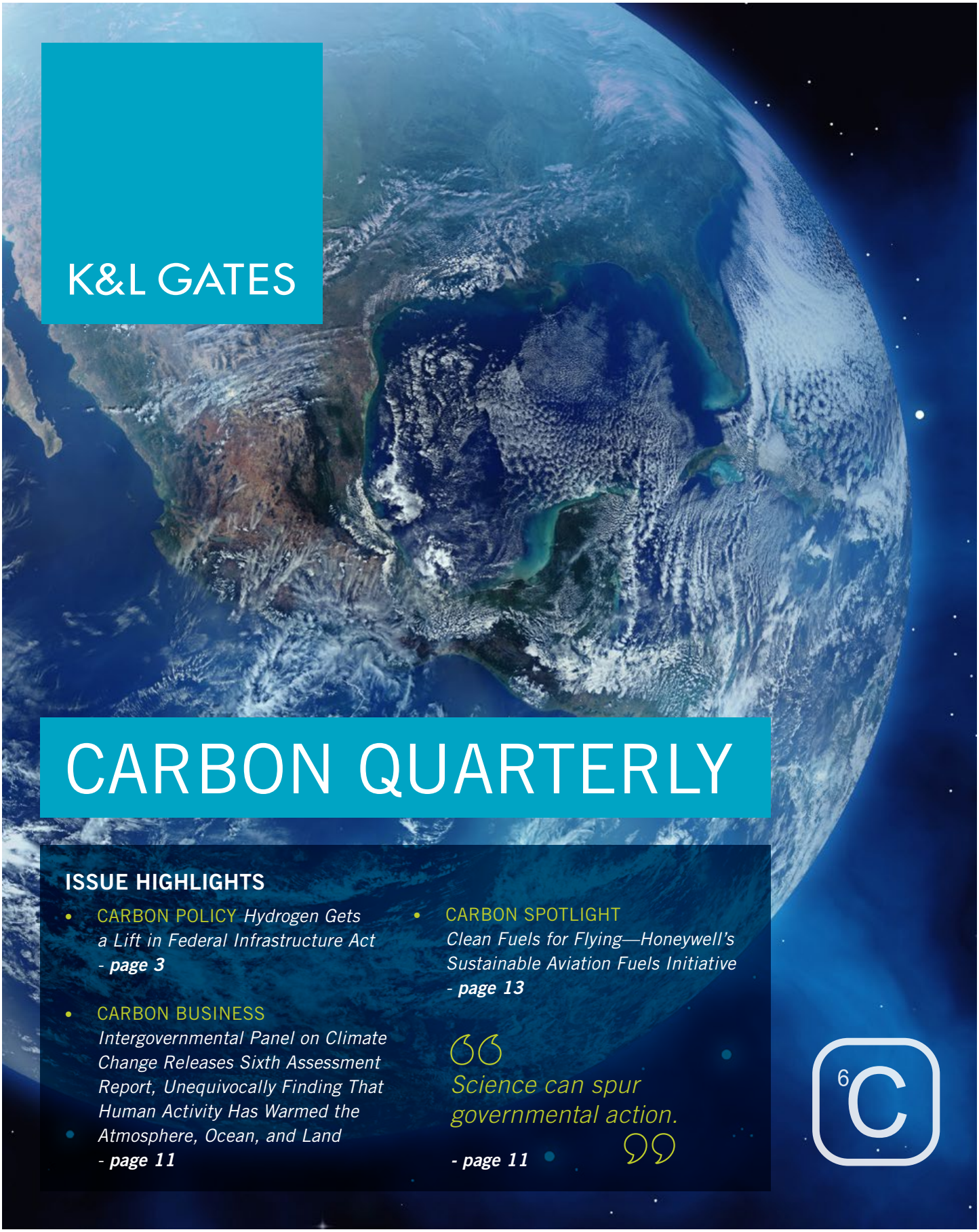

K&L GATES

CARBON QUARTERLY

ISSUE HIGHLIGHTS

> *Science can spur governmental action.*
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What's Inside

The Carbon Quarterly is a newsletter covering developments in carbon policy, law, and innovation. No matter your views on climate change policy, there is no avoiding an increasing focus on carbon regulation, resiliency planning, and energy efficiency at nearly every level of government and business. Changes in carbon—and more broadly greenhouse gas—policies have the potential to broadly impact our lives and livelihoods. Carbon Quarterly offers a rundown of attention-worthy developments, including:

Carbon Policy

HYDROGEN GETS A LIFT IN FEDERAL INFRASTRUCTURE ACT

On 5 November 2021, the U.S. House of Representatives passed the Infrastructure Investment and Jobs Act (IIJA), a/k/a the "infrastructure package," by a vote of 228 to 206. Six Democrats voted against the bill, but 13 Republicans voted for it, providing the votes needed for it to pass. The Senate had passed the bill on 10 August, and President Biden signed the bill into law on 15 November.

The bill includes significant programming for hydrogen, including funding to build out new charging and fueling infrastructure that includes hydrogen fuel cells; language directing the Department of Energy (DOE) to "develop a national strategy and roadmap to facilitate wide-scale production, processing, delivery, storage, and use of clean hydrogen"; funding for research and development (R&D) related to clean hydrogen manufacturing and recycling; and funding for electrolysis demonstrations and for four regional clean hydrogen hubs to "demonstrate the production, processing, delivery, storage, and end-use of clean hydrogen."

The Department of Transportation (DOT) and the DOE have begun issuing Requests for Information (RFI) and holding webinars to outline the path forward for the hydrogen provisions in the bill.

Below we discuss each of the new hydrogen programs in more detail.

Charging and Fueling Infrastructure Grants

The bill authorizes US$2.5 billion from the Highway Trust Fund over five years for a new grant program for charging and fueling infrastructure as follows:

- US$300,000,000 for fiscal year 2022;
- US$400,000,000 for fiscal year 2023;
- US$500,000,000 for fiscal year 2024;
- US$600,000,000 for fiscal year 2025;
- US$700,000,000 for fiscal year 2026.

