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Four Decades of Subsidy Rationales for Uncompetitive Energy

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Summary

The modern rationales for energy subsidies have varied in prominence over the decades, but none has been broadly discredited in the public discussion despite the reality that each suffers from fundamental analytic weaknesses. The rationales can be summarized as follows:

- Energy "independence."
- Support for infant industries.
- Leveling the subsidy playing field.
- Adverse external effects of conventional generation.
- Resource depletion or "sustainability."
- Employment expansion through the creation of "green jobs."
- The "social cost of carbon."

Energy "independence"---the degree of self-sufficiency in terms of energy production---is irrelevant analytically, particularly in the case of such energy sources as petroleum traded in international markets, an economic truth demonstrated by the historical evidence on the effects of demand and supply shifts from the 1970s through the present.

Capital markets can sustain promising industries or technologies in their infancy---the early period during which technologies are proven and scale and learning efficiencies are achieved---so that the "infant industry" rationale for renewables subsidies is a *non sequitur*. Moreover, there is little evidence that there exist additional learning or scale cost reductions remaining to be exploited in wind and solar generation in any event.

There is no analytic evidence that renewables suffer from a subsidy imbalance relative to competing conventional energy technologies---the data suggest the reverse strongly---and the conventional "subsidies" that are purported to create a disadvantage for renewables are not "subsidies" defined properly as a matter of economic analysis.

Wind and solar power create their own set of environmental problems, and even in terms of conventional effluents and greenhouse gases it is far from clear that they have an advantage relative to conventional generation, particularly because of the up-and-down cycling of conventional backups units needed to preserve system reliability in the face of the intermittency (unreliability) of renewable power. And those backup costs---an economic externality caused by

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the unreliability of renewable power---are substantially larger than the externality costs of conventional power even under extreme assumptions.

The "sustainability" or resource depletion arguments for renewables subsidies make little sense analytically---the market rate of interest provides powerful incentives to conserve resources for consumption during future periods---and are inconsistent with the historical evidence in any event.

Nor does the "green jobs" employment rationale for renewables subsidies make analytic sense, as a shift of resources into the production of politically-favored power must reduce employment in other sectors---resources, after all, are limited always and everywhere---and the taxes needed to finance the subsidies cannot have salutary employment effects. Moreover, the historical evidence on the relationships among GDP, employment, and electricity consumption does not support the "green jobs" argument.

The newest environmental rationale for renewables subsidies---the "social cost of carbon"---is an argument deeply flawed both conceptually and in terms of the quantitative estimates now underlying a large regulatory effort. In particular, the Obama administration estimate of the social cost of carbon suffers from three central benefit/cost analytic flaws: the application of (asserted) benefits global rather than national to the net benefit calculation; the failure to use an appropriate discount rate; and the addition of such "co-benefits" as particulate reductions to the net benefit calculation. Moreover, the policies being proposed to reduce emissions of greenhouse gases would have temperature effects trivial or unmeasurable even at the international level, under assumptions highly favorable to the policy proposals. More generally, the terms "carbon" and "carbon pollution" are political propaganda, as carbon dioxide and "carbon" are very different physical entities, particularly given that some minimum atmospheric concentration of the former is necessary for life itself.

It would be hugely productive for the U.S. economy writ large were policymakers to adopt a straightforward operating assumption: Resource allocation in energy sectors driven by market prices is roughly efficient in the absence of two compelling conditions. First: It must be shown that some set of factors has distorted those allocational outcomes to a degree that is substantial. Second: It must be shown that government actions with high confidence will yield net improvements in aggregate economic outcomes. Given the weak history of analytic rigor and policy success in the context of energy subsidies, greatly increased modesty on the part of policymakers would prove highly advantageous.

