Creating value through decarbonization: hydrogen's role in achieving net-zero

Decarbonization of high-carbon intensive processes, industries, and fuels can create added value streams with the right technology. By Christine Newell, Director, ClimateBright™, Babcock & Wilcox.

B&W is involved with several major projects including jointly developing a biomass-to-hydrogen clean energy project with Port Anthony Renewables Limited in Port Anthony, Victoria, Australia using B&W's BrightLoop™ technology

Social and regulatory pressure to lower emissions, coupled with the costs of doing so, can put many businesses at risk. But there are simple, yet impactful actionable steps plant owners and operators can take to build a solid foundation for a successful low-carbon business model while controlling costs.

Regardless of where a business is in its energy transition, owners may discover going green can create new revenue streams and help make a business more competitive.

Some key near-term steps plant owners and operators need to take including familiarizing themselves with greenhouse gas regulations and proposed regulations applicable to their industries, including tax credits, possible penalties and potential sources of government funding. Businesses also should work to create an Environmental, Social, Governance (ESG)/Sustainability Report if they haven't done so already.

Owners and operators also should plan now to source advanced technologies that create value while lowering emissions, source sustainable materials and create partnerships with carbon-conscious suppliers.

Climate Change Urgency Drives an Evolving Market

According the Climate Action Tracker web site, global greenhouse emissions peaked in 2020 at 53 GtCO2e which has led to warming of 1.2°C in 2021 above pre-industrial averages. The intention of the United Nations Framework Convention on Climate Change Paris Agreement, adopted at COP21 in 2015, was to keep warming below 2°C, preferably to 1.5°C, through drastic reductions in emissions.

With varying levels of decarbonization policies, nationally determined contributions (NDCs), and targets, the U.N. predicts the global mean temperature is more likely going to be 1.8-2.7°C by 2100 unless significantly more is done.

Fossil fuels for energy, transportation, and industry are heavy contributors to global warm-

	ETS or Cap-and-Trade (aka cap-and-invest, cap-and-dividend)	Carbon Tax
CO_2 Price	Varies; pre-defines carbon price but changes as emissions limits decrease	Constant
Emissions	Sets a cap, cap drops over time	Varies
Certainty of reducing emissions	High (emission reduction outcome is predefined)	Low (emission reduction outcome is not predefined)
Control	Emissions limits are controlled by offering permits; Pay to emit carbon up to cap; trade credits if under/over limits	Carbon levels restricted on a per ton basis; oil/natural gas/electricity is then taxed; Taxed on rate of carbon (and other GHGs) content of fossil fuels
Carbon Pricing Dashboard Status	32 initiatives covering 38 national and 31 subnational jurisdictions; represents 17%, 10 $GtCO_2e$, of the global GHG emissions	36 initiatives covering 28 national and 8 subnational jurisdictions; represents 5%, 3 $GtCO_2e$, of the global GHG emissions

Carbon Credits and taxes (see https://carbonpricingdashboard.worldbank.org/)

ing prior to 2020 but are expected to fall from 80% of the energy mix to 50% by 2050, according to DNV's Energy Transition Outlook. Oil and coal are expected to continue to have the largest declines, 50% or more reduction each, while natural gas use will remain mostly stable.

Policymakers need to be flexible in adopting new technologies and sources of clean fuels to lower emissions coupled with carbon capture to keep global warming at a minimum.

The Role of Hydrogen in Decarbonization

Excitement around hydrogen and carbon capture to facilitate emissions reductions has been gaining speed in the last few years with new technologies, infrastructure, and policies being developed backed by strong public support. Early adoption in strong markets such as in Europe, set the stage for future successes. The high cost of "going green" is projected to come down over the next decade as reliance on fossil fuels becomes more expensive.

Hydrogen has potential to be used in various applications such as: hydrogen for high-grade heating in steel/cement/pulp and paper processes, ammonia for fertilizers and chemicals, refining processes, blended with natural gas turbines for electricity generation, transportation fuel, or in the production of ammonia and methanol for large container ships. Hydrogen has many benefits and challenges:

• Plentiful, but costly to produce as a low-carbon energy carrier

• Combustible, but it reacts differently than natural gas

• Lightweight, but low energy density is an issue for transportation

• Liquid hydrogen and derivatives overcome this issue, but conversion is not efficient

• Great potential but also poses challenges for wide adoption

The carbon intensity for hydrogen applications varies but is often referred to by color, most typically: gray (high-carbon hydrogen) made with natural gas and no carbon capture, blue (low-carbon hydrogen) made with natural gas and uses carbon capture, and green (clean or green hydrogen) made with renewables or biogenic material with carbon capture. Currently, the cost of producing gray and blue hydrogen is cheaper than producing green hydrogen, but is expected to flip as carbon taxes increase, making blue and green hydrogen the more economical choices.