The Highway Trust Fund is funded mainly by federal gas and diesel taxes. Since the charging and fueling infrastructure grants are funded by the Highway Trust Fund, the program can move forward immediately without going through the appropriations process.

Grants will be for charging and fueling infrastructure, including hydrogen fueling infrastructure, that is publicly accessible along major national highways that the DOT is to designate within 180 days of enactment of the bill (mid-May). The bill requires the DOT to establish a recurring process for updating and redesignating corridors.

The deadline for the DOT to establish the grant program is one year following enactment of the bill (mid-November 2022). Before then, the DOT, along with the DOE, will develop guidance for this new grant program. To assist with guidance development, the Federal Highway Administration (FHWA) at the DOT issued an RFI, inviting the public to provide comments, noting that they are "especially interested in comments suggesting ways that the guidance could promote equity in the deployment of EV charging infrastructure…." FHWA will accept comments through 18 January 2022.

Entities that are eligible to receive grants under this program are:

- states or political subdivisions of states;
- metropolitan planning organizations;
- units of local government;
- special purpose districts or public authorities with a transportation function, including port authorities;
- Indian tribes;
- territories of the United States;
- authorities, agencies, or instrumentalities of, or entities owned by, one or more entities described above;
- a group of entities described above.

The entities listed above are expected to contract with a private entity for the acquisition and installation of publicly accessible hydrogen fueling infrastructure, and other charging and fueling infrastructure, for charging or fueling vehicles.

Grants will be provided to applicants on a competitive basis, and while the DOT will develop guidance for the grant program, the bill outlines some information that should be included in any proposal, including a description of how the organization seeking a grant has considered public accessibility of the proposed infrastructure; real-time public information about the infrastructure; "payment methods that ensure secure, convenient, fair, and equal access"; information about the applicant's collaboration

with stakeholders including auto manufacturers, utilities, infrastructure providers, metro planning organizations, states, fleet managers, and others; the long-term operation and maintenance of the equipment; and an assessment of the estimated emissions reduction expected through the use of the charging or refueling infrastructure using a tool called the Alternative Fuel LifeCycle Environmental and Economic Transportation (AFLEET).

In selecting grant awardees, the DOT is instructed in the bill to consider to what extent the application would, among other things, meet market demands for fueling infrastructure; provide access to charging or refueling infrastructure in areas of need; accelerate construction of charging or fueling infrastructure that would be unlikely to be completed without federal assistance; deploy charging or hydrogen fueling infrastructure for medium- and heavy-duty vehicles in proximity to intermodal transfer stations; and ensure, to the maximum extent practicable, geographic diversity among grant recipients.

Awardees may use a portion of grant funds for operating assistance for the first five years of operation following installation, while the facility transitions to operate independently.

Community Grants

Fifty percent of the funding above will be used for community grants, which will be capped at US$15 million each, and the federal share shall not exceed 15% of the total project. These grants will be provided to government entities listed above to fill in the gaps in charging and fueling infrastructure. Community grants can be used to locate charging and fueling infrastructure on public spaces, including public roads, buildings, parking facilities, public schools, and public parks. The legislation directs the secretary of transportation to give priority consideration to projects in rural areas, low- and moderate-income neighborhoods, and communities with a low ratio of private parking spaces to households or a high ratio of multiunit dwellings to single-family homes.

Appalachian Regional Energy Hubs

The IIJA gives the Appalachian Regional Commission the authority to provide grants, technical assistance, and other funding to individuals or entities in the Appalachian region for a variety of energy-related projects, including establishment of a regional energy hub in the Appalachian region for natural gas and natural gas liquids including hydrogen produced from the steam methane reforming of natural gas feedstocks. Senator Manchin (D-WV), Chair of the Energy and Natural Resources Committee, is very supportive of hydrogen, and this provision would support production of hydrogen from natural gas reforming, a process that currently produces over 90% of U.S. hydrogen.

Generally, grants will be capped at 50% of the cost of the project. But grants for projects or activities carried out in a county with a distressed county designation will be capped at 80%. For those in a county for which an at-risk county designation is in effect, funds will be capped at 70% of the project cost. The bill provides US$5 million/year from 2022 through 2026 for this program.

Clean Hydrogen Research and Development Program

The bill expands the existing hydrogen program at the DOE, setting a number of goals for the department, including demonstrating and commercializing technologies for the use of clean hydrogen in the transportation, utility, industrial, commercial, and residential sectors; and demonstrating a standard of clean hydrogen production in those sectors by 2040. The bill also addresses the use of hydrogen to enhance sources of fossil fuels with carbon capture, utilization, and sequestration; renewable fuels; biofuels; and nuclear energy.

The DOE is directed to work with the private sector to develop a schedule of hydrogen cost goals and accelerate the production of clean hydrogen from a number of energy sources, including fossil fuels with carbon capture, utilization, and sequestration; renewable biomass; hydrogen-carrier fuels like ethanol and methanol; and nuclear energy. In addition, the bill directs the DOE to work with the private sector to advance the use of clean hydrogen for commercial, industrial, and residential electric power generation and in industrial applications including steelmaking, cement, chemical feedstocks, and process heat.

The hydrogen R&D program will also focus on the safe and efficient delivery of hydrogen or hydrogen carrier fuels, including transmission by pipelines, tanks, and other distribution methods. In addition, the program is to advance the convenient and economic refueling of vehicles, locomotives, maritime vessels, and planes.

The list of priorities for the hydrogen R&D program includes the storage of hydrogen or hydrogen-carrier fuels; the development of safe, durable, affordable, and efficient fuel cells; and the development of appropriate, uniform codes and standards for the safe and consistent deployment and commercialization of clean hydrogen production, processing, delivery, and end-use technologies.

Within 180 days of enactment of the IIJA, the DOE is directed to establish a timeline for challenge targets that the program will aim to address.

The bill provides US$500 million in appropriations, split evenly over five years from 2022 through 2026.

