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Boston University Institute for Sustainable Energy

Target – Plan – Finance:
A Framework for Climate Policy in Federal Infrastructure Legislation
A Discussion Draft

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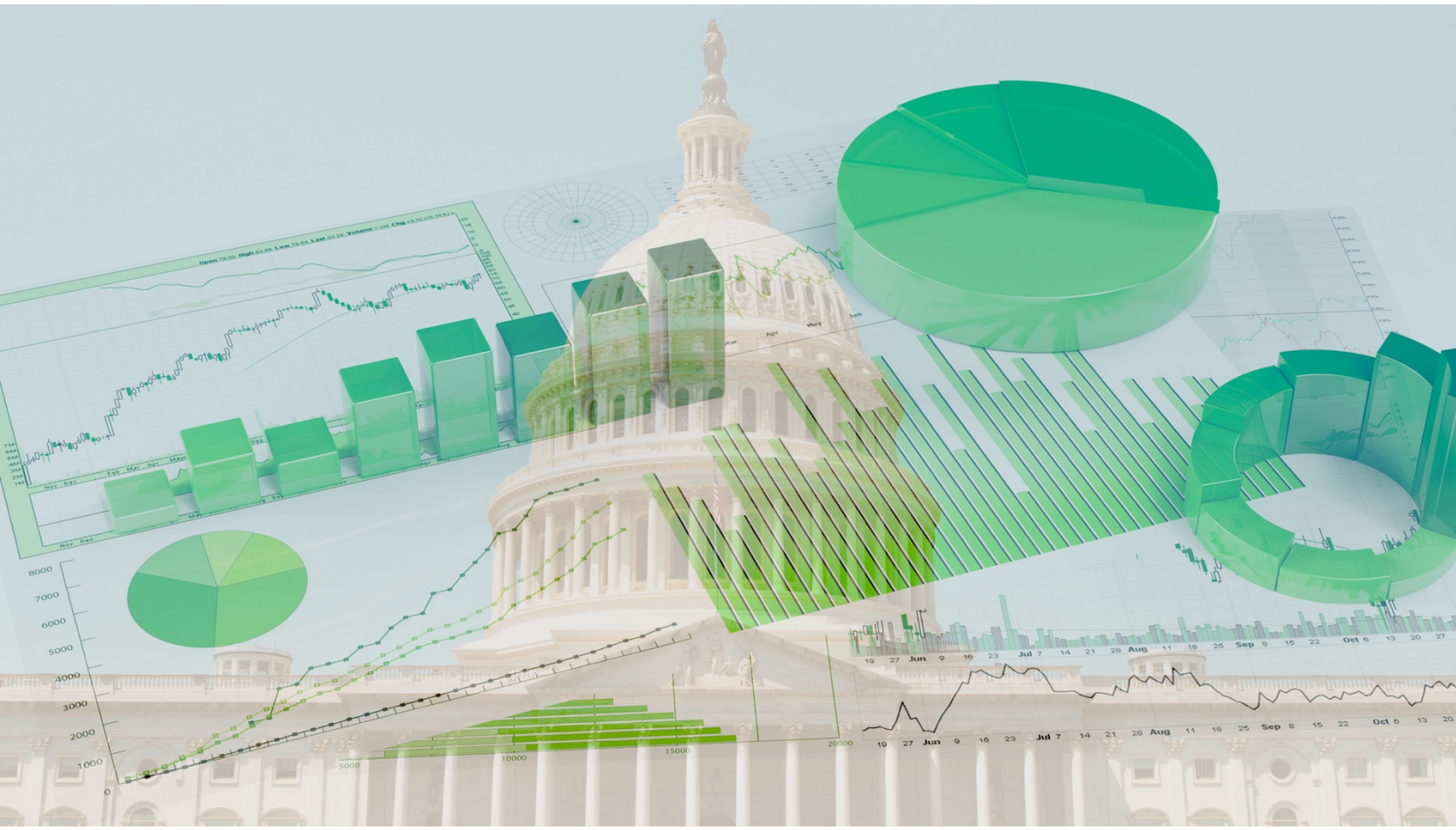

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Summary

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Enacting a successful national climate policy to achieve economy-wide net zero emissions by 2050 is unlike almost anything America has legislated in its history. The climate problem presents many features that will require planning to solve, including many chicken-and-egg market and infrastructure problems, economies of scale, and timelines far longer than most legislative careers or private capital investment periods. A climate policy in the form of dozens of new standalone programs, each subject to its own appropriation and legislative imperatives, is not the best path to lasting success.

Current American climate policies are particularly vulnerable to a failure to construct energy infrastructure – transmission lines, hydrogen transport and storage, CCS facilities and the like – in a timely manner. With the exception of electric transmission, there is no regional or federal planning whatsoever for energy infrastructure. Even for transmission, we show that current processes are yielding capacity additions in the range of *one-third* to *one-tenth* the needed rate. Planning processes must also integrate multiple types of infrastructure rather than create separate siloed plans.

We suggest a policy framework we call "target-plan-finance" that is institutionally and politically designed to continue, modify itself, and remain on course as the country and the world undergo decades of change. As the title suggests, it has three parts:

1. Set clear targets in law for each sector of the economy
2. Require states and large, carbon-intensive industries to submit plans every five years that show how they will meet these targets;
3. Provide increased R&D funding and federal financing for elements of these plans that the private market won't support due to the level of risk or other factors.

By establishing measurable targets for all sectors, this framework creates a clear national north star that every state and industry can steer towards. It also recognizes that no Administration or Congress can write legislation that foresees what climate action needs to be over multiple decades. In addition, this framework embraces the practical reality that our country and our economy are too large and diverse to reconfigure top-down. Instead, in the proposed framework, planning is done by the states and by collaborative industry-led consortia based on requirements set by the federal government.

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1. The Uniqueness of Climate Policy

As we recover from the worst pandemic in a century, public support for action to mitigate global climate change has never been stronger. From the Texas deep freeze to soon-to-be snowless northern ski resorts, extreme weather events alongside our experience with COVID-19 have strengthened public support for reducing climate change. Resources for the Future's 2020 survey found 82% of Americans supporting "at least a moderate amount" to fight climate change, an all-time high, while two-thirds say that developing clean energy should be a "high or very high" priority for government action.[i] With this level of support, bipartisan action to adopt a sound, effective national climate policy ought to someday soon be within reach.

A national climate policy is larger and different than nearly anything else a national policymaker will enact during their career. First, the policy has a highly measurable and unforgiving scientific goal set decades in the future, roughly translated as reducing U.S. greenhouse gases in all sectors to net zero by 2050 (0x50). To do this it is essential to make immediate progress in this decade, but the policy must also be sustained, monitored, and corrected across seven more U.S. presidential administrations and fifteen new Congresses before 2050 – not to mention many decades of subsequent work.

Climate policy's second unique feature is that success requires deep changes in every sector, not just the electricity, gas, and oil industries. The policy must upgrade most of the 124 million buildings in the United States and change roughly half their heating systems[ii], replace essentially all 272 million of our vehicles[iii] and their fueling infrastructure, retool tens of thousands of industrial facilities[iv] and create thousands of miles of entirely new energy infrastructure for fuels like hydrogen and CO2.[v] Importantly, the things that are being changed are very long-lived, so that changes must often occur ahead of normal replacement cycles, and new facilities and infrastructure must anticipate rather than lag behind changing market demand.

The speed as well as the breadth of the transformation is also unprecedented. Leading scholars of techno-economic change such as Vaclav Smil have found no examples of societies able to change the systems of energy production and use faster than roughly one century.[vi] In response, some practitioners argue that vastly better information technology and manufacturing techniques and our well-developed financial system will allow us to exceed historic rates of change. Nonetheless, it has already taken 55 years for all renewable energy

sources to increase from 6% of world energy supplies to a little over 11%.[vii] To reach our climate goals, we will have to change much faster than ever before.