I. Introduction: A Brief History of Modern U.S. Energy Subsidies

Congress passed and the president signed late last year the *Consolidated Appropriations Act, 2016*.[1] In the context of energy subsidies the legislation renewed production tax credits for wind and other power technologies retroactively to January 1, 2015, with new expiration dates

[1] See the text of the legislation at https://www.gpo.gov/fdsys/pkg/BILLS-114hr2029enr/pdf/BILLS-114hr2029enr.pdf.

and phaseouts varying by technology.[2] Investment tax credits were extended for solar, fuel cell, small wind, geothermal, microturbines, and co-generation ("combined heat and power") projects, with gradual phaseouts of these tax subsidies between 2019 and 2022.[3] It borders on the implausible that this latest extension of such subsidies for uncompetitive electric power technologies will prove to be the last when the 2019-2022 Congressional sessions arrive, as a brief history of U.S. energy policy suggests strongly both in general and with respect to "renewable" and other unconventional energy sources in particular.[4]

In terms of the modern history of U.S. energy policy, we usefully can begin in the mid-1970s with the energy "crisis" and the perceived need to achieve an expansion of the supply and "independence" of U.S. energy production.[5] This original rationale has been expanded greatly over time, with environmental and "sustainability" arguments added to "energy independence"; but the early policy history begins with the dominant energy security concerns of that period. The 1978 *National Energy Act* (NEA) was focused for the most part on reducing dependence on foreign oil and on measures intended to increase conservation and efficiency in domestic energy consumption.[6]

As an aside, that overriding rationale was driven in substantial part by the perverse effects of the price and allocation controls imposed upon the energy sector during much of the 1970s.[7] Market prices serve a number of economic functions, among them the imposition of

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[2] The expiration of the wind production tax credit was extended to December 31, 2019, with a phase-down imposed for wind projects beginning construction after the end of 2016. Tax credits for other eligible technologies (geothermal, biomass, and others) were extended for projects beginning construction before 2017. See the Department of Energy summary at http://energy.gov/savings/renewable-electricity-production-tax-credit-ptc.

[3] See the Department of Energy summary at http://energy.gov/savings/business-energy-investment-tax-credit-itc.

[4] With respect to the fundamental economic inefficiency of "renewable" and other such unconventional energy sources, see Benjamin Zycher, *Renewable Electricity Generation: Economic Analysis and Outlook*, Washington: AEI Press, November 15, 2011, at http://www.aei.org/publication/renewable-electricity-generation/. Such energy is "unconventional" precisely because it is uneconomic, and thus uncompetitive. See also Robert Bryce, "Energy Policies and Electricity Prices: Cautionary Tales from the E.U.," monograph, Manhattan Institute, March 2016, at http://www.manhattan-institute.org/sites/default/files/R-RB-0316.pdf; and Robert Bryce, "What Happens to an Economy When Forced to Use Renewable Energy?, Manhattan Institute Issue Brief, May 4, 2016, at http://www.manhattan-institute.org/sites/default/files/IB-RB-0516.pdf.

[5] Useful discussions and information are provided by the Energy Information Administration (EIA), "Policies to Promote Non-hydro Renewable Energy in the United States and Selected Countries," February 2005, at http://nrec.mn/data/uploads/Nom%20setguul%20xicheel/PV/nonhydrorenewablespaper_final.pdf; Fredric Beck and Eric Martinot, "Renewable Energy Policies and Barriers," *Encyclopedia of Energy*, Vol. 5 (2004), pp. 365-383; EIA, "Renewable Energy 2000: Issues and Trends," February 2001, at http://pbadupws.nrc.gov/docs/ML0932/ML093280377.pdf; Eric Martinot, Ryan Wiser, and Jan Hamrin, "Renewable Energy Policies and Markets in the United States," at http://www.martinot.info/Martinot_et_al_CRS.pdf; and North Carolina State University, North Carolina Clean Energy Technology Center, *Database of State Incentives for Renewables and Efficiency*, at http://www.dsireusa.org/.

[6] This legislation comprised five statutes: *The Energy Tax Act, The Natural Gas Policy Act, The National Energy Conservation Policy Act, The Power Plant and Industrial Fuel Use Act,* and *The Public Utility Regulatory Policies Act.*

[7] See Benjamin Zycher, "Emergency Management," in S. Fred Singer, ed., *Free Market Energy: The Way to Benefit Consumers*, New York: Universe Books, 1984, pp. 74-98. See also Benjamin Zycher, "In Defense of Price Gouging and Profiteering," *The American*, August 7, 2014, at http://www.aei.org/publication/in-defense-of-price-gouging-and-profiteering/.

discipline on consumption, and incentives for efficiency in the allocation of available supplies across competing uses. Such functions are crucial for achievement of the most productive use of supplies made more limited by supply disruptions, the central examples of which during the 1970s were the reduction in the output of crude oil by Arab OPEC during 1973-1975, and that caused by the Iranian revolution during 1978-1980.[8] Prices suppressed artificially by regulatory fiat can perform those central economic functions far less effectively, and in particular encourage consumption that is inefficient and total demands that exceed the supplies available, and a misallocation of those available supplies across competing uses.