Regional Clean Hydrogen Hubs

A much-discussed new program in IIJA is the Clean Hydrogen Hubs program. The bill includes US$8 billion in appropriations, divided evenly over five years from 2022 through 2026 (US$1.6 billion/year for five years).

The Clean Hydrogen Hubs program will be administered by the DOE and is described in the bill as a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity.

The bill authorizes the secretary of energy to establish this program, which will support a minimum of four regional clean hydrogen hubs. These hubs are to help the DOE achieve goals they will set for meeting established challenges in order to accelerate deployment of a hydrogen economy. In addition, the DOE will choose hubs that ultimately can be developed into a national clean hydrogen network.

Within 180 days of IIJA's enactment (mid-May), the DOE will solicit proposals for the clean hydrogen hubs. And within one year after the deadline for the submission of proposals, the DOE is directed to select at least four regional clean hydrogen hubs.

The bill mandates that the hubs will have diverse feedstocks for the production of hydrogen: at least one hub shall demonstrate clean hydrogen production from fossil fuels; at least one will demonstrate clean hydrogen production from renewable energy; and at least one will demonstrate clean hydrogen production from nuclear energy.

The bill also mandates diversity in the end use of the hydrogen produced by the hubs. At least one hub will demonstrate the end-use of clean hydrogen in the each of the following sectors: electric power generation; industrial, residential, and commercial heating; and transportation.

Finally, the bill urges the secretary of energy, to the maximum extent possible, to select regional hubs in geographically diverse areas of the country where the hubs use energy resources abundant in those regions. The secretary is strongly encouraged to locate two hubs in areas of the United States with the greatest natural gas resources.

On 8 December 2021, the DOE's Hydrogen and Fuel Cell Technologies Office (HFTO) held a webinar to discuss both its recently completed Hydrogen Shot RFI related to the agency's goal of getting to US$1 per one kilogram of hydrogen in one decade (also referred to as 111), as well as its general approach on the Regional Clean Hydrogen Hubs. In particular the HFTO noted that it will be launching "H2 Matchmaker," a new voluntary tool to facilitate the development of teams to "compete" in the US$8 billion Regional Clean Hydrogen Hubs initiative. The goal of this tool is to "increase regional hydrogen project awareness and opportunities; foster partnerships and catalyze investments; and promote regional business development opportunities."

The tool is an interactive map, to be updated weekly, based on self-identification of hydrogen activities (including, e.g., hydrogen producers, consumers, transporters, and infrastructure operators). To be featured on the map, a stakeholder must fill out an **online form**. The database will be available in beta form in January 2022, and the interactive maps will be published by February 2022. The HFTO noted that all information submitted via the form will be publicly available, including contact information, details about the hydrogen activity at the site, and projections for future activities. Thus, stakeholders should not submit any confidential information.

National Clean Hydrogen Strategy and Roadmap

The IIJA requires the DOE to develop a National Clean Hydrogen Strategy and Roadmap to help direct the agency's efforts to accelerate wide-scale production, processing, delivery, storage, and use of clean hydrogen. The DOE is instructed to provide the National Clean Hydrogen Strategy and Roadmap to Congress within 180 days of IIJA's enactment and update it every three years after that.

The bill directs the DOE to focus on developing a standard of hydrogen production, including interim goals; clean hydrogen production and use from natural gas, coal, renewable energy sources, nuclear energy, and biomass; and identifying potential barriers, pathways, and opportunities to transition to a clean hydrogen economy. The roadmap also will address economic opportunities for the production, processing, transport, storage, and use of clean hydrogen that exist in major U.S. shale natural-gas producing regions and merchant nuclear power plants operating in deregulated markets. In addition, the roadmap will tackle environmental risks associated with potential deployment of clean hydrogen technologies in those regions and ways to mitigate those risks.

Electrolysis R&D

The IIJA creates a new DOE Clean Hydrogen Electrolysis Program focused on improving the efficiency, durability, and economics around hydrogen production using electrolyzers. The bill gives the DOE 90 days from enactment of the bill to establish the program, which, like many DOE programs, will fund R&D, demonstration, commercial applications, and deployment. The bill provides US$1 billion in appropriations, divided evenly over five years, for grants and cooperative agreements, eligibility for which is to be determined by the secretary of energy.

The main goal of this program will be to reduce the cost of hydrogen production through electrolysis to less than US$2/kilogram of hydrogen by 2026, an interim step on the way to the agency's Hydrogen Shot 111 goal, discussed above. And the bill directs the DOE to focus the program's work on improving the cost and efficiency of a variety of different electrolyzer technologies; production of domestic manufacturing of electrolyzers at a high volume; clean hydrogen storage technologies; technologies that integrate hydrogen production with clean hydrogen storage and transportation or stationary systems; and systems that combine hydrogen production with renewable or nuclear power generation.

Clean Hydrogen Manufacturing and Recycling

Domestic clean energy manufacturing is a priority for the administration and Congress. To advance domestic manufacturing of clean hydrogen, the infrastructure bill authorizes the secretary of energy to award multi-year grants and enter into cooperative agreements, or other agreements for research, development, and demonstration projects to advance equipment manufacturing for clean hydrogen production, processing, delivery, storage, and use. Eligibility for funding and agreements is left to the DOE.

The legislation directs the DOE to prioritize grants and agreements for clean hydrogen equipment manufacturing projects that increase efficiency and cost-effectiveness of the manufacturing process. In addition, priority consideration is to be given to grants that support domestic materials and components supply chains; identify and incorporate nonhazardous alternative materials for components and devices; operate in partnership with tribal energy development organizations, Indian Tribes, Tribal organizations, Native Hawaiian community-based

organizations, or territories or freely associated states; and are located in economically distressed areas of the major natural gas-producing regions of the United States.

The bill also establishes a recycling, research, development, and demonstration program focused on hydrogen recycling, through which the DOE is authorized to award multi-year grants, and enter into contracts, cooperative agreements, or any other agreements.

