Report- Accelerated Adoption of Hydrogen Fuel Cells: Policy and Regulatory Building Blocks

Abstract

At His Royal Highness The Prince of Wales' invitation, business leaders have formed a Taskforce, as part of the Sustainable Markets Initiative (SMI), to support accelerating the deployment of hydrogen as one of the decarbonization tools critical to achieving global net-zero emissions.

The SMI recognizes the important role that hydrogen will play in reaching global decarbonization goals and are committed to taking action that accelerates the deployment of renewable and decarbonized hydrogen across a broad range of uses. These include: the decarbonization of transport, industrial processes, feedstock, building heating, and enabling the large-scale integration of higher levels of renewables and other forms of clean energy; the efficient storage and distribution of energy across regions; and the improvement of energy systems resilience.

In this report, the Taskforce details the policy and regulatory levers needed to accelerate adoption of hydrogen fuel cells specifically for transportation, though keeping in mind the systemic advantages of hydrogen deployment and use the benefits of economy-wide hydrogen technology adoption are also taken into consideration. This document is intended to serve as a framework within which industry leaders could commit to a market-based plan to utilize the supply of renewable and decarbonized hydrogen while also providing guidance for an accelerated path with the right complementary policy measures.

Ultimately, to accelerate hydrogen adoption throughout the global economy, governments should design and execute national strategies; enact policies that reduce demand uncertainty; invest in infrastructure; continue research and development throughout the hydrogen value chain; implement policies to accelerate deployment of hydrogen; and work with international bodies to implement common definitions, codes and standards. These are the building blocks of accelerated adoption, and they are detailed in the sections that follow.

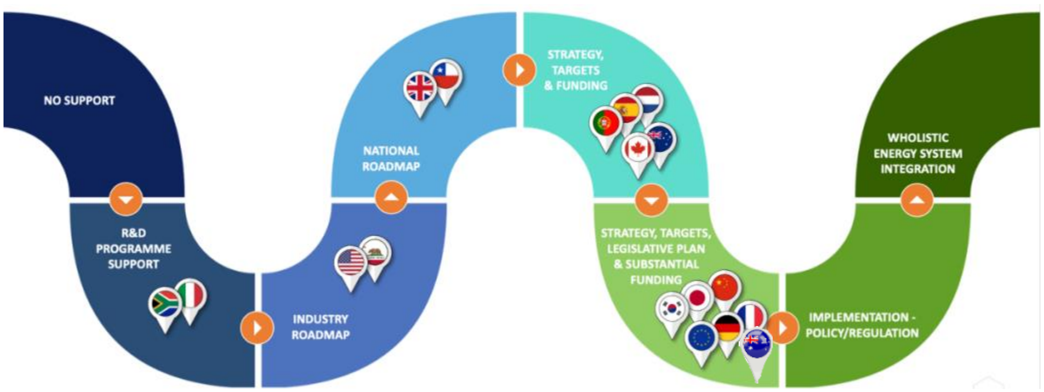
Hydrogen as Key Enabler of Transportation Decarbonization

A key component of any strategy to decarbonize the global economy and promote regionally localized manufacturing and innovation is hydrogen. Hydrogen is a versatile energy carrier that can be used as a feedstock to decarbonize products and processes in sectors including steel and chemicals, as a fuel in the mobility, heat and power sectors, and as seasonal energy storage for the integration of more renewable energy in the electricity and gas grids. Its potential applications also include hydrogen-based fuels such as power to liquids or power to gas, and feedstocks such as ammonia and methanol. It can be produced from renewable and decarbonized electricity, renewable gases and fossil fuels with carbon capture and storage. It produces zero emissions at point of use in a fuel cell, can be stored and transported at high energy density in liquid or gaseous form and can be combusted or used in fuel cells to generate heat and electricity.[1] All of these qualities make it a critical enabler of the energy transition as a means to store renewable electricity, as a zero-tailpipe emissions transportation fuel, or as a clean solution for industrial processes.

Across the globe countries and regions have adopted varying policies and strategies to accelerate hydrogen deployment, as seen in Figure 1. Initial policies and direct investment in new projects have been announced. However larger efforts are required as widespread adoption faces challenges.

