UNIVERSITY of VIRGINIA

JEFFERSON INNOVATION SUMMIT

Decarbonizing the Global Economy

PLAYBOOK FOR POLICYMAKERS AND BUSINESS LEADERS • SPRING 2023

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Executive Summary

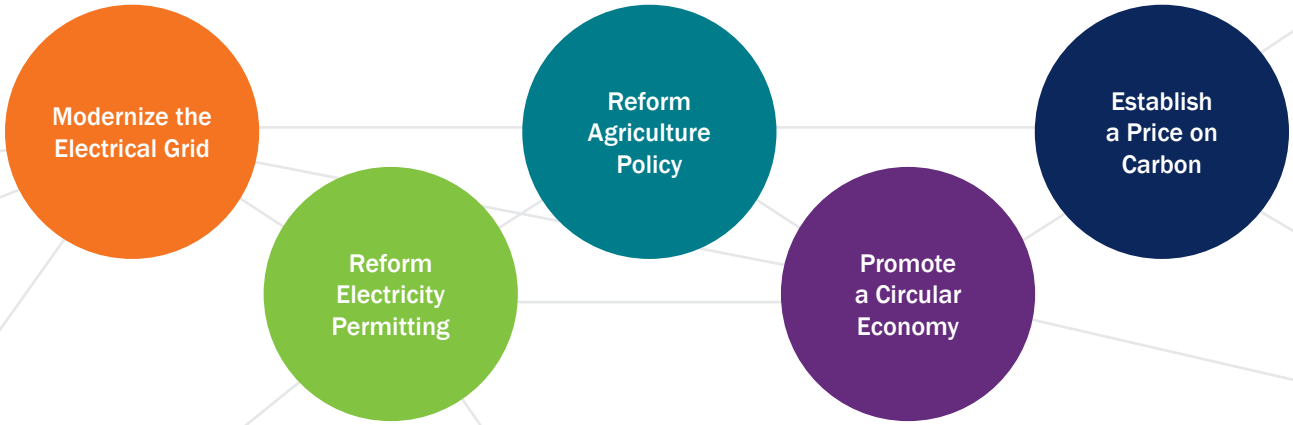
Climate change is the challenge of our lifetimes. Time is of the essence. According to climate scientists, we must reduce net global greenhouse gas (GHG) emissions to zero by 2050, if not before, to avoid its worst impacts.

To achieve such an ambitious decarbonization goal will require substantial innovation across virtually every sector of the global economy: transportation, energy, buildings, industrials, agriculture — and the numerous downstream industries these sectors support.

To tackle the decarbonization challenge, the University of Virginia's Darden School of Business, Miller Center, and Environmental Institute hosted the Jefferson Innovation Summit in Charlottesville, Virginia on 2 December 2022. The event brought together 25 delegates from the public and private sectors to discuss the actions needed to accelerate global, cross-sector decarbonization. Following a public-facing discussion in the historic Dome Room of UVA's Rotunda, the delegates spent the remainder of the day debating challenges — and ideating viable and scalable solutions.

New and innovative approaches were discussed among the delegates with the shared goal of accelerating adoption in the U.S. As the second biggest emitter of GHG emissions, global progress on emission reduction must start at home. Working in small groups, the delegates workshopped hundreds of ideas, ultimately settling on five actions as critical to achieving a decarbonized economy. These five key actions are presented herein. This playbook does not provide detailed steps for deploying each action. Rather, our aim is for leaders in both the public and private spheres to be inspired by these ideas and mobilize the investment and workforce needed for deployment.

