



**ENERGY**

INFRASTRUCTURE

MINING & METALS

NUCLEAR, SECURITY & ENVIRONMENTAL



# ENERGY TRANSITION Hydrogen

**Energy plays a key role in promoting social and economic progress — and technological advancements have created new opportunities to improve how we bring power to communities worldwide.**

## Hydrogen

Countries worldwide are accelerating the development and use of hydrogen technology to tackle environmental concerns and enhance energy security. Hydrogen technology can serve as a long-term, large-scale clean energy storage medium that aids power generation from renewable sources.

# 26

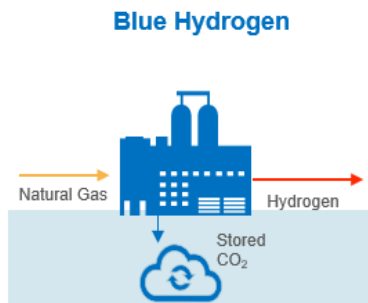
completed hydrogen and compression plants in 15 years

Hydrogen Subject Matter Experts located in London (UK), Houston (USA), and Melbourne (AUS)

services include Master Planning for Net Zero

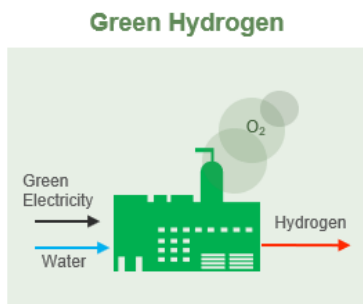
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### Blue Hydrogen

We believe in energy efficiency, carbon capture, hydrogen, and circular economy solutions to enable our customers to meet the world's growing needs for downstream products in a cleaner and more sustainable way and in alignment with their environmental, social, and governance principles.



### Green Hydrogen

Hydrogen from electrolysis and fuel cell technologies has significant potential to enable the energy transition to a clean, low-carbon energy system that will reduce greenhouse gas (GHG) emissions and improve air quality.

When developing petrochemicals, advanced fuels production (conventional and renewable), and gas processing facilities, we believe energy efficiency, carbon capture, hydrogen, and circular economy solutions are critical to enable our customers to meet the world's growing need for downstream products in a cleaner and more sustainable way.

When Bechtel is engaged early in the project lifecycle, we deliver optimized solutions to help our customers realize lower capital costs, shorter times-to-market, and projects with lower carbon emissions.

Bechtel Energy Technologies & Solutions is currently conducting a techno-economic evaluation of the three principal hydrogen technologies. We are evaluating the technical merits of the technologies, as well as undertaking a benchmarking effort to determine the relative capex and opex costs of the technologies for different sizes of facilities. This will allow us to more efficiently support our clients in selecting the most suitable technology for their project and allow Bechtel to engage technology licensors that represent the best fit for the project.

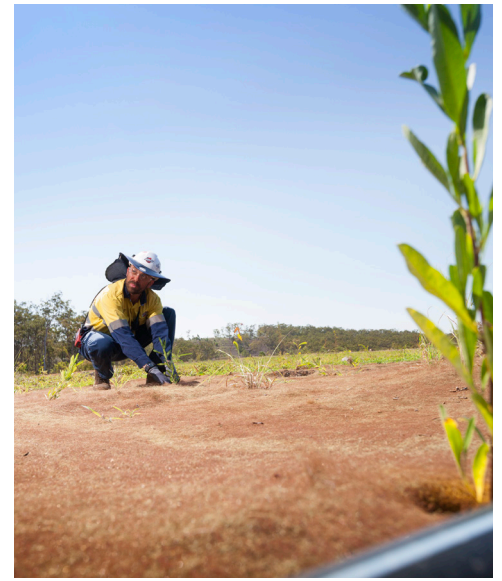
## Hydrogen

Our refining business has given us extensive experience with manufacturing and processing hydrogen; we have performed 26 relevant projects in the last 15 years. We are using this experience, coupled with our carbon capture capability, to offer blue hydrogen solutions to our customers. We are able to work closely with our customers to evaluate and select the best technology for their specific project circumstances having recently completed an assessment of the major blue hydrogen technologies.

