CANDOR, CLIMATE AND THE ENERGY TRANSITION

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INTRODUCTION

In law school I was a research assistant to a professor writing an article on antidiscrimination law—in particular the gap between the substantive school desegregation rights established in *Brown I* and the "all deliberate speed" remedies of decisions following *Brown II*.[1] The Justices and lower court judges rarely acknowledged that their remedies were wholly unequal to the rights, in part because they were concerned that such acknowledgments would induce backlash and cynicism. Admitting that school busing orders were diluted in anticipation of resistance, they perhaps feared, would invite further resistance and draw outrage from those entitled to constitutional protections.

In the middle of the long draft was a section entitled "Doing and Saying: Remedial Limits and Judicial Candor." I objected that this passage interrupted the flow of discussion of the cases and ought to be a separate essay. The professor stuck to his guns, convinced that the way in which those in power express what they are doing is part and parcel of their power. From the vantage point of today, I see that he was correct. (This confession, that the teacher was right after all, may be a milestone in the annals of research assistantship.)

"This gap between doing and saying," the professor wrote, "like the substantive compromises it hides, may itself reflect an attempt to mediate between

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[1] Paul Gewirtz, *Remedies and Resistance*, 92 YALE L.J. 585 (1983) (discussing Brown v. Board of Educ., 347 U.S. 483 (1954) and Brown v. Board of Educ., 349 U.S. 294 (1955)).

the ideal and the real."[2] But, he quoted, "'too much use of [subterfuge] by courts destroys their credibility.'"[3] He concluded that in public affairs, there should be a presumption of candor: "In making that gap visible, we not only preserve ideals but also foster conditions for giving those ideals greater force in the world."[4]

I raise today the issue of candor in the context of climate change and the astounding transformation under way in the production and use of energy across our nation and planet. Politicians, agencies, think tanks, and academics are boldly announcing goals, research agendas, and policy measures aimed at dramatically decarbonizing our energy sources—towards 90 or 100 percent carbon-free electricity or total energy for the United States or the world by a given year. In many cases, the measures are communicated and popularly reported without understanding by the general public of the context in which they are offered.

That context is vital. It begins where we start today, where we have a total budget, allocated among a variety of primary sources, both carbon and non-carbon, and divided between electricity and other forms of delivered energy. The context continues with what we are doing today, with current annual rates of increase or decrease among those sources and in the degree of electrification. In an analogy from physics, one might say those two measures tell us our position and momentum! And the context ends with the target year, in which these pronouncements envision a new budget, taking into account population growth and expanded energy uses, but reflecting anticipated gains in productivity and efficiency. When the new budget reflects a conversion of primary sources to non-carbon fuels—whether in whole or in very substantial part—that is referred to as deep decarbonization.

To continue the physics metaphor, a decarbonization policy describes the forces that will now be applied to our energy condition. When a candidate or institute announces a goal, say, of 100 percent green power by 2035 or 2050, on that context is overlaid an implicit *project*—the necessary changes in individual or collective sources—and some sense of what it would take to effect such changes.

What does it take to increase one source and retire another? Which actors

[2] *Id.* at 666.
[3] *Id.* at 667–68 (quoting G. CALABRESI, A COMMON LAW FOR THE AGE OF STATUTES 175, 180 (1982)).
[4] *Id.* at 674.

need to take (or refrain from) what actions? If the needed technology or infrastructure is not available today, how will it be available tomorrow? What life-cycle costs, risks, and obstacles will be encountered while making these changes? How will the changes be paid for and who will make the payments? What are the foregone benefits of the sources that are being discontinued or not pursued? In answering these questions is where the hard work takes place.

This article first describes the energy transition itself. Different participants express this concept in different ways. Certainly the transition is founded on decarbonization, the climate-conscious emergence from an economy based on fossil fuel. But what "decarbonization" means has evolved over time—significant shifts have occurred in just the last few years, for example, on the role of natural gas and the rise of low-carbon hydrogen. And too often the transition is simply equated with decarbonization. It is more than decarbonization. The transition has several other objectives, some of which are complementary, and others of which lead to some tension among goals.

The article then reviews some of these public announcements. From the governmental arena, we will look at the plans issued by the presidential campaign of Joe Biden and the output of the International Energy Agency (IEA). For decarbonization goals from the public policy arena, in honor of the Big Game we will learn first from some researchers at the University of California, Berkeley, and then from some researchers here at Stanford. Finally, for perspectives apart from new goals, we will review priorities outlined by investigators at Columbia University and the Massachusetts Institute of Technology (MIT).

The projects implicit in the goals are scrutinized. Particular attention is paid to where the pronouncements differ from one another, and whether and how those differences are addressed. To be clear, this article is not intended to critique any of them, in the sense of branding them as either realistic or unrealistic. In fact, judgments of that type are best formed on the basis of opinions of experts in the relevant fields—preferably experts who cross-examine one another in peer-reviewed settings and who communicate clearly. My purpose here is rather to examine whether the public literature gives readers, as participants in the energy dialogue, the information they need and deserve to have an opinion about what the proposal entails.

I finally come to candor. Should the advocates themselves be more explicit about the challenges of achieving their own visions? Or does discussion of such hurdles "chill the vibe" and make it less likely that we will even strive for or come close to the goals? Is it necessary to be guarded about the probability of success, if those cautionary notes might deflate the project and inspire skepticism and recidivism?

I conclude that an absence of candor is corrosive to the public conversation on the energy transition. But that candor can be a virtue of the overall policy dialogue, rather than having to be part of every partisan's own voice.

Candor is not a one-way street to condemnation of anything bold. There is no need to be unduly pessimistic about radical economic transformations—I will benchmark this effort against prior "moon shot" programs, none of which were fully candid in this respect! The demands for decarbonization and for the rest of the transition demand outsized, indeed unprecedented action. It should not be surprising that the targeted changes will be unprecedented as well.