The program goal is to develop innovative and practical approaches to increase the reuse and recycling of clean hydrogen technologies, including by reducing costs of recovering raw materials from components, systems such as electrolyzers and fuel cells; minimizing environmental impacts from the recovery and disposal processes; addressing any barriers to the research, development, demonstration, and commercialization of technologies and processes for the disassembly and recycling of devices used for clean hydrogen production, processing, delivery, storage, and use; developing alternative materials, designs, manufacturing processes, and other aspects of clean hydrogen technologies; developing alternative disassembly and resource recovery processes that enable efficient, cost-effective, and environmentally responsible disassembly of, and resource recovery from, clean hydrogen technologies; and developing strategies to increase consumer acceptance of, and participation in, the recycling of fuel cells.

Clean Hydrogen Production Qualifications

The IIJA authorizes the secretary of energy, after consulting with the administrator of the Environmental Protection Agency, and with input from stakeholders, including industry, to develop an initial standard for the carbon intensity of clean hydrogen production that shall apply to DOE clean hydrogen activities.

Clean hydrogen is defined in the infrastructure bill as "hydrogen produced with a carbon intensity equal to or less than two kilograms of carbon dioxide-equivalent produced at the production site per kilogram of hydrogen produced."

Within five years after the initial standard is developed, the secretary of energy, after consultation with the administrator of the Environmental Protection Agency along with input from stakeholders, including industry, shall determine whether the definition of clean hydrogen should be adjusted below the standard included above. The secretary of energy is given the authority to change the definition, if it is determined that the standard should be changed.

The standard shall apply to clean hydrogen production from renewable; fossil fuel with carbon capture, utilization, and sequestration technologies; nuclear; and other fuel sources.

Clean School Buses and Ferries

This program, which will be administered by the Environmental Protection Agency (EPA), will provide grants and rebates for the replacement of existing school buses with clean and zero-emissions school buses, including hydrogen-fueled school buses. Priority will be given to replacement in areas that are rural, low-income, Bureau of Indian Affairs-funded, and high need. The EPA has the discretion to determine whether the funding will be through a grant, a rebate, or a combination, and up to 100% of the replacement costs can be awarded.

Within 120 days of the bill's enactment, the EPA will develop an education and outreach program to promote and explain the award program, including workforce development and apprenticeship programs. Under this program, the DOE and the Energy Information Agency are directed to modify some existing surveys, analyses, and modeling systems to incorporate hydrogen. Funding is provided at US$1 billion each year from 2022 through 2026.

The bill also establishes a pilot program at the DOT to provide grants for the purchase of electric or low-emitting ferries, including those fueled by hydrogen. At least one grant must go to a ferry service that serves the state with the largest number of Marine Highway System miles. (A little searching turns up Alaska as the state with most Marine Highway miles.) At least one grant must go to a bi-state ferry service with an aging fleet and whose development of zero- and low-emission, power-source ferries will propose to advance the state of the technology toward increasing the range and capacity of zero-emission power-source ferries. The clean ferry program is funded at US$250 million divided evenly over five years from 2022 through 2026.

Port Infrastructure Development Program

The bill provides the existing DOT Port Infrastructure Development Program with US$2,250,000,000, to remain available until 30 September 2036, and directs the DOT to provide port development grants to projects that improve resiliency of ports to address sea-level rise, flooding, extreme weather events, earthquakes, and tsunami inundation, as well as projects that reduce or eliminate port-related criteria pollutant or greenhouse gas emissions, including projects for hydrogen refueling infrastructure for drayage, and medium- or heavy-duty trucks and locomotives that service the port and related grid upgrades. This is a significant amount of money and will add to federal efforts to decarbonize the marine industry.

Carbon Litigation and Regulation

ILLINOIS EQUITABLE CLIMATE BILL

On 15 September 2021, Illinois Governor J.B. Pritzker signed the Climate and Equitable Jobs Act (CEJA or the Act) into law, establishing one of the most comprehensive state-level reforms of renewable energy initiatives in the United States. CEJA attacks the issue of climate change on multiple fronts: targeting renewable generation investment, carbon neutrality, energy efficiency standards, and ethics reforms, all the while seeking to protect consumers, workers, and disadvantaged communities.[1]

Most notably, CEJA counterbalances progressive goals to increase the market share of renewables in the state's energy mix, while aggressively reducing the carbon footprint of traditional fossil fuel generators. The Act memorializes a path for Illinois to achieve 40% renewable energy in its generation mix by 2030 and 50% by 2040.[2] CEJA also will require all private coal- and oil-fired generating units to reach zero emissions standards by 2030; municipal coal generating units must meet the same goal by 2045, and natural gas-fired units to reach zero emissions by the same year.[3] To accomplish these goals, CEJA provides annual funding to assist entities conversion of their coal-fired facilities to solar generation stations or energy storage facilities.[4]

The Act is also one of the first of its kind that envelops environmental justice and equity standards within its legislative mandates. CEJA provides support for transition programs and assistance to support the energy workforce; requires diversity reporting and mandated standards for renewable energy producers; and revamps ratemaking practices, abolishing automatic formula rates to better align with performance measures driven by reliability, equity, affordability, and clean energy goals.[5]

Illinois now joins the ranks of California, Hawaii, New Mexico, New York, Virginia, and Washington—all states that have legislated carbon-free goals to lessen climate change. As the first state in the Midwest and the home to one of the largest metropolitan areas in the country, Illinois has blazed an aggressive path to reach its 100% clean-energy goals.

CALIFORNIA OFFSHORE WIND RAMPING UP

In September 2021, California passed a new law, AB 525, which requires the California Energy Commission (CEC) to (i) establish offshore wind planning goals for 2030 and 2045 and (ii) develop a strategic plan for offshore wind energy developments off the California coast. The new law complements recent efforts by the Biden administration and California Governor Gavin Newsom to rapidly deploy offshore wind off the coast of California.