We should certainly not forget that these massive, unprecedented shifts will yield enormous benefits in employment, public health, and competitiveness. Several studies of the U.S.' pathway to decarbonization (see Table 1) find millions of net new jobs created, a commercial sector better able to compete in the global economy, and greatly improved public health from reduced pollution and better lifestyles. To cite one example, in 2020, UC Berkeley conducted a report to examine the technical and economic feasibility of achieving 90% clean (carbon-free) electricity in the United States by 2035. The 90% Clean case supports over 500,000 more jobs each year compared to the No New Policy case and also avoids about $1.2 trillion in environmental and health costs through 2050, including approximately 85,000 premature deaths.[viii]

The final unique aspect of climate policy is that it must bring along the rest of the world if it is to succeed. Our best hope of spurring both developed and emerging partners to cut their own emissions is to enact a policy that convinces them that our own actions are strong, effective, and stable. This is of even greater import now that we have twice reversed our membership in the Paris Accord and thus lost much of our leadership credibility.

Table 1

Net Jobs Created in Deep Decarbonization Studies

Decarbonization Study	Target Description	Job Creation
Princeton: Net Zero America	Net zero CO2 by 2050	"In the 2020s, net-zero pathways support an annual average of ~3 million supply-side energy jobs, a net increase of ~0.5-1 million jobs relative to a business-as-usual scenario."
Sustainable Development Solutions Network: America's Zero Carbon Action Plan	Net zero CO2 by 2050	"We estimate that the clean energy sector and its supply chains will create around 2.5 million net jobs per year on average between 2020 and 2050, taking into account the decline in jobs in the fossil-fuel industries."
National Academies of Sciences, Engineering, and Medicine: Accelerating Decarbonization of the U.S. Energy System	Net zero CO2 by 2050	"Studies estimate that the transition could increase net employment in the energy system by roughly 1 million to 2 million jobs domestically over the next decade."
Energy Innovation: A 1.5°C NDC for Climate Leadership by the United States	Near zero GHGs by 2050	Transition will "create more than 3.2 million new job-years by 2030 and nearly 5 million new job-years by 2050."

2. A Constitutional Challenge

A policy of this length, depth, and breadth is unlike almost anything America has legislated in its history. Climate advocates often talk about the need for a World-War-II-style mobilization, but the carbon transformation will take much longer than any of our past wars, pandemics, or other periods of national emergency.[ix] We need a policy that takes effect right away, yet is institutionally and politically designed to continue, modify itself, and remain on course as the country and the world undergo decades of change. This is closer to enacting a national constitution than a single, even massive, piece of legislation or policy.

There is perhaps one good parallel in U.S. history. Between around 1900 and 1930 two-thirds of the U.S. economy gained electricity service for the first time. The entire fabric of the American economy and social system was utterly transformed by electricity, just as it will be changed by decarbonization. The original electrification of factories was "the most sweeping and complex change in manufacturing over the past century," says historian Richard DuBoff.[x] Commercial activity was also revolutionized by lighting that was cleaner and, for the first time, enabled widespread commerce after dark. Electricity also allowed for remote communications, allowing managers to assemble larger organizations. In the words of historian Jill Jonnes, electricity "drove the relentless growth of large and complex corporations, the economic basis for a century of astonishing societal and material change."[xi]

Social systems were also radically transformed. For the first time, people who worked in fields and homes all day could read and learn at night. In the cities, refrigeration and appliances like electric washing machines greatly changed the lives of many women, who then handled the vast majority of household tasks. The arrival of electricity in rural American villages brought even larger changes, including modern plumbing, and running water. Before electricity, rural farmwives spent more than 20 days a year doing laundry by hand. Entertainment began its unstoppable march from exclusively small, local live performances to the global mega-channel streaming services we have today.

This transformation didn't come about from a single federal appropriation or one-time enactment. Instead, the federal government created several permanent institutions that directed progress and changed over decades. In the cities, states created regulators who governed private utilities or city-owned counterparts. Both were given the same target – electrify every customer without discrimination or excess cost – and both were given stable, long-term financial support. In rural areas, the federal government created an administration to electrify rural communities using local cooperatives backed by federal funds, again with the

requirement for universal service and fair pricing. Several federal and state power development administrations were also started to develop areas with high potential, such as the Tennessee Valley Authority and the New York Power Authority. Finally, the Federal Power Commission – created in 1920 largely to develop hydropower– was recast in 1935 to coordinate and govern the interstate power grid.

This system of institutions was not the result a single enactment – though many came out of the New Deal – nor were they a specific set of appropriations or programs. Instead, they were institutions that were given a long-term but concrete mission, stable federal assistance to achieve it, and oversight to ensure that objectives were met. The federal government also contributed research and development and other forms of financial assistance, but it did not plan or run the enterprise from a windowless bunker in Washington D.C. Instead, it set a clear national mandate for universal service at cost-based rates, created oversight bodies, and ensured that financing was available to achieve that goal.

3. A Framework for Sustained Action

A large new Federal Climate Administration might seem like the most logical way to mimic electricity's installation on a faster timetable. However, this does not fit well with the evolution of U.S. federalism nor the sprawling and diverse regional economies that today make up our nation. Because the changes span so many sectors, and involve so many processes and activities, a "whole of government" approach is much more appropriate. A climate uber-agency risks relieving each unit of government of its responsibility to embed climate policy in all its actions, actions that build on decades of governing experience and relationships with its stakeholders.

Nonetheless, sustained action that gives any sort of confidence that a distant, ambitious target will be reached requires some sort of durable governing system. One would hardly launch a spacecraft on a 30-year mission without extensive planning and a system to monitor and correct course towards the destination. Climate policy in the form of dozens of new standalone programs – each subject to their own appropriation and legislative imperatives – doesn't do this.

One framework that seems achievable, if ambitious, for this task relies on establishing targets, requiring plans to meet the targets, and providing federal assistance – notably, financing – to

help the plans succeed. This approach, which we call target-plan-finance (TPF), has three parts:

1. Set clear targets in law for each sector of the economy, much like the proposed Clean Energy Standard would for electricity; for most sectors this would probably be something like net zero by 2050;

2. Require states and large, carbon-intensive industries to submit plans every five years that show how they will meet these targets[xii];

3. Provide increased R&D funding and federal financing for elements of these plans that the private market won't support due to the level of risk or other factors.

This approach takes much of what is already happening and places it into a framework that has a number of advantages. First, by establishing measurable targets for all sectors it creates a clear national north star that every state and industry can steer towards. The old chestnut that 'you can't manage what you can't measure' applies to climate policies, too. Clear, science-based targets – coupled to the rest of the framework – will also send a strong signal of commitment to friends and foes alike and will do much to reclaim the mantle of leadership.

Second, this framework recognizes that no Administration or Congress can write legislation that foresees what climate action needs to be over multiple decades. The founders of our country did not meet in Philadelphia to decide the laws that our new country needed, they met to set out the nation's goals and create a mechanism for determining the authorities and institutions that would achieve these ends. In a similar sense, this framework is a mechanism designed to best guide the country to a safe and sound economy, not a specific set of programs or policies.

This does not mean that we should put a pause on the multitude of immediate policies now under debate in the American Jobs Plan nor the many other legislative proposals being considered. Far from it. There is a clear, urgent need to act now on many policies, from expanded climate science and research and development (R&D) to standards such as the Energy Efficiency and Clean Electricity Standard (EECES) to the immediate deployment of measures that save carbon and money while creating jobs. If we enact these alone, however, we will have no framework to guide the effort nor guarantee the result, and in a few years or less we'll be back to needing another giant package of course-correcting measures. Washington veterans know that it sometimes takes decades for Congress to come back around to revisiting major enactments, decades we simply don't have in this particular case.

The framework's third advantage is that it embraces the practical reality that our country and our economy are too large and diverse to reconfigure top-down. Instead, in the proposed framework, planning is done by the states and by collaborative industry-led consortia, based on

requirements set by the federal government. Although federal oversight of these plans will be necessary, this eliminates the need to create a large federal planning bureaucracy without giving up on planning itself. In addition, this allows us to leverage a huge amount of energy and climate planning already underway in many states and by a wide variety of companies and industries (more on this below).

One part of this advantage is that civil society stakeholders, including environmental justice advocates, can more easily play a much larger role in these multiple state- and industry-led efforts than they can in a single federal mega-plan. In many policy areas, stakeholders find it more challenging to help shape programs that originate in Washington versus those that originate in local cities or counties and end up in a statewide plan. A huge number of federal programs already operate this way for precisely this reason, and the TPF framework follows this logic without giving up on a common and binding nationwide goal.

