Electricity decarbonization is not that expensive, so let's get on with it

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by Leonard S. Hyman and William I. Tilles

Summary

To slash greenhouse gas emissions substantially the US must convert consumers of fossil fuels into consumers of fossil-free electricity. For that plan to succeed the electricity sector must first reduce or eliminate its own significant consumption of fossil fuels. At the same time, given the advanced age of its infrastructure, the industry must also enter a new-build cycle to maintain reliability against an increasingly harsh climate (as evidenced recently by fires and outages in California and Australia) as well as plan for increasing economy -wide electrification, starting with transport. Whether and how rapidly the electric industry decarbonizes is the key issue. In this paper we assume a 20 year transition. Even though adding several trillion dollars to utility plant and tripling its asset size, modernizing and decarbonizing the electric sector can be financed without government aid, with only single digit annual price increases required to pay for it. Furthermore, we believe that financial markets will fund the program at a historically low cost if the industry acts expeditiously. In sum decarbonizing the grid is a multi-trillion dollar business and growth opportunity for US electric utilities.

The electricity sector will play a crucial role in eliminating greenhouse gas (GHG) emissions that contribute to climate change. Electric generation in 2018 emitted 26.2% of all GHGs in the United States. Hence converting it to non-fossil energy sources (such as wind, solar, nuclear and water power) will significantly reduce GHG emissions. Electrification of transportation (27.0% of 2018 GHG emissions) will not by itself reduce GHG emissions unless the electric power it consumes is essentially carbon free. Otherwise we merely trade tailpipe emissions for smokestack emissions.[1]

There are three related questions we hope to address. What will decarbonization cost? Can the US economy afford it? And what, if anything, may hasten this process? From our perspective these have become financial and regulatory than technical questions.

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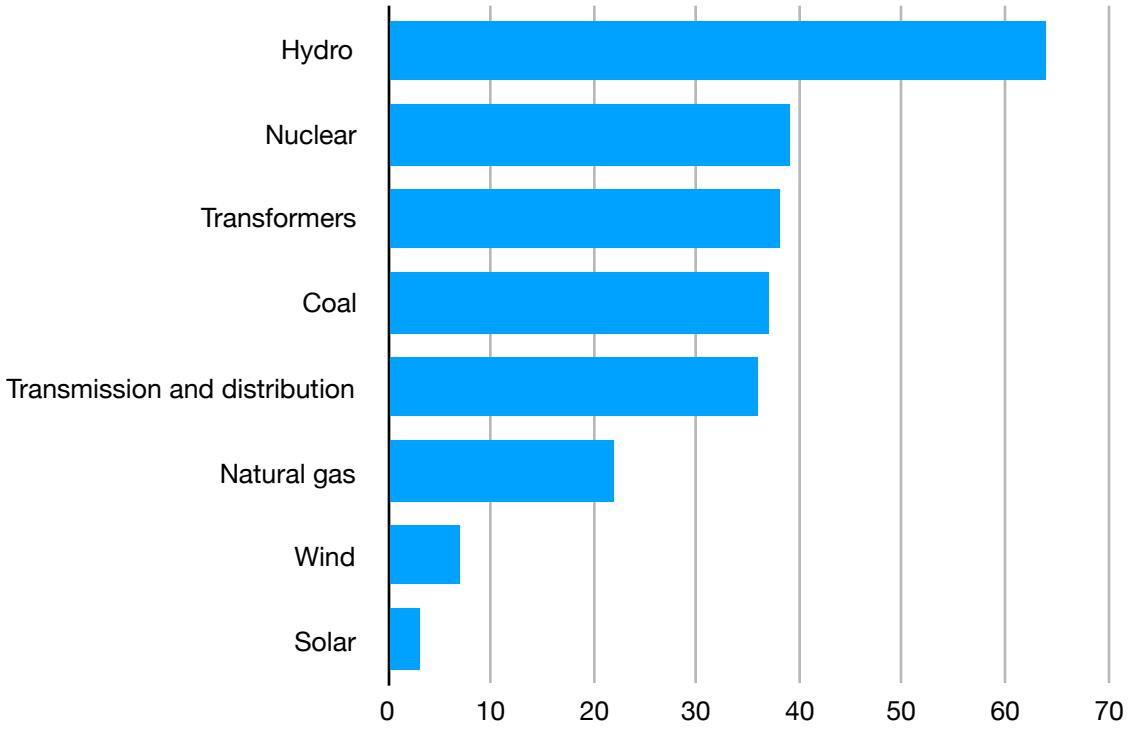
[1] Environmental Protection Agency, *Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018*, EPA 430-P-20-001.

Decarbonization or modernization?