And so subsidies for conservation and efficiency during that period in part represented an attempt to achieve by government fiat the market discipline and allocational outcomes suppressed by price and allocation regulations. But government incentives to achieve the same outcomes engendered by market prices are weak, and in any event government cannot achieve market-driven patterns of resource use because decisionmaking processes centralized by government cannot replicate the information revealed by market competition and market prices.[9] Instead, incentives for policymakers to use price and allocation regulation to bestow benefits upon favored constituencies are powerful. As an example, the allocation regulations imposed during the 1970s were based upon historical geographic consumption patterns; this meant that greater supplies than otherwise would have been the case went to rural areas, and lesser supplies to urban ones, an outcome that was predictable given the disproportionate political power enjoyed by less populated states in the U.S. Senate and in the electoral college, and because of the effects of gerrymandered congressional districts on the identity and policy preferences of the hypothetical median voter.[10]

The 1978 NEA included the *Public Utility Regulatory Policies Act*, intended ostensibly to increase conservation and efficiency in the electric utility sector. PURPA required electric utilities to purchase electricity from "qualifying facilities," which were defined as electric power producers smaller than 80 MW (megawatts) in capacity using cogeneration processes or renewable technologies.[11] From an analytic standpoint, such purchase requirements are a tool

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[8] See Benjamin Zycher, "OPEC," in David R. Henderson, ed., *The Concise Encyclopedia of Economics*, Indianapolis: Liberty Fund, 2008, at http://www.econlib.org/library/Enc/OPEC.html. See also the historical production data reported by BP in the *Statistical Review of World Energy 2015*, at http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

[9] See Zycher, 2014, *op. cit.*, fn. 7 *supra*.

[10] See Zycher, 1984, *loc. cit.*, fn. 7 *supra*. See also Aaron Wildavsky, *The Politics of the Budgetary Process*, Boston: Little, Brown, and Co., 1964, esp. pp. 102-108; Nelson W. Polsby, *et. al.*, *Presidential Elections: Strategies and Structures of American Politics*, Lanham: Rowman & Littlefield, 2011, esp. ch. 2; Cary M. Atlas, *et. al.*, "Slicing the Federal Government Net Spending Pie: Who Wins, Who Loses, and Why," *American Economic Review*, Vol. 85, No. 3 (June 1995), pp. 624-629; Frances E. Lee, "Senate Representation and Coalition Building in Distributive Politics," *American Political Science Review*, Vol. 94, Issue 1 (March 2000), pp. 59-72; George Rabinowitz and Stuart Elaine Macdonald, "The Power of the States in U.S. Presidential Elections," *American Political Science Review*, Vol. 80, Issue 1 (March 1986), pp. 65-87; Benjamin Zycher, "The Electoral College Does It Better," *Los Angeles Times*, October 27, 2004, at http://articles.latimes.com/2004/oct/27/opinion/oe-zycher27; and Gary C. Jacobson and Jamie L. Carson, *The Politics of Congressional Elections*, Lanham: Rowman & Littlefield, 2016, esp. pp. 246-252.

[11] Cogeneration facilities, now more commonly called "combined heat and power" (CHP) facilities, produce electricity and then capture the resulting heat for heating purposes. Under PURPA, utilities were required to purchase this power at "avoided cost," the determination of which was left to the state regulatory authorities; but the upshot is that under this requirement higher-cost power is "bundled" with lower-cost power in the determination of

with which to shift financing of renewables subsidies from the taxpayers writ large to the electricity market itself, as most state regulation of electricity prices bundles (or combines) lower- and higher-cost power into a single set of rates. This has the effect of subsidizing the producers of higher-cost power at the expense of consumers and the producers of lower-cost power. These implicit regulatory tax/expenditure transfers do not appear in government fiscal accounts. However, the very need for such implicit but sizeable subsidies, however financed, suggests, again, a fundamental competitiveness problem.

