BrightLoop™ Technology

For hydrogen, steam or syngas production with CO_2 isolation

BABCOCK & WILCOX

RENEWABLE | ENVIRONMENTAL | THERMAL

Providing solutions for the low-carbon **energy transition**

As the world advocates for decarbonization, industry is responding by looking for innovative ways to optimize its processes for a cleaner tomorrow. Emerging technologies to support the continuous drive to reduce greenhouse gas (GHG) emissions can form a cornerstone of corporate stewardship.

The BrightLoop™ process from Babcock & Wilcox (B&W) is a versatile and flexible technology which can be used for a wide range of applications. We've demonstrated that BrightLoop can effectively separate carbon dioxide (CO_2) while producing hydrogen, steam and/or syngas, as well as being ready for commercial scale-up.

A particle breakthrough made it happen. Our proprietary particle is an extremely versatile oxide in terms of application, cost and abundance making chemical looping possible for practical implementation in a low-carbon world.

The ultimate in flexibility

The BrightLoop system produces clean energy with complete in-situ CO_2 capture. You can simultaneously accomplish low-carbon initiatives and energy transition objectives. Just as importantly, there is built-in flexibility to maximize its potential for your specific needs.

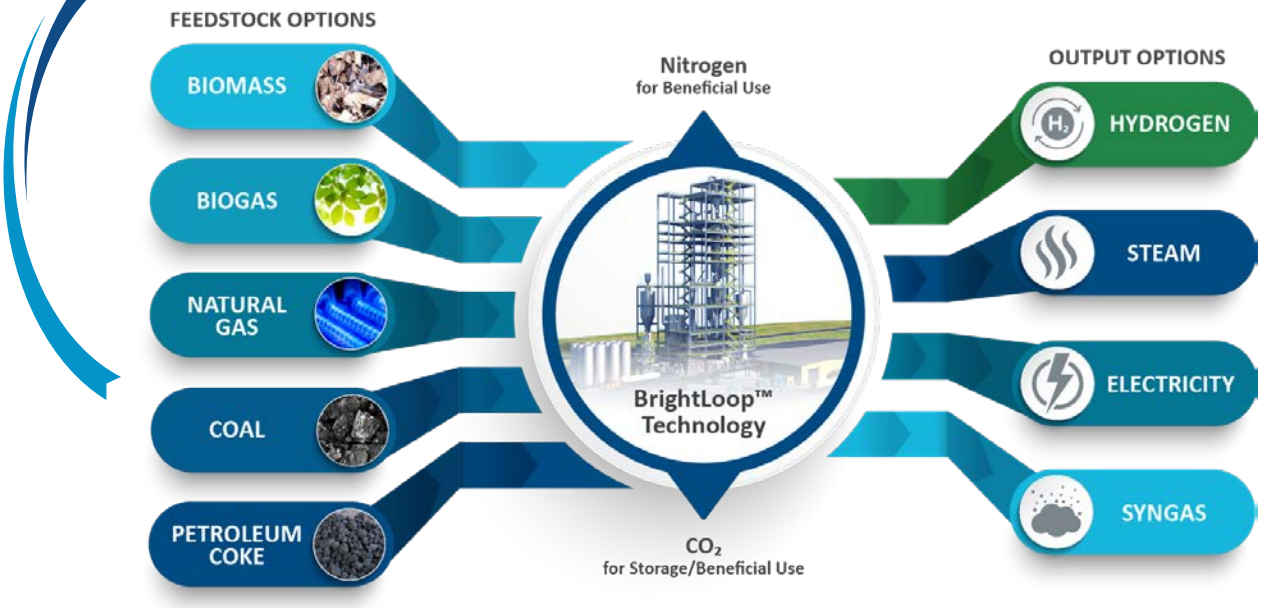
HYDROGEN FROM MULTIPLE FEEDSTOCKS B&W's BrightLoop chemical looping technology utilizes a variety of solid and gaseous fuels as feedstock to produce a stream of nearly pure hydrogen separate from a stream of CO_2. This greatly reduces the amount of energy and fossil fuel required to produce hydrogen from hydrocarbons while also effectively and inexpensively isolating carbon dioxide.

COMPETITIVE HYDROGEN COST BrightLoop chemical looping can produce low-carbon hydrogen at a cost better than current large-scale hydrogen generation technologies such as steam methane reforming (SMR) with carbon capture or electrolysis.