Energy consulting firm Wood Mackenzie has recently written that decarbonizing the US electric industry will cost $4.5 trillion: $1.5 trillion for generation, $0.5 trillion for transmission and $2.5 trillion for energy storage. Joshua Rhodes of the University of Texas put the cost of modernizing the existing electric grid at $5.0 trillion: $2.7 trillion for generation, $0.5 trillion for transmission and $1.8 trillion for distribution. Based on those estimates, a complete modernization and decarbonization of the US electricity sector will cost $6-8 trillion depending on the time frame and scope of the project. Electricity providers had less than $2 trillion of gross plant in place in 2018. A capital program of this magnitude represents an enormous long term undertaking. Why, though, the conflation of decarbonization and modernization?

The average electric plant in the US is roughly 35 years old. Its accounting life is typically 31-40 years depending on the asset. The average plant is on borrowed time with nuclear and coal-fired generation, hydroelectric projects and transformers being particularly old. Given that we are approaching the beginning of a replacement cycle, the electric industry will have to modernize and replace most of its plant within the next two decades whether it decarbonizes or not. (See Table 1.)

Figure 1. Average age of electric utility plant and equipment (years)



Note: Ages derived from Energy Information Administration, American Society of Civil Engineers, Lawrence Berkeley National Laboratories, Harris Williams and Rhodes, *op. cit*.

Owing mostly to inflation new generating plants cost at least two- and -a -half times more than those installed 35 years ago. The electricity sector will spend a large part of the money that goes into non-carbon generation and storage anyway to install modern plant to replace existing assets.

Raising and spending trillions (in context)

A contemplated industry capital expenditure (capex) budget of $8 trillion spread over 20 years ($400 billion per year) far exceeds the industry's spending of over $130 billion in 2019. These added sums would be used to modernize and replace plant, improve reliability, digitize and build transmission required to connect renewable resources. The industry has already embarked on the road to modernization and decarbonization. But it maintains a leisurely 30-40 year pace for "going green" or adopts something far more aggressive (and appropriate to the needs of the moment) remains to be seen.

In 2019 the electric utility industry accounted for a small part of America's $ 3 trillion in business capital spending (private nonresidential fixed investment). In the same year the electric industry accounted for perhaps a mere $50 billion out of the $1.8 trillion of corporate and municipal debt issued. Electricity suppliers, to meet the twin goals of system decarbonization and modernization, would need to triple annual capital expenditures. Executing such a large program, though, might put greater pressure on the industry's human capital than its finances. We can no longer simply assume the existence of legions of engineers and trained linemen ready to integrate new carbon-free assets into a modernized grid.

Electric company equity and debt are likely to remain attractive to investors desperately seeking positive, relatively safe returns. These same investors have placed more than ten trillion dollars in securities that pay negative interest rates (meaning that the depositor has to pay the bank or bond issuer to take the money) and even more in securities and accounts that pay barely any return. This elevated capital and financing program will push even more money in the direction of good quality electric companies.

Insurance companies and pension funds for example have had to invest in higher yielding, below investment grade securities to maintain some semblance of income flows. They would welcome the issuance of large volumes of investment grade securities, especially "green" bonds, whose proceeds would be used for environmentally beneficial purposes. No doubt $120 billion a year of electric utility bonds sold to decarbonize generation and improve grid efficiency would find ready buyers.

In short, the needed capital program, despite its size, should not put undue pressures on the financial markets. But gearing up the industry for a far bigger capital expenditure program will involve more than simply enlisting investment houses to market securities to a yield hungry public.

Timing the spending

Does the electricity sector have 20 years to decarbonize? It does in our view if it front end loads one major change— eliminating coal-fired generation without replacing coal with other fossil fuels. In 2018 coal accounted for 65.7% of the electric sector's GHG emissions but only 27.4% of its power generation. Coal stations are mostly old, largely depreciated (reducing potential write-offs) and many are barely hanging on economically given presently low natural gas prices. These facilities are likely to be permanently shuttered once they require even modest incremental investment or repair.

Eliminating coal-fired electricity, will reduce the nation's GHG emissions by 17.2%, then, but only if electricity generators do not replace coal with natural gas.

Displacing output from coal-fired units to existing power stations will at least temporarily tighten power markets and boost prospects for financially challenged power producers including nuclear generators. Replacing coal-fired stations with new gas-fired ones, as some utilities contemplate, also increases rate base (and earning power) of utilities. But building new base load gas-fired stations delays decarbonization. Grid operators, we believe, will want to keep gas-fired generating stations on line. One can view this as something of a crutch. They will claim, we expect, that new base load gas generation will provide flexibility and reliability necessary until the grid has sufficient energy storage in place. The battle lines are already clearly drawn.