Figure 1 – Many countries are well advanced with national strategies, targets and funding

(Source: Hydrogen Council)

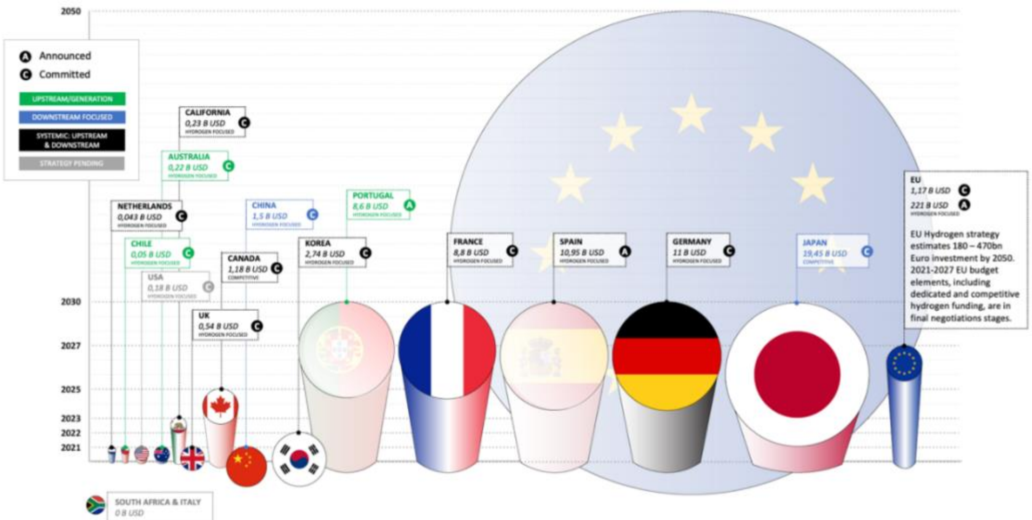


Europe and East Asia are investing heavily in hydrogen and fuel cell promoting policies, with the European Union pledging to invest hundreds of billions of dollars in in their "hydrogen strategy for a climate-neutral Europe", South Korea committing to invest $34B USD, and Japan publishing the first ever national hydrogen plan[2], as seen in Figure 2.

Figure 2 – Significant Funding Commitments for Systemic Support **(Source: Hydrogen Council)**

[1] (Hydrogen Council, 2017)

[2] (Hydrogen Council, 2020)



Continued investment and planning for the hydrogen economy will create economic and competitive benefits commensurate with the decarbonization prospects of the technology. Similarly, all regions should consider investing in scaling up capacity to reduce the cost to produce renewable and decarbonized hydrogen and the associated infrastructure. Finally, policy makers may use both available and innovative tools to solve the problems the market cannot. Those tools are for example direct incentives for infrastructure and deployment; complementary policies which create demand and accelerate adoption, and universal safety and operational guidelines and regulations.

Building Block 1: Design and execute national strategies

Storage and transmission from intermittent renewable energy sources and increasing electricity demand will create enormous strain on the electricity generation capacity. Grid capability, intermittency, as well as application of low-carbon seasonal storage and back-up generation capacity will be challenges to address. Hydrogen helps optimize the power system for renewables, facilitating further increases in renewable share of generation. Policies should accelerate renewable and decarbonized hydrogen production to create scale and increase demand for renewable and decarbonized hydrogen.

Some hard-to-abate sectors cannot be decarbonized via the grid or with batteries alone, specifically commercial vehicle or off-highway transportation and industry. In many of these sectors, direct electrification is and will remain technologically challenging or economically inefficient. Renewable hydrogen or hydrogen utilizing fossil fuels with carbon capture and sequestration offer a decarbonized solution for these applications. Investing in these renewable and decarbonized hydrogen sources will realize both the economic, climate and air quality benefits governments seek.

Renewable and decarbonized hydrogen strategies are needed to ensure policy direction and integration as well as technology and investment certainty. Countries should develop long-term cross-sectoral, economy-wide strategies for hydrogen with clear long-term objectives and critical short and medium-term milestones. Key sectors include transport, refining, chemicals, iron and steel, buildings, power generation and storage, and shipping. The strategies should also discuss infrastructure and storage needs, as well as the potential role of imports and exports. Establishing hydrogen trading routes, taking lessons from the existing natural gas trading system and support from the International Maritime Organization (IMO) will also facilitate both supply and demand globally.[3] Hydrogen strategies can also ease market concerns by addressing access to suitable land, water, renewable energy, ports, and offtake markets. Accelerating adoption in any one sector will be beneficial and can also create a virtuous circle of supply and demand in other sectors.