Five Critical Actions to Advance Decarbonization



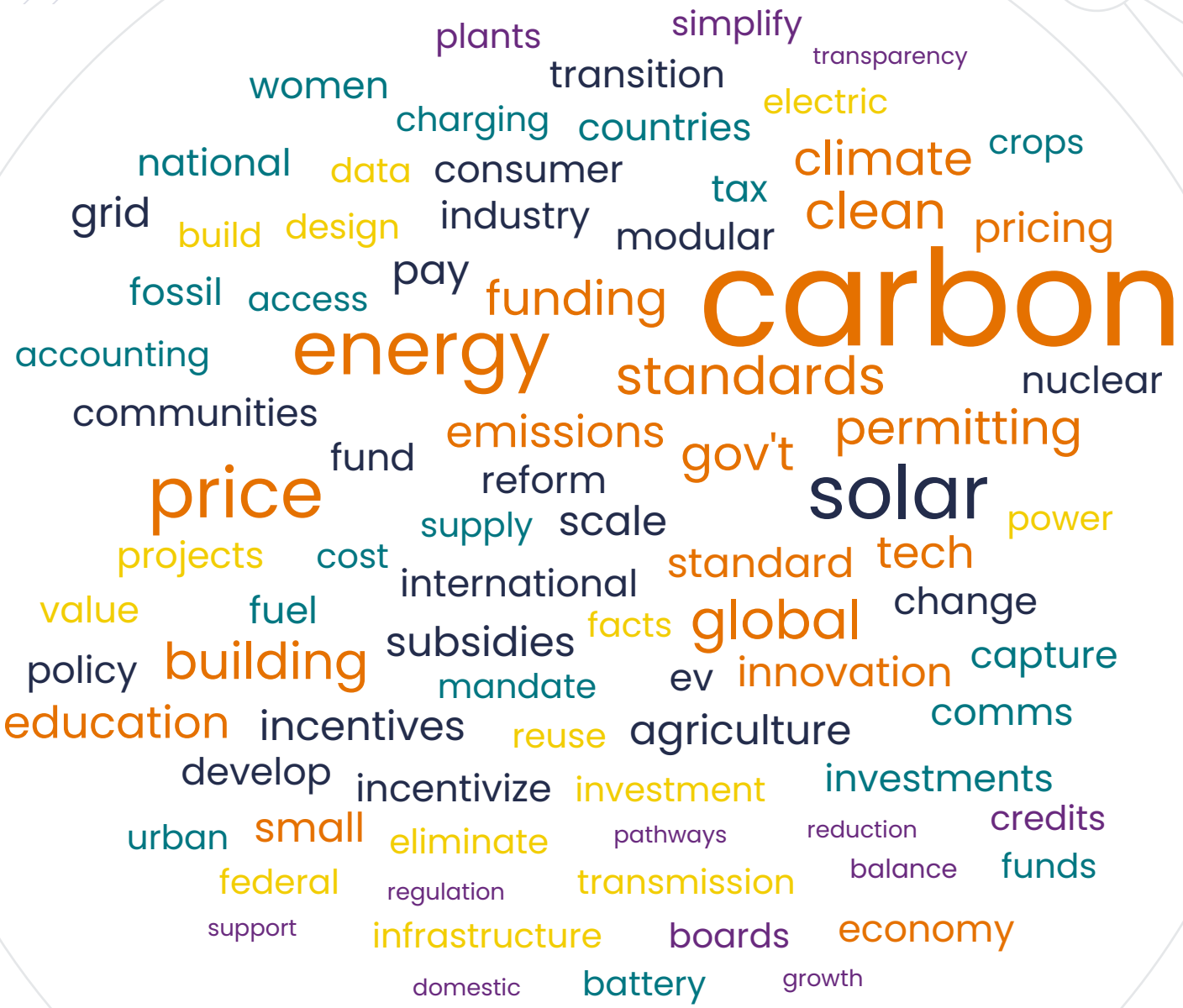
These actions reflect an evolution in public appetite for addressing climate change. Five years ago, we convened a Jefferson Innovation Summit focused on Catalyzing Cleantech Innovation. The resulting 2018 Summit playbook focused on high-level actions aimed at swaying public and private sector opinion and mobilizing investment in cleantech innovation. Today, the question is not whether clean technology that allows us to achieve net-zero emissions is viable, but rather, where to focus cross-sector investments to help catalyze the transformations already in motion. The five actions presented in this playbook attempt to prioritize collective action to accelerate decarbonization. For each action, delegates discussed the environment needed for change to happen and ways in which these assumptions could be tested.

The Ideation Process

Step 1. Conversation in the Round

We began the Summit by engaging in a Socratic dialogue, facilitated by UVA Darden Professor Michael Lenox, in which delegates debated the opportunities and challenges of decarbonization across critical industry sectors. This discussion helped to establish a foundation for the solution focus of the afternoon workshops.

More than 200 ideas generated



Word Cloud: bigger font indicates number of times this topic was proposed

Step 2. Ideation Workshop

We kicked off the workshop portion with a brainstorming exercise in which delegates crafted potential actions using a rapid, highly collaborative approach. The goal was to explore a vast range of ideas then build consensus around the most critical, high potential actions. This initial work generated **more than 200 ideas** — from the expected to the radical. Teams worked together to refine their ideas into three proposals to be shared with the broader set of delegates. In total, fifteen actionable ideas across five teams bubbled up. The session ended with a voting exercise to identify the five ideas of those fifteen that the delegates believed had the greatest potential for wide-scale impact.