HIGH RATE OF CARBON CAPTURED Inherent CO_2 isolation without the need for expensive carbon separation equipment is part of the process. Generally, BrightLoop also has much lower Carbon Intensity (CI) scores as compared to other hydrogen production methods when combined with carbon capture due to the inherent separation of CO_2 and the wide range of feedstocks available. It has the potential to allow the continued use of solid and gaseous hydrocarbons in a cleaner, more environmentally friendly way, while still contributing to net-zero goals.

SCALABLE FOR A RANGE OF APPLICATIONS The BrightLoop process is scalable to accommodate small, medium and large applications. These various sizes accommodate market needs such as supporting local generation for transportation, centralized hydrogen hub generation, and industrial uses.

The BrightLoop™ system



BrightLoop chemical looping **advantages**

HYDROGEN FROM SOLID FUELS

HIGH RATE OF CARBON CAPTURED

COMPETITIVE HYDROGEN COST

SCALABLE FOR A RANGE OF APPLICATIONS

The BrightLoop process

The BrightLoop technology is a novel chemical looping process that is based on the oxidation and reduction of an oxygen carrier particle. The feedstock reacts with oxygen-carrier particles in a fuel reactor, forming reaction products which are predominantly CO_2, while reducing the oxygen-carrier particles.

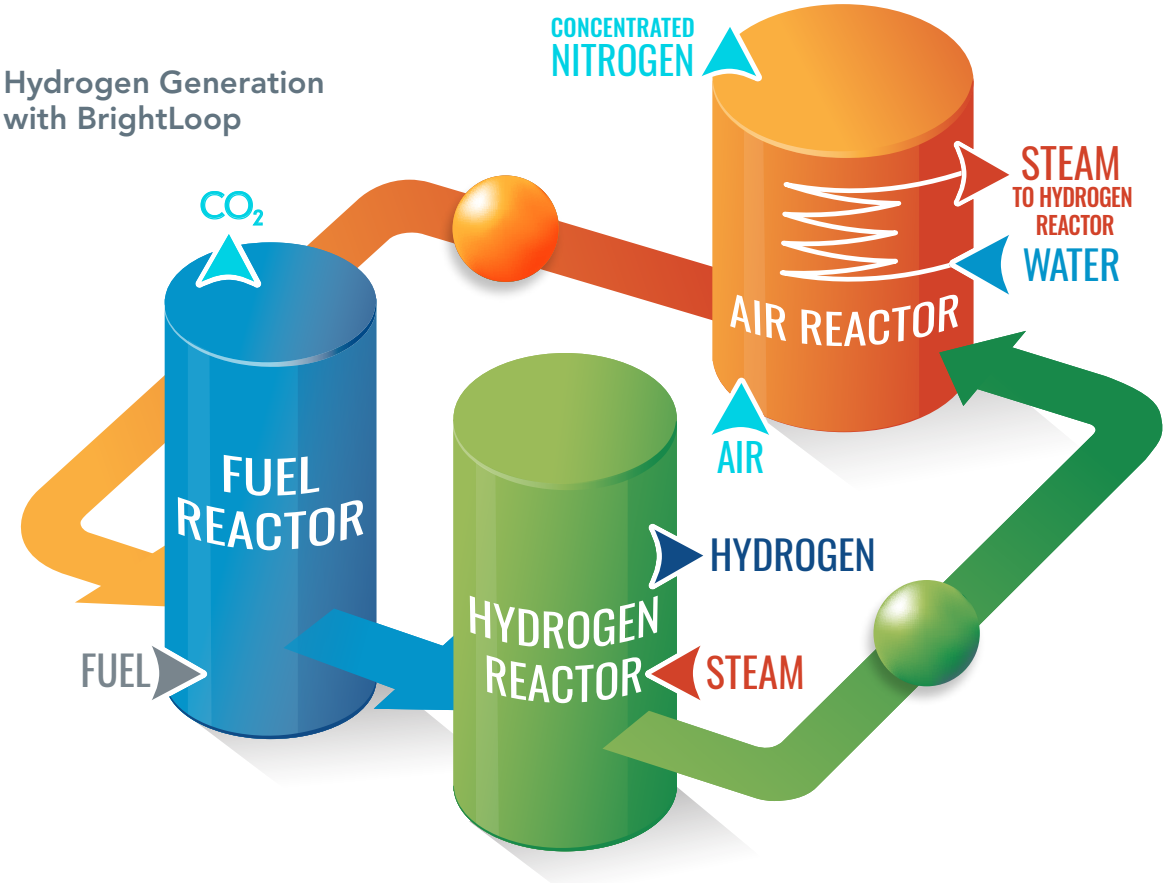
The reduced oxygen-carrier particles then move to a hydrogen reactor where they react with steam to partially oxidize the particles and generate a stream of hydrogen. This reaction means that the hydrogen is produced from the steam – it is not separated from the other constituents of the feedstock.