The CEC—in coordination with the other federal, state, and local agencies[6]—must submit a strategic report to the California Natural Resources Agency by 30 June 2023, that includes five chapters:

1. Identification of sea space for offshore wind;
2. Economic and workforce development and identification of port space and infrastructure;
3. Transmission planning;
4. Permitting; and
5. Potential impacts on coastal resources, fisheries, Native American and Indigenous peoples, and national defense, as well as strategies for addressing those potential impacts.[7]

AB 525 requires the CEC to take several planning steps prior to submitting the strategic report on 30 June 2023. First, on or before 1 June 2022, the CEC must "evaluate and quantify the maximum feasible capacity of offshore wind to achieve reliability, ratepayer, employment, and decarbonization benefits and shall establish offshore wind planning goals for 2030 and 2045."[8] The CEC must consider 12 factors when establishing these goals, including:

1. The findings of the 2021 joint report issued pursuant to Section 454.53 of the Public Utilities Code;
2. The need to develop a skilled and trained offshore wind workforce;
3. The potential to attract supply-chain manufacturing for offshore wind components throughout the Pacific region;
4. The need for reliable renewable energy that accommodates California's shifting peak load;
5. The generation profile of offshore wind off the coast of California;

6. The need for economies of scale to reduce the costs of floating offshore wind;
7. The need to initiate long-term transmission and infrastructure planning to facilitate delivery of offshore wind energy to Californians;
8. The availability of federal tax incentives for offshore wind investments;
9. The National Renewable Energy Laboratory report finding that California has 200 gigawatts of offshore wind technical power potential;
10. The opportunity for California to participate in the federal government's intention to deploy 30,000 megawatts of offshore wind by 2030 and to create a pathway to unlocking 110,000 megawatts by 2050;
11. Any executive action from the governor regarding offshore wind;
12. Potential impacts on coastal resources, fisheries, Native American and Indigenous peoples, and national defense, as well as strategies for addressing those potential impacts.[9]

The CEC is also directed to "identify suitable sea space for wind energy areas in federal waters" to accommodate the offshore wind planning goals for 2030 and 2045.[10] The CEC, in coordination with state and local agencies, will then "develop a plan to improve waterfront facilities that could support a range of floating offshore wind energy development activities, including construction and staging of foundations, manufacturing of components, final assembly, and long-term operations and maintenance facilities."[11] On or before 31 December 2022, the CEC must submit to the Natural Resources Agency and relevant committees of the state legislature "a preliminary assessment of the economic benefits of offshore wind as they relate to seaport investments and workforce development needs and standards."[12] The plan to improve waterfront facilities will be included in the strategic plan submitted to the Natural Resources Agency and the legislature by 30 June 2023.[13]

The CEC is also required to develop and produce a "permitting roadmap that describes timeframes and milestones" for an "efficient permitting process for offshore wind energy facilities and associated electricity and transmission infrastructure off the coast of California."[14] The permitting roadmap must be submitted to the Natural Resources Agency and relevant committees in the legislature by 31 December 2022.[15]

Carbon Business

CO_2 SHORTAGE IN THE UNITED KINGDOM

Most discussion of carbon dioxide these days centers on the fact that there is too much of it—too much in the atmosphere already and too much being emitted on a daily basis. However, in September 2021, the United Kingdom was faced with a seemingly unlikely challenge: a carbon dioxide shortage. Scarcity of this gas threatens a wide variety of activity in the carbon dioxide merchant market, from the beverage industry, which relies on carbon dioxide bubbles, to British abattoirs, which uses it to humanely stun pigs, to the oil recovery industry, which uses liquid carbon dioxide during the oil extraction process.

In the United Kingdom, most carbon dioxide used in the merchant market is captured as a byproduct of ammonia production. As ammonia is a fertilizer used by farmers, many ammonia producers conduct planned closures in the summer, when demand for fertilizer is lower. Poor timing was widely seen as the cause of a previous shortage in 2018, when planned closures coincided with hot weather and an increased demand for carbonated beverages.

A spike in the price of natural gas, a key ingredient in ammonia, exacerbated the shortage this year. In September, high natural gas prices prompted CF Industries—an American ammonia producer that supplies 60% of the United Kingdom's carbon dioxide as a byproduct—to shut down operations for an extended period. When the cost of operating its ammonia production became economically unfeasible, the company shut its doors, cutting off much of the country's supply of carbon dioxide.

September's shortage spurred government action. On 23 September, the UK government agreed to cover CF Industries' operating costs for one of its plants for three weeks while the carbon dioxide market adapted to the rise in global natural gas prices. On 11 October, the UK government announced it had brokered a deal between CF Industries and its customers that will ensure production of carbon dioxide until January 2022.[16] However, carbon dioxide prices remain elevated, so consumers will likely continue to feel the impact of the shortage for months to come.

The United Kingdom is particularly vulnerable to carbon dioxide shortages because it stores little of its natural gas supply. While the United Kingdom's European neighbors store approximately 20% of their annual demand for natural gas, the United Kingdom stores less than 6%,[17] making the island nation—fresh out of the European Union—more vulnerable to variations in supply and demand. In 2018, the UK government decided against building new natural gas storage facilities, compounding the problem underlying the current carbon dioxide shortage. Industry players have called on the government to increase its natural gas storage capacity and long-term planning.[18]

In addition to the challenge that this shortage poses to governments and industry, however, it also presents an exciting opportunity for the burgeoning carbon-capture industry to enter the carbon dioxide merchant market. The need is evident: the European merchant market for carbon dioxide, which includes carbon dioxide used in food and beverages, uses 20 million metric tons annually. And as alluded to above, there is no shortage of carbon dioxide being released into the atmosphere. Europe emits 4.4 billion metric tons of carbon dioxide from fossil fuels annually.[19] Despite this potential, much needs to be done to scale up new technologies to allow this supply to meet demand.