Being frank about the tasks that lie ahead will pay dividends in ensuring that the required focus is resilient and sustained. But we cannot assume that such a disclosure will be supplied by the enthusiasts for any one vision. It is therefore up to others who are engaged in the conversation to furnish the necessary candor.

I. THE ENERGY TRANSITION

What is the energy transition? Many works omit a definition, and the definitions that do exist widely differ. Daniel Yergin recently wrote:

> [W]hile energy transition has become a pervasive theme all around the world, disagreement rages, both within countries and among them, on the nature of the transition: how it unfolds, how long it takes, and who pays. "Energy transition" certainly means something very different to a developing country such as India, where hundreds of millions of impoverished people do not have access to commercial energy, than to Germany or the Netherlands.[5]

It may be best to plunge into some uses of this term. The World Economic Forum, the folks who bring you Davos, publish with the McKinsey consulting firm an Energy Transition Index ranking the progress of individual countries.[6]

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[5] DANIEL YERGIN, THE NEW MAP: ENERGY, CLIMATE, AND THE CLASH OF NATIONS xix (2020).
[6] WORLD ECONOMIC FORUM, FOSTERING EFFECTIVE ENERGY TRANSITION (2020 ed.)

The Forum begins with a description of the factors driving a global energy system in flux:

- Shifts in policies favoring or disfavoring specific sources, based on their environmental impacts;
- Changes in supply and demand of sources, such as decreases in both renewable generation and natural gas prices;
- Changes in consumption patterns, such as that toward greater electric usage;
- Geopolitical shifts and the emergence of popular nationalist movements;
- Revolutions in supply chains and technologies; and
- Emergent efficiencies and productivity gains.

Amid all this volatility, the core goals of what the Forum calls "System Performance" remain constant—(i) security of supply and access to affordable energy; (ii) inclusive economic development and growth; and (iii) environmental sustainability. That is to say, while decarbonization is happening, there is an energy equation that still demands to be solved, for the lives and livelihoods of all.

True, the energy transition has among its peak priorities the environmental considerations that drive decarbonization. But decarbonization is just one part of sustainability. The latter concept also embraces life-cycle impacts and the desired shift from a linear model of consumption and disposal to a circular economy founded on reuse and recycling. And beyond sustainability, the transition is to have many other virtues—it is also to be timely, inclusive, affordable, and secure. The Forum thus attempts to solve an equation in multiple variables.

Other studies more concretely define the transition with measurable criteria. One roster of metrics includes the following:

- Decarbonization, the movement from fossil to low-carbon primary sources, such as renewable, nuclear, fuels with carbon capture, and advanced geothermal technologies.
- Electrification, the degree of increase in the share of electricity in the mix of end uses.
- Reduction of energy intensity—in other words, achieving improvement in economic conditions (whether measured by gross domestic product (GDP) or a standard of happiness) using less energy per unit of wealth or income.

The Wood Mackenzie consultancy has visualized three "technology levers" (or gears) in the transition in addition to expanding renewable generation and storage—energy efficiency, use of carbon-free hydrogen, and carbon removal (for the production and use of natural gas during the period of transition).[7]

Note that these decarbonization measures are strongly focused on the sustainability objective for the transition. Less attention is given to the other objectives, but they are momentous in their own right. For one, there are approximately 7.8 billion people on our planet, and an increase of over a billion is estimated by the year 2050. Of the humans here today, an estimated 860 million lack electricity and 2.6 billion lack clean cooking fuels.[8] How do we assure secure and diversified sources of energy, expanding affordable energy access to those lacking it, facilitating economic development and growth—and retire the world's fossil fuels and fossil fuel infrastructure while we do so?[9]

The changes in attitudes toward energy sources in the last several years have been dramatic. Two examples stand out. First, natural gas, long thought of as a bridge, has become in some circles something of a pariah. It is still an extremely large source of electricity generation (far exceeding wind and solar in absolute terms). The displacement of coal-fired by natural gas-fired power has been a strong factor in decarbonization, stronger to date than the growth in renewable sources. Some nonetheless object that development of gas resources and end uses still results in unacceptable carbon emissions and diverts attention from cultivation of the renewables solution.

Second, hydrogen has gone from a fringe part of the discussion a few years ago to being the major solution praised by governments, industry, and nongovernmental organizations alike. Hydrogen offers the dream of a green storage medium and a fuel and heat source—one capable of use in baseload generation as well as in energy-dense and high-heat industrial and mobile transport operations. Thus, for some observers and participants, the recipe looks very different

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[7] WOOD MACKENZIE, ENERGY TRANSITION OUTLOOK (2020).

[8] INTERNATIONAL ENERGY AGENCY, SUSTAINABLE DEVELOPMENT GUIDE 7 (SDG7) ENERGY PROGRESS REPORT (2019).

[9] More from YERGIN, *supra* note 5, at 407: "'We're told we have to move on beyond natural gas, to the next thing,' said Timipre Sylva, Nigeria's minister of petroleum. 'The reality is that Africa is not there yet on renewables. We have to overcome the issue of energy poverty in Africa. Many, many things are not being taken into account with all the talk about renewables and electric vehicles.'" The World Health Organization (WHO) estimates that three billion people suffer indoor air pollution from poor fuels, leading to extensive health risks and high mortality. *Household air pollution and health*, WORLD HEALTH ORGANIZATION (May 8, 2018).

in 2020 than it did in 2016—even on the progressive wing of the body politic.