Finally, this framework is an integrated combination of carrots and sticks, which is likely to be both the fairest and most effective approach. A policy that is a series of unfunded mandates is, of course, least likely to pass and may also be unfair in the incidence of it impacts, not to mention ultimately unsuccessful. A policy that is all financial inducements of one form or another, while creating jobs and other benefits, will be most costly to the treasury and also carries no assurance of reaching a science-based outcome. A framework that links important financial assistance to specific plans calibrated to reach the goal combines the best of both worlds, allowing for both effectiveness and fairness.

4. Why Planning is Important

Energy production and use facilities require years to plan, permit, build, and debug, while lasting for many decades. Reaching a fully decarbonized energy system in thirty years will be extremely difficult, and more importantly difficult to ascertain in advance, without meaningful forward planning. There are at least four major reasons.

First, in the U.S. our energy *infrastructure* planning is weak-to-nonexistent. This is true even for the heavily regulated electric industry, which generally does reliable planning and has already made great strides in climate action by bringing emissions down 39%. In the case of electric transmission, the Federal Energy Regulatory Commission (FERC) oversees a non-binding regional transmission planning process that has rarely yielded major new lines[xiii] (there are some helpful new proposals brewing, but likely not enough)[xiv]. For the rest of the clean fuels –

hydrogen, biofuels, captured carbon, and even natural gas – there is no regional or national planning whatsoever.[xv]

This lacuna does not square with the scale and speed of energy infrastructure needed to decarbonize. Even transmission, which involves considerable planning, is falling short. The U.S. has built roughly 3,000 miles of transmission lines a year in recent years, about 1.3% annual growth. However, most of these new lines were added to bolster local reliability, not enable renewable capacity. Yet, the Princeton University Net Zero plan shows a need for a transmission system *more than twice the size of the current system.* The same study shows carbon dioxide pipelines for CCS increasing from 8,500 kM today to 110,000 kM by 2050, an increase of almost 1200%.[xvi] New England has a relatively strong record on climate action that provides a cautionary tale. Here transmission connections to large new renewable sources have averaged 300 MW/year in the last decade. To reach the states' 2030 climate targets, this rate of connection must nearly triple, to 830 MW a year. To reach 2050 goals, the rate of grid-connected additions must increase *tenfold.* (see Appendix One).

There are many specific U.S. examples of transmission lines needed for clean energy goals failing to move forward. After five years of seeking permission and losing to multiple opponents, New England utility Eversource abandoned the Northern Pass transmission line to Canada[xvii]. Entrepreneur Mike Skelly's failed attempt to build a line to ship wind power from Oklahoma to Tennessee – one of several lines Skelly imagined, but could not get built – is chronicled in the book *Super Power.*[xviii] In the Midwest, Xcel Energy recently asked its regulators for permission to buy power from one particular wind generator because it was the last one with transmission access large enough to serve its demand; in 2019 it failed to buy all the renewable energy it needed because its bidders could get only half the transmission they needed.[xix] "Transmission build-out might be the limiting factor for growth of solar or storage and dictating the pace of change," writes Colin Smith of Wood Mackenzie.[xx] The Midwest's independent grid planner and operator just recently "issued dire warnings about the possible fallout if the grid operator doesn't pursue big ticket transmission projects," according to one industry trade publication[xxi].

Revising its planning process to create an integrated decarbonization plan, the European Union wrote last year that:

> Today's energy system is still built on several parallel, vertical energy value chains, which rigidly link specific energy resources with specific end-use sectors...This model of separate silos cannot deliver a climate-neutral economy…*Energy system integration – the coordinated planning and*

> *operation of the energy system 'as a whole,' across multiple energy carriers, infrastructures, and consumption sectors* – is the pathway towards an effective, affordable, and deep decarbonization."[xxii]

The EU is correct. To decarbonize quickly, we need integrated planning of the whole clean energy system, not sector-by-sector planning processes. A second reason why planning is critical is that the clean supply sectors and customer demand for clean fuels can't be allowed to get far out of synch, as they both change rapidly. We are asking industries like steel and chemicals to shift their energy supplies with unprecedented speed. They need confidence that the specific form of clean energy they plan to use will be delivered when and where needed. Likewise, power generators need to know that transmission will be available to transport their energy; hydrogen suppliers and users both need transport and delivery facilities between them; and decarbonized gas generators need CCS infrastructure to take and store their CO2 on an ongoing, real-time basis. Decarbonizing one part of the value chain only to find that the other parts didn't get the necessary permits, or weren't able to get financing, will stall or even reverse the transition.

One related aspect of supply-demand matching that argues even more strongly for planning is the need to start building infrastructure in advance of demand. It often takes ten years or more to plan, site, and build energy infrastructure, while building most facilities that make or use energy takes much less time. If you don't plan, you wait until energy producers "send a market signal" by clamoring for access to infrastructure, the way wind and solar generators are now complaining in the Midwest and New England. Waiting for this clamor to emerge and then starting to plan and build is fine if you aren't racing against the climate clock, but it is not a recipe for moving quickly. Put simply, the market-based planning paradigm we use in the United States to prompt the construction of infrastructure is simply not suited to decarbonizing at the necessary speed.

Returning briefly to the power grid, there are a few scattered examples of the sort of proactive planning we will need to decarbonize quickly. The first of these is the Competitive Renewable Energy Zone (CREZ) project Texas built in 2005. While Western Texas has tremendous wind energy resources, the majority of the energy demand is located in the state's eastern cities. Recognizing the economic potential trapped in the windy but remote regions without transmission, the Texas legislature passed a bill in 2005 that ordered that the Public Utility Commission of Texas (PUC) develop a transmission plan to deliver 18.5 gigawatts of renewable power to customers.[xxiii] This was, and still is by most regions' standards, a radical planning action: building out high-voltage electric transmission infrastructure in anticipation of demand.

Planning wasn't easy or cheap. The effort took nearly ten years to complete from beginning to end, with the expected protests of landowners, and cost $7 billion to finance – two billion more than the original price tag. In return, however, CREZ resulted in over 18 GW of new wind generation capacity, yielding annual electricity cost savings of roughly $2 billion per year and $5 billion in added economic development – benefits far beyond initial estimates.[xxiv] In fact, the project is credited with making Texas the leading state for renewable energy capacity in the country, with nearly twice as much capacity (39 GW) as the next state (California with 20 GW).[xxv]

A second success story was led by the Midcontinent Independent System Operator (MISO), a FERC-chartered planner covering much of the Midwest. Over 10 years ago, MISO began planning in anticipation of the development of wind generation capacity to meet the state-by-state Renewable Portfolio Standards in its territory. To do so, MISO came to a consensus with the states in its region that it would plan for half the needed renewables to come from out of state and half produced locally.

The transmission projects developed through this process provided the start of what would become a portfolio of 17 Multi-Value Projects (MVPs). Diverging from transmission planning's typical narrow focus, the MVP planning process identified a comprehensive set of upgrades across its footprint that would provide a mix of reliability, policy, and economic benefits to the system, which are often only considered one at a time. Similar to Texas' CREZ, the MVP projects have delivered benefits above initial estimates. The projects allow over 11 GW of wind to be delivered that would be curtailed without the projects, and the economic net-benefits over the next 20-40 years are $12 to $53 billion.[xxvi]

A third reason why planning is important is that decarbonizing processes and industries is almost always best done in stages, not according to what seems cheapest or most feasible at the moment. The market is unquestionably smarter than any one government, technologist, or consumer, but decarbonizing often requires a series of decisions as to which technologies to pursue and which to drop in the presence of great uncertainty. In these situations, markets often choose options that look best in the short run but don't work in the long run, getting all the way to net zero emissions. In other cases, the smart approach is to decarbonize some market segments and industries now while we pour large R&D efforts into new solutions for sectors that are now expensive or impossible.

We face many choices like this already. We can decarbonize some types of buildings in some climates with current heat pumps, but for others these technologies need a fossil backup system for heating on cold days or very expensive electricity grid changes to provide electric backup. Should we simply skip the difficult-to-convert buildings for now and wait for better technologies in a decade? Decarbonize partially and keep the current fossil-based backup? Expand the local grid to provide electric backup? These are not decisions any single building owner can make – they involve everything from the global supply chain for heat pumps to at least two regulated infrastructure providers, electricity, and gas.