To help close the cost gap with hydrogen produced from Steam Methane Reformation (SMR) governments should implement time-limited subsidies. The level of the subsidy should be determined through a competitive allocation process. Today, many funding schemes applied are focusing on CAPEX subsidies. In an accelerating hydrogen space, the investment alone is not the challenge anymore. Even more so, the cost difference between hydrogen produced with SMR compared to renewable hydrogen is the bottleneck for more project investment.

Additionally, specific support for renewable and decarbonized hydrogen in renewable transport fuel obligations, like multipliers that allow for renewable and decarbonized hydrogen to be counted X times its energy content towards a defined target, will incentivize production for transportation.

Continued research and innovation funding programs are needed to encourage development of technologies which are still at low readiness levels (e.g. liquefaction of hydrogen at scale, hydrogen-based fuels, hydrogen-powered ships and aircrafts) and improve or upscale existing technologies (e.g. fuel cell-powered trucks, electrolyzers, 100% hydrogen pipelines, high efficiency compression technologies and underground storage). Policy options include allocation of more support to R&D and the creation of partnerships/programs that cover the entire hydrogen value chain, and further coordination between national R&D bodies to align R&D funding opportunities.

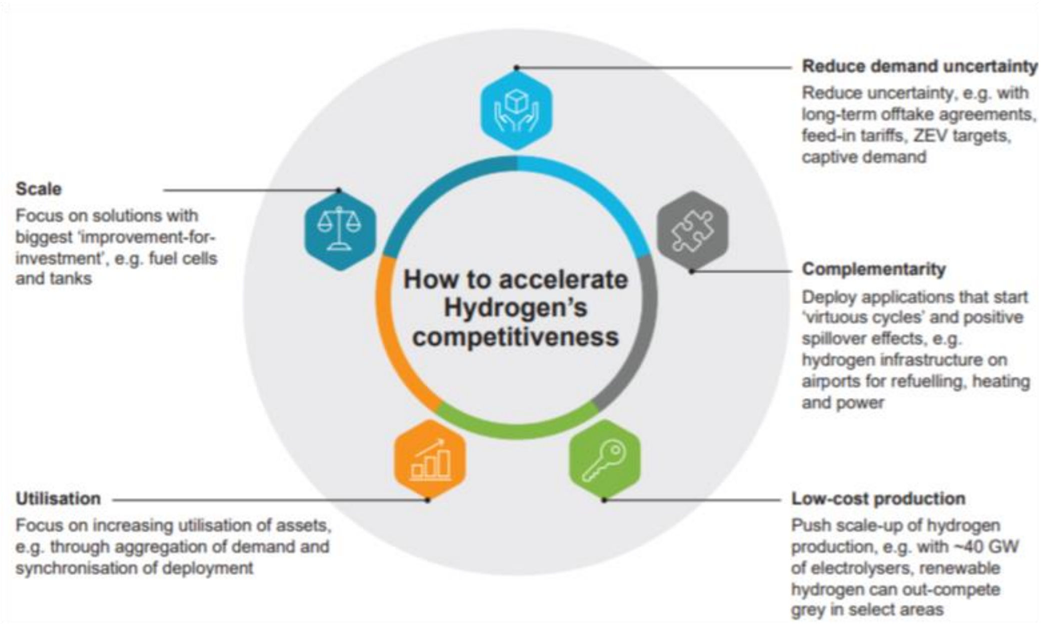
Finally, in conjunction with industry commitments to invest, support is needed for industrial scale integrated demonstration projects and associated infrastructure including carbon capture, transportation and storage or use until production levels of renewable and decarbonized hydrogen achieve critical levels. This can be achieved through public grants or subsidies (covering both capital and operating expenditures), loan guarantees and policies to support to secure long-term storage liability for CO_2 storage.