I believe we need to keep a more complete roster of drivers for the energy transition. A robust description includes most if not all the following initiatives:[10]

1. *Renewable Generation.* A great expansion of onshore and offshore wind, photovoltaic (PV) solar power and concentrated solar power (CSP), geothermal, hydroelectric, and other forms of renewable electricity generation—and of alternative liquid fuels generated from biological sources—by means of expedited siting, financing, development, and operation.
2. *Storage of Electricity and Heat.* A proliferation of distributed storage facilities not limited to pumped hydroelectric storage and batteries, including fuel cells and thermal sinks, with long-lasting discharge cycles suitable for baseload dependability and related valuable services, and for harnessing output from intermittent renewables.
3. *Carbon Consciousness for Fuels in Transition.* Improved management of fossil fuels during the period of transition, including reductions of emissions in production, processing, and transport; carbon capture and storage (CCS) and the production of "blue" hydrogen from natural gas coupled with CCS; and retirement and safe decommissioning of existing assets. Efficient ongoing uses for petroleum in petrochemical and a host of other non-fuel applications.
4. *Hydrogen from Renewables.* Development of the hydrogen value chain, both the production of "green" hydrogen from renewable or nuclear sources, and hydrogen infrastructure and end-use applications.
5. *Efficiency in Infrastructure.* Improvements in energy efficiency in the design, construction, operation, and life-cycle costs of our built infrastructure (whether residential, commercial, industrial, or public).
6. *Enhancements to the Grid and to Distributed Generation and Storage.* Accompanying expansion of storage, grid streamlining, transmission, distribution, and infrastructure for baseload generation, and for distributed and "behind the meter" storage as well as generation.
7. *Greening of Transportation, Industrial, and Public End Uses.* A revolutionary

[10] *See generally* VACLAV SMIL, ENERGY TRANSITIONS: HISTORY, REQUIREMENTS, PROSPECTS (2010); Benjamin K. Sovacool, *How long will it take? Conceptualizing the temporal dynamics of energy transitions*, 13 ENERGY RESEARCH & SOCIAL SCIENCE 202 (2016).

change in transportation, industrial and transmission infrastructure, and the ultimate uses in favor of electrical and hydrogen sources, including light-duty, medium-duty, and heavy-duty vehicles on land, vessels on the sea, and planes in the air.

8. *New and Enhanced Energy Technology.* Exploration of advanced generation, storage, and use techniques, potentially including advanced nuclear reactors (even nuclear fusion), bio-energy with carbon capture (BECC), direct-air capture (DAC), solar radiation management (SRM), and advanced geothermal systems.
9. *Affordability, Sustainability, Security, Environmental Justice, and Equity.* Delivering energy at a total cost, inclusive of consideration of externalities, that is affordable. Handling of life-cycle impacts in a sustainable manner, including safe and secure mining and manufacturing, circular-economy treatment of components, and resilience against wildfire, sea level rise, and drought risks. Diversification of sources and resilient supply and distribution chains across national borders. Making energy supply as well as investment and job opportunities available to wider populations, including vulnerable and underserved communities, with training, relocation, and employment benefits to those impacted by the transition.

The task of the energy transition is not merely to decarbonize on an urgent basis, as important as is our response to climate change. The transition is also to maintain and enhance security, access, economic development, and all measures of environmental health, including but not limited to reduced carbon emissions. Sometimes those other objectives are not heard amid the loud policy calls on one and only one goal—namely the achievement of 100 percent green electricity, or 100 percent green total energy usage, by a given date.

Calls for an energy transition must address the cost, availability, and access of energy—for the present and future world populations. Some of this need will be accomplished by greater efficiencies, including the efficiencies inherent in electrification, and by increased productivity per unit of energy input. Other improvements come from increases in energy output, or reallocation of energy use from one subgroup to another.

II. THE END ZONES

"Everyone is entitled to his own opinion, but not to his own facts."
attributed to many, including authors before *Daniel Patrick Moynihan*

The energy transition goals are expressed in different ways, but one consolation is that they must all begin with the actual circumstances today. Participants in the conversation should have a bundle of facts in the back of their minds as they hear the proposals. I covered others in my articles on numeracy and subsidization.[11]

Let us take United States electricity production as our primary example. The U.S. Energy Information Administration (EIA) reports 4,178 billion kilowatt-hours generated in the United States in 2018.[12] BP similarly reports 4,401 terawatt-hours (TWh) generated in the United States in 2019.[13] A billion kilowatt-hours in fact *is* one terawatt-hour. (This is an easier conversion than for prior editions, when BP measured outputs in British thermal units.) The IEA's figure is somewhere in between, 4,194 TWh for 2019. [14] So we are on comparatively firm ground to begin with.

BP reports that electricity production actually fell 56 TWh from 2018 to 2019. The COVID-19 pandemic and government and private responses may cause a more significant drop in 2020. One might expect the electricity output to rise significantly in 2021, either in a recovery or on an ongoing basis.

Of this output, again according to both EIA and BP, fossil fuels are 62 percent of the primary source, with natural gas at 38 percent and rising and coal at 24 percent and falling; nuclear at about 20 percent, where it has been for some years; and renewables at 17.5 percent. Within renewables, hydroelectricity is about 7 percent, wind (virtually all onshore in 2019) another 7 percent, and solar (both PV and CSP) about 1.8 percent. Wind and solar were the stars of the additions to the source in 2019, with natural gas close behind, but as can be seen renewables have some ground to make up.

Some renewable benchmarks are needed. The United States currently has

[11] Robert A. James, *Numeracy for Energy and Environmental Lawyers*, 8 JOURNAL OF LAW (5 J. LEGAL METRICS) 33 (2018); Robert A. James, *How Much Is Energy Subsidized?*, 10 JOURNAL OF LAW (7 J. LEGAL METRICS) 7 (2020).
[12] U.S. ENERGY INFORMATION ADMIN., ELECTRIC POWER ANNUAL 2019 at Table 1.1 (2019).
[13] BP STATISTICAL REVIEW OF WORLD ENERGY 2020 at 59 (2020).
[14] INTERNATIONAL ENERGY AGENCY, 2020 WORLD ENERGY OUTLOOK (2019).

about 64,000 wind turbines, adding about 3,000 a year according to government and industry sources.[15] We have perhaps 1.5 million roofs with solar panels.[16]

That basic bundle of facts gives us some idea of our "own end zone," the one from which we receive the kickoff in 2020, if you will. What does the other end zone, the "destination end zone," look like?

A year must be selected—the cases below mention 2035, 2050, and 2070, so let us start with 2050. There will likely be some downward forces on the electricity output—due to greater efficiencies and productivity. And there will likely be some upward forces—due to population growth and the increasing electrification of the transportation and industrial sectors. Whether explicitly or implicitly, the proposals must assume some number of terawatt-hours generated in the United States in the target year.

