Engineering & Technologies

Hydrogen Technology

Market leadership for more than two decades

Technip

take it further.

Technip at a glance

Technip is a world leader in project management, engineering and construction for the oil and gas industry.

With a global footprint, our talents constantly offer the most innovative technologies and best solutions to our clients to optimize their investments and meet the world's energy challenges.

Our mission is to deliver safe, sustainable and quality projects across the world.

We operate in three main businesses:

Subsea

In subsea hydrocarbon field development, Technip's activities include the design, manufacture and installation of rigid and flexible subsea pipelines and umbilicals.
Thanks to our portfolio of technologies, industrial and operational assets on all continents and a state-of-the art fleet, we offer a unique vertically integrated model in the industry.

Offshore

In the Offshore business, our activities include engineering, procurement, construction (EPC) and installation of fixed and floating platforms.
We use a complete range of technological solutions to answer the challenges faced by our clients. We are leveraging our expertise in full-range of offshore facilities, as well as our strong know-how with added-value process skills and proprietary platform design.

Onshore

In the Onshore business, we deliver to our clients all the experience we have acquired for almost 60 years, combined with a large technology solutions portfolio. We are working on onshore facilities that the energy sector needs, in particular for oil and gas industry players. Technip is one of the global leaders for the refining business and petrochemical units. We also reinforced our position on project management consultancy (PMC) activities, by leveraging our expertise in the management of complex projects.

Hydrogen: Our core expertise supporting your business goals

Austria - 30,000 Nm^3/h Hydrogen

> Technip's hydrogen plants have demonstrated the highest on-stream reliability in the industry.

Hydrogen, either in its pure form or as a component of syngas, is the most widely used industrial gas in the refining, chemical and petrochemical industries.

Over the years, hydrogen demand has grown extensively, especially in refineries for achieving the desired quality and yield of clean transport fuels.

Being the lightest gas, hydrogen is not easy to store; hence, it is mostly generated on-site or supplied through pipelines.

Hydrogen applications call for high on-stream reliability, cost-effectiveness, efficiency and the highest Health, Safety & Environment (HSE) standards.

Consistent worldwide market leadership

- Technip has been the hydrogen market leader for more than 20 years, having provided its proprietary steam reforming technology in more than 270 plants worldwide. This represents a global market share of over 35%.
- Technip has designed and supplied several of the world's largest steam reformers for hydrogen-syngas applications.
- Technip tailors its solutions for every hydrogen plant, often leading to industry "firsts" (see Key References).
- Having supplied hydrogen-syngas plants worldwide, Technip understands the need for flexibility in the scope of work and forms of contract - from reimbursable to lump sum EP (engineering and procurement) or EPC (including construction) and turnkey projects.
- Being a world-class EPC company, Technip offers its clients a single-point responsibility from concept to commissioning including start-up operator training, plant optimization, troubleshooting and maintenance support.

Key differentiators and continuous improvement

Since pioneering the steam reforming process in the early 1960s, Technip has enhanced its hydrogen technology and plant designs through continuous improvement, product development and technology advancement programs. This commitment has resulted in commercially proven solutions such as:

- Enhanced energy efficiency flow sheets with optimised reforming severity, optional pre-reforming, conforming level of shift conversion and advanced heat integration
- Value engineering solutions for lowest unit cost of hydrogen
- Recuperative reforming with Technip Parallel Reformer (TPR®) allowing up to 30% additional reformed gas using process heat
- Specific design and execution philosophy for smaller hydrogen plants
- Gas turbine combined cycle and exhaust integration for steam-power synergy and reliable captive power
- Advanced modularization for faster, cost-effective execution
- High purity export steam based on high pressure stripping of condensate, segregated or 'dual-steam' systems or feed saturation concepts
- World-class project management and execution