15 Semi-Finalist Actionable Ideas


Modernize the Electrical Grid


Cap Emissions + Invest In Cleantech


Reform Agriculture Policy


Create CCS Moon Shot Fund


Hold Companies Liable for Emissions


Create Equitable Transition Fund


Establish a Price On Carbon


Incentivize Affordable Cleantech Solutions


Ensure Investments are Equitable

Expand Transmission and Storage


Promote a Circular Economy


Create International Financing Standards

Electrify + Zero Carbon Generation


Reform Electricity Permitting

Increase Awareness of Carbon

Step 3. Action Refinement

With the five most promising actions identified, the delegates worked in teams to further develop them. To begin, they created a napkin pitch – a short description and argument for the action. Next, they developed the set of assumptions underlying the proposed action, focused on the value it would create and for whom, the conditions necessary to be able to execute on it, and the overall impact the action would have in catalyzing decarbonization. Lastly, the teams identified ways to test those assumptions with a primacy placed on quick and inexpensive tests that would allow for rapid progression in learning whether an action item was promising.


Modernize the Electrical Grid


Reform Electricity Permitting

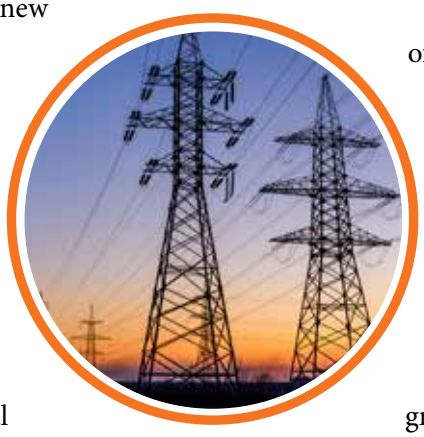

Reform Agriculture Policy


Promote a Circular Economy


Establish a Price On Carbon

1. Modernize the Electrical Grid

According to the International Energy Agency (IEA), utility-scale wind and solar are increasingly becoming the cheapest options for new electricity generation around the world. In the U.S., renewables account for 20 percent of total utility-scale electricity generation. Wind and solar together represent nearly 70 percent of new capacity additions compared to natural gas at 21 percent. A clean energy future seems within reach. However, the rate at which renewables grow and displace fossil fuel sources is contingent on how quickly we can modernize the electrical grid.



Building out renewable generation will require a massive capital investment, on the order of $4.5 trillion in the U.S. alone.[1] This includes not only constructing new solar fields and wind farms but the build-out of high voltage transmission lines to transport electricity from source to use. Changes need to be made in permitting and transmission to allow for inter-regional planning and connectivity. (We discuss Permitting Reform in **Action 2** of this playbook.)

> Grid-edge technologies like energy trading, EV charging, energy storage, and grid-interactive buildings will need significant investment that will likely look very different from traditional grid infrastructure investment.

In addition, we will need to address intermittency. The grid system in the U.S. and its electric utility companies were built around a business model of integrated delivery of service through generation and distribution. Historically, coal and nuclear power plants provided consistent and reliable baseload power, while natural gas generators were dispatched as needed to meet peak demand throughout the day. Enter renewables, specifically solar and wind. Their intermittent nature — the sun does not always shine and the wind does not always blow — creates complications to this system that threaten reliability without additional interventions.

One such intervention is the addition of adequate on-grid storage solutions to store electricity from wind and solar generation to be deployed when needed. Pumped storage hydropower can provide the long-duration energy storage needed to park electricity for long periods of time until dispatching it back to the grid when needed. However, its growth as a solution is constrained by geography. Li-Ion batteries are the better option in terms of its flexibility, but they face high costs and global supply chain disruptions and fall short of the desired duration. Investing in other battery chemistries that allow for domestic sourcing and continued investment in battery technology R&D to extend storage duration and drive costs down will help to accelerate their inclusion in the grid.

Another intervention is to move to more distributed electrical generation. Imagine millions of generators as homeowners and businesses add solar panels to their roofs. Combine that with storage in the form of electric vehicles in the garage and battery walls in homes and businesses and you can begin to create an integrated electrical system that allows for

bidirectional flows of electricity and creates efficiencies by flatting peak demand and economizing loads. Industry experts believe that a modernized, highly interconnected electrical grid that includes a high number of intermittent renewable sources can be reliable even with limited energy storage.

Ultimately, for the electrical grid to deal with distributed generation, it needs to be smart. A smart grid uses digital and other advanced technologies to manage and monitor electricity distribution. There is innovation happening at the utility level and at the grid "edge" at the end of transmission, such as sensors, switches and artificial intelligence that ramp up to support multiple point sources and two-way communication. Grid-edge technologies like energy trading, EV charging, energy storage and grid-interactive buildings will need significant investment that will likely look very different from traditional grid infrastructure investment. Our electrical grid needs to digitally transform.

But this isn't just a grid readiness problem. A first step in achieving grid stability is to simply reduce demand. Starting in 2010, U.S. electricity generation slowed thanks in part due to national minimum energy efficiency standards and certification programs. After a brief drop during the Covid pandemic, electricity consumption in the U.S. is now on the rise. The quickly expanding electric vehicle market and efforts to electrify other industries will contribute to the increased demand on the grid. Slowing consumption will be important to avoiding strain on an electrical grid already being tested by the deployment of intermittent energy sources. Rolling out national building energy performance standards will help decrease the intensity of electricity use while helping to accelerate the replacement of existing fossil fuel energy assets with solar and wind plants.