The 1978 NEA included also the *Energy Tax Act*, which gave an investment tax credit of 30 percent to residential consumers for solar and wind energy equipment, and a 10 percent investment tax credit to businesses installing solar, wind, geothermal, and ocean energy technologies. These tax credits ended in 1985.[12]

The 1992 *Energy Policy Act* created the production tax credit, set originally at 1.5 cents per kWh (kilowatt-hour) in 1993 dollars, adjusted for inflation, for some technologies, and 0.75 cents per kWh for others. The credit now is either 2.3 cents per kWh or 1.2 cents per kWh, respectively.[13] This credit has had a somewhat erratic history, having expired and been extended several times; the most recent extensions were in February 2009, January 2013, December 2014, and December 2015.[14]

A number of other federal policies encourage the use of renewable energy in electricity generation. Qualified investments are eligible for accelerated depreciation and bonus depreciation under the 2008 *Energy Improvement and Extension Act* (part of the Troubled Asset Relief Program),[15] the 2009 legislation just noted, and the 2010 *Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act*. Certain rebates for renewable energy offered consumers by electric utilities are excluded from taxable income. Several other grant, subsidy, and loan programs are administered by various federal agencies.[16]

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cost-based electricity rates. This has the effect of increasing the demand for the higher-cost power. The Federal Energy Regulatory Commission took over the determination of avoided cost in 1995.

[12] Wind technologies were practical for only very small numbers of residential and business consumers, and the same proved true for geothermal and ocean technologies.

[13] See fn. 2 and fn. 3, *supra*. The production tax credit is 2.3 cents per kWh for wind, closed-loop biomass, and geothermal generation; and 1.2 cents per kWh for open-loop biomass, landfill gas, municipal solid waste, qualified hydroelectric, and marine and hydrokinetic power.

[14] Respectively, the 2009 *American Recovery and Reinvestment Act*, the 2012 *American Taxpayer Relief Act*, the 2014 *Tax Increase Prevention Act*, and, as noted above, the *Consolidated Appropriations Act, 2016*. The 2009 legislation allowed facilities that qualify for the production tax credit to choose instead to take either the federal business energy investment credit or an equivalent cash grant. The latter two subsidies generally are 30 percent of eligible costs. Note that the investment tax credit/cash grant is based upon the capital cost of the renewable generation capacity, and thus is independent of the amount of electricity actually produced. With a few exceptions, facilities are eligible for the production tax credit for ten years. For an earlier discussion of ongoing problems with implementation of these programs, see *Memorandum for the President*, from Carol Browner, Ron Klain, and Larry Summers, "Renewable Energy Loan Guarantees and Grants," October 25, 2010, at http://www.politico.com/static/PPM182_101105_renewable_energy_memo.html.

[15] See http://thomas.loc.gov/cgi-bin/query/z?c110:H.R.1424.enr:. [Note: Colon correct as part of the hyperlink.]

[16] Examples include renewable energy grants from the Treasury Department, various grant and loan guarantee programs from the Agriculture Department, and loan guarantee programs from the Energy Department. See North Carolina State University, *op. cit.*, fn. 5 *supra*.

Section II offers summary critiques of the shifting policy rationales commonly asserted in favor of energy subsidies. Section III discusses in greater detail the newest "social cost of carbon" externality rationale for renewables subsidies, as estimated by an interagency working group of the Obama administration;[17] the attendant effects on temperatures in the year 2100 are discussed as a rough benefit/cost test. Finally, section IV offers some concluding observations.

II. Observations on the Expanding Rationales for Energy Subsidies

As noted above, the policy rationales for energy subsidies have expanded over time. What has not changed is their rather poor analytic quality; not one is convincing, and the most prominent modern rationale---subsidies for renewable electricity ("clean energy") as an adjunct of climate policy---is deeply flawed. The central arguments for energy subsidies can be categorized as follows:

- Energy "independence."
- Support for infant industries.
- Leveling the subsidy playing field.
- Adverse external effects of conventional generation.
- Resource depletion or "sustainability."
- Employment expansion through "green jobs."
- The "social cost of carbon."

