to be converted

- Examination of as-built documentation
- Integrity check
  - Cleaning and inspection under natural gas operation
    - Cleaning of the pipeline (if necessary, examination of pig residues / impurities)
    - Inspection of the pipeline using intelligent pigs

2. Planning preparation for the implementation of technical and organizational measures

- Technical engineering of the conversion and adaptation measures (time, cost and detail planning)
- Preparation and planning of the activities required for hydrogen operation

The steps in detail (2)

3. Decommissioning

- Shutting off the pipeline section to be converted from the pressurized plant components (adjacent sections or stations)
- Pressure reduction in the pipeline section
- Implementation of natural gas recompression
- Bringing the pipeline section into a non-pressurized state
- Creation of gas-freeness in the pipeline section

The steps in detail (3)

4. Implementation of technical measures to prepare the pipeline for hydrogen operation

- Repairs of the pipeline (e.g. in relation to MOP H_2)
- Dismantling of the interconnectors (separation from the rest of the natural gas system)
- Conversion measures on slide stations and pigging stations
- Establishment of Break in Points and Break out Points
- Conversion measures at compressor stations
- New construction of bypass lines to bypass complex areas, e.g. metering or compressor stations
- Installation of appropriate equipment for metering, control and safety equipment to ensure safe operation with hydrogen
- Construction of (temporary) parking spaces for H_2 trailers (LH2/GH2) for recommissioning

5. Recommissioning of the pipeline with hydrogen

- Flushing (incl. inerting) and H_2 filling of the pipeline section
- Pressurization up to the intended operating pressure, taking into account the available quantities of hydrogen

Putting out of operation

- **Steps to follow:**
  - Define decommissioning requirements
  - Decommissioning preparation
  - Carrying out the decommissioning
  - Post-decommissioning measures

According to
ÖVGW G B111

- **Interface management:**
  - Fundamental deregistration of the capacity of the pipeline to be converted
  - Notification of capacity restrictions during the conversion process due to dismantling of the interconnectors
  - Station-specific separation and construction of a control system for natural gas and hydrogen for remote control technology (dispatching) and station control technology (SCS)
  - Cathodic corrosion protection: Temporary separation (for conversion measures) & new adjustments

Cleaning the pipeline

- **Methods for cleaning the pipeline**
  - Pigging → most common method & to be carried out in accordance with ÖVGW H E210
    - Mechanical removal of fine, loose deposits and dust, pipe covering and rust
    - Removal of condensates (drainage)
  - Pressure flushing with nitrogen (High velocity gas purge)
    - High-speed cleaning of the gas stream for mechanical removal of deposits, loose particles, moisture and residual gases
    - Measure may require more frequent filter changes in the stations
  - Water flushing or hydrocleaning (special case)
    - High-speed water flow cleaning to mechanically remove deposits, loose particles, moisture and residual gases
    - Disposal of contaminated water
    - Subsequent use of nitrogen required to dry the pipeline

Pigging

- If technically and economically viable, pigging (cleaning and inspection) should be carried out in natural gas operation before the switch to hydrogen
- Pigging in the current reverse flow (from Arnoldstein towards Baumgarten → probable flow direction in H_2 operation) requires technical adjustments to pigging stations
- Depending on the condition, age and degree of contamination of the pipeline, additional cleaning pigs are required if necessary

- Extreme example known, where more than 20 passes with a cleaning pig were required

Steps for decommissioning

1. Shutting off a natural gas pipeline or plant from the existing structure (i.e. the pressurized parts of the plant (sections or stations))
2. If possible, lowering the gas pressure
3. Performing recompression (pumping over)
4. Pressure relaxation to ambient pressure
5. Creation of natural gas freedom or natural gas flushing

Implementation of adaptation measures

- Repairs to the pipeline (upgrades with regard to MOP H_2)
- Dismantling of the interconnectors (separation from the rest of the natural gas system & dismantling of systems / equipment that are not required)
- Conversion measures at valve stations, pigging stations
- Establishment of Break in Points (BiP) and Break out Points (BoP)
- Conversion measures at compressor stations
- Adaptation or new construction of the measuring stations when they are handed over to upstream or downstream TSOs
- Installation of appropriate equipment for measuring, control and safety equipment to ensure safe operation with hydrogen
- Construction of (temporary) parking spaces for H_2 trailers (LH_2/GH_2) for subsequent recommissioning

Interface management

- Consideration of personnel capacities in the planning of adaptation measures, so that, for example, construction supervision and execution are equally distributed over time across the competence centers
- Accounting aspects (e.g. depreciation, etc.)
- Linepack (pressure reduction and quantity management depending on putting out of operation schedule)
- Notification of capacity restriction due to the conversion measures
- Fundamental capacity restriction, as a pipeline is taken out of the natural gas distribution network

Reconstruction measures on the pipeline

- Production of metal, electrically conductive bridging of the disconnection point for protection against dangerous contact voltage and ignitable spark flashover
- Avoidance of slipstick tuft discharges: conductive painting or coating with a maximum layer thickness of 0.2 mm on above-ground plant components (DIN EN ISO 80079-36)