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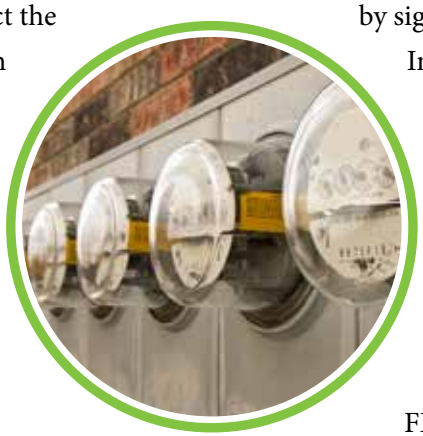
ASSUMPTIONS	**Utilities can be incentivized to facilitate the generation and transmission of distributed sources of electricity.**	**There exist opportunities for game-changing innovations that further decrease costs of generation and storage.**	**There is community buy-in for local infrastructure investment – such as solar plants and transmission lines.**	**When provided with the right incentives, investments will be made in clean energy projects.**	**There is political will to make substantive investments in the electrical grid.**
TESTS	Convene a consortium of utility leaders, electricity regulators and edge-tech providers to advance smart grid adoption.	Convene leading scientists and technologists to highlight where R&D investments are most likely to generate breakthroughs, e.g., road mapping efforts of the International Energy Agency.	Engage community leaders to understand concerns and to develop protocols for quickly approving new projects.	Assess projects developed as a result of incentives provided in the Inflation Reduction Act and the Infrastructure Investment and Jobs Act.	Canvas political leaders to gauge their desire for change and to understand their concerns.

2. Reform Electricity Permitting

The permitting process for bringing new generation sources online is time consuming and complex involving federal, state and local authorities. Complicating matters further is the need for long-distance transmission that crosses state lines to bring renewable energy to areas of need. While these permitting processes are important to ensure that new projects don't negatively impact the environment and communities in which they are built, we must lower the barriers to permitting to accelerate grid decarbonization.



Permitting begins with renewable energy developers submitting projects to be added to the interconnection queue — a database of power generation and transmission projects requesting grid connection. These submissions are reviewed by electricity transmission system operators and a series of studies are completed to ensure the project meets reliability, safety and facility standards.

By the end of 2021, the interconnection queue included projects totaling 1,400 gigawatts of generation and storage capacity; 90 percent of which represented renewable energy projects such as solar and wind with battery storage.[2] Historically, the time to connection is simply too long. One example is the South Fork Wind offshore project off the coast of Rhode Island that was first proposed in 2015 and won't be operational until the end of 2023. In a report by Lawrence Berkeley National Laboratory, projects were taking almost 4 years to complete on average.[3] Permitting delays can be found at all points of electricity delivery from bringing new generation online to building out transmission lines. They are driven largely by a lack of integration across local, state, and federal jurisdictions.

President Biden paved the way for grid expansion by signing the 2021 Infrastructure Investment and Jobs Act (IIJA), providing the Federal Energy Regulatory Commission (FERC) with new interstate electric transmission authority. Through the IIJA, Congress further directed FERC to amend its permitting processes. Included in FERC's December 2022 proposal was the allowance of simultaneous review of applications by states and the FERC pre-filing process. Other time-saving measures proposed include clustering requests prioritizing those projects that have robust financial backing (as opposed to the order in which the request is received).[4] The comment period for the FERC proposal ended March 2023.

Eminent domain policies are another source of delay for projects especially on multi-state transmission lines. Current policies allow government seizing of private property with just compensation if the project serves the public good. Historically, it has been utilized by the fossil fuel industry to expand pipelines across the country. While eminent domain has been controversial, its application could lead to a more

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rapid expansion of high voltage transmission lines. While FERC has the authority to grant eminent domain to gas and oil pipelines across states it does not have the same authority regarding high voltage transmission lines. Of course, any such expansion should consider safe guards to ensure that policies do not further negatively impact sensitive environmental areas and communities historical disadvantaged by such policies and that contribute to inequity.