Our capacity to deliver renewable energy facilitates the potential for green hydrogen. To this end, we are collaborating with green hydrogen technology providers and also studying the logistical challenges associated with hydrogen export.

We have developed a close partnership with many of the leading equipment and technology suppliers and are now developing their hydrogen liquefaction technology from pilot-size to full-scale. Through our relationships with them and experience in using their products, Bechtel is well positioned to deploy and integrate their technology for future H2 growth.

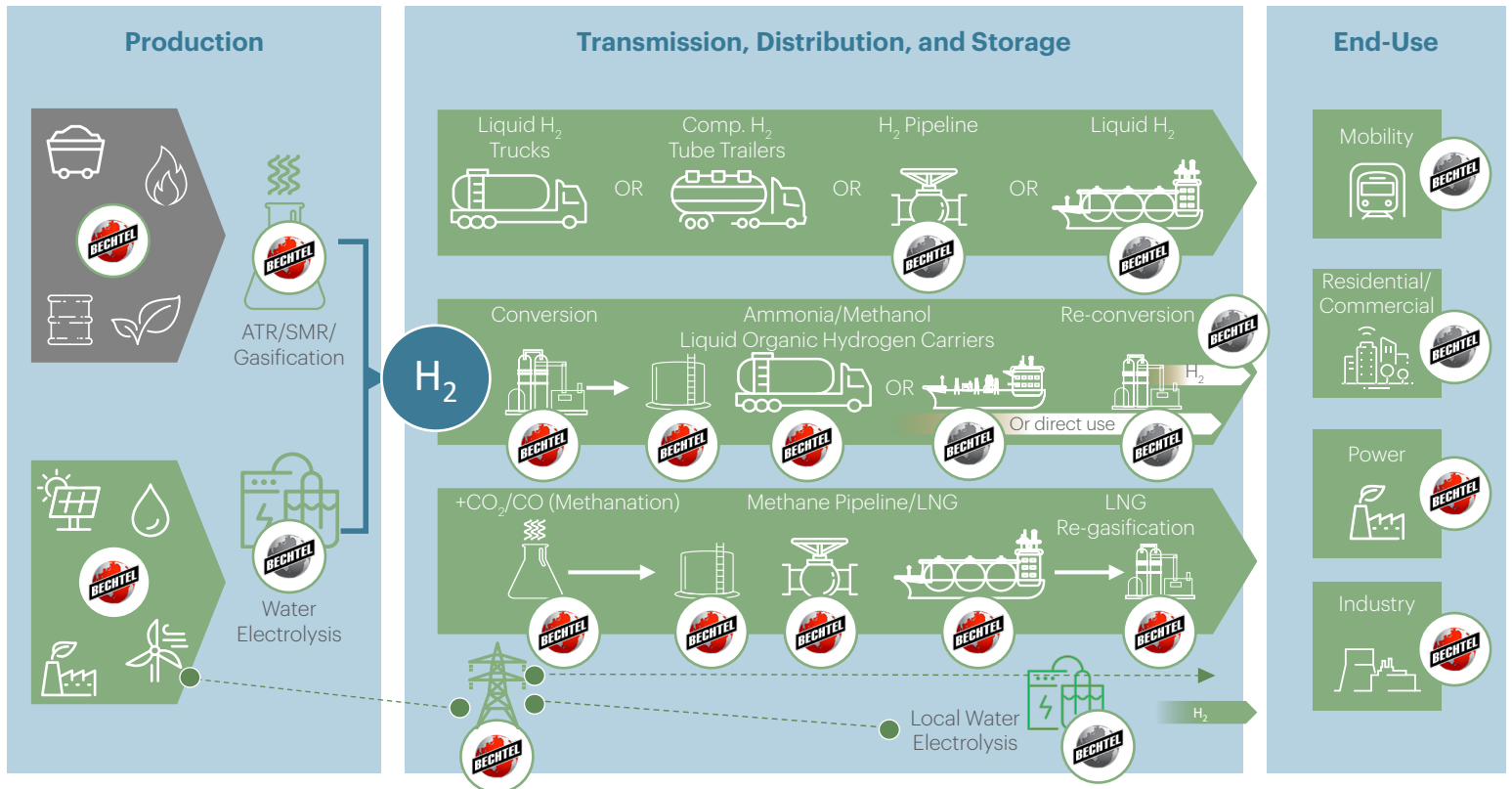
The graphic below demonstrates our experience across the end-to-end hydrogen chain.