- **Interconnectors**
  - Separation and complete dismantling of the connections to the rest of the natural gas system (pipelines incl. two T-pieces each)

Reconstruction measures at the pigging stations

- Pigging currently only technically possible in normal flow (natural gas)
- Conversion measures: Install omega arches and kicker lines at the current transmission gates, which serve as receiving gates under hydrogen operation (reverse flow natural gas)

- Further examination:
    - Separation of the pigging station from the compressor station & vent tower/system
    - For specific stations, a separate section blower suitable for hydrogen must be erected, taking into account the propagation areas
    - Testing whether the natural gas pigging station meets the requirements for hydrogen with regard to ATEX

Reconstruction measures at the compressor stations

- Restructuring measures:
  - Untying the compressor station
  - Compressor stations bypass for free flow (either bypass already given or new bypass lines required)
  - Conversion of compressor station or new hydrogen compressor (H_2-ready)
  - Integrating the H_2 compressor station into the H_2 pipeline
  - Untie the blower of the hydrogen pipeline from the collector blower and rebuild it
  - Preparation of an integration for a compressor station (avoidance of renewed decommissioning and recompression)

Example: Compressor station Ruden

- Separation of the 36" connecting lines to the VS Ruden and subsequent dismantling of "dead line ends" (spatial separation of the systems)
- Modification of the piping of the future connection point of the compressor including shut-off valves, blow-out valves and measuring instruments (red areas) taking into account the "forward flow" and "reverse flow" operating modes
- Separation of 12" blower and 4" instrument lines
- Separation of the 12" blowout line and installation of a new 12" blower (in the 14L fitting area)
- Separation of instrument line 4" in the area of the instrument trays on 17L and 18L fittings
- Optional: Implement 6" filling bypasses around the 4L, 5L, 6L and 7L fittings
- In the future, so-called "double-insulation-and-bleed ball valves" (DIB-1) will be used

Inspection & TÜV approval

- After completion of the reconstruction work: inspection of the pipeline at all accessible points to assess the condition of the internal surface
- Early coordination with the acceptance body

- Possible procedure regarding release:

  - Leak test at maximum possible pressure under natural gas
  - Newly installed parts are inspected at 200% (both 100% visual inspection and 100% non-destructive inspection)
  - Soaping of the joints at low internal pressure (1 bar), so that immediate pressing up to the MOP is not necessary
  - Later date: successive departure or scanning of the pipeline required after pushing the pipeline up to the MOP

Safety first

- Maintain minimum distances from electrical installations
- Corrosion protection: physical disconnection of the CP system line not required
- Adaptation of the CP system with regard to hydrogen is not necessary, as electrochemical corrosion is independent of the medium transported
- Protection against electrical influences: See VEXAT concept for gate valve stations or compressors

Commissioning with H2

- **Contents:**
  - Commissioning requirements
  - Preparation for commissioning
  - Implementation of commissioning
  - Measures after commissioning

ÖVGW H B210
ÖVGW H E210

- **Interface management:**
  - Personnel requirements
  - Personal protective equipment
  - Work equipment
  - Marking (adaptation of the marking system)

ÖVGW H B210

ÖVGW H E200 / H E210

Preparation for commissioning

- H_2 quantity determination (flushing and filling volume) → Flushing quantity: 150% Vgeo
- Availability check and coordination with the hydrogen supplier(s)
- Planning & construction of suitable (temporary) installation sites for H_2 trailers in accordance with EIGA
- Determination of the filling method, the filling sections and release points, including hazardous areas
- Determination of the minimum H_2 concentration to be achieved after filling
- Preparation of work program (measures, circuit and sequence diagram, necessary equipment, communication lists)
- Function and leak testing of shut-off valves for line circuitry
- Needs-based involvement of third parties (residents, authorities, etc.)
- Determination of safety measures (also with regard to the adjacent plants)

Implementation of commissioning

- Rinsing (incl. inerting) & H_2 filling according to TÜV approval (gas-in)
- Determination of the filling method
- Step-by-step pressurization with predefined holding points up to the intended operating pressure
- Leak testing of components (valves, flanges, fittings) that could not previously be subjected to pressure testing
- Test operation if necessary
- Takeover into regular operation

Rinsing process & filling (1)

- Indirect flushing with hydrogen (hydrogen filling by means of an inert gas separation layer)

  - Required N_2 volume to build a separation layer: 11% Vgeo
  - Minimum flushing speed for N_2 separation layer: 0.6 m/s
  - N_2 Output Temperature: ≥ -5 °C
  - N_2 filling rate TAG-Loop II (DN1000): 28 m3/min or 1,680 m3/h → at least 2 parallel evaporators
  - Purge gas quantity H_2: 150 % Vgeo
  - Flushing with H_2 must be carried out until the H_2 concentration specified at the discharge point is determined (TAG assumption grade A: ≥ 98 vol.-% H_2)

Rinsing process & filling (2)