Energy storage is critical for expanding renewable generation. However, deploying it can be challenging. Most zoning ordinances don't allow for the installation of utility-scale battery energy storage systems without variances or special use permits. For example, in Virginia, a developer must go through multiple steps to be approved by a local planning board and then obtain a permit-by-rule (PBR) with the Virginia Department of Environmental Quality if under 150 MW or a certificate of public convenience and necessity (CPCN) through the State Corporation Commission. There are several requirements that must be met under both local and state permitting, including extensive community outreach to allow residents to express concerns about the project. Some states like California have facilitated deployment through new policies that allow for the bypassing of local planning boards to approve large energy storage projects.[5]

The creation of a centralized entity to help reduce the permitting, technical and cost barriers faced by renewable projects in the queue could help to accelerate deployment. U.S. DOE announced last fall the launch of i2X: The Interconnection Innovation e-Xchange, which aims to facilitate grid interconnection while ensuring continued safety and reliability along the national grid. DOE and its national laboratories are partnering with utilities, grid operators, state and local governments, energy justice groups and other key stakeholders to share data, develop a roadmap and facilitate solutions to improve grid interconnection procedures.

While eminent domain has been controversial, its application could lead to a more rapid expansion of high voltage transmission lines.

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ASSUMPTIONS	**Broad stakeholder engagement will lead to faster permitting and project development.**	**Eminent domain can be evoked in a way that is fair and equitable.**	**Giving more authority to federal regulators will help accelerate project execution.**
TESTS	Conduct pilot projects with existing and new strategies to learn how stakeholders respond.	Conduct analyses of previous national efforts such as the U.S. highway system or recent inter-state energy projects to identify opportunities and challenges.	Undertake an interstate transmission project to explore the pros and cons of federal interventions.

3. Reform Agriculture Policy

Agriculture and land use represents a quarter of global GHG emissions. A significant contributor to global warming, the sector will also be the hardest hit by changes to the climate. Changing weather patterns, water scarcity, soil degradation, pests and disease create significant challenges for farming as well as food quality and safety. These challenges are compounded by the need to feed another two billion people globally by 2050. With deforestation removing the carbon sinks needed to help balance global emissions, expansion of farmland is not the answer. The critical question is how do we grow more food while using less land and resources?

In the U.S., the federal government has long played an active role in shaping the food system. The current U.S. Agriculture Improvement Act (U.S. Farm Bill) was enacted in 2018. Originally created in the 1930s to ensure fair food prices, adequate food supply and protect natural resources, the bill has seen small revisions over time in response to shifts in political interests. Reviewed every five years, Congress will have the opportunity this year to debate and propose revisions to the bill. With the Biden Administration leaning in on climate, policy analysts expect to see climate change more prominently featured in the next version.

Currently, three-quarters of direct funding goes to nutrition-focused programs. About 25 percent of funding was earmarked for the agriculture portion of the bill, which addresses commodities, crop insurance, conservation and other miscellaneous projects. Of that quarter, only 7 percent was set aside for efforts to protect natural resources. There are elements of the bill that support improved soil and forest conservation and climate-friendly farming practices that directly impact emissions, but it is not enough to move the needle on decarbonization.

The agriculture sector provides unique carbon capture and emission reduction opportunities. For example, incentivizing farmers to implement no till and cover crop best practices reduces N_2O emissions and helps to sequester carbon in soil. Commonly referred to as carbon farming, there are many programs that exist today where farmers can sell carbon credits to companies looking to reduce their own carbon footprint. While the Farm Bill mentions low carbon farming practices, subsidizing these practices and investing in farmer education would encourage greater adoption.

To meet the needs of an additional two billion people will require technological innovation. Innovations like indoor farming and plant-based proteins hold promise but require significant investment to improve efficiency and increase their market share. Since 1970, public funding of agriculture R&D in the U.S. has been in a steady decline. Fortunately, private sector investment in R&D has been rapidly increasing since 2003.[6] Yet, the focus of their investments tends to be more on food manufacturing and farm machinery compared to public investment in agriculture productivity and environmental protection. The Farm Bill could serve as an innovation engine, directing funding toward practices and technologies that reduce emissions while increasing food production.

To decarbonize agriculture, change also needs to

happen at the end of the food chain. According to the Food and Agriculture Organization (FAO), one-third of food produced globally is wasted – representing 8 percent of global GHG emissions. What if food waste could be part of the climate solution? Composting can be used to support healthy and fertile soil and replace synthetic fertilizers responsible for harmful N_2O emissions. However, the facility and equipment needed can be cost-prohibitive in comparison to synthetic fertilizers. Regional pilot programs using centralized composting facilities could be funded through the 2023 Farm Bill. These pilots coupled with a subsidy for producing composted soil could help pave the way for fertilizer market disruption.

Ultimately, changing consumer purchasing and eating habits could be the most effective means to decarbonize agriculture. Public buy-in will be critically important. Product labeling can help to identify climate-friendly foods and educate consumers. The USDA could create a standardized label, like the USDA Organic Certified label, for food produced using climate-friendly practices or that are climate-positive themselves, like plant-based proteins.