We face similar choices in many other sectors, from steel to heavy-duty transportation to hydrogen production to EV charging infrastructure. Each of these has a variety of near-term but incomplete carbon-saving options and uncertain future full-scale solutions that require more R&D or deeper institutional change. Outside of a planning process, how can we evaluate the multi-faceted pros and cons of taking one policy and technology path over another?

The final reason why planning is critical that few if any large energy using sectors have undergone the kind of rapid, policy-led transition now needed. In contrast to the states and utilities, there are almost no formal industrywide planning institutions – indeed, industries eschew them for fear of violating antitrust laws. Even where industries have started to plan together, they see the need for a strong partner in the federal government. As one example, the trade association for major U.S. airlines, Airlines For America (A4A) recently announced a "commitment" to a "positive partnership" that would lead to net zero industrywide emissions by 2050. Yet A4A's announcement stresses the critical role it expects government to play in achieving its goal:

> The A4A airlines are committed to working in partnership across the commercial aviation sector and beyond to help advance and deploy commercially viable technology, operations, infrastructure and SAF to meet our ambitious climate goals. At the same time, it is imperative that the U.S. federal, state and local governments implement supportive policies and programs that enable innovation, scale-up, cost-competitiveness and deployment in each of these areas, while avoiding the implementation of policies that would limit the aviation industry's ability to invest in emissions-reducing measures.[xxvii]

The importance of planning is also highlighted by the statements of many industry leaders who have made commitments to achieving net zero emissions but confess that they do not have a

plan to get there. Seventy-one percent of 250 senior U.S. industry executives now say that they are deferring climate action until after 2030 even if they have made a net zero commitment, and the investor group Climate Action 100+ recently revealed that, despite more than two years of seeking disclosures, not a single one of the 159 companies they targeted has "fully disclosed" their net zero plans.[xxviii] One of the 159 is Arcelor Mittal, the world's largest steel company, whose CEO recently said "the largest challenge the world is going to face over the next 30 years is how we decarbonize."[xxix]

Several experts point to the government planning efforts during the Second World War as good models for the rapid retooling of high-emissions industries.[xxx] While planning efforts clearly helped win the war, the parallels are not altogether apt. In WWII, planning was led by government agencies that were quickly dismantled just a few years later when the fighting stopped. Their goal was to redirect factories quickly into making very different products temporarily. In contrast, our goal is to produce the same products without carbon, permanently changing the production process to yield more of the same output. For this, a more collaborative and longer-term planning structure is needed. Following a study of economic transitions like decarbonization, two Roosevelt Institute scholars recently concluded that the "need for active managing [i.e., planning] of major economic transitions has been experienced by almost every country that has rapidly industrialized, including the U.S."[xxxi]

Regional planning will not just avoid mishaps – it will create giant new opportunities. The creation of clean energy infrastructure hubs, where industrial energy users, hydrogen production facilities, electric transmission systems, and sequestration facilities all connect in a single local area, is a bold new idea. Two pilot hubs are under development in Europe, and the Energy Futures Initiative (EFI) and the Princeton Net Zero America Project have both advanced the idea in the U.S.[xxxii] EFI has produced Figure 1, mapping the approximate locations of possible future sources and sinks for sequestered carbon and hydrogen production.[xxxiii] Hubs like these could create huge new investment and employment opportunities in transitioning parts of the U.S., but they will not happen on a rapid time scale without federally-assisted regional planning.

FIGURE 1 ENERGY FUTURES INITIATIVE'S MAP OF POSSIBLE CARBON HUBS

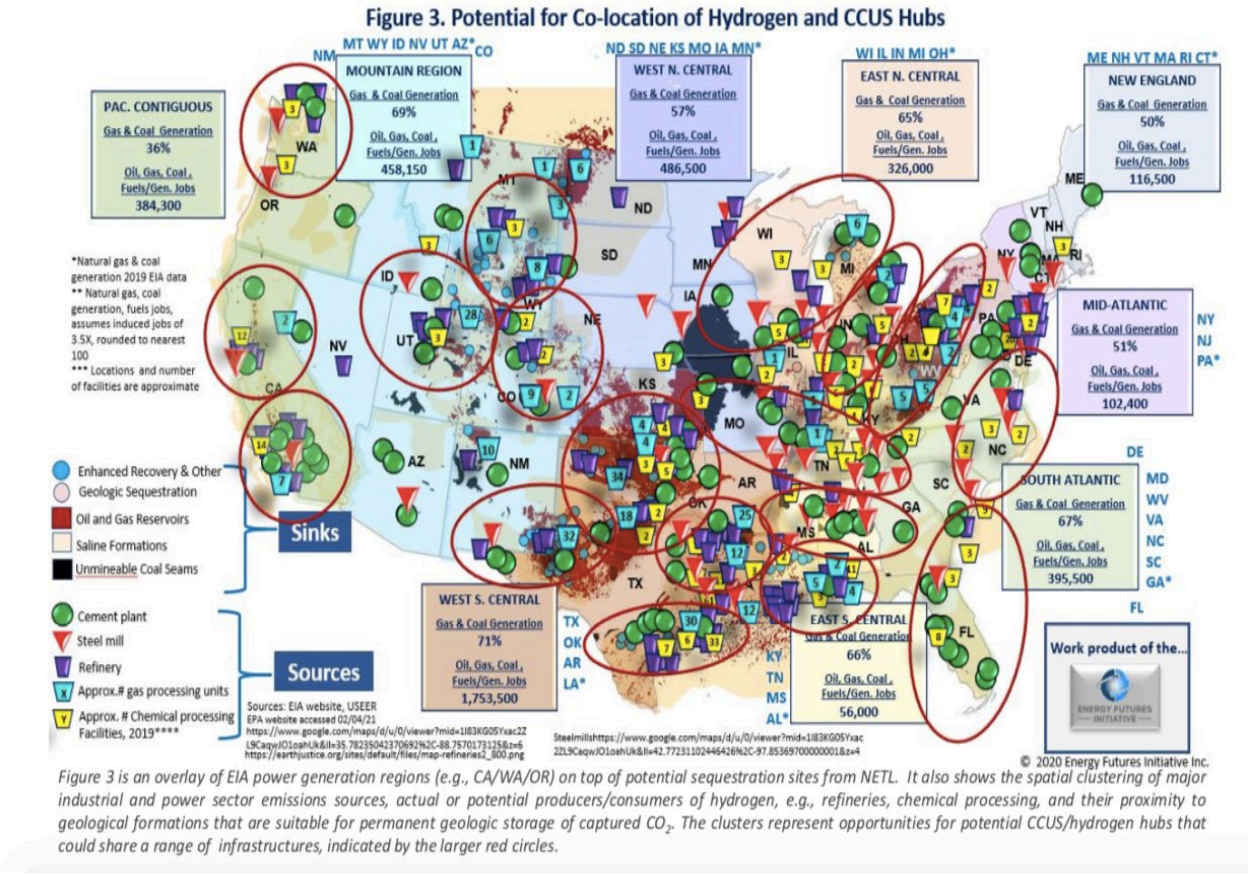

Figure 3 is an overlay of EIA power generation regions (e.g., CA/WA/OR) on top of potential sequestration sites from NETL. It also shows the spatial clustering of major industrial and power sector emissions sources, actual or potential producers/consumers of hydrogen, e.g., refineries, chemical processing, and their proximity to geological formations that are suitable for permanent geologic storage of captured CO_2. The clusters represent opportunities for potential CCUS/hydrogen hubs that could share a range of infrastructures, indicated by the larger red circles.

Source: E.J. Moniz testimony, House Energy and Commerce Committee, 3.22.21

Dwight Eisenhower is famously credited with saying that "plans are useless, but planning is indispensable." This wise and successful general knew that the test of a plan was not its ability to avoid error or perfectly predict the future. It is rather the greater commitment, accountability, and auditability that plans convey which make them critical tools for achieving difficult objectives.

But plans, alone are not the answer either. They must be tied to the right targets, and they must be financed. During World War II the country pulled together to finance a massive war effort using every available financial tool. No less is needed today.