A slow phase-out of fossil fuels weakens the electric industry's role as provider of the GHG-free energy that will replace fossil-fuels in the economy. Our belief is that the owners of green cars and green buses will also demand green energy. That phase-out of fossil fuels can go on only so long. Electric vehicles may become competitive with gasoline-powered cars by the mid 2020s. Certain European nations are contemplating a ban on sales of all gasoline powered vehicles starting in 2035. The handwriting is on the wall. If the US electric industry cannot or refuses to sell a green product then others may eagerly step in to do so. Pursuing the electric vehicle market is the electricity sector's clearest path to growth. But it needs a suitable product to sell. Electricity still half produced by carbon emitting fuels is not that product.

The *Annual Energy Outlook 2020* projects that fossil fuels will generate 61% of electricity in 2020 and 49% in 2050 with GHG emissions per kilowatt hour (kwh) falling only 40%—a slow decline in the face of an urgent problem.[2] A 20 year decarbonization program, then, suffices only if it begins by quickly replacing coal with non-fossil electricity sources. The leisurely effort contemplated by the government and much of the industry seems wholly inadequate to the climate challenge.

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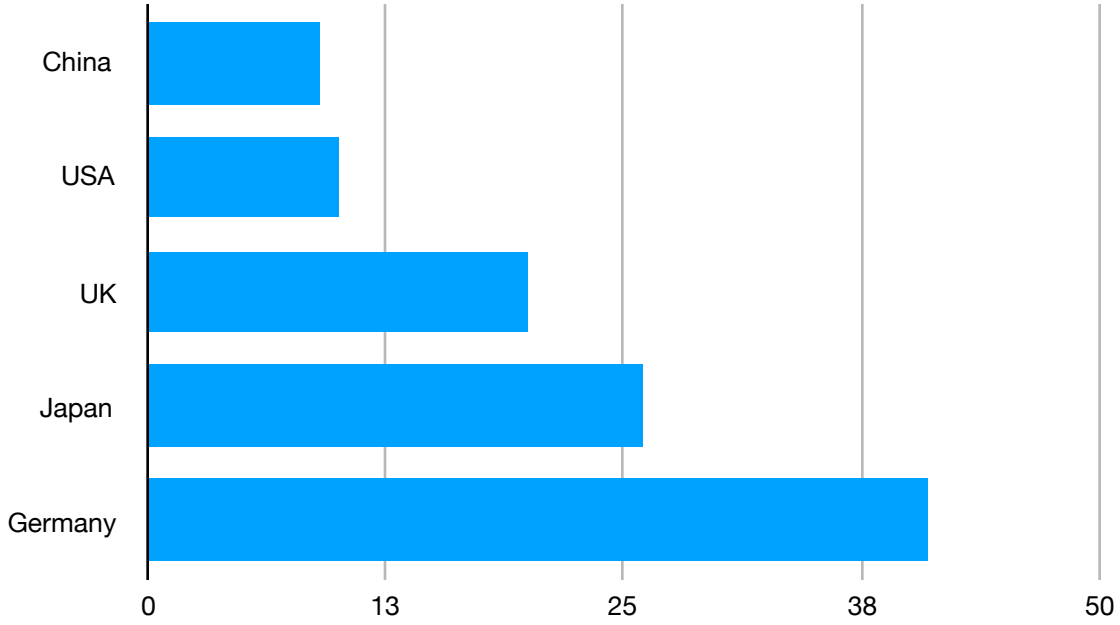
[2] Energy Information Administration, *Annual Energy Outlook 2020*, Jan, 29, 2020, pp. 62, 147.

Electricity suppliers need a push and regulators and government officials need the political will to nudge them along.

Cost components

Consumers will pay for a multi-trillion dollar capital program in monthly installments spread over the lives of the plant investments. On average, Americans pay 11 cents per kwh for electricity — an exceptionally low price. (See Figure 2.) America's industry pays less for electricity than China's.

Figure 2. Calculated price for electricity per kwh.(¢) in 2018



Note:
Statista, "Global electricity prices in 2018 by select country," Not equivalent to average price per kwh sold, which is calculated as total revenue divided by the number of kwh sold. Most international comparisons price on the basis of a fixed level of consumption. Approximate 2018 prices on comparable basis.

Both simple modernization or decarbonization will raise electricity prices because new plant costs more than old plant. But decarbonization will also require massive investments in storage. To approximate the price increase we made a simple analysis designed to provide the proverbial "ball park" figure that decision makers need.

A coal industry executive, Michelle Bloodworth, using Energy Information Administration (EIA) and Federal Energy Regulatory Commission (FERC) analyses summed up the problem this way:

> … existing power plants have lower fixed costs but similar variable costs compared to electricity sources that might replace them… the reason new plants have higher fixed costs is that they begin their operational lives with a full burden of construction costs to recover. Since existing … plants have already paid for … those costs, their ongoing fixed costs are lower…[3]

Owners of new plant must collect more, though, not just because the old plants have been depreciated ("paid for"). Inflation raises the cost of new over old. Renewable resources, whose prices have declined sharply in recent years, require storage as well as the generation source and the capital cost of that package may exceed in nominal terms that of the old generator put in 40 years ago.