With 75 percent of the U.S. Farm Bill budget allocated to nutrition programs, there is an opportunity to impact how the U.S. funds equitable access to food that is both nutritious and sustainable to everyone. One vehicle that could be used to do this is the Supplemental Nutrition Assistance Program (SNAP). Unlike other federally funded programs like the Women, Infants, and Children Program (WIC), SNAP does not include nutrition standards for food served or purchased. And with no incentives at retail to purchase healthy food, a large majority of recipients are making unhealthy choices. The 2023 U.S. Farm Bill should include provisions to SNAP for healthy and sustainable food and set aside funding for pilot projects focused on providing education and incentives at retail.

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ASSUMPTIONS	**Carbon pricing will not place undue burden on either farmers or consumers.**	**Labeling on the health and environmental impacts of food products will change purchasing behavior.**	**Existing opportunities for game-changing ag innovations that increase yields while decreasing impact and resources.**	**There is political will to make substantive changes to the 2023 Farm Bill.**
TESTS	Formal economic modeling of the impacts of specific carbon pricing regimes on the agriculture sector.	Run experiments on how consumers react to various presentations of environmental and health data.	Convene leading scientists and technologists to highlight where R&D investments are most likely to generate breakthroughs.	Survey political leaders to gauge their desire for change and to understand their concerns.

4. Promote a Circular Economy

A circular economy is one that keeps materials and products in circulation for as long as possible before entering the waste stream. While the primary benefit is waste reduction, a circular economy can also help drive decarbonization. For example, using reusable containers doesn't just keep plastics out of the ocean and landfills, it also reduces the carbon emissions associated with manufacturing them in the first place. As another example, steel manufacturing emits a significant amount of CO_2 — 8 percent of global GHG emissions. Melting down recycled steel to create new products greatly reduces the carbon emissions that go into our energy, transportation and building infrastructure.

Circularity is a shift in mindset from produce-consume-dispose to "product as a service." Supporting this shift means designing new systems to collect, resale, rent or remanufacture products. It also encourages companies to design products for longer life. There are many benefits for businesses that embrace circularity, including lower material costs and deeper customer relationships. Yet, despite interest in circularity that goes back decades, business adoption of a circular economy remains nascent. The benefits of circularity often face the reality of the costs of coordinating closed-loop supply chains.

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Much of the business activity around circularity is happening in consumer product markets where there is demand for such offerings. Dozens of new companies are emerging that have circularity at the core of their business model and well-known brands are rolling out new initiatives. Established brands like IKEA and H&M are taking back and selling gently used furniture and clothing, respectively. Adidas launched its Three Loop Strategy in 2020, which includes taking back, recycling, and remanufacturing shoes. Rental services are gaining popularity in the clothing and furniture markets.

Establishing a broad, multi-sector circular economy requires that circularity be the easy, cost-effective, default option. This can be driven by collective corporate action to push transformation in supply chains. Industry consortia can help push forward circularity principles. In 2022, the American Circular Textiles policy group — featuring RealReal, Rent the Runway and ThredUp — formed with the goal of scaling up circular fashion. These consortia can influence policymakers to lower the barriers to circularity. Building codes could be changed to promote the use of recycled materials. Subsidies for low-cost virgin material could be eliminated. Taxes could be imposed on fossil-fuel dependent materials, like plastic packaging.

Financial incentives can also accelerate change. These might include tax credits for designing higher quality, long-lasting products or diagnostic tools that could support maintenance and prolong usage. Electric vehicle batteries are poised to decarbonize transportation, but their use has also invited concerns around the environmental waste their

disposal will create. Start-up Rejoule has developed a battery diagnostics technology that improves battery performance, lifetime use and supports a secondary market for used batteries.

The adage that one person's trash is another's treasure is a central element of the circular economy. Waste from one industry can be a valuable input for another. Most companies have sophisticated systems for tracking resources like energy and water, but there is less insight into waste. The low cost of disposal does little to change behavior. Increasing these costs would get the attention of company leaders and encourage exploration of circular principles. Simply put, we must view waste as a resource.

Perhaps the most important stakeholder in the circular economy movement is the consumer. Demand for alternatives has shifted product offerings in even the most stubborn of industries. The shift to antibiotic-free meat, restaurants offering paper instead of plastic straws, and elimination of artificial food dyes were all driven by shifts in consumer preferences. Change in consumer behavior will be critical for a circular economy to grow and thrive.

Transparency is one lever to cultivate and attract sustainability-minded customers. Standardization in the way companies track waste will help with direct comparisons in company offerings and securing customer trust. Measuring and verifying waste along the supply chain present some serious challenges. Third-party certification, such as that provided by Total Resource Use and Efficiency (TRUE) and Carbon Trust Zero Waste to Landfill programs, offer guidance to companies looking to reduce their waste streams and offer customers confidence in their claims.