Within that destination end zone budget, these goals propose that all or almost all of the electricity is to be generated through low-carbon means. The "low-carbon" definition varies, with existing nuclear power plants and gas power plants with CCS often continuing. But coal assets and other gas assets, sources that currently provide 62 percent of output, are generally to be retired. A key task of the transition is thus to assure replacements and retirements that satisfy the new budget.

The same exercise can be applied to other concepts, such as United States total energy production, global electricity generation, and global total energy production. In each case, the proposal must start with the facts in 2020, assume or posit some end budget, and propose some means of getting from 2020 to that target. Remember the 7.8 billion souls here in 2020; the 9 billion or so who may be here in 2050; the 860 million now without electricity; and the almost 3 billion now without clean cooking fuels. What will be the demands on the energy transition across the globe while any decarbonization project is undertaken?

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[15] B.D. HOEN et al., UNITED STATES WIND TURBINE DATABASE (U.S. Geological Survey, American Wind Energy Association, & Lawrence Berkeley National Laboratory, July 2020).

[16] Charles W. Thurston, *Stanford Maps 1.47 Million Solar Roofs in America*, CLEANTECHNICA (Dec. 19, 2018).

III. GOVERNMENTAL GOALS

A. *Biden Plans*

The unity paper produced by advisers to the 2020 political campaigns of Vice President Joe Biden and Senator Bernie Sanders is instructive. The Biden-Sanders report, and a subsequent Biden paper (collectively here the "Biden plans"), call for bold initiatives on many fronts ranging from social justice to tax policy.[17] Chief among them is a $2 trillion energy and infrastructure plan with concrete decarbonization goals—100 percent electric new buildings by 2030, 100 percent U.S. green electricity by 2035, and 100 percent green total energy by 2050.

The quantity of energy needed in these destination end zones is not reported in the paper—in each case, it may be the same or a bit more than in 2020. Some tactics are expressed numerically with respect to the transition. Let us examine those features at greater depth than I will supply for the other examples in this article.

Among all the adjectives and adverbs in the Biden plans, certain figures stand out in their simplicity and specificity. The 100 percent goals set forth above are followed by calls for 60,000 wind turbines onshore and offshore, all made in the United States, and 500 million solar panels on 8 million roofs and community solar facilities, to be in place during the next five years (2021-2025).

Some of the press coverage either did not report the specific figures at all or restated them with matter-of-fact exactitude.[18] It was important for the candidates' materials to say the numbers, for the press to report the numbers, and for the targeted audience to applaud the numbers. An understanding of the numbers appears to have been optional.

Only in the comments of ordinary readers and credentialed academics to

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[17] See *Biden-Sanders Unity Task Force Recommendations* (July 8, 2020), followed by *The Biden Plan to Build a Modern, Sustainable Infrastructure and an Equitable Clean Energy Future* (late July or early August 2020). As a complete aside, I appreciate Senator Sanders' proposal to use federal highway rights of way as high-voltage transmission corridors. Whether that is feasible in many places is another question, but it is a relevant response to the evident land-use challenges at local and interstate levels.

[18] *Compare Joe Biden and Bernie Sanders Deepen Their Cooperation*, N.Y. TIMES, July 10, 2020 (reporting "a goal from the climate change task force to eliminate carbon emissions from power plants by 2035" with no reference to numbers of turbines or panels) *with Sanders-Biden climate task force calls for carbon-free power by 2035*, THE HILL, July 8, 2020 ("The plan also calls for a significant investment in renewable energy, including installing 500 million solar panels and manufacturing 60,000 wind turbines").

some of the press coverage did I see the questions that such numbers in isolation might deserve:

- Sixty thousand, eight million, five hundred million—for any of these, *is that a lot?* How does that compare to how many turbines and panels we install today?
- Are these figures inclusive of business as usual, installations already planned and permitted under the Obama and Trump Administrations, or are they incremental?
- How would the United States cause those projects to appear? We know how wind and solar projects are sited, developed, financed, and connected to customers in a locality, and the multitude of federal, state, and local laws, regulations, and causes of action that apply to them. How will government make this expansion happen?
- And if we were to install that many resources on this timetable, how far would that go, by 2026, in reaching the goal—that of 100 percent green power by 2035?

The readers supplied some calculations themselves.[19] Those of us who have considered the starting point—our own end zone—also have some feel for the figures. In a typical year, 3,000 turbines are being installed nationally. So 60,000 turbines would suggest a ramping up from 5,000 to 20,000 annual turbine installations in the five-year term. That does not appear out of the question from a scale and a financing perspective—similar growth in other renewable applications has recently been observed. That growth took place in the context of a global supply chain, however. More interesting are two bookends: how such an increase in U.S. manufacturing capacity would be accomplished, and how the site-permitting process could be so expanded, given that in some locales the best and easiest-to-permit installations may have already been launched.

The solar calculation is trickier. A typical solar panel measures 1 by 1.65 meters.[20] A typical residential solar installation might use twenty panels—some fewer, some much more. A community solar installation could be of any size.

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[19] *See, e.g.*, Meredith Fowlie, *Biden's New Climate Plan*, ENERGY INSTITUTE BLOG (Aug. 3, 2020).

[20] The panel width is specified in some U.S. materials as "39 inches." I thought that was a curious dimension, until it finally dawned on me that what they are reporting is "1 meter." For other examples of odd American figures that turn out to be exact metric retro-conversions, see BRIAN W. KERNIGHAN, MILLIONS, BILLIONS, ZILLIONS: DEFENDING YOURSELF IN A WORLD OF TOO MANY NUMBERS (2018).

Five hundred million solar panels might equate to some teens of millions of residential and commercial roofs and some thousands of community solar facilities installed in this period. In 2019, we had about 350,000 installations. To achieve the Biden plans, the installations might have to rise to 500,000 in 2021, and then well into the millions annually between 2022 and 2025. This rate of increase is not incomprehensible but it is somewhat daunting, recognizing again that the best and easiest sites may be taken.