One might conclude, from these analyses that the consumer is best served economically on a short term basis when the electric industry installs no new equipment and runs what it has into the ground. Unfortunately, the climate crisis makes that strategy unworkable as we have seen in California and Australia, for example., where plant built for past conditions, could not provide service in a changed environment. Long term, the electricity sector will not only invest in decarbonizing but also in strengthening its network to operate under increasingly harsh climate conditions.

We can disaggregate the electric bill into four components. 1) Fossil fuel expense, which will decline to zero as a result of decarbonization. 2) Depreciation, the annual decline in value of plant due to wear and tear and aging, which will rise substantially due to the massive size of the new investments and the shorter expected life spans of new equipment. 3) Other operating expenses, all non-fuel operating and administrative expenses, which we believe will show no significant change unless sales volume increases. 4) Operating profit, the sum of interest payments and profits set aside for providers of capital, which will rise because of the need to compensate for a far larger capital base, with some offset from a lower cost of capital.

The return required to attract capital, the "cost of capital, " is determined by the market's assessment of the inherent risk of the investment. [4] Thus, any projection must employ realistic capital costs or no investment is likely to take place. Government or consumer-owned electricity suppliers (public power) raise money at a lower cost than investor-owned utilities (IOUs) due to favorable tax laws, government backing and the absence of higher cost equity in their capital structures. Regulated investor-owned utilities have lower cost of capital than unregulated power producers because they incur substantially less business risk.

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[3] Michelle Bloodworth, "What are the Cheapest Sources of Electricity?, *American Coal*, Issue 2, 2019, pp. 28-29.

[4] F. Modigliani and M. H. Miller, "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review,* 48: 261-197, (June 1958).

Pretax cost of capital for new investment is about 8% for unregulated producers, 6% for regulated utilities and 4% for government agencies.[5] Each percentage point of incremental return adds 0.5% to price of electricity delivered to ultimate customers.

As a result of differences in cost of capital and increasing importance of capital as a component of total cost (see Figure 3 below), investment will have to migrate to projects with the lowest capital costs (regulated and public power projects and those backed by sales contracts to regulated and public power entities).

Price increases

The EIA's base case projection to 2050 anticipates minimal changes in price and minimal kwh sales growth, and that through 2050 fossil fuels continue to dominate the generation mix. We choose to ask a different question: how much would electricity price per kwh have to increase to enable the electric industry to raise the capital needed to both decarbonize and modernize existing assets over the next 20 years (2019-2038)? To simplify, we assume that kwh sales remain unchanged, as do cost of new equity and debt capital, industry ownership, tax laws, non-fuel operating expenses per kwh, and investment grade ratings. And we assume that owners of regulated plant put in service before 2009 but not fully depreciated during the 20 year period, receive compensation, i.e. no penalties for stranded costs.

These assumptions appear reasonable to us. Electricity sales have barely grown over the past decade. The American economy has become both more energy efficient while also transitioning to a less energy intensive service economy. As a result the EIA's projected 1% per year growth rate could prove high without new products to drive increased demand.

Professional investors anticipate that low returns will prevail for a decade, so they accept low returns now which will benefit electricity consumers by reducing cost of capital. [6] Electric sector ownership has shifted little over decades. Unregulated, merchant generators cannot gain traction and efforts to sell off public power agencies have proved futile. Non-fuel expenditures (encompassing labor, administrative and sales, local taxes and maintenance) have shown little change over time, possibly reflecting slow growth within the business. Finally, we believe that regulators will remain responsive to the industry's requests to collect compensation for undepreciated assets.

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[5] Aswath Damodaran, "Cost of equity and capital (updateable)" , 8 Jan. 20 ", NYU-Stern. Current bond yields used are those of investment grade corporate and municipal bond averages as reported in FRED data base.