Building Block 2: Reduce demand uncertainty

To achieve this potential, it is critical that governments set a vision for scaling up. The transition cannot happen overnight, and investments by both public and private sector should be done thoughtfully, with a focus on closed eco-systems that may operate independently of broader regional energy systems and can transition broadly and early, with accompanying air quality benefits, like ports and industrial facilities. The following graphic from the Hydrogen Council's Pathways to Hydrogen Competitiveness Study outlines the 5 complementary levers to encourage efficient deployment:

Figure 3- Hydrogen Acceleration Cycle **(Source: Hydrogen Council)**

[3] (International Energy Agency, 2019)



To reduce demand uncertainty for hydrogen, electric grid regulation adopted by public utility regulators and markets like long-term offtake agreements, feed-in tariffs and transportation emissions reduction targets can ensure investors of continuing demand and reduce uncertainty as a barrier to developing hydrogen projects. Early deployment in complementary/adjacent applications, like ports, can create virtuous cycles that quickly scale up and reduce cost. A port, for example, could invest in renewable electricity for green hydrogen production through electrolysis and use the hydrogen produced to power its forklifts, drayage trucks and facilities. That initial ecosystem could grow to power the rail and long-haul trucks that move goods inland, and even the ships the ports serve. This, of course, would require integrated planning and low-cost production of renewable and decarbonized hydrogen, which can be achieved by continued scale from these initial pilot programs. This type of deployment speaks to the utilization potential of hydrogen across the industrial value chain. Government funded sectoral pilot projects to decarbonize hydrogen for industrial processing facilities that already use hydrogen produced by steam-methane reformation (SMR) to refine fuels, among other things would also be an effective use of demonstration funds. Deployment of large scale electrolyzers in these hard-to-abate sectors will enable efficient utilization of the resources available. Finally, focusing on scaling up complementary technologies with the most room for improvement per investment- like proton exchange membrane (PEM) or alkaline fuel cells that run on hydrogen and hydrogen storage tanks, can further increase the use-cases for the hydrogen produced. Each piece of this puzzle not only reinforces the use case, but lowers cost for the others, enabling a smart and strategic scale up for industry.

National governments should also undertake economy-wide infrastructure planning and investment to accommodate hydrogen. This can include strategic industrial areas, multi-user facilities, and multi-user infrastructure. To address mobility infrastructure specifically, public private partnerships to develop refueling stations help eliminate first mover risks and pave the way out of the chicken and egg dilemma between supply and demand.

The retrofitting of existing and new gas infrastructure to transport hydrogen and the development of new dedicated hydrogen infrastructure including storage should be included in infrastructure regulations. This includes support for the retrofitting of unutilized gas infrastructure to transport hydrogen including cross-border networks, provisions that support the development of new dedicated hydrogen infrastructure, hydrogen and CO_2 storage and potential future retrofitting of LNG terminals. Appropriate incentives (e.g. grants, subsidies, tax rebates) should also be in place at a federal and state/province level to support the construction of a hydrogen infrastructure network in strategic locations.

Conditions to create a future well-functioning liquid hydrogen market should start to be developed now. To do that, governments should support pipeline modernization and further expand the scope of unbundling of network related activities to accommodate production and sales of hydrogen. Policies should allow non-discriminatory third-party access (TPA) to network infrastructure to ensure different competitive parties can participate in the hydrogen market without the need to build their own network infrastructure. Further, transparent and non-discriminatory tariffs for access to networks can ensure tariffs reflect efficient costs and do not create a barrier to trade.

Building Block 3: Invest in Infrastructure

Governments seeking to accelerate adoption of hydrogen and fuel cell technologies should adopt three goals: promoting infrastructure, development, and deployment. These goals should also address hydrogen and fuel cell supply chains both in terms of responsibly sources raw materials and adequate supply to avoid some of the critical mineral complications of battery supply chains. There are several levers policymakers can use to achieve those goals. They can enact tax policy and establish development and deployment grant programs throughout government and procurement agencies. Regulators can implement standards that reduce emissions for current technologies and close the difference in cost between conventional and decarbonized technologies. All policies should promote long-term shared vision strategies to give investors and business visibility to invest in the right technology and project development.