Again, I derive all of this from reader and blog posts and my own online research, because neither the Biden plans nor the independent press coverage penetrated even to this level of detail. There is more groundwork supplied by a similar proposal from the Goldman researchers, considered below, but it was not cited in the campaign materials I saw. My point is that someone who is interested in participating in the energy dialogue finds it difficult to access the information needed to have an intelligent understanding of the goals, their contexts, and their implicit projects.

It is also interesting that President Biden has separately called for restricting the production of fossil fuels through new leases for hydraulic fracturing (or "fracking") on federal lands, but not for prohibiting fracking on private property. His campaign documents call for investment in research for advanced technologies including CCS (hence continuing natural gas usage), nuclear, and biofuels for applications that include aviation. His comprehensive plan thus includes fuel sources that are not on the menu for other proposals, in part because each has important political constituencies. Including these other fuel sources may also pay homage to our own end zone proportions—62 percent fossil sources cannot be quickly replaced in their entirety by renewables and storage in any short time period.

The Biden campaign's plans were circumspect on where the $2 trillion price tag came from and what funds would pay for it. As of May 2021, the Biden administration favors funding its proposed infrastructure and clean energy program through a combination of tax increases on corporations and individuals rather than adopting a carbon cap-and-trade or carbon tax.[21]

[21] Jim Tankersley & Emily Cochrane, *Biden Wants to Pay for Infrastructure Plan with 15 Years of Corporate Taxes,* N.Y. TIMES (Mar. 30, 2021).

B. *International Energy Agency*

The IEA refers to the Paris Agreement and its call for net-zero carbon total energy by midcentury. The IEA's principal focus is development of new technology, stating that of the forty-odd new technologies needed for that goal, only six are currently on track to be available on a timely basis.[22]

The IEA discusses two cases: a 2050 "faster" scenario involving "unprecedented" speed of research, development, and deployment, and a 2070 "sustainable" scenario. In either case, the solutions to decarbonization lie in large improvements in energy efficiency (smart buildings, grid enhancements); renewable generation; storage not only in batteries but also in the form of hydrogen, fuel cells, and heat sinks; and addressing the hard-to-electrify parts of the economy with fossil fuel sources coupled with CCS, blue and green hydrogen, advanced nuclear, and bioenergy.

The IEA is to be commended for illustrating the scale of the task. For the steel industry, for example, it cites the pace of two hydrogen-fired steel plants being placed into service every month for thirty years, and ninety BECC facilities every year over those three decades. It also attaches price tags, such as $350 billion annually on research.

The IEA candidly recommends that existing hydroelectric facilities be modernized and that nuclear facilities be extended beyond their current retirement dates. It also says that permitting worldwide cannot follow "business as usual delays"; fast-tracking of vital grid improvements and other energy developments will be needed.

It is hard to get a picture of how practical the 2070 IEA goal is, let alone the 2050 IEA goal. But solid marks should be given for the agency's candor as to the present state of the technology and its illustration of the practical challenges to implementing new energy sources and applications.

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[22] INTERNATIONAL ENERGY AGENCY, SPECIAL REPORT ON CLEAN ENERGY INNOVATION: ACCELERATING TECHNOLOGY PROGRESS FOR A SUSTAINABLE FUTURE (2020).

IV. ACADEMIC GOALS

A. *Goldman School, UC Berkeley*

The Goldman School of Public Policy in its *2035 Report* articulated a goal of 90 percent United States green electricity by 2035.[23] That ambition reflected a judgment that getting rid of the last 10 percent of fossil fuel sources would be uneconomic or impractical in certain sectors of our economy.

The Goldman report was accompanied by a series of Appendices, the first of which is a literature survey. The authors forthrightly cite the other papers on the subject, and briefly identify salient differences in approach or result. They acknowledge one older paper on its own terms, for example, and then observe that since its publication the cost and performance of renewables have significantly improved.

Another aspect to be admired is that quantities and proportions of sources for the destination end zone are explicitly called out—in this case, as being higher than our own end zone figures in 2020. The charts show 4,100 TWh in generation in 2020 rising to about 4,800 TWh in 2035. The logic is laid out well: the upward forces include population growth, greater electrification, and increased energy needs, while the downward forces include efficiencies and gains in productivity.

The task ahead is not minimized. The Goldman 2035 report, and later reports by the affiliated Energy Innovation group seeking to fill in the final 10 percent with green power,[24] cite the need to double the annual growth rates in the 2020s and to triple such rates in the 2030s—and the aspiration even to accelerate those rates. A budget of $1.7 trillion is forecast as the capital cost of the needed improvements.

One positive outcome of the Goldman 2035 report is that its authors project per-unit costs of electricity generated in the end state would be only 4.6 cents per kilowatt-hour. Moreover, they report that the total societal costs of

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[23] See the awkwardly entitled 2035 THE REPORT (Goldman School of Public Policy, UC Berkeley, June 2020) (herein "Goldman 2035 report").

[24] *See* Amol Phadke et al., *Illustrative Pathways to 100 Percent Zero Carbon Power By 2035 Without Increasing Customer Costs*, Energy Innovation Policy & Technology LLC (Sept. 2020) (supplement to Goldman 2035 report). A goal of 90 percent may not have been sufficiently inspiring as a political clarion call. *Cf.* Fowlie, *supra* note 19 ("[T]here is something seductive about going all the way, so the Berkeley team has recently expanded their nationwide analysis to assess the costs of pushing past 90% to 100%").

power will be greatly reduced when taking into account the environmental and health benefits of green sources. Since current San Francisco electricity rates average over 24 cents per kWh, this would be a large welfare gain if it proves out.

Finally, I admire the report's embrace of the political issues associated with transmission and permitting. There are specific recommendations for federal and state regulators regarding generation, transmission, and usage, and for streamlining the entitlements process. Regardless of what one may make of the decarbonization goals and the present state of the technology needed to achieve them, I credit the Goldman 2035 report for its candor.