Bechtel Direct Experience



Focus Area with Expertise



### Production

- Experienced in large-scale power generation and petrochemical facilities.
- Designed and built multiple hydrogen facilities within our core refining business.
- Large footprint in green energy projects, including wind and solar.

### Transmission, Distribution, and Storage

- Skilled in developing extensive pipeline networks under challenging conditions and locations.
- Development of over 40 LNG trains, terminals, jetties, pipelines, tanks, and loading arms. This experience will be invaluable in hydrogen liquefaction and distribution.

### End-Use

- Experienced in project delivery for large-scale networks and cities.
- Experienced in all major transport and mobility groups.
- As a leader in power generation projects, we are currently evaluating the potential for new high-H2 content gas turbines.
- Experienced in using H2 in manufacturing industries.



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# ENERGY TRANSITION

# Carbon Capture

## STUDY EXPERIENCE

### 2021 - ONGOING

- Department of Energy, Sherman, TX, USA
- Conceptual Study - New Build Biomass CCUS Plant
- FEED for LNG Facility
- Coal Creek, USA

### 2020

- Post-combustion CO<sub>2</sub> Capture Using Membrane-based Technology

### 2018

- Retrofit of Brown Coal Power Station with Post-combustion Capture

### 2016

- MX TF Carbon Capture, Utilization, and Storage Development in Mexico

### 2015

- Peterhead Post-combustion Capture FEED Study Review
- Assessment of Post-combustion CO<sub>2</sub> Capture for Pulverized Coal Power Plant Application, AL, USA

### 2013

- Chilled Ammonia Process Design Ultra-super Critical Pulverized Coal Power Plant, Mountaineer Plant, WVA, USA

### 2011

- EPRI/Nexant - 5 Pre-FEEDs

### 2009

- CO<sub>2</sub> Capture Facility Report, Karsto, Norway

### 2008

- Report for the European CO<sub>2</sub> Test Center Mongstad

**Carbon capture and storage are essential in enabling the global energy transition as we become smarter and more innovative in how we manufacture, generate electricity, and live our day-to-day lives.**

For more than 20 years, US, UK, and European leaders have turned to Bechtel to develop and refine carbon capture solutions for the energy generation sector. To date, we have built more than 40 amine-based CO<sub>2</sub>/H<sub>2</sub>S removal systems for liquefied natural gas plants, gas processing plants, and refineries.

## Collaborating to Improve Carbon Capture Technology

Bechtel delivers best-fit solutions for our customers by combining our deep knowledge of flue gases with a technology-agnostic approach.

We actively leverage our knowledge and skills to develop scalable, economical solutions to the carbon challenge that include a generic amine offering that has been optimized for energy balance and ongoing operational costs.

### Reclaiming 65% power lost in carbon capture processes

Through patented processes and technology, Bechtel helps our customers reduce the power lost in capturing carbon by almost 65 percent and lower the overall capital cost for gas-fired plants by more than 30 percent.

We have delivered 18 post-combustion CCUS projects to date, including major FEEDs and studies for governments and energy companies. This is in addition to more than 50 additional amine projects in the last 15 years delivered as part of our Energy business. Our expertise and capability provides differentiated value to our customers in the following ways:

### Licensors and non-proprietary solutions

Bechtel is one of the few contractors who has worked with and evaluated all major amine licensors. We have also delivered FEEDs without the need for a licensor by using our in-house design capability.

### End-to-end project delivery

With our power generation, amine, and pipeline capability, we can offer an integrated solution for the entire power, capture, and compression scope.

### Project continuity

We are able to deliver studies to full EPC projects.