Perhaps the most important stakeholder in the circular economy movement is the consumer. Demand for alternatives has shifted product offerings in even the most stubborn of industries.

Another lever is the U.S. government. It is the largest consumer of goods and services in the world.[7] Procurement standards around remanufactured and low-carbon products and materials could help spark the circular economy. Last year, the Biden Administration announced new actions under its Buy Clean Initiative aimed at spurring demand for low-carbon goods.[8]

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ASSUMPTIONS	**Circularity in supply chains advances decarbonization.**	**Circularity is valued by customers by either providing lower costs, greater accessibility, or sense of responsibility and cachet.**	**Circularity helps drive profitability by either reducing costs, increasing demand or enhancing customer lifetime value.**
TESTS	Analyze current closed-loop supply chains to measure carbon impact.	Conduct surveys of customers in various sectors to gauge the desirability of circularity.	Undertake pilot projects to explore business case in various sectors.

5. Establish a Price on Carbon

Pricing carbon has long been hailed as the holy grail of climate action. By creating economic incentives for reducing GHG emissions, market players can efficiently decide where to prioritize decarbonization efforts. In some hard to decarbonize sectors, a carbon price could incentivize carbon removal, for example, through reforestation, the growing of sea grass, or direct carbon capture and storage (CCS).

Historically, economists and policy makers have largely focused on two types of carbon pricing to reduce GHG emissions: a cap-and-trade system and a carbon tax. In a cap-and-trade system, the government sets a limit on total emissions (the cap) by issuing tradable permits that grant companies the right to emit a specific amount which in total add up to the cap. A carbon tax charges a dollar amount for every ton of emissions produced. According to the World Bank, in 2022, there were 70 carbon pricing initiatives being implemented around the world representing 23 percent of global GHG emissions.[9]

In the U.S., establishing a national cap and trade policy or a carbon tax has proven politically challenging. Past bills, including some bipartisan efforts, have failed to get through Congress. A 2022 Brookings study reports that nearly all of 68 policy actors interviewed for the study – politicians, federal agency offices, business leaders and associations, environmental groups, prominent scientists and other political organizations – opposed any type of national cap and trade program.[10] Support for a national carbon tax is stronger, however there is little expectation of seeing such legislation in the 118th Congress.

After more than three decades of advocacy for a carbon price, the global patchwork of sub-scale carbon pricing highlights the political challenges of both cap-and trade and taxation. In response, there are growing efforts around private solutions focused on climate-related financial disclosure. Many companies are starting to voluntarily disclose their carbon emissions. Yet, there are challenges with current practice particularly with respect to reporting emissions within a company's extended value chain. The carbon emissions tied to each of step of the value chain are often difficult to estimate and lead to frequent over-counting.

After more than three decades of advocacy for a carbon price, the global patchwork of sub-scale carbon pricing highlights the political challenges of both cap-and trade and taxation.

There are efforts in place to standardize carbon accounting. The GHG Protocol[11] is the most widely used voluntary standard for measuring and reporting emissions. The protocol provides guidance on Scope 3 emissions including tools to estimate downstream emissions if they fall within 15 categories of activity.

A new way of accounting for carbon is gaining traction that treats GHGs like liabilities, i.e., E-liabilities.[12] The E-liability approach uses cost accounting principles to record and transfer carbon emissions at each step of the value chain allocating

emissions to unit output. Companies can compile their E-liabilities in the form of a carbon balance sheet and more accurately report their carbon footprint. With an accurate understanding of emissions flows (i.e., the total value of transactions in sales or purchases, incomes, or expenditures during an accounting period) and stocks (i.e., the value of an asset at a balance date or point in time), companies can value investments in their value chains to reduce emissions. Firms will then have an incentive to invest in carbon removal to balance their liabilities.[13]

With an accurate understanding of emissions flows and stocks companies can value investments in their value chains to reduce emissions... and have an incentive to invest in carbon removal to balance their liabilities.

Much like a defined contribution plan, firms will manage their emissions liabilities against a pool of corresponding assets. In this way, accounting endogenizes the cost of carbon by requiring firms to manage their emissions liabilities. Emissions Liability Management (ELM) encompasses this suite of activities.[14] Through proper carbon accounting, firms need not wait for governments or caps to set the price of carbon. Rather, the price of carbon will be driven by the availability of natural carbon sinks and the forward cost curves for technology-based removals and the cost to insure them.

Fundamentally, efforts to price carbon through disclosure are dependent on emissions liabilities being seen as material by economic actors. In other words, investors and businesses believe there is a cost to GHG emissions born by various parties in the value chain. There remain important questions about the extent to which there exist private incentives to reduce emissions. Consumers may demand at the point of purchase that companies honor net-zero pledges. Significant carbon footprints may represent risks of exposure to transition risks as markets transform to green alternatives, such as the electrification of vehicles. Perhaps, most likely, emissions will be seen as a policy risk if, in fact, global governments are able to establish a carbon tax or cap-and-trade system.