Building Block 4: Continue research and development

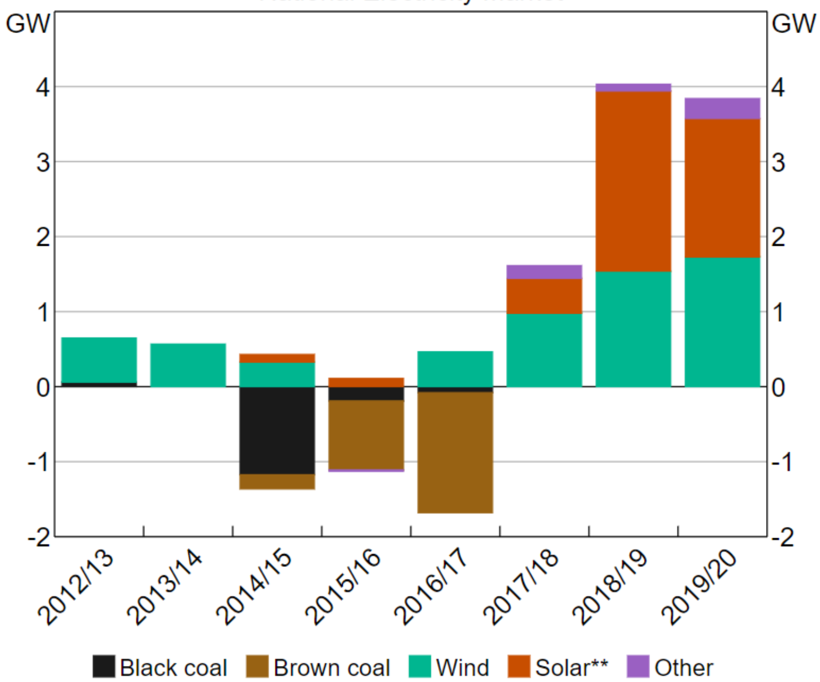
Clean energy technologies like wind and solar were adopted because of technological advancements made in partnerships between industry and government resources, and tax and procurement policy that incentivized adoption. Hydrogen, similarly, can solve for the development side of the equation by continued robust funding for research. Australia serves as a good example where rising gas costs and falling solar prices, along with complementary policies enabled a quick scale up as seen in figure 4:

Figure 4- Australian Power Generation Investments **(Source: Reserve Bank of Australia)**[4]

[4] (Reserve Bank of Australia, 2020)

New Generation Investment and Withdrawals*

National Electricity Market



* Estimate for 2019/20 based on planned commissioning of committed projects in the NEM

** Excludes rooftop solar photovoltaic installations

Sources: AEMO; AER; RBA

For hydrogen to achieve a similar trajectory, additional research is needed to optimize for weight, cost, efficiency and manufacturing capability of both hydrogen and fuel cell technologies, and to optimize their performance for various applications like long-haul trucking and stationary power generation.

Building Block 5: Accelerate deployment

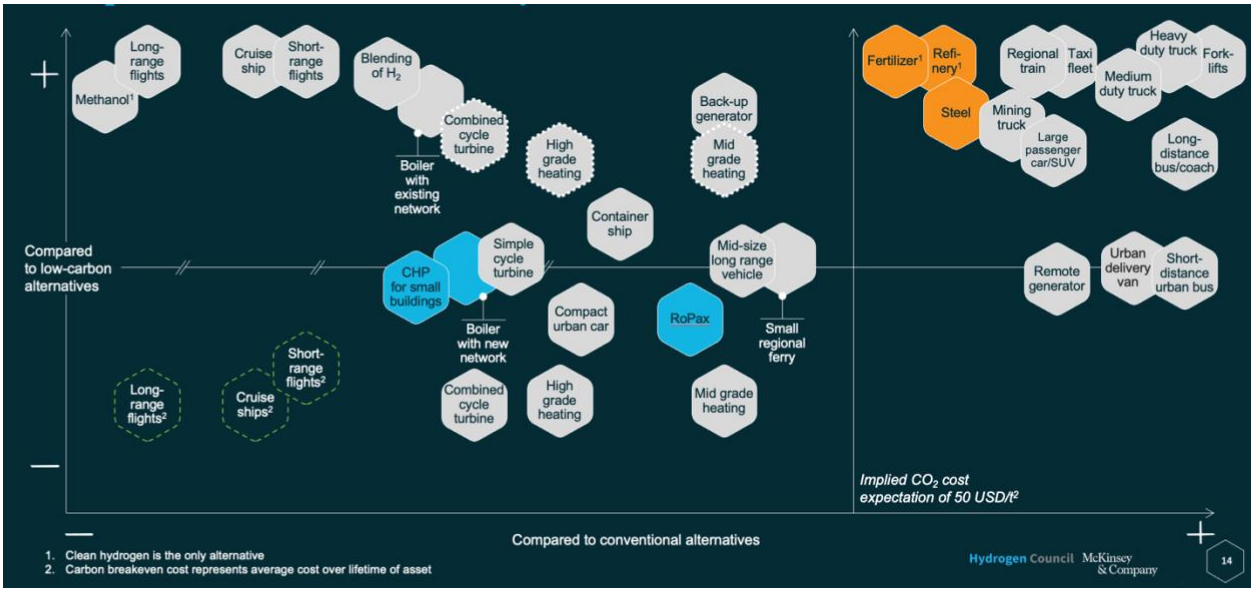
Deployment can be achieved by extension and expansion of subsidies for hydrogen production, fuel cell powered vehicles, hydrogen fueling infrastructure and fuel cell stationary power that phase out with market maturity. Complementary technologies like carbon capture, utilization and sequestration that can effectively decarbonize hydrogen should also subsidized.[5][6] Existing or new grant programs for government procurement of fuel cell powered federal fleets, grid-wide clean energy standards, and low carbon fuel incentives can also drive adoption. Explicit carbon pricing mechanisms are also crucial to build the social cost of carbon into economic decision-making and to internalize the externality of the emissions. Countries can also implement a Carbon Contract for Difference (CCfD) mechanism to subsidize hydrogen deployment. Government should also make sure the additional measures complement and don't undermine any existing policies that are in placed to drive industrial decarbonization. To protect from the carbon leakage risk, rules would need to be simultaneously implemented to avoid losing competitiveness in domestic and international markets. To that end, some