### Brownfield projects

Bechtel has experience performing retrofit CCUS to existing power plants. We have leveraged our extensive retrofit/expansion experience from both the power and oil and gas industries to de-risk the design and construction execution planning.

● Pre-FEED Study ● FEED Study



66+

MTPA

post-combustion CO<sub>2</sub>  
capture projects to  
date

successful  
project delivery  
across the spectrum  
of technology options,  
including all major

Amine  
Licensors,  
Open-  
Technology,  
and Chilled  
Ammonia

Bechtel has built  
more than

40

Amine-based  
CO<sub>2</sub>/H<sub>2</sub>S  
Removal Systems  
for liquefied natural gas  
plants, gas processing  
plants, and refineries



### Department of Energy FEED Study

Sherman, Texas, USA

Bechtel is currently performing a comprehensive FEED study for the US Department of Energy to add a carbon capture and compression plant to Panda Energy Fund's existing CCGT power plant in Sherman, Texas.

The post-combustion capture plant is an amine-based conventional absorber-stripper scrubbing system with a non-proprietary solvent.

By using conventional amine, we are providing a non-proprietary solution to capture CO<sub>2</sub> without the need for licensors, reducing opex and de-risking project outcome.

Bechtel Energy Technologies & Solutions works collaboratively with customers to select the best technology, including continued assessment of traditional and emerging technologies, by experts with over 30 years of experience.

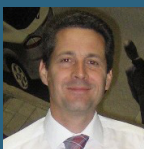
### Subject Matter Experts (SMEs)



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# ENERGY TRANSITION Advanced Fuels

15  
 waste-to-energy  
 projects



## Project Highlight

World's First Methanol to Gasoline Plant — Bechtel performed engineering, procurement, and construction management for this first-of-a-kind project.

- First commercial-scale application of the proprietary catalytic methanol to gasoline (MTG) process developed by Mobil Oil Corporation with a production of 14,700 barrels per day of high-octane, low-lead gasoline using natural gas from the offshore Maui field. The plant was also the world's largest methanol production facility.

## Advanced Fuels

Today, our customers are building new gas to gasoline projects and converting existing refining assets into advanced fuel production facilities because of the emergence of technologies that enable economically viable solutions.

Bechtel is applying emerging technologies in the earliest phases of project development, increasing energy efficiency throughout the design, and decarbonizing our execution across the project lifecycle to deliver clean energy projects for our customers.

## Biofuels

Our team's experience extends from guiding licensor input to optimal feedstock types and blends, technology specification, evaluation and selection, technical review of licensor designs, design integration with utilities and other facilities, and operational feedback and lessons. Areas of specific focus include:

- Bridging the differences in on-stream and reliability requirements between typical pretreatment technology provider scopes in edible oil (corn, soybean, etc.) service versus fuel production.
- Optimizing the extent of feedstock flexibility to be incorporated in the pretreatment design.
- Assessing the operational costs and implications of various pretreatment technologies based on chemicals usage and utilities consumption.

## SWSPPlus<sup>SM</sup>

SWSPPlus process is a proven and reliable solution for recovering H<sub>2</sub>S and ammonia separately from the wastewater effluent. By recovering ammonia from the sour water instead of incinerating it, the refinery is able to avoid NO<sub>x</sub> emissions, generate an additional source of revenue, and meet strict environmental regulations while converting oils, fats, and greases to renewable diesel and jet fuel.

A Sulfur Recovery Unit (SRU) is meant to convert hydrogen sulfide (H<sub>2</sub>S) into a salable elemental sulfur product.



Unsurprisingly, an SRU **does not** convert NH<sub>3</sub>, CO<sub>2</sub> and other non sulfur species into **sulfur**. If NH<sub>3</sub> is not destroyed in the SRU Reaction Furnace (as it is in all BHTS Sulfur Plants), then it will precipitate, forming



**solid ammonia salts.** These can cause the unit to experience an **unplanned shutdown**.

To avoid this, sulfur plant licensors must specify the SRU Reaction Furnace to destroy the ammonia, resulting in a difficult demand to control temperature."