5. Financing

All climate policies identify many kinds of large, required capital outlays. With proper policy support, the vast majority of these investments can be made by non-federal investors, including utilities of all types, competitive firms, and public-private partnerships. There is every indication that global capital markets stand ready to finance this multi-trillion-dollar transition. As one recent sign, 43 banks, insurance companies, and funds that manage $70 trillion in assets formed the Glasgow Financial Alliance for Net Zero, a group dedicated to funding net-zero efforts by countries and firms.[xxxiv]

However, private capital markets simply cannot do it all. Private capital is limited in its ability to fund rapid transitions with new technologies at large scale. It will not readily fund pre-commercial development expenses and will not finance energy infrastructure unless the costs and revenues are reasonably assured. This is true regardless of whether we enact a clean energy standard or carbon price.

The carbon transition will involve many investments where private capital will do the vast majority of the work, but not all of it. For example, some of the resources needed for compliance with a CES will be innovative technologies whose costs have not yet come down the learning curve to the point where their costs do not raise utility rates. There will be resistance to making any purchases of this nature without federal financial assistance that is project-specific, not technology-specific, like renewable tax incentives. Utilities and their capital providers will be wary of these investments unless there is assurance that costs won't be stranded. Federal financial backstops can help lower this risk. The Net Zero America Project examined the division between public and private capital providers in a transition to net zero and concluded that about $600 billion of pre-commercial (i.e., public) development financing is needed to decarbonize by 2050.[xxxv]

There are many successful examples of federal financing for infrastructure and public works as well as some very good new proposals. Past successes include the Marshall Plan and other World War II programs, public power and cooperative utilities, electric utility energy efficiency programs, state revolving loan funds, state green banks, and public-private partnerships such as Path 15 in California. The Department of Energy has run a very successful loan guarantee program under Obama and is now ramping up for an even larger program, but the need for full-scale financing tools likely goes well beyond loan guarantees.

One of the most attractive new proposals is in the Clean Energy and Sustainability Accelerator Act[xxxvi], already introduced by five senators and Congresswoman Dingell. It proposes a Green Bank that would be capitalized at $100 Bn, which is a good start, and appears to have wide latitude to invest in clean energy infrastructure of all types with many types of debt and equity instruments. The new National Academy study of U.S. decarbonization also recommends a Green Bank. If a Green Bank has sufficient capitalization, the latitude to deploy several financial instruments, and the authority to invest in any facility that is a) part of a decarbonization plan, and b) not suited to private financing, it would be an excellent solution. In addition to generally supporting progress, the terms of public financing can be shaped to further incent and reward states and industries that are more ambitious and proactive, such as further reducing interest costs for first movers, or rewarding states that plan and permit regional and interregional facilities.

Although a clean energy financing facility with broad authority and a linkage to planning is crucial, each of the major use sectors already has many specialized federally-supported programs and funds. Consistent with President Biden's whole-of-government approach, each of these should be instructed to make funding and financing projects and investments that contribute to climate targets an integral part of their mission. To cite just a few examples:

- The Federal Housing Finance Agency can require Fannie Mae and Freddie Mac to help make residential mortgages primary tools for upgrading existing homes and building new net-zero housing, as recommended by RMI;
- HUD's public housing financing can help decarbonize public housing while it is being upgraded;
- The last proposal for the America's Transportation and Infrastructure Act contained nine separate federal grant making and investment funds directed at various parts of the transport system, including specific funds for electrifying ports, adding EV chargers on highways, and general carbon reduction; and
- The Transportation Infrastructure Financing and Innovation Act (TIFIA) fund could be modified to encourage decarbonization as one element of the projects it funds, as suggested by the Natural Resources Defense Council.

Whether narrow or broad in their remit, entities with the authority and resources to finance the public part of the energy transition are the fourth crucial ingredient in a good policy. The first three ingredients – a firm target, use sector programs, and required infrastructure planning – are essentially directives to plan and deploy capital to save our climate and create jobs. The

federal government should support these requests with the capital that private markets won't provide. This creates a fair bargain that balances mandates that are very much in the national interest with financial resources that unlock and multiply clean economic growth and job creation.

6. Building on Existing Efforts

While there is nothing approaching systematic national climate planning in the U.S., there is a veritable cornucopia of state, local, and industry planning efforts that a federal planning mandate should leverage rather than replace.

Almost every state does some form of energy planning now, sometimes with very clear net zero targets. Typically, State Energy Offices are charged with guiding energy planning processes, and in the cases where GHG targets and energy standards exist, officials account for them in the energy plans they produce. These documents are incredibly important because they inform allocation of resources related to energy infrastructure and programs, create directives which encourage economic development, and recommend future energy policies for the state. Not only do state and local agencies rely on these plans to inform their decision-making, but companies in the private sector use them to guide their investment decisions.[xxxvii] The most actionable and robust state energy plans are those that offer goals and recommended actions linked to climate and energy-related policies, codes and standards, tax credits, investment incentives, and market-based programs such as cap-and-trade.[xxxviii]

While every state in the nation has passed some kind of climate or clean energy policy, only sixteen have adopted binding statutes that codify their greenhouse gas emissions targets. This approach of setting statutory GHG targets began with Maine (2003) and California (2006), and was adopted most recently by Virginia, Massachusetts, and Rhode Island.[xxxix] The most effective versions of these policies not only create targets for GHG reduction requirements, but require state agencies on an annual, biennial, or triennial basis to conduct a GHG emissions inventory or reporting process to measure emissions from major sources. Nine states – California, Virginia, Maryland, New Jersey, Connecticut, Massachusetts, New York, Vermont, and Maine – model comprehensive policies which combine both reduction and reporting requirements.

As in other areas, Congress can build on and strengthen these planning processes. And while it is minimally essential for states to plan alone, regional planning is much better, and should be a strongly encouraged alternative to individual state plans. As recognized by the longstanding

successes in regional energy planning in the Pacific Northwest, and the recent NESCOE statement calling for reformed and strengthened regional grid planning, the natural geographic limits for energy system plans are regions, not state borders.

Although they are quite different in history and detail, California, Massachusetts, and New York have each adopted state systems of targeting, planning, and financing that are quite similar to the framework we propose. California has sector-by-sector emissions reductions targets set by state law and a regular process of statewide planning designed to help ensure these targets are met. This includes an extensive biennial statewide planning proceeding and an elaborate process of merging all utility investment plans, overseen by the state regulator, into a single simulation model to predict future emissions.[xl]

In 2019, New York passed a law establishing a target of net zero electricity by 2040 and 85% reduction in GHGs by 2050. One year later it enacted the Accelerated Renewable Energy Growth and Community Benefit Act, which required its public service commission to create two integrated planning processes, one for each local grid and one for the statewide transmission system. "Among other things," its regulators wrote, "the Act direct the Commission to develop and implement plans for future investments in the electric grid."[xli] Similarly, New Jersey's Energy Master Plan (EMP) released in 2020 serves as an example of an actionable plan that is tied to state-level carbon reduction policies.[xlii] In addition to using utility regulation to improve existing programs, the plan also adopts new clean energy and energy efficiency financing mechanisms, and strengthens building and energy code and appliance standards.[xliii]

Massachusetts' latest climate law (Bill S.9) adopted in March 2021 provides a prime example of a policy that mandates GHG emissions targets alongside planning and financing.[xliv] In addition to setting a state-wide emission reduction target of 85% below 1990 levels by 2050, the bill requires sector-specific targets for the electricity, transportation, heating and cooling, industrial process, and natural gas distribution and service sectors. Furthermore, the bill sets interim emissions limits for each 5-year interval leading up to 2050 and requires relevant state agencies to pair every limit with a roadmap that contains implementation plans and key performance indicators (KPIs). Beyond publishing roadmaps, these agencies will have to submit compliance statements to the legislature every 5 years that that indicate how effective the state was in meeting each limit and offer recommendations for future actions in the case that limits are exceeded. These measures encourage transparency and hold both public officials and industry accountable for making progress.[xlv]

Turning from states to industry sectors, there is much work already underway that could form the basis for federally sanctioned plans. Apart from many individual corporate commitments, several industries such as the Portland Cement Association are already developing roadmaps to net-zero. Four industries – aluminum, concrete, chemicals, and steel – have formed global coalitions to produce net zero roadmaps as part of the Mission Possible Partnership. The aviation, shipping, and trucking industries have also formed worldwide coalitions to plan for decarbonization.[xlvi] The aviation industry has formed the Clean Skies for Tomorrow (CST) Coalition is "a global initiative for leaders throughout aviation's value-chain to collaboratively facilitate the industry's transition to net-zero emissions by mid-century." In ocean shipping, the Getting to Zero Coalition "works towards ensuring the viability of zero-emission vessels (ZEVs) along deep-sea trade routes by 2030, as well as building the infrastructure for scalable zero-carbon energy sources across production, distribution, storage, and bunkering." The trucking industry's coalition, with similar structure and goals, is called Road Freight Zero.[xlvii]. Toyota is on its *seventh* five-year Environmental Action Plan.