B. *Atmosphere/Energy Program, Stanford*

A set of ongoing studies by researchers affiliated with the civil and environmental engineering department of the Stanford School of Engineering contemplates 80-85 percent green United States total energy production (not just electricity generation) by 2030, and 100 percent green United States total energy production by 2050.[25] Its goals are thus earlier and more comprehensive than those of the Biden plans, the IEA, and the Goldman 2035 report.

The first feature that strikes the reader of these studies is that the destination end zones have *lower* levels of output than the figures reported for our own end zone in 2020. IEA data are used for baseline levels of generation and demand. Thus, for the United States alone, the IEA's U.S. retail electricity figure (4,194 TWh for 2019) is brought down, by the greater efficiencies inherent in electric and hydrogen applications and government incentives, to 3,836 TWh in 2050. Global all-purpose end-use power demand in 2050 is forecast to be 57 percent less in an all-renewables system than in a "business as usual" scenario at that date.[26] This decrease over time is different from the projections of some of the other approaches, a difference that calls out for a clear comparison and for an explanation of the variance.

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[25] *See, e.g.*, Mark Z. Jacobson et al., *Low-cost solution to the grid reliability problem with 100% penetration of intermittent wind, water, and solar for all purposes*, 112 PROCEEDINGS OF NAT'L ACAD. SCI. (PNAS) 15060 (2015) (herein "Jacobson 2015a"); Mark Z. Jacobson et al., *Impacts of Green New Deal Energy Plans on Grid Stability, Costs, Jobs, Health, and Climate in 143 Countries*, 1 ONE EARTH 449 (2019) (herein "Jacobson 2019").

[26] *See* Mark Z. Jacobson et al., *100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for the 50 United States*, 8 ENERGY ENVIRON. SCI. 2093 (2015) (herein "Jacobson 2015b"); Jacobson 2019 at 449–63, Table S2.

One wonders if officials in Nigeria, India, and China would agree that 2050 global usage will decrease so substantially. Will disadvantaged residents of Lagos, Kolkata, and Wuhan have access to cooking fuel, air conditioning, or other goods and services under these assumptions? The Indian steel industry desires to increase output from 122 million metric tonnes in 2015 to 300 million tonnes in 2030.[27] Can that growth be accommodated? The reader will want either to confirm that the destination end zone levels are consistent with their development expectations, or instead to modify those expectations.

The papers have detailed descriptions of technologies that need to be deployed at great scale and accelerated pace. The authors estimate that 11.5 percent of electric generation would be dedicated to the production of green hydrogen. Efficient infrastructure and hydrogen- or electric-powered vessels, vehicles, and aircraft would all be implemented, on a timetable extending from the 2020s to the 2040s. The end state features 484,000 onshore and offshore wind turbines (compare to the 60,000 current turbines, and the 60,000 additional turbines called for by 2026 by the Biden plans); over a 48 percent contribution from PV and CSP (compare to 1.8 percent today from solar sources); and 75 million solar "residential systems" (compare to 1.5 million roofs today). The authors are quite candid that these figures would require significant scaling from the starting levels in 2020.[28]

Technologies are said to be available or close to deployment today. To take one example, an all-hydrogen or all-electric airplane fleet, with cryogenic hydrogen for flights over 1500 kilometers (km), is said to be capable of implementation by 2040. The papers cite the existence today of a 1500-km range, 4-seat hydrogen fuel cell plane. Research on hydrogen and electric airplanes has picked up the pace, and even further progress has been made with renewable jet biofuels. But entirely fossil-free aviation skies by 2040 remains an ambitious goal.[29]

A positive aspect of these studies is the great attention paid to different types of thermal storage as mass media for deployment of the energy of intermittent solar and wind sources. Technologies that are in use in Denmark are proposed for widespread application in the United States and elsewhere.

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[27] *See National Steel Policy sets capacity target of 300 MT by 2030-31*, DOLLAR BUS. BUREAU (Jan. 12, 2017).

[28] *See* Jacobson 2015a, Jacobson 2015b, and Jacobson 2019.

[29] *See* Jacobson 2015a. For current reports of the state of zero-carbon aircraft, see Alex Dichter et al., *How airlines can chart a path to zero-carbon flying*, McKinsey & Company (May 13, 2020) (use of renewable liquid biofuels); *Airbus looks to the future with hydrogen planes*, BBC NEWS (Sept. 21, 2020); *"Commercially available" hydrogen plane takes flight*, ENGINEERING & TECH. (Sept. 25, 2020) (20-minute test flight of six-seat Piper).

The materials expressly state that "The main barriers to getting to 100 percent clean energy are social and political, not technical or economic."[30] But a barrier is no less a barrier because it is political or social. The reader will need to supply his or her own judgments on how those final barriers might be overcome or brought down.

V. OTHER ACADEMIC PERSPECTIVES

A. *Center for Global Energy Policy, Columbia*

Like the IEA study, the Columbia University general research report takes from the IPCC the goal of deep decarbonization by "midcentury." The Center for Global Energy Policy calls for research, development, and deployment dollars to be allocated and spent on the applications that will move the decarbonization and energy transition needle the furthest. Among those are bringing large decreases to the cost of offshore wind—the steadiest and least intermittent form of wind/solar power—and pursuing CCS, BECC, and advanced nuclear technologies.[31]

A later report issued jointly by this center and the Global CCS Institute advocates for carbon capture from fossil fuels as necessary for reduction of emissions by 50 percent by 2030 and a further 25 percent by 2040, leading to the desired decarbonization by midcentury.[32] CCS is urged both for existing uses—heavy industry, blue hydrogen, and recently built coal- and gas-fired power plants—and for new applications such as DAC, BECC, and carbon mineralization. This report calls for CCS hubs to facilitate efficient logistics for gas transportation, and streamlining and incentivizing CCS projects and research and development. It candidly notes that tax and other incentives are needed, as well as legal reforms for ownership of pore space in the United States; better definitions of the necessary monitoring requirements; and project company liability cutoffs and risk transfers. Project-on-project risks for capture, transport, and

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[30] *Mark Jacobson: Barriers to 100% Clean Energy are Social and Political, Not Technical or Economic*, ECOWATCH (November 20, 2015); Mark Z. Jacobson et al., *100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World*, 1 JOULE 108 (2017).