Process designs that satisfy the most challenging hydrogen needs

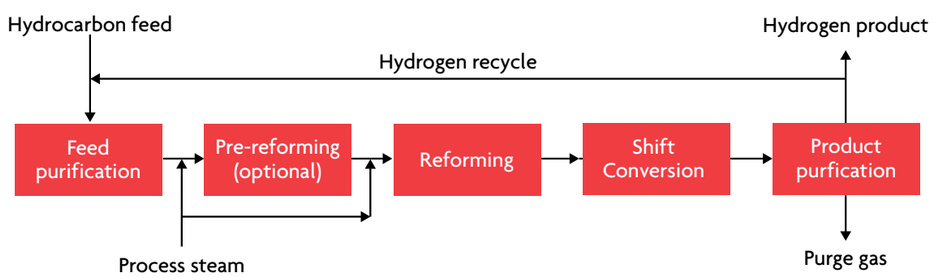
Steam reforming is the most widely applied process for hydrogen production

- The steam reforming process is cost-effective, simple, flexible, efficient and proven.
- The level of heat integration, export steam philosophy and overall thermal efficiency are important factors in the design and optimization of a hydrogen plant.
- Technip's design solutions and software tools are utilized to optimise the plant flowsheet and operating conditions.

Feedstock flexibility

- Many of today's refinery hydrogen plants require flexibility in utilizing multiple feedstocks ranging from refinery off gases (ROG) and natural gas to LPG and naphtha to suit economics and operational needs.
- Application of adiabatic pre-reforming step facilitates or enables the plant to achieve the required feedstock flexibility.
- Technip has leading experience in applying pre-reforming technology to address industry needs ranging from multiple feedstock flexibility and export steam minimization to high severity reforming and enhanced process efficiency.
- Advanced control configurations have been implemented for on-line changeover of feedstocks with minimal impact on production capacity.

Main process steps in a Hydrogen Plant



Canada – 200 MMSCFD Hydrogen and 75 MW power

Financial benefits from careful process and design selection

Hydrogen economics can be enhanced through proven process options.

- The steam reformer is the most capital-intensive item in a hydrogen plant and its type and configuration impacts both fixed capital expenses (Capex) and variable operating expenses (Opex).
- Technip tailors its hydrogen plant designs with respect to both. For most plants, especially large capacity units, the top-fired arrangement is preferred.
- Process options such as ROG integration and CO_2 recovery have successfully been implemented to not only meet specific needs but to improve project economics.
- Strategic application of co-generation ensures cost-effective (captive) power availability and reliability, especially in developing countries, and improves overall economics.
- Early assessment and timely interactions between the owner and design contractor is key to careful design optimization and successful project execution.

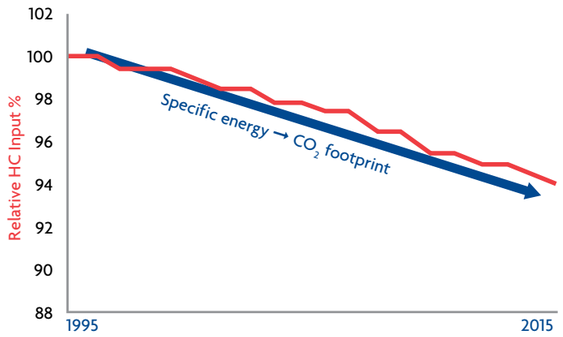
China – Hydrogen and Syngas reformer

Tailored designs

France – 97,000 Nm3/h Hydrogen

Health, Safety & Environment (HSE) and Quality

Progression of Energy Efficiency over 20 years



Technip's plants are designed to meet the highest HSE and Quality standards and address long-term sustainability

- Technip's foremost focus is Safety without compromise, from process concept and design to installation, operation and maintenance. In addition to extensive HAZOP reviews and safety studies, detailed Computational Fluid Dynamics (CFD) simulations and critical design analysis are conducted to ensure safety of personnel and equipment.
- Advanced operational diagnostics and control provisions are incorporated for critical and transient conditions, especially with regard to reformer operation.
- Technip's hydrogen plants have proven reliability and on-stream availability of more than 99% (excluding turnarounds and forced outage) based on extensive operational feedback, especially from "over the fence" plants which inherently require enhanced reliability.
- Based on its vast experience in critical furnaces, Technip utilizes the best available technology for environmental performance and compliance in terms of (ultra) low-NOx burners including our own LSV® burner technology and Selective Catalytic Reduction (SCR) de-NOx systems for more stringent requirements.
- Liquid effluents are minimized through full re-utilization of process condensate for the steam system, thereby also reducing the amount of make-up water.
- Incorporation of Technip's PULSE safety program and QUARTZ quality system.
- Carbon management and capture strategies for future needs.