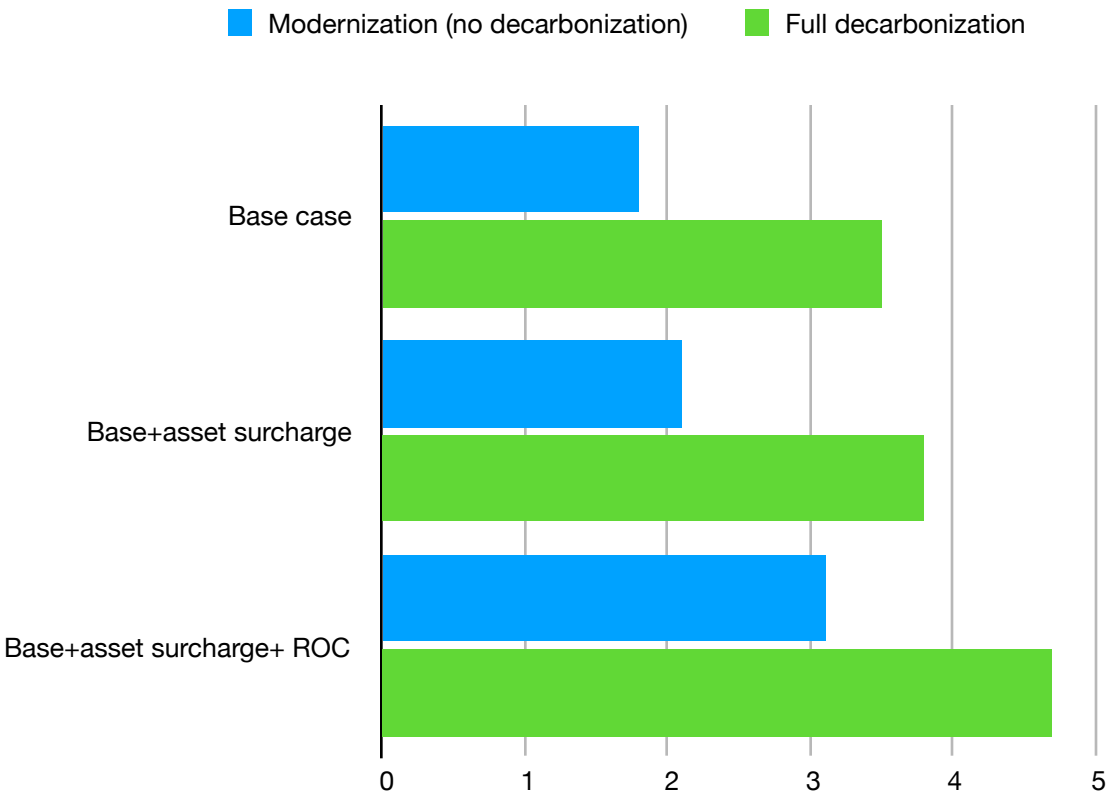
[6] Robin Wigglesworth, "Investors braced for 'low return decade', after years of robust gains", *Financial Times*, 13 December 2019, p.17.

To finance the contemplated capex and pay for undepreciated assets, based on our assumptions, electricity providers will raise real price per kwh sold to ultimate customers by 112% over the 20 years. However, if rapid decarbonization is abandoned and system improvement limited to modernization with the existing fuel mix, then price rises 53%. Over our contemplated 20 year horizon, including a surcharge to cover undepreciated plant, prices rise 3.8% per year with full decarbonization and 2.1% per year with a carbon indifferent modernization. However, if cost of capital were to rise to the levels prevailing before the Great Recession, price for decarbonized electricity increases 4.7% per year versus only 3.1% for modernized electricity (because modernization will require less capital investment than decarbonization) This underscores a reason to begin action while capital costs remain accommodatingly low. (Figure 2.)

Although those price increases look high in the present non-inflationary environment, they will have a minimal impact on the average consumer. In 2018, ultimate customers paid $406 billion for electricity, equal to 2% of GDP. Residential customers paid roughly 2% of household income for their electricity. The projected price increases (roughly 5% of 2%) would raise most budgets by 0.1% per year. Electricity plays a vital role in modern society and a key one in decarbonization, but an insignificant role financially or economically. Raising its price a little bit each year will make little difference to the average customer, although it will disproportionately affect those in regions presently relying on low cost fossil fuels. Presumably, if decarbonization has value to the nation as a whole, the government will aid those most affected by the transition rather than delay the process until all fossil-fueled units have been retired.

In sum, we believe consumers should expect single digit and probably unavoidable price increases.

Figure 2. Estimated % annual real increase in price per kwh (2018-2038)



Note: "Base case" is growth rate from 2018 revenue of $406 billion to that required to support either a fully modernized or decarbonized industry in 2038. "Base + asset surcharge" is growth in revenue required to meet base case plus surcharge to recover undepreciated assets over five years commencing 2038. Base + asset surcharge + ROC" is growth in revenue to meet base requirement plus asset recovery surcharge plus added growth to provide four percentage point increase in return on capital (pretax). i

Policy questions

We do not advocate full decarbonization of the electric industry as the only or best solution. Nor are we disregarding the difficulties of implementing such a program. Who knows, we may witness the proliferation of non-grid solutions or the rapid development of a hydrogen-based economy. Public policy discussions should revolve around the proper method for sharp curtailment or elimination of GHG emissions, or removal of GHGs from the atmosphere in the most expeditious and economical manner possible, not on the promotion of renewables. Society should provide resources to the most economic means of meeting that goal. Our intent here is simply to examine the financial, business and regulatory issues of grid decarbonization.