[31] VARUM SIVARAM ET AL., ENERGIZING AMERICA: A ROADMAP TO LAUNCH A NATIONAL ENERGY INNOVATION MISSION (2020).

[32] S. JULIO FRIEDMANN ET AL., NET-ZERO AND GEOSPHERIC RETURN: ACTIONS TODAY FOR 2030 AND BEYOND (Center on Global Energy Policy and Global CCS Institute, Sept. 2020).

sequestration must be addressed, the report notes, because CCS proposals typically contemplate several developers playing complementary roles and any one part of the project can be thwarted if other parts fall behind in implementation.

B. *MIT*

The MIT study focuses on research needed for achieving any deep decarbonization goals. It gathers sources into three groups: *fuel-saving*, being solar, wind, and run-of-river hydroelectric generation; *fast-burst* batteries, thermal storage, and demand-management incentives and systems; and *firm resources,* being reservoir-based hydroelectricity, nuclear, gas with CCS, biogas, and biomass. The researchers ran hundreds of scenarios in hypothetical locations in the northern and southern United States and concluded that decarbonization using firm resources can be up to 62 percent less costly than if firm resources are discarded. They candidly admit that energy costs may be higher in the course of the transition to green fuels, but assert that they can be managed better with the firm sources of supply.[33]

It is difficult to fit the Columbia and MIT research agendas into my spectrum of decarbonization goals. In part that is because pursuit of research cannot guarantee the success or scale of any particular technology. Measuring interim progress along the way is more challenging for research than for actual deployments and retirements, so it is hard to know when one should redouble efforts on a promising approach and when one should cut losses on an unsuccessful one.[34]

VI. CANDOR IN THE ENERGY TRANSITION

Robert Socolow co-authored the paper that unveiled the famous wedge concept of multiple, incremental contributions to an overall reduction

[33] Nestor A. Sepulveda et al., *The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation,* 2 JOULE 2403 (2018).

[34] After the election, a Princeton University study and *New York Times* article displayed considerable candor about the tasks that lie ahead. *See* ERIC LARSON ET AL., NET-ZERO AMERICA: POTENTIAL PATHWAYS, INFRASTRUCTURE, AND IMPACTS, ANDLINGER CENTER FOR ENERGY & THE ENVIRONMENT, PRINCETON UNIVERSITY (Dec. 15, 2020); Brad Plumer, *To Cut Emissions to Zero, U.S. Needs to Make Big Changes in Next 10 Years,* N.Y. TIMES (Dec. 15, 2020). In a similar vein, a recent IEA report notes that wind and solar generation entails extraction of metals in processes that raise their own environmental risks. INTERNATIONAL ENERGY AGENCY, THE ROLE OF CRITICAL MINERALS IN CLEAN ENERGY TRANSITIONS (2020).

in carbon emissions over time.[35] That paper presented the wedges in a matter-of-fact way, and Socolow felt that little progress was made against the goals in the ensuing years. Later, he mused that the paper should have been more frank:

> I wish we had been more forthcoming with three messages: We should have conceded, prominently, that the news about climate change is unwelcome, that today's climate science is incomplete, and that every "solution" carries risk. I don't know for sure that such candor would have produced a less polarized public discourse. But I bet it would have.[36]

The Green New Deal resolutions introduced in the United States Congress[37] have also attracted a great deal of attention. They articulate broad social goals across many fronts, including jobs, health care, housing, food, high-speed rail, and clean energy. Since they are declarations of objectives, their proponents can take the position that their cost is zero—the costs will appear in the specific initiatives, which may be paid for by sources of funds available or currency issued under new monetary policies, by new taxes, or by both.

The reception of these resolutions illustrates some of the hazards of attempts to supply candor when the supply is coming from partisans. On one wing, co-sponsor Senator Edward Markey (D-Mass.) cited research to the effect that climate change could cause a 10 percent loss in GDP by 2090 if policies like those in the Green New Deal are *not* put into action. On the other wing, conservative think tanks waded in with hypotheticals of costs of implementing the Green New Deal up to $93 trillion, promptly rounded by politicians to $100 trillion.

It turns out much of that $100 trillion figure is attributed to the top-line costs of the healthcare policies, and even in that arena there may be insufficient accounting for reduced costs occasioned by the policies, such as reduced insurance premiums, greater worker productivity, and fewer major illnesses. Conversely, the think tank that produced the chart from which the 10 percent of GDP figure was drawn objected, saying their more-likely scenario was a 4 percent drop in GDP. They said their task was to describe scenarios, not to predict

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[35] *See* Stephen Pacala & Robert Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, 305 SCI. 968 (2004).
[36] Robert Socolow, *Wedges reaffirmed*, BULL. ATOMIC SCIENTISTS (Sept. 27, 2011).
[37] H.R. Res. 109 and S. Res. 59, 116th Cong. (2019).

the future.[38]

Sources of candor thus need some candor themselves. Self-proclaimed fact-checkers should be prepared to have their own facts checked, or to be called on occasions where they are not checking facts of what was actually said, but expressing opinions or supplying other facts that could have been mentioned.

Some defenders of deep decarbonization have dismissed objections that the goals for decarbonization expressed in the policy pronouncements, or implicit in the Green New Deal, are too audacious. I believe they have a point.