To achieve net zero targets, the International Energy Agency states that cumulative investment must increase to $1.2 trillion USD by 2030 and $10 trillion by 2050, but forecasts vary widely and at present there are just over $300 billion in identified projects. Only 13% of these projects are at the realized stage where final investment decision has been made or is in construction or operation. The IEA reports demand for low-carbon intensive hydrogen ranges from 100 metric tonnes in 2020 to 500 metric tonnes by 2050 and the demand for hydrogen is closely aligned with decarbonization strategies.

Coupled with carbon capture, blue hydrogen is a cost-competitive bridge to the costlier but more environmentally beneficial green hydrogen. Carbon reduction in hard-to-abate sectors is a key driver in meeting 2050 goals and is expected to require $9.7 trillion with current investment projections coming in short at $5 trillion. Carbon capture and storage (CCS) is included in 11 of the submitted NDCs with 2030-35 targets, and the IEA projects $700 billion per year will be needed between 2030 to 2035 via carbon pricing systems such as taxes and cap-and-trade.

Carbon dioxide is a versatile by-product of energy and hydrogen production and can be captured and stored underground in approved wells or under the seabed, or it can be captured and compressed to be transported to industrial facilities such as steel and cement mills and food and beverage plants for myriad uses. To achieve large-scale, competitive carbon capture, the costs to capture/store/trans-

B&W's ClimateBright Portfolio	Description	Possible Revenue Streams
BrightLoop	Chemical looping with proprietary regenerable oxygen carrier particle to generate hydrogen from a variety of fuels, including biomass, natural gas, petroleum coke, coal, municipal solid waste for waste-to-energy and syngas while creating a concentrated stream of carbon dioxide for sequestration or utilization	Low-carbon intensive hydrogen (sell to off-taker, use at site, credits), liquid nitrogen, ammonia, green steam for power, alternative fuels (green methanol, sustainable aviation fuels, etc.) Carbon dioxide utilization, credits, and tax avoidance
OxyBright	Post-combustion CO_2 scrubber, reduces 100% of CO_2 emissions, produces steam for power	
SolveBright	Post-combustion solvent CO_2 scrubber capturing 80-90% of CO_2 at the stack	

B&W's ClimateBright™ Portfolio

port typically needs to be under $50/metric tonne as the subsidies for fossil fuel powered entities are diminished or ended.

As of early 2022, the Global CCS Institute shows 29 carbon capture projects commercially operational in 11 countries: 1 Australia, 1 Brazil, 4 Canada, 4 China, 1 Hungary, 1 Iceland, 2 Norway, 1 Qatar, 1 Saudi Arabia, 1 UAE, 12 USA. In preparation of meeting net-zero goals, 500 sites in 13 countries have been determined to be capable of storing more than 12,000 billion tonnes of CO2, which is more than enough to meet global demand.

Cap-and-trade and Emissions Trading System schemes set the quantity of emissions reductions and let the market determine the price. By creating supply and demand for emissions allowances, these systems establish a market price for greenhouse gas emissions. A carbon tax sets the price of carbon dioxide emissions and allows the market to determine the quantity of emission reductions. The carbon market is estimated to be $0.4 billion in 2020 and $90-450 billion by 2050, according to CarbonCredits.com.

Government funding to facilitate research and development of new technologies and the build-out of required infrastructure is available from the U.S. Department of Energy, the government of Alberta, Canada, various funding tracks in the E.U., and from other government entities elsewhere. Government support and development of hydrogen hubs and carbon capture hubs including storage is a critical step to reaching net-zero.

The US announced $8 billion to develop at least four major hydrogen hubs and $12.1 billion for carbon management technologies and have Matchmaker programs for each to connect companies and build partnerships. Bilateral partnerships from approximately 35 countries are in talks or have been established to help facilitate a global hydrogen market.

Emerging Hydrogen and Decarbonization Technologies

As a global leader in decarbonization and hydrogen generation technologies Babcock & Wilcox (B&W) is positioned as a major partner in low-carbon intensive hydrogen production and carbon capture with its advanced ClimateBright™ portfolio of solutions. This exclusive portfolio contains the type of groundbreaking, game changing technology that is needed to propel us towards net-zero. B&W has paved the way to create value from waste by-products with revolutionary changes to traditional chemical looping and carbon capture technologies.

B&W continues to expand its decarbonization portfolio to include Direct Air Capture, Long Duration Energy Storage, and Green Steam while also holding themselves to high standards as outlined in their 2022 ESG report. An ESG report is a way for corporations to be held accountable for their sustainable practices.

Being an engineering firm, B&W supports the guidelines provided by Sustainability Accounting Standards Board's framework for Construction and Engineering Services. They are also a proud participant of the United Nations Global Compact, a volunteer initiative with over 16,500 companies in 158 countries determined to have fair and just sustainable future.