Our calculations show that decarbonization of electricity will add roughly $238 billion to our annual electricity costs in order to eliminate 1.8 billion metric tons of GHGs produced by electric generation. This number is the difference between revenue required to modernize the grid and revenue required to decarbonize and modernize. That is a cost of $132 per metric ton, a number in line with other estimates.[7] That contrasts dramatically with the Obama Administration's much criticized calculation of social benefits from removing the GHGs of around $46 per ton and with more economical means to cut GHG emissions such as changing consumer behavior (no cost), reforestation ($1-10 per ton), Obama's Clean Power Plan ($11 per ton) and methane flaring regulation ($20 per ton). [8]

However forcing the electric industry to act ahead of others has advantages despite the seemingly high cost. First, there is no reason to believe that our bifurcated regulatory regime of FERC and state utility commissions will prove incapable of handling these regulatory challenges. Our system, where a relatively small number of governmental bodies supervise a small number of suppliers, can effectively manage a process on the scale we are contemplating here. The cost itself, bundled within small monthly bills, is not onerous as we have shown.

Second, decarbonization of electricity is necessary before other industries can decarbonize by electrifying. Most economists argue for a carbon tax to prompt action rather than have the government target particular industries and processes for GHG reduction. But a carbon tax, to be truly effective, might need to be far higher than the $20-50 numbers commonly mentioned in the past. And raising taxes are anathema to many politicians. It might be better to ask: do we do something in a cost-ineffective manner or do nothing at all?

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[7] Michael Greenstone and Ishan Nath, "Do Renewable Portfolio Standards Deliver?", Energy Policy Initiative at the University of Chicago, Working Paper 2019-62, May 2019, reports $129 per metric ton for past renewable initiatives.

[8] Kenneth Gillingham and James H. Stock, "The Cost of Reducing Greenhouse Gas Emissions," August 2, 2019.

Third, should policy makers push for a totally GHG-free electricity industry? Or for a totally renewable industry, which is not the same? A recent MIT study noted that "… additional system costs of wind and solar are minimal until they reach about 40% of power supply…" [9] In 2019, solar and wind accounted for about 12% of power supply, suggesting lots of headroom before these operating constraints become evident. More to the point, the MIT study argues that costs would be far lower if the industry were 90% carbon-free and made judicious use of nuclear power. (Nuclear power is another divisive issue for environmentalists.) The point, though, is that the country might get a better bang for its buck by not seeking 100% decarbonized energy as the immediate goal despite the environmental merits.

From a practical standpoint, dealing with low hanging fruit first makes sense. The first and easiest first step is to shutter coal fired power generation but not replace it with new natural gas generation. Aging, coal plants are ready for retirement and are no longer economic in the current low price environment for natural gas. Removing coal from the utility generating mix (but allowing the generators to keep their existing gas-fired stations will reduce costs and alleviate industry opposition by not requiring premature closure of gas plants. Taking these steps has the potential to reduce the industry's GHG emissions by two-thirds. Carbon-free generators can serve future growth thereby moving the industry toward a lower carbon profile.

As a cautionary note the British set in motion a rapid, forced program of decarbonization. The government handed out big contracts early on which effectively crowded out later and more economical proposals. It may pay to go slowly initially in order to obtain the most economical and timely results. [10]

Thirdly, conversion to a carbon-free operation would fundamentally change the cost structure of the business and rationale for the electricity market. Electric companies in the decarbonized future will look more like leasing or real estate companies. They will feature low variable costs (fuel expense will trend towards zero) and the bulk of expenses, apart from salaries, maintenance and taxes, will be devoted to compensate providers of equity and debt capital. (See Figure 3.)