The oxygen-carrier particles are then transported to an air reactor where they are regenerated with air back to their original state. The products of these reactors are predominantly concentrated nitrogen with minimal oxygen. The fully regenerated particles are then returned to the fuel reactor to continue the "loop" process. The fuel and hydrogen reactors use moving-bed technology while the air reactor uses fluidized-bed technology.

Gaseous products generated in each reactor are cooled using various heat exchangers including steam generators that produce the steam needed to create hydrogen and cleaned of undesirable emissions using typical environmental control technologies.

The process can also be configured to produce steam for process or electricity generation, or syngas for liquid fuel or methanol production, all with CO_2 isolation.

Hydrogen Generation with BrightLoop



Applications with Various Product Outputs in a Low-Carbon Environment

The flexibility and scalability of B&W's BrightLoop technology, both in terms of usable feedstock and product outputs, provides for a wide range of industry applications. While hydrogen production is certainly considered a key component of the energy transition, other configurations and functions of BrightLoop chemical looping are available to meet low-carbon initiatives. Examples include:

- **Low-carbon hydrogen production as an alternative to steam methane reforming**
- **Net-negative energy production utilizing biomass**
- **Clean coal power production**
- **Waste byproduct utilization**

BrightLoop Ideal for Wide Range of Applications

Small Scale

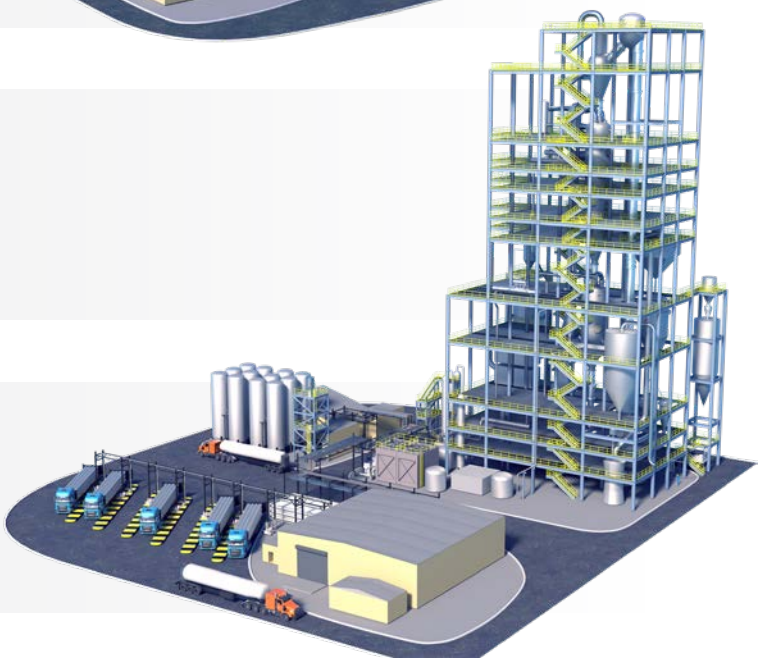
1–3 tons per day of hydrogen for industry, industrial equipment or transportation

Medium Scale

10–50 tons per day of hydrogen for industry

Large Scale

100–250 tons per day of hydrogen for central hub and power generation



Hydrogen Production Without Incineration or Gasification

Ready for Commercial Deployment

Under a DOE-sponsored project, B&W built a 250 kW_t coal-based CDCL pilot facility to demonstrate the fuel reactor and air reactor operation for application to steam (and subsequently, power) generation. On another project, continuous low-carbon hydrogen generation was demonstrated at the 250 kW_t pilot unit constructed and tested at the National Carbon Capture Center in Alabama.

Given the success of the pilot units, we are ready to commercially demonstrate the technology at a larger scale. B&W is working on projects to demonstrate low-carbon hydrogen and steam production while utilizing the most applicable fuel feedstock.

BrightLoop™ Technology

The bright way to an energy transition

Each day is another opportunity to:

CO_2llaborate, CO_2operate, CO_2mmunicate and CO_2nserve.

We have the *clean energy* ready for the energy transition.

babcock-decarbonization.com

B&W's BrightLoop technology can combine carbon capture with energy production while reducing or eliminating unused waste. It can help reduce the risk of operating within the uncertainty of a carbon-constrained world.

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Established in 1867, Babcock & Wilcox is a global leader in renewable, environmental and thermal technologies and services for power and industrial applications.

For more information or to contact us, visit our website at www.babcock.com.

E101-3260 D23J