B&W recently announced a partnership with Kiewit Industrial to develop the world's largest net-negative CO2 biomass-to-energy facility for Fidelis New Energy using B&W's advanced biomass and proprietary OxyBright™ carbon capture technologies. The project, Project Cyclus, will produce sustainable aviation fuel, renewable diesel, green hydrogen, and bio-plastic feedstock with a net-negative carbon dioxide footprint.

In late 2021, B&W also entered into an agreement with Port Anthony Renewables Limited to jointly develop a biomass-to-hydrogen clean energy project in Port Anthony, Victoria, Australia using B&W's BrightLoop™ technology. When completed, the plant is expected to be part of the largest green hydrogen hub in southeastern Australia.

BrightLoop technology is part of B&W's ClimateBright suite of decarbonization solutions. It utilizes a proprietary regenerable oxide particle to generate hydrogen from a variety of fuels, including biomass, natural gas, petroleum coke, coal, municipal solid waste for waste-to-energy and syngas while creating a concentrated stream of carbon dioxide for sequestration or utilization.

One of the possible major hydrogen hubs in the US may be in the Ohio tri-state area. B&W joined the Stark Area Regional Transit Authority and 60 other companies to form the Ohio Clean Energy Hub Alliance to build support for the hub which is seeking $2 billion in grants from the U.S. DOE.

Tens of thousands of jobs could be created and would help build up the area's hydrogen bus fleet while also lowering the cost of hydrogen from $6-10/kg to $1/kg.

New Business Models

There are other opportunities in this changing market besides joining major hub alliances or developing new technologies. New business models may include reducing emissions to prevent tax penalties and/or become eligible for carbon credits if sequestering, storing, or utilizing carbon depending on market regulations.

If producing blue or green hydrogen, selling to an off-taker, using it on-site, or selling a by-product such as nitrogen, oxygen, or steam could be additional revenue streams. Hydrogen may also be eligible for low-carbon fuel tax credits as indicated in Alberta, Canada and the U.S. planning.

When natural gas prices are high, and coal is no longer an option, having alternative feedstocks (fuel for hydrogen production) is key in carbon-intense industries. By using green feedstocks such as certain biomasses, green hydrogen and green steam can easily be produced. Development of smaller hydrogen and carbon hubs through partnerships and alliances in addition to the government-funded major hubs creates a strong network to meet future supply and demand.

Several technologies already exist or are being developed to support these new business models including chemical looping, CO2 scrubbers, direct air capture, nature-based solutions such as planting trees and growing specific algae, and more. Carbon capture as a service (CCaaS) is a more recent development to fill a gap in the market where a company will take care of a customer's carbon needs from production to storage to utilization. Hydrogen as a reliable energy source is possible and economical with long-duration energy storage (LDES) of more than 60 hours.

Actions

We have less than three decades to meet net-zero targets by 2050 and are currently projected to have a gap of 19-23 GtCO2e to stay under 1.5°C under current pledges. This new low-carbon market provides ample opportunity for small and large companies, new and old, to participate in carbon reduction while adding jobs and increasing revenues.

What can businesses do?

Short-term (1-2 years)

• Determine current greenhouse gas (GHG) emissions output and what penalties may result for failing to reduce emissions within a certain timeframe. Learn local regulatory requirements. Businesses may not qualify for credits even if they are available; some markets are mandatory, some are voluntary.

• Source materials from sustainable companies

• Develop an ESG (Environment, Social, Governance) or Sustainability report showcasing GHG reduction goals

• Create a carbon reduction plan with achievable, incremental steps and contingencies for missing goals (pay penalties, adjust suppliers, etc.)

• Apply to government funding opportunities for technology development and scale up, and/or look for partners and alliances to join

Mid-term (3-5 years)

• Implement blue solutions like B&W's ClimateBright portfolio with a path to green

• A/B test new business models or continually adjust current business models to meet new goals

• Identify ways to fit within a circular economy

• Watch for new carbon storage locations and pipelines

• Watch for new hydrogen supplier hubs and pipelines

Long-term (5-10 years)

• Implement carbon-free solutions

• Partner with new carbon-conscious suppliers

• Tap into hydrogen and carbon networks

• Continue to innovate and reduce carbon until zero or negative

We face many challenges in reducing emissions to meet the Paris Agreement. Transparent assessments of governing policies, access to funding and collaborations, and active participation of all companies large and small will help us achieve net-zero. Under current policy, we are projected to miss the 1.5°C target, landing closer to 1.8°C or even 2.7°C.

Advanced technologies in conjunction with the development of hydrogen and carbon hubs and overall infrastructure, supported by policy, credits, and taxes, may not be enough to decarbonize the globe before overheating-past 1.5°C.

Now is time to be an active, impactful partner in the net-zero effort. With a growing suite of advanced low-carbon solutions available, Babcock & Wilcox is excited to collaborate in hard-to-decarbonize industries and find the ideal solution for your needs to create value in this time of transition.

More information

B&W is committed to environmental sustainability, designing, engineering and deploying technologies proven to help preserve the earth's natural resources.

www.babcock.com/hydrogen