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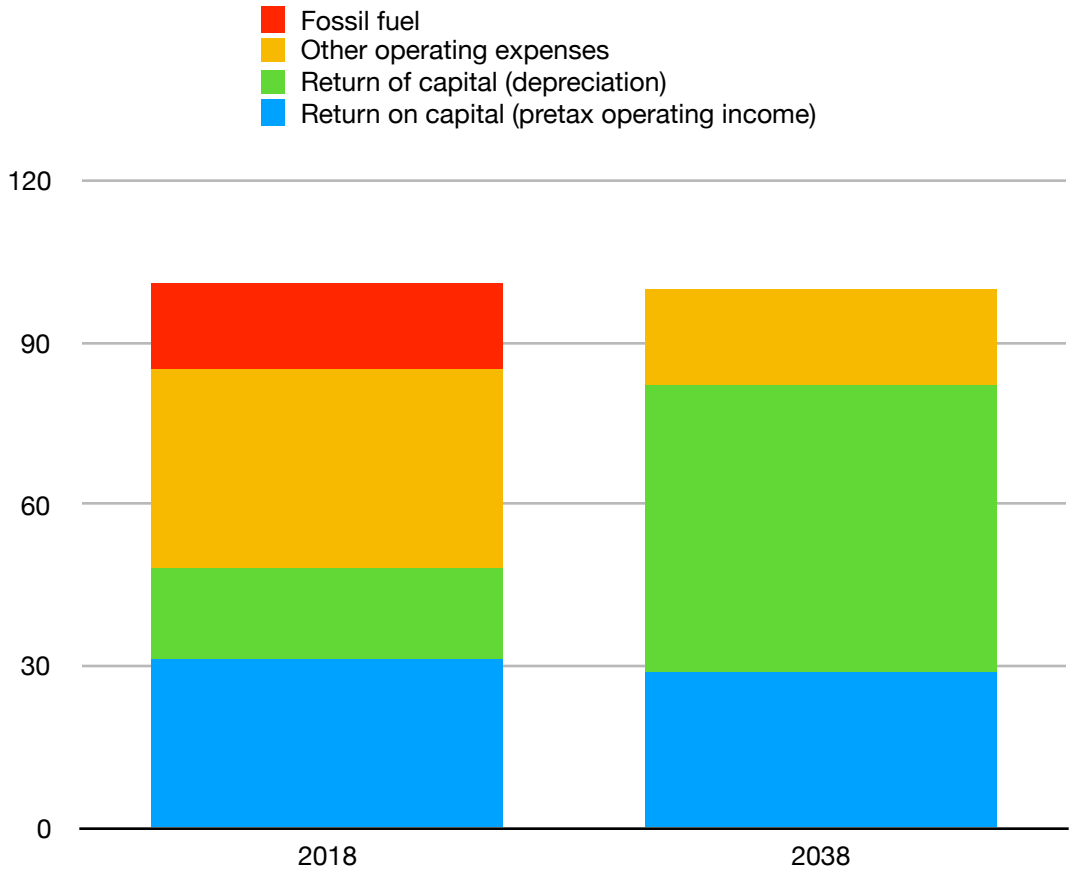
[9] Karen D. Tapia-Ahumada, John Reilly, Mei Yuan and Kenneth Strzepek, "Deep Decarbonization of U.S. Electricity Sector: Is There a Role for Nuclear Power?", Report 338, MIT Joint Program on the Science and Policy of Global Change, Sept. 2019, p.1.

[10] Leonard S. Hyman, *Electricity Acts: A Cautionary tale and case study of how British electricians pioneered the technology, the government regularly interfered, privatization produced big profits and electricity consumers usually ended up a losers* (Reston, VA: Public Utilities Reports, 2-17).

Figure 3. Estimated Distribution of Electric Revenue (%)
Note:



Note: Authors' estimates.

Note that the return on and of capital rises from 48% of the electric bill in 2018 to 82% in 2038. (Looking at the number differently, the ratio of plant required to generate one dollar of revenue rises from 4x to 8x. What we are postulating is that an already capital intensive utility industry will become even more so. Once again this emphasizes the centrality of a constructive regulatory process with its cost of capital determinations.

With so much overhead, the electric industry has to reduce the variability of its revenue streams. Leasing companies and other firms that own and manage fixed assets usually borrow heavily but creditors demand that asset owners have contracts with users to secure adequate cash flows for debt service. While we may see a greater reliance on regulation or regulated contracts to stabilize cash flows for the utilities, the very centrality of electricity for both individuals and corporations may require the same need for stability.

Government agencies build and own the most capital-intensive projects such as bridges, tunnels and highways. And these are financed entirely with low cost municipal debt. It is not unreasonable to believe that these entities may elect to participate more in the power business as a means to lower costs even further to consumers and ultimately foster regional development. However we would also not be surprised to see more government involvement as the default supplier of electricity in areas where an investor owned utility either will not or cannot provide service. For example in California, a franchised utility has blacked out thousands of its customers for protracted periods in the name of fire safety. This is the type of gap we expect to be filled either by the state or other governmental entities.

Finally, asset owners can create vehicles that separate ownership from management, which permits them to fashion securities that appeal to investors who want a fixed return from ownership but not the responsibilities of management. This calls for reexamination of existing business models to seek lower cost means of doing business.

Decarbonization will have a profound effect on electricity markets. Prices are presently determined on a day to day basis by short term marginal costs (especially the cost of natural gas as a boiler fuel). Non-fossil generators have little or no marginal costs. Since no generator will survive on a zero price, and all will have heavy fixed costs, their suppliers of capital will demand fixed price contracts. Generators will most likely bid for or negotiate fixed price contracts with a central authority or buyer, a deal that nails down revenues and get paid via a contract for differences. Or does the market revert to a power pool, with the pool manager allocating the demand among suppliers depending on grid conditions?