Energy "Independence." It still is asserted commonly that it was the 1973 Arab OPEC oil "embargo" that created the sharp price increases in 1973 and 1979, and the market dislocations experienced in the U.S. during that decade.[18] In the wake of the 1970s experience, many have argued that explicit and implicit subsidies for domestic energy production would increase energy "independence" and thus insulate the U.S. economy from the effects of international supply disruptions.[19]

Those arguments were and remain largely incorrect. Since there can be only one world market for crude oil, a refusal to sell to a given buyer (i.e., impose a higher price on that buyer only) cannot work, as market forces will reallocate oil so that prices are equal everywhere (adjusting for such minor complications as differential transport costs). The 1973 embargo aimed at the U.S., the Netherlands, and a few others had no effect at all: All the targeted nations obtained oil on the same terms as all other buyers, although the transport directions of the global oil trade changed because of the reallocation process. It was the production cutback by Arab OPEC that raised international prices; and it was the U.S. system of price and allocation controls

[17] See "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866," Interagency Working Group on Social Cost of Carbon, revised July 2015, at https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.
[18] See, e.g., Greg Myre, "The 1973 Arab Oil Embargo: The Old Rules No Longer Apply," NPR Parallels, October 16, 2013, at http://www.npr.org/sections/parallels/2013/10/15/234771573/the-1973-arab-oil-embargo-the-old-rules-no-longer-apply.
[19] See, e.g., the discussion of "Energy Security" presented by the Renewable Fuels Association at http://www.ethanolrfa.org/issues/energy-security/.

that created the queues and other market distortions. Note that there was no embargo in 1979, but there was a production cutback in the wake of the Iranian revolution, and the U.S. again imposed price and allocation regulations. And, once again, there were queues and market distortions.[20]

Furthermore, however counterintuitive it may seem, the degree of "dependence" on foreign sources of energy is irrelevant, except in the case in which a foreign supplier or foreign power can impose a physical supply restriction, perhaps through a naval blockade or a military threat to ocean transport through, say, a narrow strait. Russian pipeline delivery of natural gas to Europe is a related example. But in the general case, because the market for crude oil is international in nature, as noted above, nations that import all of their oil face the same prices as those that import none of their oil. The cases of Japan and the UK, respectively, illustrate this point nicely: Changes in international prices, caused perhaps by supply disruptions, yield price changes in the two classes of economies that are equal, except for such minor factors as differences in exchange-rate effects and the like. Accordingly, the degree of energy "dependence" is irrelevant, the quest for energy "independence" is guaranteed to impose costs without offsetting benefits, and policy tools intended to increase such "independence" should be abandoned.

As an aside, many observers and commentators on the international oil market often refer to pricing and production behavior by "the OPEC cartel," but that characterization is not correct.[21] OPEC has never behaved like a cartel in the classic sense of allocating production shares so as to equate marginal production cost across producers. It is Saudi production that historically has determined world market prices simply because Saudi production and reserves have been so large. It is more useful analytically to view OPEC as one big producer determining the market price, and a number of smaller ones who accept that price and then try to find ways to erode it so as to garner bigger market shares for themselves. An example of such price shaving is an extension of credit for buyers beyond the usual thirty days. Games can be played also with the qualities of oil delivered, and with a number of other parameters.[22]

The Infant Industry Argument. Many argue that new technologies---wind and solar power are good examples---often cannot compete with established ones because the available market at the beginning is too small for important scale economies to be exploited, and because the downward shifts in costs that might result from a learning process cannot be achieved without substantial expansion in capacity and production. Accordingly, policy support for expansion of the newcomers' share of the market is justified as a tool with which to allow the achievement of both scale and learning efficiencies.

The central problem with this argument is that the market for electric power already has several competing technologies, each of which began with a small market share virtually by definition. More generally, many industries employing competing technologies are characterized

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[20] See Zycher, 1984, *loc. cit.*, fn. 7 *supra*.

[21] See, e.g., Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power*, New York: Free Press, 1992, esp. pp. 718-724.

[22] See Zycher, *op. cit.*, fn. 8 *supra*; and the Saudi historical production data for crude oil at https://www.eia.gov/forecasts/steo/tables/?tableNumber=7#startcode=1997.

by the presence of scale economies and/or learning efficiencies; but market forces operating through domestic and international capital markets provide investment capital in anticipation of future cost savings and higher economic returns. Accordingly, the infant industry argument is a *non sequitur*: The market can foresee the potential for scale and learning efficiencies, and invest accordingly. This argument provides no efficiency rationale for subsidies or other policy support.[23]