For example, the largest direct air carbon-capture plant in the world recently opened in Iceland, which will take in about 4,000 tons of carbon dioxide per year, which is equivalent to about 0.001% of the UK's 2019 emissions.[20] Even if carbon dioxide prices rise because of increased demand, no new carbon-capture technology has yet demonstrated that it is cost-effective at the scale necessary to participate in the merchant market. The Iceland plant, run by the carbon-capture firm Climeworks, increased Earth's annual carbon-capture capacity by 40%, to 13,000 metric tons, compared with the approximately 31.5 billion metric tons of carbon dioxide emitted in 2020. But the estimated costs for capturing one metric ton of carbon from the atmosphere currently run between US$600 and US$1,000. In contrast, one metric ton of recovered carbon sells for about US$200.[21]

While it may take years for advances in carbon-capture technology to fully erase the gap between supply and demand, opportunities have been demonstrated at a small scale. For example, Climeworks' first direct-air carbon-capture facility, in Hinwil, Switzerland, recycles captured carbon and sells it to local greenhouse operators to increase plant productivity. Carbon-capture apparatuses attached to coal-fired power plants could provide a more cost-effective source of carbon dioxide in the short-term, but such an approach likely is not sustainable as coal-fired power plants are phased out.

Natural gas prices will likely remain volatile in the coming years, putting continued pressure on carbon dioxide suppliers. As carbon-capture technology improves and becomes cheaper, the feasibility of using carbon capture to supplement carbon dioxide supply may increase. The improvements already can be seen on a small scale: the modular units used at Climeworks' plants are cheaper than previous direct-air carbon-capture devices, and the company hopes to scale up quickly.

Further, as governments are pressured to meet increasingly stringent carbon dioxide reduction goals, many could begin subsidizing carbon capture as a viable addition to their arsenal of weapons for fighting climate change. Climeworks' Iceland facility demonstrates the carbon-negative possibilities of carbon capture by injecting the captured carbon deep underground.

In a world where nations grapple with the fastest and most effective way to reduce carbon dioxide in the atmosphere, the carbon dioxide shortage in the United Kingdom illustrates challenges faced by industry and governments. But it also represents an opportunity for the carbon-capture industry to grow. Time will tell whether the industry is able to scale up to take this opportunity.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE RELEASES SIXTH ASSESSMENT REPORT, UNEQUIVOCALLY FINDING THAT HUMAN ACTIVITY HAS WARMED THE ATMOSPHERE, OCEAN, AND LAND

The Intergovernmental Panel on Climate Change (IPCC), on 6 August 2021, released its Sixth Assessment Report (AR6),[22] setting the table for recent and future international climate negotiations. In the report, the IPCC unequivocally finds that human influence has warmed the atmosphere, ocean, and land, and for the first time, depicting a causal relationship between climate change and natural disasters. In response, United Nations Secretary-General António Guterres called the report "a code red for humanity" and urged all nations, especially major emitters, to adopt net-zero emissions policies before 26 November's Conference of Parties (COP26) climate talks in Glasgow.

Since 1990, the IPCC has released five major climate science assessments along with special reports detailing specific climate issues in between. The First Assessment emphasized the global consequences of climate change and played a role in the creation of the United Nations Framework Convention on Climate Change, which established the seminal international treaty to reduce global warming and address climate change. Governments relied on material from the Second Assessment, published in 1995, in drafting and adopting the 1997 Kyoto Protocol. The Fifth Assessment (AR5), finalized in 2013, provided important scientific input for the 2015 Paris Agreement. More recently, a 2018 IPCC special report, which focused on the consequences of planetary warming of more than 1.5°C, provided an example of how science can spur governmental action. Following the report, the UK government asked its Committee on Climate Change to develop a plan for net-zero greenhouse gas (GHG) emissions.

AR6 describes five scenarios for human GHG emissions and what the planet will do in response. The full report is nearly 4,000 pages long, with 234 authors and some 14,000 citations to existing scientific studies. Since AR5, methodological advances and new datasets have provided a more complete spatial representation of changes in surface temperature, including in the Arctic, allowing for more accurate and refined predictions of planetary reactions in various GHG emission scenarios. Notably, AR6 found that a doubling of CO_2 concentrations compared to pre-industrial levels would warm the planet by about 3°C, with a likely range between 2.5°C and 4°C, whereas AR5 gave a range of 1.5°C to 4.5°C of warming.

Each of the AR6 scenarios (called "shared socioeconomic pathways" or "SSPs") makes different assumptions about shifts in policy, economics, and technology. The scenarios consider population growth, advances in clean energy, and an observer effect, in which alarming climate science spurs action to limit greenhouse gas emissions. Global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered. Further, AR6 indicates that global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other GHG emissions occur in the coming decades. While every scenario in AR6 will likely overshoot the 1.5°C target established by the Paris Agreement, under the best-case scenario global average temperatures would decline below that level by 2100.

AR6's depiction of a causal relationship between climate change and natural disasters stands in contrast to past reports that primarily focused on rising global surface temperatures, but lacked the definitive evidence to support a connection between climate change and natural disasters. Unlike other major IPCC reports coming next year, which are expected to provide more detail on specific impacts of climate change and ways to mitigate them, the IPCC's release of AR6 months before the recent COP26 talks placed it at the heart of global climate negotiations. AR6 gave negotiators at the COP26, billed as the most consequential climate policy meeting since

the Paris Agreement in 2015, a robust scientific basis for decision-making,

The agreement that came out of the COP26—the Glasgow Climate Pact, which world leaders signed onto and builds on the Paris Climate Agreement—stopped short of pursuing the level of GHG emission reductions that AR6 indicates will be necessary to avoid worst-case climate scenarios. The Glasgow Climate Pact draws upon AR6 several times, including AR6's finding that "climate and weather extremes and their adverse impacts on people and nature will continue to increase with every additional increment of rising temperatures."[23] While world leaders committed to raising more money for developing countries to combat the effects of climate change, major emitters offered new national emission reduction pledges that, collectively, fall short of the level of ambition AR6 suggests is warranted. On a more hopeful note, the United States and China did release a last minute joint declaration in which the two countries agreed to "strengthen and accelerate climate action and cooperation aimed at closing the gap" between current international efforts to address climate change and those needed to achieve the goals of the Paris Agreement.[24] Time will tell if this joint announcement will ultimately yield national and international commitments to pursue climate actions commensurate with the challenge presented in the AR6 report.