It is also important to note that federal agencies such as the Department of Energy (DOE) and the Department of Transportation (DOT) already do much collaborative planning with industry. To cite just one example, the DOE and several national labs have developed "roadmaps" for decarbonizing several industries.[xlviii] Under the new Administration these efforts are already increasing.[xlix]

In many respects, our proposal is little more than the idea of making these efforts required, consistent as to their target, and linked to the availability of federal financing for parts of the plan the market will not support. Absent our framework, these planning efforts will undoubtedly continue, but they will be literally as well as figuratively all over the map. There will be no assurance of hitting a difficult but essential science-based target, particularly when elements of each plan must geographically and technologically interact with elements of other plans in a time-sensitive manner.

7. Conclusion

In so-called planned economies there is never a question as to whether governments need a plan. The plan is a principal means of mediating competing stakeholder demands, in effect substituting for the legislative process in multiparty democracies. In the United States, where the planning tradition is modest and largely private, elections and the legislation take the place of long-term planning. If, alongside a hundred other important political issues, our climate policies are not in synch with our electorate's preferences and our moral duty, we replace our

policymakers in an election. Presidential candidates' climate platforms are the national means by which we assess the effectiveness of current climate policies and propose new ones.

Even without the immense polarization and paralysis in the US' governing system, this is not the right management framework for a mission to rapidly change the long-lived, high-capital energy systems that underpin our existence. We find ourselves acting something like the Americans of 1780, attempting to wage war against a powerful foe with only a loose, voluntary governing framework – the Articles of Confederation – to manage the effort. Like our young country, we now need a better governing framework to take on a new existential challenge. While we have a window to reset our climate policy, it would be ideal to set one within a framework that is inherently less volatile, less politicized, and designed for long-term success.

To its immense credit, the Biden Administration has unleashed a torrent of bold proposals and ideas for a new climate policy. This is a vital part of democracy, and many important and innovative ideas are coming forth. However, individual new directives, programs, tax credits, and authorizations are far more likely to succeed if they occur in a framework of long-term requirements to plan, monitor, and report on progress.

That framework should be some form of net zero requirement for every sector, public-private and state-level planning to identify needs and gaps, increased federal RD&D funding, and multiple forms of federal financing, linked to planning and aimed directly at unlocking private capital. With this sort of mechanism, the U.S. stands a good chance of safeguarding the climate, achieving sustained economic and job growth, and retaining its position as a beacon of democracy and progress.

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Appendix 1: Transmission Infrastructure Needs – A Closer Look

CREZ

While Western Texas has tremendous wind energy resources, the majority of the energy demand is located in Eastern Texas. Recognizing the economic potential trapped in the windy but remote regions without transmission to deliver supply to demand, the Texas legislature passed a bill in 2005 that ordered that the Public Utility Commission of Texas (PUC)—in consultation with the Electric Reliability Council of Texas (ERCOT)—to designate competitive renewable energy zones (CREZ) and develop a transmission plan to deliver 18.5 GW of wind power to customers.[1,2] This was, and still is by most regions' standards, a radical planning action: building out high-voltage electric transmission infrastructure in anticipation of demand. The majority of transmission historically and today is planned, approved, and built-in response to a narrow set of pressing concerns, such as maintaining system reliability, not based on a forward-looking vision of the future power system and recognition of multiple value categories.

Planning wasn't easy or cheap, but the large investment enabled Texas to become the leading state for renewable energy capacity in the country with nearly twice as much capacity (39 GW) as the next state (California with 20 GW).[3] The effort took nearly ten years to complete from beginning to end, with the expected protests of landowners against building lines in near their properties. The projects also ran

[1] Cohn, J., Jankovska, O. Texas CREZ Lines: How Stakeholders Shape Major Energy Infrastructure Projects. Center for Energy Studies. 2020.
[2] Texas as a National Model for Bringing Clean Energy to the Grid. Americans for a Clean Energy Grid. October, 2017.
[3] https://cleanpower.org/facts/state-fact-sheets/

over budget, costing $7 billion to finance the entire build-out (two billion more than the estimated price tag). In return, however, CREZ resulted in over 18 GW of new wind generation capacity, reduced wind

curtailments from 17% to 0.5%, and have resulted in benefits far beyond initial estimates.[4] Annual electricity production cost savings are estimated to be roughly $2 billion per year, plus another $5 billion in incremental economic development.

MVPs

The Midcontinent Independent System Operator (MISO) includes X states from Minnesota to Louisiana and oversees transmission planning in one of the most wind-rich regions of the country. Over 10 years ago, MISO began planning in anticipation of the development of wind generation capacity to meet the state-by-state Renewable Portfolio Standards in its territory in its Renewable Generation Outlet Study (RGOS). To do so, MISO came to a consensus with the states that they would plan their system for half of the RPS to be achieved with in-state resources and half with out-of-state resources.

The transmission projects developed through this analysis provided the starting off point for what would become a portfolio of 17 Multi-Value Projects (MVPs). Diverging from transmission planning's typical narrow focus, the MISO MVP planning process identified a comprehensive set of upgrades across its footprint that would provide a mix of reliability, policy, and economic benefits to the system, which are often only considered one at a time.

Similar to Texas' CREZs, the MVP projects have delivered benefits above initial estimates. The projects allow over 11 GW of wind to be delivered that would be curtailed without the projects, and the economic net-benefits over the next 20-40 years are $12 to $53 billion.[5] Simply the optimization of wind generation siting resulting from the MVP planning process saved over $1B in capital expenditure.

[4] Billo, J. The Texas Competitive Renewable Energy Zone Process. ERCOT. 2017.

[5] A 2017 review of the public policy, economic, and qualitative benefits of the Multi-Value Project Portfolio. MISO. 2017.

Appendix 2: Applying the TPF Framework: Some Examples

Electricity and fuels are used primarily by three sprawling sectors of the US economy: buildings, transportation, and industry. Much of the equipment in these sectors must be completely replaced or substantially upgraded if the US is going to reduce its emissions to safe levels, even after a CES is adopted. This calls for significant measures analogous to the CES on "the demand side." These sectors are extremely large and diverse, and many sector-specific policies will be needed. However, there is a common high-level approach that mirrors and amplifies supply-side policies. First, create emissions targets leading to zero tailored to each end use within each sector. Second, fund R&D to develop better and cheaper solutions. Third, require public-private collaborative planning to meet the targets. Fourth provide financing in several forms to leverage private capital and create jobs.

Industry

Industry now accounts for 22 percent of U.S. GHG emissions and is projected to become the largest emitting sector by 2030 as utilities and transportation continue their downward trend.[6] More than 80% of this comes from five industries: iron and steel, cement, petrochemicals, lime, and ammonia.[7]

Decarbonizing these processes will require aggressive R&D, dedicated funding for scaling up and demonstrating processes, industrywide collaboration, federal "buy green" policies, and infrastructure planning and funding. These policies, described more completely in several recent works,[8] include:

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[6] David Hart, Building Back Cleaner With Industrial Decarbonization Demonstration Projects, https://itif.org/publications/2021/03/08/building-back-cleaner-industrial-decarbonization-demonstration-projects, citing Ben King et al., "Clean Product Standards: A New Approach to Industrial Decarbonization," Rhodium Group, December 9, 2020, https://rhg.com/research/clean-products-standard-industrial-decarbonization/.