Leveling the Subsidy Playing Field. Another central argument made in favor of policy support for renewables is essentially a level-playing-field premise: Because conventional generation ostensibly benefits from important tax preferences and other policy support, renewables cannot compete without similar treatment. A recent EIA analysis presents data from which federal subsidies and support for a range of different energy types can be compared.[24] These data are presented in Table 1.[25]

Table 1
FY2013 Electricity and Non-Electricity Subsidies: Direct Outlays and Tax Expenditures
(year 2013 dollars)

	Electricity per mWh		Non-Electricity per quadrillion btu	
Fuel/Technology	Outlays	Tax Exp	Outlays	Tax Exp
Natural Gas, Petroleum Liquids	0.02	0.58	1.24	45.11
Coal (pulverized)	0.04	0.41	4.59	48.27
Hydroelectric	0.72	0.06	92.06	7.94
Biomass	1.03	0.15	492.70	68.27
Nuclear	0.05	1.41	n.a.	n.a.
Geothermal	13.00	1.29	1516.03	150.63
Wind	25.44	9.61	n.a.	n.a.
Solar	128.84	90.11	2501.14	1748.86

Source: Energy Information Administration, *op. cit.*, fn. 24 *supra*; and author computations. Computation of direct subsidies and tax expenditures for fuels used outside electric power sector assumes same proportions as for total subsidies.
n.a.: not applicable.

[23] For a discussion of the data on scale and learning efficiencies for renewable electricity, see Zycher, *op. cit.*, fn. 4 *supra*.
[24] See U.S. Energy Information Administration, "Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013," March 2015, at http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf.
[25] Other things held constant, subsidies that affect the marginal (or incremental) cost of generation or the per-unit prices received by particular technologies are likely to affect market prices, even under standard rate-of-return regulation, and so might create a competitive disadvantage for other technologies not receiving equivalent treatment. An example is the per-unit production tax credit for renewable power. Other credits might improve profitability without affecting marginal costs or prices directly; investment tax credits for renewables are a good example. The latter would attract additional investment into the industry over time, thus perhaps affecting market prices, but that price effect would be felt by all producers regardless of which actually received the subsidy. At the same time, even such subsidies as the latter would serve to reduce or eliminate whatever competitive disadvantages confront renewables as a result of policies that purportedly support conventional generation.

With respect to energy sources used for electric generation, these data show that federal subsidies and financial support, whether in the form of outlays or tax expenditures, are vastly higher for renewables than for conventional fuels used in power production, on a per-mWh basis. This reality holds *a fortiori* for wind and solar power, for which federal financial support was higher than that for fossil fuels by approximate factors of sixteen to sixty-four hundred. The same pattern holds for fuels used outside the power sector; on a per-btu basis, biomass, geothermal, and solar subsidies exceed those for conventional fuels by approximate factors ranging up to two thousand. Accordingly, it is clear that renewable power technologies are not at a competitive disadvantage because of average federal subsidy outlays and tax expenditures received by conventional generation; quite the reverse is true.[26]

A somewhat older calculation of marginal subsidies and support through tax expenditures has been reported by Metcalf, yielding estimates of effective marginal tax rates on investments in alternative electric generation technologies. Computation of such effective marginal tax rates incorporates the many subsidies and preferences that affect choices among those alternatives, and so offers a direct test of the degree to which federal tax expenditures favor given technologies over others.[27] Table 2 summarizes his findings, which are for 2007.

Table 2
Metcalf Findings on Effective Marginal Tax Rates For Electric Generation Investment
(percent)

Technology	Current Law	No Tax Credits	Economic Depreciation
Coal (pulverized)	38.9	38.9	39.3
Gas	34.4	34.4	39.3
Nuclear	-99.5	32.4	-49.4
Solar Thermal	-244.7	12.8	-26.5
Wind	-163.8	12.8	-13.7

Source: Metcalf (2010), *op. cit.*, fn. 27, *supra*.
Note: Current law is as of 2007.

[26] This is only part of the "subsidy" issue: We should examine also the relative subsidies or tax expenditures net of royalty and other such payments made to the federal government as compensation for the use of federal land. I have made that computation for the Ivanpah thermal solar power facility in California; per million btu of energy produced, Ivanpah pays $0.88 while oil and gas producers pay $1.23. See Benjamin Zycher, "California's New Solar Plant: Burning Up Taxpayer Money, Land, and Wildlife," *The American*, May 21, 2014, at http://www.aei.org/publication/californias-new-solar-plant-burning-up-taxpayer-money-land-and-wildlife/.