CHEVRON EXPANDING GREEN HYDROGEN PORTFOLIO

In September 2021, Chevron announced a major step toward increasing its production of green hydrogen. Chevron's New Energies division has acquired an interest in ACES Delta, the company developing the Advanced Clean Energy Storage project (ACES). The ACES project will produce green hydrogen—hydrogen produced through electrolysis of water—through the use of 1000 megawatts of electrolysis to generate 450 tons per day of green hydrogen. The electricity supplying the electrolysis will be sourced from excess electricity generated by renewable sources, such as wind and solar. The ACES project consists of facilities above and within the Magnum Salt Dome. The Magnum Salt Dome consists of five geologic caverns, and the project aims to use one of the caverns for large scale storage of liquid hydrogen that will eventually be used as fuel for energy generation.

ACES Delta is a joint venture between Mitsubishi Hitachi Power Systems (MHPS) and Magnum Development. MHPS has developed a gas turbine technology that enables a mixture of renewable hydrogen and natural gas to produce power, with a roadmap to using 100% renewable hydrogen as a fuel source. Using the technology created by MHPS, the ACES project aims to convert the stored green hydrogen to deployable electricity capable of serving 150,000 households for an entire year.

Carbon Spotlight

CLEAN FUELS FOR FLYING—HONEYWELL'S SUSTAINABLE AVIATION FUELS INITIATIVE

Producing headlines around the world, the International Air Transport Association (IATA) recently approved a **net-zero carbon emissions goal by 2050** for the global aviation industry. Implementing this goal depends on sustainable aviation fuels (SAF) in addition to other strategies, such as new aircraft technology, more efficient operations, and sourcing energy from hydrogen and renewable electric power. Here, we focus on SAF and the opportunities and challenges it presents.

According to William Walsh, the director general of the IATA, 65% of the 1.8 gigatons of carbon that need to be mitigated could be abated via SAF. To be sustainable, aviation fuels must reduce lifecycle greenhouse gases by half compared to conventional fuels; the feedstock used to accomplish this varies widely, from oilseeds and grease and waste fats to forest and crop biomass waste.

At-Scale Commercial Viability—Honeywell & United Airlines Joint Investment

In line with these ambitious goals, Honeywell and United Airlines **recently announced** a joint multimillion dollar investment in Alder Fuels, which focuses on at-scale sustainable aviation fuel that uses forest and crop biomass wastes to produce low-carbon, drop-in replacement crude oil that can be used to produce SAF. The partnership, which is the largest sustainable fuel agreement in aviation history at 1.5 times the size of the known purchase commitments of all global airlines combined, aims to produce a carbon-negative fuel that completely replaces petroleum jet fuel. The ability to produce SAF on a commercially viable scale of this size and scope is fueled by Honeywell's focus on sustainable refining technology and its joint efforts with Alder Fuels' waste biomass conversion process, which was supported in part by the U.S. Defense Logistics Agency, the U.S. Department of Energy (DOE), and a partnership with the DOE's National Renewable Energy Laboratory (NREL).

The forestry and agriculture industries are well positioned to enter into this market. According to the DOE, up to 75% of aviation fuel consumption could be replaced by biomass from U.S. forestry residues and agricultural residues alone. Further, regenerative agricultural practices, if adopted widely in the United States, could generate an additional seven billion gallons of SAF, because these practices capture more carbon in healthier soils. This greenhouse gas (GHG) profile is distinct from more traditional feedstocks, such as soybean oil and corn ethanol, which may be precluded from qualifying for federal subsidy credits because their greenhouse gas impacts are too high.

Honeywell and Alder are seeking to be leaders in the SAF industry, focusing their efforts on the lower carbon feed stocks to produce SAF with some of the lowest carbon impacts in the industry.

Sustainable Aviation Fuel Grand Challenge

Honeywell's initiative is likely to be replicated and amplified by the Sustainable Aviation Fuel Grand Challenge, launched by the DOE, the Department of Transportation (DOT) and U.S. Department of Agriculture in September. The agencies' objectives are memorialized in a **Memorandum of Understanding** between these agencies, which lays out the following goals and pathways:

- Minimum of 50% reduction in lifecycle GHGs compared to conventional fuel;
- Supplying at least three billion gallons of SAF per year by 2030;
- By 2050, supplying enough SAF to meet 100% of aviation fuel demand, projected to be about 35 billion gallons per year;
- Support U.S. farmers with feedstock genetic development, sustainable crop and forest management, and post-harvest supply chain logistics;
- Support fuel producers with carbon modeling of SAF feedstocks, including grants to quantify feedstock GHGs and soil carbon dynamics at field-level;
- Expedite regulatory approval to support newly developed fuels that may be able to generate Renewable Identification Numbers (RINs) under the Federal Renewable Fuel Standards (RFS) program;
- Grants and loan programs to commercially scale SAFs and support projects that use innovative technology to avoid, reduce, or sequester GHGs.

Bipartisan Infrastructure Bill and Build Back Better Act

In mid-November 2021, the U.S. House of Representatives passed the **Infrastructure Investment and Jobs Act**, a/k/a the

Bipartisan Infrastructure Framework (BIF). While the BIF did not contain specific provisions for SAF, it does allocate millions of dollars to adjacent initiatives, including airport infrastructure upgrades and carbon capture and sequestration that will facilitate the ability to produce, store, and access SAF. The Build Back Better Act was passed by the U.S. House of Representatives on 19 November, which if it passes the Senate as currently drafted, proposes a US$1 billion investment in biofuels infrastructure that more specifically supports SAF, including a production tax credit of a base rate of US$0.35/gallon and bonus rate of US$1.75/gallon, and direct payment of clean fuel production tax credits.

Flying Into the Future

The joint efforts of Honeywell, United Airlines, and Alder, particularly on the scale made possible by their collaboration, will be critical in order to obtain the lofty goals set out in by the IATA and the Sustainable Aviation Grand Challenge. Support from the U.S. government is crucial. Along with innovation and leadership from the aviation, agricultural, and forestry sectors, SAF is poised to play a pivotal role in the battle against climate change.