Poland – 111,000 Nm³/h Hydrogen

Innovative Solutions and Clean Technologies

Oil refiners are often looking for more hydrogen to process heavier and sour crudes and/or maximize the middle-distillate pool while meeting stricter clean fuels requirements.

Operational feedback

Refinery Hydrogen Management

Refinery hydrogen management is a methodology that optimizes and balances the production and consumption of hydrogen within a refinery. Objectives include:

- Maximizing refinery off gases (ROG) utilization and hydrogen recovery
- Minimizing hydrogen-to-fuel losses
- Cascading hydrogen purity and pressure based on end-user requirements
- Optimising the hydrogen compression and distribution network
- Integrating the production of by-products, especially in case of petrochemical link-up
- Lowering the capacity of 'on-purpose' hydrogen to improve overall economics and environmental performance

Hydrogen Network Advanced Optimization

Technip's proprietary Hydrogen Network Design Tool (HyNDT™) helps achieve the Refinery Hydrogen Management objectives. The tool analyzes a refinery's hydrogen network and identifies ways to optimize its performance, cost efficiency, operational flexibility and HSE targets. Features include:

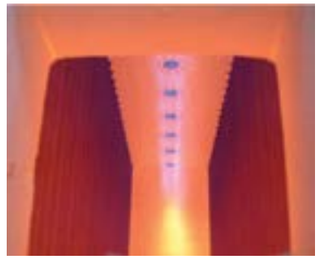
- Advanced LP Modelling on Aspen PIMS™ platform with hydrogen pinch analysis and pressure-purity cascading
- Unit process and utility models for rigorous simulation, reconciliation and optimization
- Optimization of on-purpose hydrogen capacity and overall energy balance
- Incorporation of Technip's extensive cost database to compare Capex costs for each network configuration option
- Lowered overall carbon-footprint
- User-friendly console for selection of desired objective function, refinery inputs and displaying layered overviews
- Applicable to both grassroot refineries and revamp projects

Steam Methane Reformer

Technip has supplied its proven, efficient and reliable proprietary steam reformer design in more than 270 plants worldwide. Being the heart of hydrogen-syngas generation plants, the reformer offers following merits:

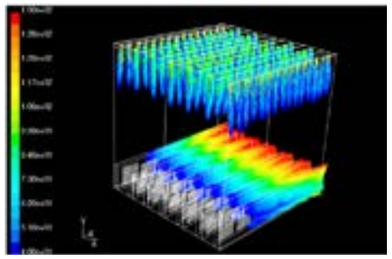
- Compact, cost-effective design, especially for larger capacities
- Customized design for each application
- High thermal efficiency and lower carbon emissions per unit of syngas
- Case-optimised level of modularization
- Highest standards of operational safety, reliability and flexibility
- Extensive track record of high performance, versatility and long-term integrity

USA – 27 MMSCFD Hydrogen



SMR Firebox Interior View

SMR Radiant Section



Radiant box CFD Model

Ultra-low NOx Large Scale Vortex® (LSV) Burner

This advanced burner offers ultra-low NOx emission significantly below the limits set by industry standards. The design is based on an innovative flame stabilizer and unique fuel pre-mix injection system, enabling operation under lean conditions. Features include:

- Low NOx levels (down to 30 ppmV) without secondary measures
- Uniform flame heat release profile
- Good turn-down stability
- Reduced excess air limits
- No coking or plugging

The LSV burner is another example of Technip's commitment to the highest standards of HSE and sustainability.

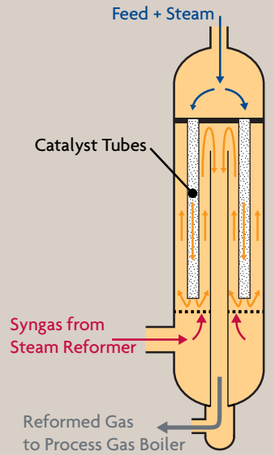
Technip Parallel Reformer (TPR®)

TPR is Technip's proprietary convective recuperative heat exchange reformer. It has catalyst-filled tubes in a shell and uses process gas heat to reform part of the feed.