Candor does not imply timidity. Time and again, we have accomplished audacious things for which we probably would not have received approvals before the fact:

- As World War II began, the United States was building 3,000 airplanes a year. President Franklin D. Roosevelt called for 185,000 planes to be built. By the end of the war in 1945, over 300,000 planes had been built.
- According to one estimate, the Manhattan Project to develop the atomic bomb cost $2.2 billion from 1942 to 1946 ($22 billion in 2008 dollars). That greatly exceeded the original cost and time estimate of approximately $148 million for 1942 to 1944. Of course, money would have been no object so long as the prospect of a German atomic bomb was live.
- The Interstate Highway System cost approximately $500 billion (in 2016 dollars) to build. The economic impacts of that system and its impact on United States land-use policies have been extensively studied. But President Dwight D. Eisenhower did not broach a multi-billion budget figure in his 1956 inaugural highway system address.
- The original budget for the San Francisco Bay Area Transit District system was $992 million. The original 71-mile system, including the engineering marvel of the Transbay Tube, was completed for approximately $1.7 billion (both figures in nominal dollars of the 1960s). Elsewhere, I have surmised that the $992 million figure is itself an engineering marvel, designed to secure bond approval from a public that would likely have never approved the project for an actual cost that *exceeded* a

[38] Jessica McDonald, *How Much Will the 'Green New Deal' Cost?*, Factcheck.org (Mar. 14, 2019).

billion dollars.[39] Of course, now the cost of building a comparable system would be nearly prohibitive, even assuming one could secure the entitlements and pay for the land rights.

- According to NASA, the total cost of the Apollo program for 1960-1973 was $19.4 billion ($97.9 billion in 2008 dollars). When President John F. Kennedy made his speech to Congress in May 1961 setting a goal to land a man on the moon and return him safely "before this decade is out," he was not asked for a critical-path method timetable, or for a spreadsheet outlining the expenditures fiscal year by fiscal year.[40]
- And of course for 2020 and 2021 we are in the midst of a pandemic unprecedented in our lifetimes, during which the federal government is spending (or foregoing collection of) trillions of dollars in unemployment and business relief without a necessary expectation of a return on any "investment."

At the same time, I believe that some proponent, opponent, or observer should make good-faith inquiries into the pathways by which any audacious goal could be achieved. It is true that 300,000 planes far exceed 3,000 planes. But it is at least understandable how more assembly lines, under wartime conditions and with access to the raw materials and know-how, could produce more and better aircraft over the time allotted. It is a larger step to go from one hydrogen four-seat Cessna to visions of nothing but hydrogen passenger planes crisscrossing the skies.

CONCLUSION

I conclude as I began: *the way in which those in power express what they are doing is part and parcel of their power*. As with constitutional rights, so with climate and energy policy.

Greater candor in the overall process is conducive to intelligent public debate and lasting policy transformations. Aspirational goals need someone to vet

[39] *See* Robert A. James, *Wally Kaapcke and the Birth of BART*, Pillsbury Winthrop Shaw Pittman Legal Education Program (Apr. 6, 2007). There are many other public-works projects whose actual costs greatly exceeded the estimates used to secure public approvals. The Sydney Opera House was budgeted at US$7 million and cost US$102 million; the Boston Big Dig was budgeted at $2.8 billion and cost upwards of $8 billion (not accounting strictly for constant dollars).

[40] *See* Deborah D. Stine, *The Manhattan Project, the Apollo Program, and Federal Energy Technology R&D Programs: A Comparative Analysis,* Congressional Research Service (June 30, 2009).

the nature and quality of the aspirations. Some aspirations are just that—if we had landed a man on the moon in 1972 or in 1966, it is hard to see who at this date could object to that. But other aspirations have actual costs. British Columbia set a target of five percent of all cars, whenever purchased, to be electric vehicles by 2020. The province was criticized for spending scarce resources building out the charging station infrastructure for such a fleet, when actual sales were proving to be only a fraction of that figure. Acting in reliance on ambitious timetables may untimely divert funds from other vital needs.[41]

It is probably too much to ask of human nature to expect advocates, particularly those in the public sphere, to accompany their own broad goals with full downside disclosures of costs and risks—in the manner of an environmental impact statement or a securities prospectus. (I conducted an Internet search of *"should politicians be candid"* and received very few hits.) If their proposals depend on a think tank or academic study, though, it would be civil and courteous for them to cite that study, so anyone interested could see how that study fits with other studies in the marketplace of ideas.

Politicians will continue to speak in aspirational terms. They may do so initially as a matter of bargaining, to get a better result than if they had set their asking level lower. They may do so as a means of moving the "Overton window" to modify public perceptions of the reasonable middle position on a given issue. Or they may simply assert an audacious goal with no intent or resolve to carry it out, or to see it through if it runs into trouble.[42]

Public policy is too important to be left entirely to proponents. Experts can speak to the prospects of a proposal in their respective fields, but the general public is at least entitled to understand what the proposal *is*. There is thus a role for opponents and observers to examine the goals, in the manner suggested in this article, so that all engaged in the discussion can understand the proposals, see the implicit projects behind them, and be prepared to evaluate appraisals of their likelihoods of success.

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[41] For such a criticism, see Markham Hislop, *Beware the clean energy technology 'hype cyclers,'* ENERGIMEDIA (Feb. 1, 2017).

[42] *See* Maggie Astor, *How the Politically Unthinkable Can Become Mainstream,* N.Y. TIMES (Feb. 26, 2019) (Overton window). *Cf.* ERIC ALTERMAN, LYING IN STATE: WHY PRESIDENTS LIE – AND WHY TRUMP IS WORSE (2020) (lies by U.S. presidents); SISSELA BOK, LYING: MORAL CHOICE IN PUBLIC AND PRIVATE LIFE (1978) (lies by everybody). Perhaps more germane than lying is being more concerned with appearance than reality, especially not really caring whether what one is saying is or is not true. *Compare* HARRY FRANKFURT, ON TRUTH (2006) *with* HARRY FRANKFURT, ON BULLSHIT (2005).

Candor can enrich debate in a democracy and harden our resolve to accomplish bold initiatives. That frankness may be supplied by opponents, akin to the Anglo-American system of legal advocacy, or by neutral parties, like the investigating judge in civil-law regimes. But it needs to be supplied by *someone*, so that all of us may come to informed opinions on our energy future.

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