U. S. STEEL'S BEST FOR ALL℠ STRATEGY TOWARD A SUSTAINABLE FUTURE

United States Steel Corporation (U. S. Steel) has been on the forefront of transformational societal change since its inception. The ever-evolving company continues to tackle the challenges of our times. The challenge posed by the global climate crisis differs in nature and scope from those that the company faced at pivotal junctures during the 20th century. In the pioneering spirit of its founders, U. S. Steel is tackling the challenge head-on, through an ambitious transition to its Best for All strategy.

Best for All is an evolution of U. S. Steel's Best of Both℠ strategy that the company pursued since 2018. Best of Both focused on making the company competitive in the global steel market by combining the best of both "integrated" and "mini mill" steel making technologies. Integrated steel making, which U. S. Steel historically employed across its operational footprint, is the more traditional, multi-step process that involves converting raw materials (iron ore and limestone) into primary steel products, typically with the help of blast furnaces powered by coke (refined coal). More modern mini mill technologies, on the other hand, produce steel from secondary scrap metals, relying on electric arc furnaces (EAFs) that run on electricity to power the operation. Mini mills have the potential to provide substantial sustainability benefits in terms of both their contribution to the circular economy and a reduced carbon footprint.

In December 2020, U. S. Steel advanced Best of Both with the successful completion and start-up of its first EAF at its Fairfield Works location in Alabama. With momentum building, the company completed its acquisition of Big River Steel and its LEED certified mini-mill in northeast Arkansas in January 2021. The Big River Steel facility is often referred to as a flex-mill, since it is one of the newest, largest, most advanced, EAF-oriented flat-rolled mills in North America.

U. S. Steel's Best for All strategy ramps up that momentum in aggressive pursuit of broader sustainability goals that will benefit the company, its customers, and stakeholders over the long term. As part of this vision, the company is intensifying efforts to become an industry leader in lower-carbon production methods. In line with Best for All, in April 2021, U. S. Steel announced an ambitious goal to achieve net-zero carbon emissions by 2050. This commitment builds on the company's prior pledge to reduce greenhouse gas GHG emissions intensity 20% across its global footprint by 2030 (compared to a 2018 baseline).

Most recently, in June 2021, U. S. Steel announced a joint feasibility study with Equinor US Holdings to assess the potential for carbon capture and storage and hydrogen development in the tri-state region of Ohio, Pennsylvania, and West Virginia. And in September 2021, the company announced an exploratory site selection process to build a new state-of-the-art mini mill in the United States – an estimated US$3.0 billion investment. These business ventures flow directly from U. S. Steel's Best for All vision and provide a pathway for substantial progress toward achieving the company's sustainability goals.

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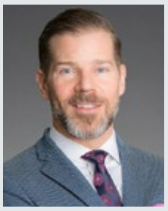

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Endnotes

[1] *See generally* S.B. 2408, 102d General Assemb. (Ill. 2021).

[2] *See* S.B. 2408, § 1-75(c)(1)(B), 102d General Assemb. (Ill. 2021) (codified in 20 ILL. COMP. STAT. 3855/1-75 (2021)).

[3] The bill provides an exception for municipal natural gas-fired units if the units have been converted to green hydrogen or similar technology that will approach zero-carbon emissions. *See* S.B. 2408, § 9.15(i)(5), 102d General Assemb. (Ill. 2021) (codified in 415 ILL. COMP. STAT. 5/9.15 (2021)).

[4] *See* S.B. 2408, § c-30(d)(5), 102d General Assemb. (Ill. 2021).

[5] *See* S.B. 2408, § 16-108.18(c)(9), 102d General Assemb. (Ill. 2021) (codified in 220 ILL. COMP. STAT. 5/16-108.18 (2021)).

[6] The law requires the CEC to coordinate with "the California Coastal Commission, the Ocean Protection Council, the State Lands Commission, the Office of Planning and Research, the Department of Fish and Wildlife, the Governor's Office of Business and Economic Development, the Independent System Operator, and the Public Utilities Commission, and other relevant federal, state, and local agencies as needed." *See* AB 525, Energy: offshore wind generation, § 2 (Sep. 23, 2021) (to be codified at 15 Cal. Pub. Res. Code § 25991(a)), https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220AB525 (hereinafter AB 525).

[7] AB 525, § 2 (to be codified at 15 Cal. Pub. Res. Code § 25991(c)).

[8] AB 525, § 2 (to be codified at 15 Cal. Pub. Res. Code § 25991.1(a)).

[9] Id. (to be codified at 15 Cal. Pub. Res. Code § 25991.1(b)).

[10] Id. (to be codified at 15 Cal. Pub. Res. Code § 25991.2(a)).

[11] Id. (to be codified at 15 Cal. Pub. Res. Code § 25991.3(a)).

[12] Id. (to be codified at 15 Cal. Pub. Res. Code § 25991.3(d)).

[13] Id. (to be codified at 15 Cal. Pub. Res. Code § 25991.3(e)).

[14] Id. (to be codified at 15 Cal. Pub. Res. Code § 25991.5).

[15] Id. (to be codified at 15 Cal. Pub. Res. Code § 25991.5(f)).

[16] https://www.gov.uk/government/news/agreement-reached-to-ensure-supplies-of-co2-to-businesses.

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[18] https://theconversation.com/gas-price-spike-how-uk-government-failures-made-a-global-crisis-worse-168324.

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[20] https://www.wired.co.uk/article/climeworks-carbon-capture.

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[23] Glasgow Climate Pact (Nov. 13, 2021), https://unfccc.int/sites/default/files/resource/cma2021_L16_adv.pdf.

[24] U.S.-China Joint Glasgow Declaration on Enhancing Climate Action in the 2020s (Nov. 10, 2010), https://www.state.gov/u-s-china-joint-glasgow-declaration-on-enhancing-climate-action-in-the-2020s/.

[25] See Institute for Energy Research, "Biden and House Democrats Subsidize Sustainable Aviation Fuel," (October 13, 2021).

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