[7] Inventory of U.S. Greenhouse Gas Emissions and Sinks, Table 4-1, https://www.epa.gov/sites/production/files/2021-04/documents/us-ghg-inventory-2021-main-text.pdf

[8] Major works and sources of recommendations in this area, summarized in this post, include: Sivaram ,et al Energizing America, https://www.energypolicy.columbia.edu/energizingamerica; David Hart and Ben King, *supra* note 2; R. Dell Build Clean: Industrial Policy for Climate and Justice, https://www.climateworks.org/report/build-clean-industrial-policy-for-climate-and-justice; several works by the Energy Futures Initiative, including Moniz, Kenderdine, Hezir, and Keyser, EFI's Portfolio for Accelerating the Clean Energy Transition, https://static1.squarespace.com/static/58ec123cb3db2bd94e057628/t/6011a80ac4719d2ad47909fd/1611769880568/EFI+Clean+Energy+Policy+DOE+Biden-Harris+Transition+Team.pdf.pdf; and the work of the Clearpath project. Bill Gates' recent book, How to Avoid a Climate Disaster, also contains many recommendations involving R&D and industrial decarbonization.

- Tripling the federal RD&D budget over the next five years, focused on ten "technology pillars" that are key to decarbonization;
- Funding large-scale demonstration projects at the level of $5 billion over five years;
- Directing the development of federal buy-clean standards for federally-funded construction projects at the state and local levels, and;
- Directing the development of low-carbon standards for major-emitting industrial products such as concrete.

The one critical additional measure to add to this list is industry-specific planning. Just as the CES should be paired with infrastructure planning to get the electricity sector to net zero, so should standards and targets for decarbonizing industrial materials be paired with industrywide plans to ensure that the RD&D investments, standards, and supply infrastructure are aligned. These plans are especially important for emerging areas that have very high potential for job growth in the coming decades, such as hydrogen electrolysers, alternative proteins, bioplastics, and heat pumps. While the U.S. has a strong technology start in many of these areas, we are losing out to other countries who are already planning and investing to capture these opportunities.[9]

This planning should be collaborative, and not government led. The Departments of Energy and Commerce should form or select existing public-private groups to develop industrywide plans to reach net zero carbon by 2050 or sooner for the six major emitting industries. These plans should specify R&D gaps, financing needs, job creation and just transition issues, and estimates of the type, amount, and location of energy supply infrastructure each industry believes it will need. These estimates will certainly evolve as markets and technology change, so they should be updated on periodically.

There is no need for Congress to reinvent any wheels here for industry collaboratives already making net-zero plans. What legislation should do, however, is require that these plans include the specific RD&D priorities, investment timetables, and infrastructure requirements that clearly document the sector's path to net zero.

[9] See forthcoming work from the Widening the Lens project, http://www.bu.edu/ise/research/widening-the-lens-on-innovation-for-clean-manufacturing/ acc. 3.20.21

Buildings

The building sector GHG emissions that won't be automatically eliminated by a CES come primarily from fossil-fueled heating, cooling, and hot water. Cutting these emissions and their co-pollutants requires changing the heating and cooling systems in our buildings to clean electricity or supplying upgraded systems with carbon-free fuels. Both approaches will be necessary.

Many cities, states, and researchers have done considerable work identifying paths to net-zero buildings emissions (see Section IV). Federal legislation should build on these efforts and make them universal with a bottoms-up approach that includes:

- A finding that all buildings should achieve net zero emissions by mid-century;
- A directive to DOE to work with states to implement net zero building policies through changes in building codes and standards, energy use labeling, and performance requirements.[10] ACEEE's latest polling shows that 86% of all voters, including 69% of conservative Republican voters, support stronger codes for new buildings;
- Specific tax credits should be adopted for substantial efficiency upgrades to existing buildings, a measure that has 88% overall support by voters (76% among conservative Republicans), and;
- A requirement that states submit plans to decarbonize all their buildings and progress reports towards the goal as part of a larger required energy plan.

In addition, to spur the market all federally funded buildings should be required to use energy-efficient materials and building techniques, building on DOE's Advanced Building Construction Initiative, as recommended by RMI and NEMA.

Finally, several federal financing programs targeting housing and buildings should be expanded and revamped, with special attention to improving affordability for underserved groups. Financing is discussed further in Section V.

Each city and rural area in each state has its own unique building stock, climate conditions, and HVAC systems. Changing these systems will take a community-by-community, block-by-block effort that will stretch across decades of sustained effort. The end result will be carbon-free cities and rural areas with more jobs, healthier citizens, more efficient buildings, and lower utility bills. But it won't happen with the urgency needed without targeted federal action.

[10] See recommendations by ACEEE and the New Buildings Institute for more detail.

Transportation

The transport sector accounted for 27% of pre-pandemic emissions in the U.S., the largest single source. While reducing these emissions, the transportation system must maintain and expand equitable, affordable mobility and repair our crumbling transport infrastructure and urban transit systems. Moreover, the transportation sector employs more than 13 million workers – almost ten percent of the American workforce. Investment in clean transport technologies will help ensure that the U.S. economy and the industry itself remain globally competitive.

The analogy to a CES in the auto and light truck industry is a federal rule that all new vehicles sold must be carbon-free by 2050. Fourteen countries and twenty global cities have announced such phase-outs. A federal sunset would obviously support General Motors, which has already announced it will eliminate new gas vehicle sales by 2035, as well as many other carmakers and large fleet owners, including FedEx. This phase-out could be accomplished via increasing emissions standards or other approaches, though probably not by using a carbon price alone.

With or without a firm federal date ending new vehicle carbon emissions, the industry is already on a trajectory towards this outcome, almost certainly by mid-century or sooner. To facilitate this critical goal, legislation should include continued vehicle tax credits, increased R&D for vehicles, clean fuels, infrastructure, and batteries, and direct funding for transit system expansion and decarbonization.

Planning for and financing the electric vehicle (EV) charging infrastructure is an especially high priority for inclusion in a climate bill. Although most electric chargers will ultimately be privately owned, a transition planning and financing are necessary to make sure that drivers can easily charge their cars while the electric system also works smoothly. The need for electric charging infrastructure is integral to electric grid planning, which in turn is integral to a climate solution. The need for charging infrastructure, developed by utilities and the full range of surrounding stakeholders, must be a key part of each state's energy infrastructure plan described in the next section.

As with buildings plans, many utilities, cities, and states have already done significant EV infrastructure planning, and more is occurring every day. Because the vast majority of auto, light truck, and transit miles occur in metropolitan areas, and travel patterns are totally unique to each area, city, state, and regions are the only logical leaders of these planning efforts. State and regional planners should leverage and integrate all these efforts to ensure adequate,

reliable, and affordable charging power is available equitably where needed. If these plans indicate that adequate private sector and utility funding are not adequate to create this infrastructure federal financing should be made available.

The four remaining transport sectors – rail, long-haul trucking, airlines, and ships – operate national and global networks. Each of these industries should be given a net zero target year and asked to submit an industrywide plan to get there, including the electricity and clean fuel infrastructure requirements they will need.

ENDNOTES

[i] https://www.nytimes.com/2021/01/15/climate/climate-change-survey.html and https://www.rff.org/publications/reports/climateinsights2020/ accessed 3/18/21

[ii] There are 118 million residential housing units and 6 million commercial buildings in the United States. https://www.eia.gov/consumption/residential/data/2015/hc/php/hc2.1.php https://www.eia.gov/consumption/commercial/pdf/CBECS%202018%20Preliminary%20Results%20Flipbook.pdf

[iii] https://www.fhwa.dot.gov/policyinformation/statistics/2019/pdf/mv1.pdf

[iv] There are just over 2,000 manufacturing facilities in the U.S. that employ 500-999 people. https://www.statista.com/statistics/749712/number-of-factories-by-number-of-employed-persons-us/

[v] There are over 400,000 miles of oil and gas pipelines in the U.S., compared to 1,600 miles of hydrogen transmission and 4,500 miles of CO_2 pipelines. https://www.energy.gov/sites/default/files/2017/08/f36/hdtt_roadmap_July2017.pdf https://www.energy.gov/sites/prod/files/2015/04/f22/QER%20Analysis%20-%20A%20Review%20of%20the%20CO2%20Pipeline%20Infrastructure%20in%20the%20U.S_0.pdf

[vi] See references and discussion in Fox-Penner, Power After Carbon (Harvard U. Press, 2020) at p.4, note 10.

[vii] https://ourworldindata.org/renewable-energy acc 4.26.21

[viii] Phadke, A. (2020). 2035: Plummeting Solar, Wind and Battery Costs can Accelerate our Clean Electricity Future; Goldman School of Public Policy. University of California Berkeley: Berkeley, CA, USA. http://www.2035report.com/wp-content/uploads/2020/06/2035-Report.pdf?hsCtaTracking=8a85e9ea-4ed3-4ec0-b4c6-906934306ddb%7Cc68c2ac2-1db0-4d1c-82a1-65ef4daaf6c1

[ix] This is not to say that there are no lessons we can learn from the economic mobilization we undertook to help win World War II; see the discussion in Section III.