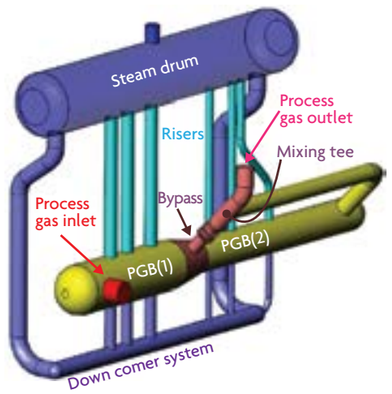
This reformer provides an exceptional solution especially for capacity revamps, along with case-specific steam reformer size reduction and export steam minimization.

The design, metallurgy and fabrication of TPR involves advanced engineering know-how and proprietary expertise developed by Technip. Advantages and differentiators include:

- Up to 30% additional reformed gas (especially attractive for revamps) without additional firing nor any major modifications to the existing fired reformer
- Substantially lowers the cost per unit of *additional* hydrogen compared to other options
- Shorter plant downtime based on modular add-on retrofit, typically matching turnaround schedule
- Minimum additional plot area, with vertical reactor adjacent to the steam reformer
- Ease of operational control and intrinsically safe
- Allows "zero" export steam and thus also stand-alone hydrogen units
- Lower CO_2 emissions per unit of hydrogen
- Proven technology with several commercial references



USA – TPR for modern Hydrogen plant capacity revamp



Technip Dual Chamber Process Gas Boiler

Our proprietary boiler enhances cost effectiveness and improves energy efficiency through extended heat recovery. Its design, as the name suggests, includes two chambers separated by an intermediate compartment with an external by-pass assembly to control the exit temperature. Advantages include:

- Reducing cost based on optimised surface area for each chamber
- Avoiding and/or minimizing risk of metal-dusting with tailored split of chambers and external by-pass, providing unprecedented reliability
- Easier bypass valve maintenance and lower related costs
- Reducing stress from thermal growth of critical components, also allowing larger scale-up

“Over-the-fence” hydrogen supply

Spain – 60,000 Nm³/h Hydrogen + 240 tpd CO_2

USA – 100 MMSCFD Hydrogen + 20 MW power

Global alliance with Air Products

Since 1992, Technip and Air Products have participated in an alliance to supply “over-the-fence” hydrogen to the global refining industry. Technip provides the design and construction expertise for steam reformers while Air Products provides the gas separation technology. Technip, from its large project reference base, and Air Products, through its extensive operating network, also bring effective operational and engineering knowledge to “design-in” high reliability and efficiency. The alliance is responsible for more than 35 hydrogen plants supplying more than 2,600 MMSCFD (2,900,000 Nm3/h) hydrogen.

AIR PRODUCTS | Technip

H_2 Alliance

Visit **www.h2.alliance.com** for more information.

Advantages of “over-the-fence” hydrogen supply

- Optimised cost of delivered hydrogen, (Opex + Capex) based on the combined strengths of Technip’s design expertise and tailored solutions with Air Products’ excellence in plant operation and performance.
- Extensive operational feedback drives design enhancements.
- Air Products and Technip are fully committed to hydrogen as their worldwide core business.
- Air Products provides the initial capital investment for the hydrogen plant based on ‘own, operate and maintain’ model under long-term contract.
- Any risk of project execution, plant efficiency and on-stream performance lies with the supplier (alliance) and not with the end-user.
- Highest HSE standards are the primary focus.
- Leading-edge reliability of hydrogen generation and/or supply, further facilitated by multi-plant, multi-customer pipeline networks and/or back-up franchise provisions.

USA – 25 MMSCFD Hydrogen

USA – 80 MMSCFD Hydrogen

Sustainability & Innovation

Hydrogen, an energy carrier which can be generated by traditional or renewable sources, is projected to play a major role in the future sustainable clean energy landscape. As the market leader in supply of hydrogen plants, Technip is committed to take this sustainability principle further, as it drives our innovation focus targeting environmental, economic and social benefits.