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## ENERGY TRANSITION

# Chemicals



# 275+

refinery expansions  
and modernizations  
successfully delivered  
around the world

# 60+

years of successfully  
executed  
petrochemical  
projects

# 80+

years of  
refinery project  
execution excellence

## Chemicals

Chemical projects represent significant investments on the part of our customers and have an important role in the Energy Transition. These projects are becoming more complex by incorporating renewable power generation, electricity storage and charging, effluent and flue gas carbon capture, and hydrogen generation. Through collaboration with our customers focused on decreasing carbon emissions, we are shaping the future of energy.

We help our customers create the facilities that produce finished polymers and other end-products such as ethylene, polyethylene, polypropylene, butylenes, polyester and polyethylene terephthalate (PET), and polyvinyl chloride. We also assist with process design packages and technology through multiple licensors for polyethylene, polypropylene, the vinyl chain, and other products.

When engaged early in the project lifecycle, Bechtel delivers optimized solutions to help our customers realize projects with lower capital costs, shorter times-to-market, and lower carbon emissions.

### Opportunities for a low-carbon chemicals plant

The opportunities to reduce carbon emissions in a chemicals plant are extensive:

- Novel chemistries and processes to convert waste materials and emissions into valuable products.
- Renewable power generation (solar/wind).
- Low energy design elements, including electric drives, efficient compression systems, and low energy ejector desalination (LEEDs) in water treatment systems.
- Using electric furnaces to drive down a significant portion of a plant's CO<sub>2</sub> emissions.
- Incorporating carbon capture, use, and sequestration, and considering opportunities to collaborate and partner with nearby industries to create a carbon capture hub and share infrastructure.



For more information,  
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SMEs are located around the world, including in multiple centers of excellence, with expertise in the following chemicals and more:

AMMONIA

METHANE

METHANOL

DME

OLEFINS

GASOLINE

JET FUEL

DIESEL

### Using plastic waste as a chemical feedstock

Pyrolysis is one technique being used to convert plastic waste into energy and new products. However, there are also new hydrothermal technologies being developed to break down plastics using superheated water, which preserves the original chemical composition of the materials and allows for wider use of the recycled materials.

Bechtel is working with our customers and partners to identify and study the process technologies that could transform post-use plastic into sources of energy as chemicals or new recycled products.

### How Can We Help?

Supported by our world-renowned experts and the depth of their technology experience, technology development capabilities, and a suite of in-house licensed technologies, Bechtel is able to examine innovative solutions and identify the best solution for our customers' needs. This includes application of proven technologies, emerging technologies, and innovative combinations of both to lower carbon emissions for our customers.

- Design new facilities with renewable power to reduce greenhouse gases.
- Develop solutions to improve the sustainability of existing facilities.
- Deliver carbon capture facilities through plant design and construction.
- Incorporate electricity storage systems.
- Reduce carbon emissions by retrofitting existing plants with sustainable technology, such as converting steam drives to electric drives that source renewable power, adding carbon capture systems and bio-feed hydroprocessing.



### About Bechtel

Bechtel is a trusted engineering, construction, and project management partner to industry and government. Differentiated by the quality of our people and our relentless drive to deliver the most successful outcomes, we align our capabilities to our customers' objectives to create a lasting positive impact. Since 1898, we have helped customers complete more than **25,000** projects in **160** countries on all seven continents that have created jobs; grown economies; improved the resiliency of the world's infrastructure; increased access to energy, resources, and vital services; and made the world a safer, cleaner place.

Bechtel serves the Infrastructure; Nuclear, Security & Environmental; Oil, Gas & Chemicals; and Mining & Metals markets. Our services span from initial planning and investment, through start-up and operations.

[www.bechtel.com](http://www.bechtel.com)



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# ENERGY TRANSITION Renewable Power

## Renewable Power

### Cleaner energy solutions to support a sustainable future

Energy plays a key role in promoting social and economic progress — and technological advancements have created new opportunities to improve how we bring power to communities worldwide.

Our customers are accelerating their efforts to reduce carbon emissions and achieve a future of net zero emissions. Today, more than half of global gross domestic product is produced in countries and regions that have committed to decarbonization targets. Ahead of the next UN climate change summit, the focus is on the shift to a carbon-free global economy.