[x] The Introduction of Electric Power in American Manufacturing

Richard B. Du Boff The Economic History Review, New Series, Vol. 20, No. 3 (Dec., 1967), pp. 509-518 at

https://www.jstor.org/stable/2593069?seq=1

[xi] Jonnes, Empires of Light, Random House, 2003, p.xiv.

[xii] These plans should be required to include RD&D gaps, investment costs and timelines, state and local policies they will employ to reach the goal; other needed federal policies, and just transition issues. In developing these plans, states should be required to work closely with and through city and county governments, many of whom already have climate plans aimed at eliminating building emissions, as well as utilities, community organizations, and NGOs.

[xiii] Since 2005 the FERC has issued two orders under its limited authority that have improved transmission planning, but still fall far short of what is needed for climate policy success. Order 890 (2007) required each jurisdictional transmission provider to "participate in a regional transmission planning process" and file a long term *non-binding* plan that adhered to eight principles. The FERC issued Order 1000 in 2011, which requires all transmission-owning utilities to "participate in a regional planning process" and file the resulting plan. These regional processes were to be run by RTOs or ISOs where they exist, thus creating what FERC hoped would be a

neutral, higher-quality process. However, transmission planning has not improved nearly as much as this order envisioned. There are no concrete planning standards – certainly not a clean energy requirement -- and nothing in RTO plans must be actually built. The net result that FERC transmission planning is uncoupled from the most important factors climate policy requires. Because planning is at best regional, it is even further uncoupled from interregional solutions and many of the state and local stakeholders whose input and support is most critical.

[xiv] FERC Chair Richard Glick has announced that he plans to update the current regional transmission planning rule, which will undoubtedly help. However, the FERC has no authority to require planned lines to be built, nor to give siting approvals, and it is unlikely to gain that authority anytime soon. In another positive development, Congressman Sean Casten has introduced legislation requiring FERC to implement an additive process specifically focused on planning interregional lines, which are especially helpful for climate goals. There is also significant electricity grid planning by utilities or states, but it is often highly localized and/or is not designed to reach carbon goals. This is starting to change, as explained in the section following.

[xv] The recent National Academy of Sciences Report, Accelerating Decarbonization of the U.S. Energy System, recommends creating a "process for planning and initiating a national network to transport and safely store CO2." P.11 https://www.nap.edu/read/25932

[xvi] Net-Zero America Interim Report, Dec. 15, 2020, p. 231.

[xvii] https://www.unionleader.com/news/business/eversource-gives-up-on-northern-pass-project-after-spending-318-million/article_62cb0b4b-878d-5b69-98a7-3cf7ff69938a.html

[xviii] https://www.wsj.com/articles/building-the-wind-turbines-was-easy-the-hard-part-was-plugging-them-in-11561176010

[xix] More completely, of the three finalist bidders one dropped out due to high interconnection costs, one sold to another buyer and the third could provide only 100 MW of the 200 MW requested. Craig Peterson, Minn. PUC Approves Last Good Priced Wind PPA in MISO. Rotinsider.com/rto/minn-puc-approves-wind-ppa-miso-196226/ 3.28.21

[xx] Colin Smith, So Big Its Boring. www.greentechmedia.com 3.15.21 acc 3/15/21.

[xxi] https://www.rtoinsider.com/articles/20045-miso-execs-defend-need-for-long-range-tx acc 7.16.21

[xxii] "Powering a Climate-Neutral Economy: An EU Strategy for Energy System Integration." Communication for the Commission to the European Parliament, European Commission, Aug. 7 2020, COM (2020) 299 final.

[xxiii] Cohn, J., Jankovska, O. Texas CREZ Lines: How Stakeholders Shape Major Energy Infrastructure Projects. Center for Energy Studies. 2020.

[xxiv] Billo, J. The Texas Competitive Renewable Energy Zone Process. ERCOT. 2017.

[xxv] https://cleanpower.org/facts/state-fact-sheets/

[xxvi] A 2017 review of the public policy, economic, and qualitative benefits of the Multi-Value Project Portfolio. MISO. 2017.

[xxviii] US Execs Not Convinced Net Zero Is Commercially Viable, Finds Standard Chartered. www.responsible-investor.com, 3.29.21 acc 3.29.21

[xxix] Stanley Reed, How to Clean Up Steel? New York Times, 3.21.21 p. B1

[xxx] See, e.g., Elsa Wenzel, The War to Electricity: America Can Do It. www.greenbiz.com acc 5.29.21

[xxxi] A. Bossie and J.W. Mason, The Public Role in Economic Transformation, Roosevelt Institute, March 2020.

[xxxii] Clean energy hubs have also been advanced by the World Economic Forum; see https://www.accenture.com/us-en/blogs/accenture-utilities-blog/industrial-clusters-four-solutions-to-net-zero

[xxxiii] E.J. Moniz testimony, House Energy and Commerce Committee, 3.22.21

[xxxiv] https://theenergymix.com/2021/04/23/carney-launches-new-net-zero-finance-alliance-with-70-trillion-in-assets/ acc. 5.29.21

[xxxv] Net-Zero America Interim Report, Dec. 15, 2020, p. 270-277.

[xxxvi] https://www.congress.gov/bill/117th-congress/house-bill/806/text

[xxxvii] https://naseo.org/Data/Sites/1/sepguidelines_2018_final.pdf

[xxxviii] This work continues to evolve and improve. Working with the U.S. Department of Energy, the National Association of Regulatory Utility Commissioners (NARUC) and the National Association of State Energy Officials (NASEO), recently released proposals for improving state electricity planning.

[xxxix] https://www.ncsl.org/research/energy/greenhouse-gas-emissions-reduction-targets-and-market-based-policies.aspx

[xl] https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2021-integrated-energy-policy-report

[xli] Order on Transmission Planning…, N.Y. Public Service Commission, Case 20-E-0197, 5.14.20

[xlii] https://njbmagazine.com/monthly-articles/new-jerseys-new-energy-master-plan/

[xliii] https://nj.gov/emp/energy/

[xliv] https://malegislature.gov/bills/192/S9

[xlv] There has been a promising trend over the past few years of states giving greater consideration to how energy infrastructure and grid modernization investments should be factored into their energy planning processes, especially as they work towards reaching GHG reduction milestones. As discussed in other areas of this paper, the need for long-term energy planning is critical given the complex and interdependent nature of energy infrastructure, as well as the slow pace at which upgrades can be made. Both New York and New Mexico recently completed power grid studies that assess what quantities of renewable resources will be required to achieve their clean energy mandates, current land area available for resource development, and the cost and type of electric transmission and distribution (T&D) infrastructure upgrades needed to reliably integrate these renewable resources. Colorado is also considering the creation of a state transmission authority that will plan the full statewide grid and pre-qualify new transmission corridors. (www.leg.colorado.gov/sb21-072 acc 6.8.21)

[xlvi] https://missionpossiblepartnership.org/action-areas All quotes from this page.

[xlvii] https://www.weforum.org/projects/decarbonizing-road-freight-initiative

[xlviii] See, for example, DOE's Hydrogen at Scale vision at https://www.energy.gov/eere/fuelcells/h2scale, the National Roadmap for Grid-Interactive Efficient Buildings at https://gebroadmap.lbl.gov/A%20National%20Roadmap%20for%20GEBs%20%E2%80%93%20Final_20210517.pdf, and the Advanced Manufacturing Office's Storage Technology Roadmap at https://www.energy.gov/articles/doe-releases-draft-energy-storage-grand-challenge-roadmap-and-requests-stakeholder-input

[xlix] Collaborative industrial decarbonization planning is even more active amongst our global allies and rivals. The UK government has also prepared an extensive industrial decarbonization strategy that includes both planning and financing linked to the plans. In the Netherlands, industry and government cooperated intensively to produce a national industrial decarbonization strategy, and the EU has an extensive, longstanding decarbonization planning effort. See Policies for Climate-Neutral Industry: Lessons from the Netherlands. OECD Policy Paper No. 108, April 2021.

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