[5] (US Fuel Cell Hydrogen Energy Association, 2020)

[6] (US Fuel Cell & Hydrogen Energy Association, 2020)

countries are giving free allowances to emissions intensive and trade exposed industries, others are considering Carbon Border Adjustments mechanisms. In parallel, policies to promote the use of low carbon products (low carbon steel, chemicals, fertilizers, fuels) in end-use sectors can accelerate the demand side of the equation. Figure 4 illustrates the wide variety of sectors that are competitive for accelerated deployment:

Figure 4 – A wide variety of Applications are Competitive **(Source: Hydrogen Council)**



Regulatory policy also has a role to play. More stringent regulations on emissions from stationary and mobile power sources will drive additional technology on incumbent applications. When that equipment becomes more expensive due to added pollution controls, the delta between incumbent technologies and decarbonized options shrinks, creating more market pull for hydrogen and fuel cells. This clarity and vision from the policymakers will send a signal to the market to continue robust investment in these technologies and projects to advance the scale up. Vehicle performance standards for NOx, Particulate Matter (PM) and CO_2 have proven to have the greatest impact on changing the fleet from fossil fuel to alternative fueled low emission and zero emission vehicles.

In parallel, customer support measures such as tax rebates or direct subsidies to encourage the take up of hydrogen vehicles, fiscal levers on energy products, financial support for building of retail sites and distribution network, acceleration of permitting processes as well as policies to encourage the building of the supply infrastructure should be in place.

Building Block 6: Implement common definitions, codes and standards

One of the most important policy aspect governments can do to accelerate deployment of hydrogen is to promulgate a common set of definitions, codes and standards. National government should work with international partnerships like the International Partnership for Hydrogen Energy (IPHE) to define a terminology for Clean Hydrogen based on GHG emissions together with a methodology to calculate life cycle greenhouse gas emissions.

Policy framework should include comprehensive definitions for the different types of hydrogen and hydrogen-based fuels, using a lifecycle analysis based GHG intensity measure. This should be aligned globally.

Local or regional markets may consider a scheme of trackable and tradable renewable and decarbonized hydrogen certificates based on greenhouse gas intensity. However, administrative complexity should be minimized, and double counting of low carbon-intensity gases should be avoided in existing systems. The EU system of Guarantees of Origin represents a methodology that could be built on. This is a highly complex and technical issue that will require the power of global governments convening the right technical experts throughout the value chain. Finally, technical standards need to be developed for hydrogen storage, pressurization, blend rates and tanks. Promulgating one set of common standards will enable industry to leverage the global supply chain and bake more certainty into the large investment this will require.

Conclusion

Hydrogen and fuel cell technologies present a fantastic opportunity to enable widespread renewable energy adoption while also decarbonizing hard-to-abate sectors. Government investment in the hydrogen economy can create jobs, growth and increase competitiveness. Scaling up the hydrogen capability globally will reduce costs and accelerate adoption of renewable and decarbonized hydrogen more quickly if done strategically and with government leadership. This can be achieved by policies that promote development, deployment and infrastructure through tax, grant and regulatory policy. To meet these ambitious goals, governments need to promote collaboration across sectors, regions, supply chains and sectors. Realizing the potential of hydrogen is a key enabler of reaching the goals of the Paris Climate Agreement of net-zero emissions by 2050.