We share this sense of urgency. As the world continues to seek efficient ways to transition to alternative sources of energy, we are providing our customers with effective ways to contribute to a clean energy future. The Bechtel team can help deliver renewable energy via wind and solar.

### Wind

On and offshore wind are two of the fastest-growing energy technologies in the world. Bechtel brings a broad range of cross-sector engineering and design experts to help optimize the design, fabrication, installation, high voltage interconnection, and transmission of these technologies. Our customers also benefit from our legacy offshore oil and gas capability that provides valuable lessons for innovations to progress wind power projects.

#### On-Shore

##### New wind farm to increase West Virginia's wind power by nearly 15%

Clean, renewable energy for West Virginia residents surged forward when Clearway Energy Group selected the Bechtel-Reed & Reed Joint Venture to build its Black Rock wind farm in Grant County and Mineral counties. The new wind farm represents a nearly 15% increase in the state's wind power and will produce enough green energy to power 34,000 homes.



#### Off-Shore

Bechtel is partnering with windfarm developer Hexicon to demonstrate innovative offshore wind technology for large-scale floating power generation projects off the coast of the UK. The floating technology could be a game-changer in offshore power generation as it can be deployed in deep waters at a lower cost of energy than other solutions. This is essential to the industry that currently relies on shallow water platforms that are fixed to the seabed.



### Master Planning for net zero

# 26,700 MW

more than 26,700 MW  
of wind, solar, and  
hydroelectric projects

expertise with  
key solar energy  
technology, including

- Photovoltaic panels
- Concentrated solar

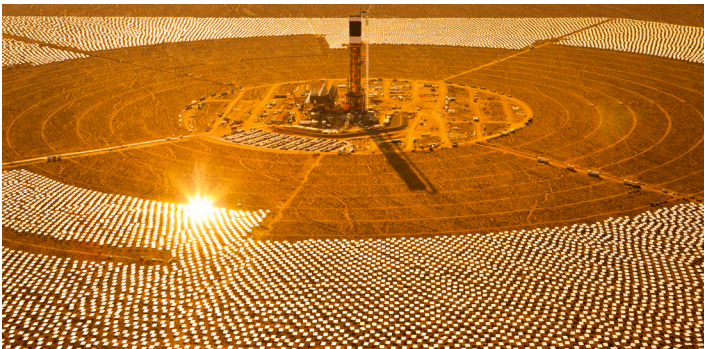




## Solar

The U.S. Department of Energy states that the world's energy needs for an entire year can be powered by the amount of sunlight that hits the earth's surface in just an hour and a half. That is an extraordinary statistic and one that focuses our minds on forward-thinking energy policies and practices to help us deliver the most efficient solar projects.

Bechtel is helping our customers add solar photovoltaic, as well as concentrating thermal solar power technologies to decarbonize their energy portfolios, including delivering some of the world's most landmark solar projects. We look forward to continuing to push the boundaries in this rapidly growing market.



### Ivanpah Solar Electric Generating System

- World's largest solar thermal energy facility that delivers clean, renewable electricity.
- Located in the Mojave Desert of southern California, the 377-megawatt Ivanpah Solar Electric Generating System is the world's largest solar thermal facility.
- Created through the joint effort of NRG, Google, and BrightSource Energy, Ivanpah produces enough clean, renewable electricity to power 140,000 homes. At the time, Ivanpah nearly doubled the amount of commercial solar thermal energy generated in the United States.



### California Valley Solar Ranch

- Renewable energy meets responsible engineering.
- California Valley Solar Ranch is one of the largest operating solar photovoltaic power plants in the world. This innovative power-generating project is generating clean, renewable energy for approximately 100,000 homes annually, helping California achieve its goal of generating 33% of its energy from renewables by 2020. In addition, 90% of construction waste was recycled on the project—40% more than required by San Luis Obispo County.
- Bechtel built the 250-megawatt facility for NRG Energy and SunPower. The California Valley Solar Ranch is a model for responsible design and construction that respects the environment and helps to advance the renewable energy industry.