Innovation

- Mega steam reformer with steam-power synergy and CO_2 capture
- Proprietary equipment (Technip SMR, TPR, LSV burners, advanced PG boiler)
- More than a dozen industry “firsts” (largest plants, multiple feed flexibility, power cogeneration and carbon management)

Hydrogen Technology

Environmental Benefits

- Technip’s technology developments during the past 30 years have improved energy efficiency of hydrogen plants by more than 10%, providing related reduction in emissions as well as operating costs.
- Advancements for optimising a hydrogen network in refineries have resulted in more effective use of hydrocarbon resources.
- For steam-power integration, gas turbine exhaust can be used as combustion air for SMR burners, thereby improving overall energy efficiency and carbon footprint of the refinery.
- We have solutions in place for carbon capture readiness in future hydrogen plants, targeting more than a 2/3rd reduction in CO_2 release from the hydrogen plant.

Economic Benefits

- Technology advancements and continuous improvements over the past 30 years have reduced Opex and Capex, resulting in up to 15% lower “unit cost of hydrogen.” At the same time, on-stream reliability has been enhanced to 99+%.
- In cases where steam has low credit, the pre-reforming and/or post reforming steps can be is employed for reducing steam export as well as fuel consumption
- Advanced hydrogen management, improved equipment, innovative revamp solutions, strategic steam-power synergies and project execution excellence ensure improved hydrogen plant economics.

Social Benefits

- Hydrogen as a carbon-free energy vector carries a potential role in the clean fuels and sustainable energy pathways, ensuring a cleaner environment and better quality of life for our coming generations.
- Feed and energy source flexibility of hydrogen generation offers vast potential for harnessing and integrating renewable energy, thus providing wider growth opportunities, employment and public participation in the future energy landscape.

Technip designs and delivers sustainable and innovative solutions to meet the world’s energy challenges.

Key References

(1 MMSCFD = 1,110 Nm^3/h)

- 69,500 Nm^3/h Hydrogen plant for Total, Vlissingen, The Netherlands; 1985
  - One of the first large modern plants for hydrocracker application
  - Expanded to 80,000 Nm^3/h; 2002
- 35 MMSCFD Hydrogen plant for Air Products, California, USA; 1993
  - First plant under the Technip-Air Products alliance
- 111,000 Nm^3/h Hydrogen plant for PKN, Poland; 1997
  - Largest plant with multiple feed flexibility (NG, LPG, naphtha & mixture)
- 106,000 Nm^3/h Hydrogen recovery plant + 21 t/h C2+ for PKN, Poland; 1998
  - One of the largest ROG recovery plants with PSA + cold box hybrid
- 200 MMSCFD Hydrogen plant for Syncrude, Ft. McMurray, Canada; 2005
  - Largest operating single-train plant, with 75 MW cogeneration
- 115 MMSCFD Hydrogen plant for Air Products (Port Arthur-II), Texas, USA; 2006
  - Largest gas turbine (exhaust) integration with 100 MW cogeneration
- 110 MMSCFD Hydrogen plant for GS Caltex, South Korea; 2007
  - Largest naphtha (and LPG) direct reforming-based plant
- 104,000 Nm^3/h Hydrogen plant for Indian Oil Corp., Haldia, India; 2009
  - Among the largest plants with pre-reforming, LT shift and dual steam system
- 100,000 Nm^3/h Hydrogen + 28,000 Nm^3/h syngas plant for Air Products, Chengdu, China; 2013
  - One of the largest HyCO facilities based on steam reforming
- 155 MMSCFD Hydrogen for Air Products, Louisiana, USA; 2014
  - Largest single-train plant for over-the-fence hydrogen supply
- 238,000 Nm^3/h Hydrogen plant for Rosneft, Tuapse, Russia, under construction (2016)
  - Largest single-train plant in the world
- 182,000 Nm^3/h Hydrogen plant for Air Products, Kochi, India, under construction (2016)
  - Integrated facility with co-production of syngas, O_2, N_2 and power
- 344,500 Nm^3/h Hydrogen and syngas plant for Petronas, Malaysia, under construction (2016)
  - One of the largest facilities (with three trains)

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