Policy proposals

Owners of our aging electricity system need to accelerate decarbonization. We believe electric utility modernization must accelerate to a pace reflecting the urgency of climate change rather than follow its traditional prime directives of fossil based central station power and shareholder value. Capital market conditions are exceptionally favorable for a system transformation of this magnitude. Interest rates are at generational lows with a glut of both domestic and international capital seeking positive investment returns. And now, they want sustainable investments, as well. Locking in low capital costs will benefit both consumers and shareholders for decades. The decarbonization/modernization program is as much a financial as an engineering project. It should require no government money in order to proceed.

Governments, of course, can prod electric companies to speed up act in more ways than by simply taxing carbon as several prominent economists suggest. State utility regulators can also require electricity suppliers to reduce GHG emissions in a more expedited fashion especially when doing so is the least cost option. We are already beginning to see this shift as traditional coal fired utilities transition their generating

fleets to renewables. The Federal government can dilute the impact of closings in regions dependent on coal with financial assistance. It can also offer debt guarantees for green investment projects especially for munis and co-ops thereby further lowering their already low capital costs. More directly Federal and local public power agencies with generation and transmission resources can act either directly or through wholesale activities to reduce the nation's reliance on fossil fuel.

In terms of convincing industry thought leaders with respect to rapid decarbonization's benefits, we propose the following thought experiment. Ask what would it take to convince the CEOs of electric companies to change plans and abandon base load natural gas fired generation as a "transition" fuel? What would it take for them to get to zero carbon emissions from their vast generating fleets? When it comes to knowing how to decarbonize in the most effective manner Industry insiders are likely to have a better handle on costs and opportunities than outsiders. We need to get them on board.

But we doubt that many industry executives will voluntarily make the Schumpeterian decision to perform an act of creative asset destruction and abandon carbon fuels for a non-fossil future. Thus, for purely practical reasons we advocate incentives to encourage electric companies to view climate change as a business rather than an all out assault on their financial well-being. To mix adages, honey attracts more flies than vinegar so make them an offer that they cannot refuse—a package of incentives that even the most politically conservative boards of directors could not reject. Their share owners would turn on them for refusing profitable, low risk business opportunities.

One simple solution in this regard is a straight forward three step glide path with respect to fossil fueled generating assets. Step one: for the first ten years all abandoned fossil assets receive full regulatory recovery. Step two, for the second ten year period these assets if abandoned only recover depreciation plus interest expense but zero return for shareholder provided capital. Step three, after 20 years all abandoned fossil assets receive zero recovery and would be treated as any other write off. This simple proposal utilizes regulatory mechanisms and principles already firmly in place. What is lacking at present is the political will.

Cost of capital is the key to any incentive plan. Regulators have reduced allowed after-tax returns on stockholder equity to 9% and many large, domestic and international utilities earn less. If current capital market conditions prevail, we predict that regulators will lower that return even further to 7% in the near future. With returns as low as they are and possibly heading lower, a small increase in revenue produces a disproportionate increase in profitability. Raising prices by just over 1% boosts return on equity by almost one percentage point, which translates into a more than 10% increase in net income. Few boards of directors can ignore those incentives. Adding two or three percentage points to return — as an added incentive for rapid decarbonization — would precipitate an avalanche of investment activity. And again this requires no radical rethink of regulatory processes or incentives.

Many electric companies have ceded generation to others and act as delivery vehicles indifferent to sources of energy they transmit to consumers. To change that attitude, regulators might grant companies a delivery bonus on carbon-free electricity to make them advocates for change rather than to behave as mere bystanders. The electric industry has to get back into the sales mode to make decarbonization via electrification happen throughout the economy and salespeople typically require commissions. Finally, we believe that the industry and its regulators should look hard at financial and ownership structures to bring in capital at the lowest possible cost. It would not surprise us if this transition leads to hybrid financial structures combining public power agencies at the generating end with IOUs retaining ownership of distribution assets for example.

Bottom line

Decarbonizing the electricity sector efficiently and economically requires appropriate business and financial strategies. The technology already exists. Decarbonization requires no government money. Electricity prices will rise over coming decades because electricity providers will have to replace aged equipment. Decarbonization may add to the bill based on current technology and fuel costs but maybe not with improved technologies. For that matter gas prices might rise when the shale drillers find that they can no longer borrow money or survive at current prices. In which case the GHG free technologies might look more attractive when gas prices rose. We calculate that the extra cost of full decarbonization (as opposed to just modernizing the system) will raise the household electric bill by an additional $24 per year every year until the program is completed. State regulators can utilize tried and true mechanisms to affect this change. The capital markets will finance the transformation at incredibly low costs.

To avoid measures too little and too late, investors and managers must focus on decarbonization via electrification — not selling electricity— as the main business proposition and view it as the biggest business opportunity for the electricity sector since the popularization of air conditioning.

Decarbonization opens the way to create a sustainable business. It can attract capital to transform electricity once again into a growth industry and thereby achieve the goal of reducing GHG emissions even more rapidly. Why wait?