- Indirect flushing with natural gas followed by direct flushing with hydrogen
  - After reconstruction measures → filling of the pipeline with natural gas (atmospheric pressure)
  - Put-into-operation with natural gas according to ÖVGW G B111
  - Subsequently, the natural gas is rinsed out by means of H_2 & combustion via mobile flare
  - The flushing process must be carried out until the specified H_2 concentration is measured (TAG assumption grade A: ≥ 98 vol.-% H_2)
  - Purge gas quantity H_2: ≈ 150 % Vgeo
  - **Advantages of this method:**
    - Avoidance of the formation of an ignitable gas-air mixture in the pipe
    - Rinsing with N_2 is not necessary
    - Experiences of German TSOs are available

Outlook for H2 operation

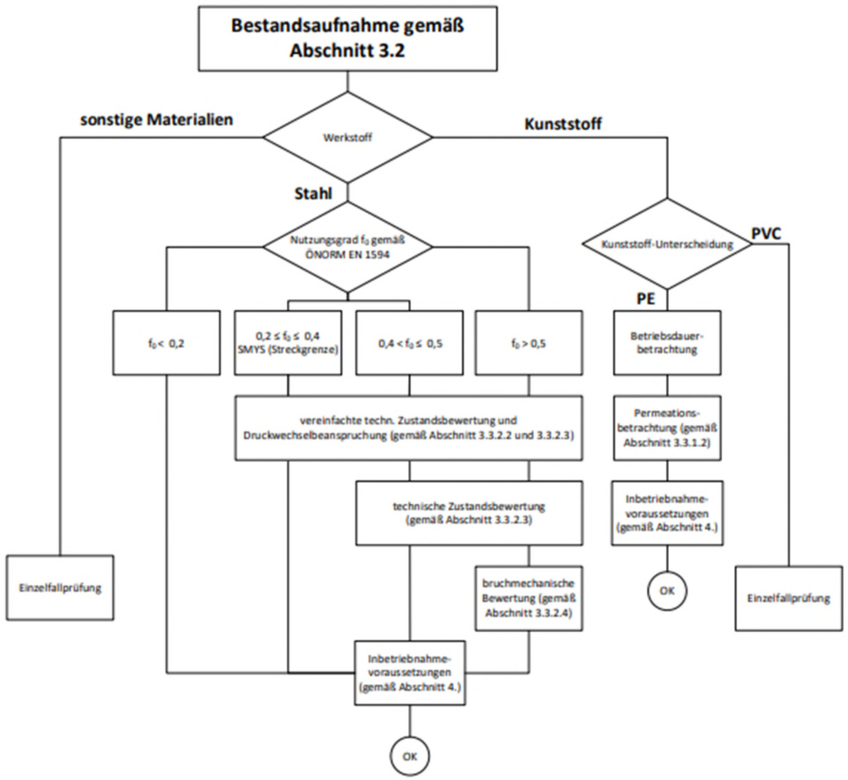
- Maintenance Program
  - 4 weeks after the changeover at key operating points leak check
  - Initially shortened maintenance intervals (e.g. 12 weeks and 1 year after commissioning)
  - With operating experience and, compared to natural gas, the same number of anomalies, approximation to the maintenance intervals typical of natural gas

- Maintenance
  - Orientation towards manufacturer and notification requirements
  - Recording of operating pressure changes

- Equipment
  - Conventional gas cameras are based on infrared absorption and are not suitable
  - Purchase of gas concentration measuring devices for hydrogen required

Summary of the Assessment of Natural Gas Pipelines for Hydrogen Use

Criteria from the ÖVGW H E210 guideline



To be investigated

- Evaluation of the effectiveness of cathodic corrosion protection (CCP); Information on non-destructive testing during construction
- Verification of the specified minimum yield strength
- Bends
- Fracture Mechanics Evaluation
- Data/Information about connection and installation method
- Data/Information from smart pigging campaign
- Material Performance Factor Hf
- Verification of the notched impact work for the pipes used
- Verification of notched impact work for welding process tests
- Qualification of hardness in the welded joint
- Verification of the maximum tensile strength of the base materials
- Verification of the maximum tensile strength of the weld seams
- Evaluation of pressure alternating stress (pressure cycle stress)

Perform a technical condition assessment

Technical condition assessment and evidence of:

- Dents and mechanical damage
- Effectiveness of corrosion protection
- Pipe book / installation method
- Pigging (wall thickness testing): If pigging is not possible → technical condition assessment in accordance with ASME B31.12

Technical condition assessment according to ASME B31.12 Option A:

- Multiplication by material performance factor (the higher the strength, the lower the maximum possible pressure).
- Notch impact energy.
- Welding procedure qualification (WPQR):
  - Notch impact test weld metal + heat-affected zone
  - Hardness limit max. 235 HV
  - Measured tensile strength max. 690 N/mm²
  - Specified yield strength max. 485 N/mm²

Fracture mechanics assessment & pressure cycle stress with fatigue

- Evaluation of permissible load cycles in accordance with AD 2000.

Potential measures for improvement

- Completion of fragmentary documentation (material certificates, process tests)
- Verification of the counter welding of the longitudinal seams
- Analysis and repair of corrosion spots and dents indicated in the pigging reports
- Improvement of cathodic corrosion protection

TAG GmbH | Wienerbergstraße 11 | 1100 Vienna

www.taggmbh.at | Follow us