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ASSUMPTIONS	**A carbon price will be high enough to incentivize innovation and drive changes in behavior.**	**There will be international standardization on carbon pricing given global supply chains.**	**Standards for measuring carbon emissions and offsets are not plagued by duplicity and manipulation.**	**The market will punish companies with unbalanced carbon balance sheets.**
TESTS	Formal economic modeling of the impacts of specific carbon pricing regimes on business behavior.	Survey different business and policy leaders on efforts for global standardization.	Pursue pilot carbon markets to test the challenges to reporting, monitoring and enforcement.	Analyze the cost of capital for firms with large carbon liabilities.

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Endnotes

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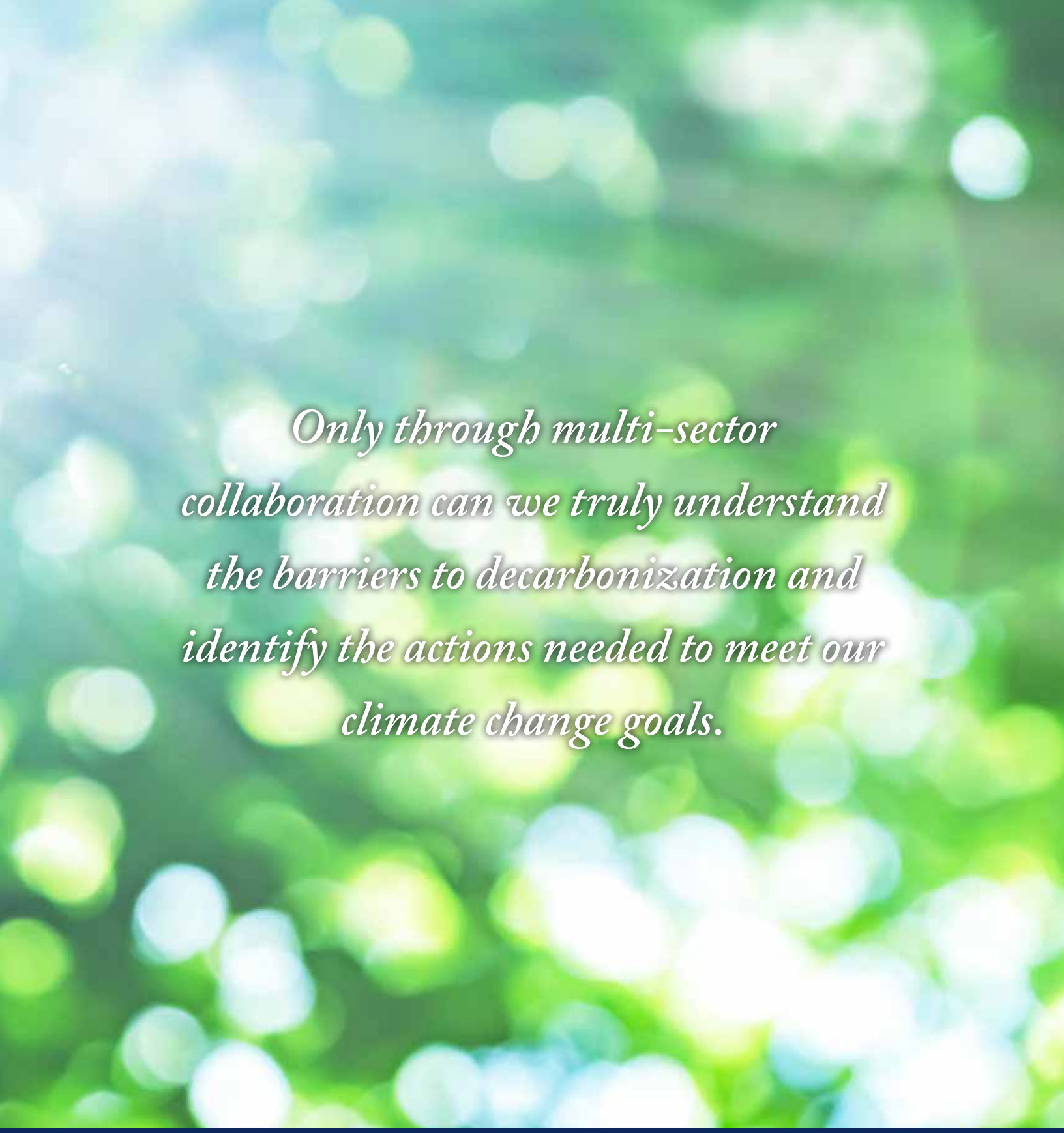

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