[27] See Gilbert E. Metcalf, "Investment in Energy Infrastructure and the Tax Code," in Jeffrey R. Brown, ed., *Tax Policy and the Economy, Volume 24*, Chicago: University of Chicago Press Journals, 2010, pp. 1-33. See also Gilbert E. Metcalf, "Federal Tax Policy Towards Energy," NBER Working Paper No. 12568, October 2006, at http://www.nber.org/papers/w12568.pdf; and Gilbert E. Metcalf, "Taxing Energy In the United States: Which Fuels Does the Tax Code Favor?", Manhattan Institute Center for Energy Policy and the Environment, Report No. 4, January 2009, at http://www.manhattan-institute.org/html/eper_04.htm.

The three columns present the Metcalf calculations of effective marginal tax rates under 2007 law, under a regime without production and investment tax credits, and with economic depreciation assumed in place of accelerated depreciation, respectively.[28] Under 2007 law, solar thermal and wind generation investments received large net percentage marginal tax-expenditure subsidies (negative effective marginal tax rates) far larger than those enjoyed by nuclear investments; and coal and gas investments faced effective tax rates greater than zero. If the tax credits are assumed away, solar thermal and wind investments faced effective tax rates roughly one-third those of the other technologies. If economic depreciation replaces accelerated depreciation, nuclear investment enjoyed a negative effective marginal tax rate (tax subsidy) larger (in absolute value) than those for solar and wind investments; but coal and gas investments faced effective marginal tax rates of over 39 percent.

The Metcalf calculations of effective marginal tax rates under 2007 law suggest strongly that the "offsetting subsidy" rationale for federal financial support of solar and wind investments is weak: Coal and gas investments face positive effective marginal tax rates, and new nuclear investment does not seem to be a serious competitive threat over the medium term.[29] Moreover, the effective subsidies enjoyed by solar and wind generation are far greater than those needed to level the playing field with respect to nuclear generation except under Metcalf's "economic depreciation" assumption.[30]

Even given the substantially larger per-unit subsidies given unconventional energy, it is interesting to address briefly whether the central tax and other preferences given conventional energy are "subsidies" under a proper analytic definition.[31] The percentage depletion allowance essentially is a form of depreciation for the capital assets represented by extractive resource

[28] Metcalf uses an exponential depreciation rate rather than straight-line depreciation as an approximation of economic depreciation over the lives of given investments.

[29] The last nuclear generation reactor to begin commercial operation is the Watts Bar-1 plant in Tennessee, on May 27, 1996. See EIA at https://www.eia.gov/tools/faqs/faq.cfm?id=228&t=21. The Tennessee Valley Authority has announced plans to bring Watts Bar-2 to commercial operation during the summer of 2016. See https://www.tva.gov/Newsroom/Watts-Bar-2-Project.

[30] The playing field is biased in favor of renewables for two additional reasons, the first of which is the implicit subsidy for backup generation capacity and transmission costs: Such costs are a direct effect of investment in renewable capacity, but are spread across electricity consumption from all sources. The Federal Energy Regulatory Commission, in a recent case involving the Midwest Independent Transmission Operator, ruled that the transmission costs attributable to wind generation may be allocated to consumers regardless of the amount of wind power actually consumed by any given ratepayer. This ruling essentially spreads such costs across the entire grid; accordingly, the transmission costs attendant specifically upon wind generation are not reduced but instead are hidden somewhat from calculations of the marginal cost of wind power. See the FERC Conditional Order, Docket No. ER10-1791-000, December 16, 2010, at http://www.ferc.gov/whats-new/comm-meet/2010/121610/E-1.pdf. Second, public subsidies for renewable power, whether in the form of direct outlays or indirect tax preferences, impose costs upon the private sector larger than the subsidies themselves, because of the excess burden (or "deadweight losses") imposed by the tax system. Essentially, the private sector becomes smaller by more than a dollar when it is forced to send a dollar to the federal government. For a nontechnical discussion, see Martin A. Feldstein, "The Effect of Taxes on Efficiency and Growth," *Tax Notes*, May 8, 2006, pp. 679-684.

[31] See a list of such tax provisions prepared by the Joint Committee on Taxation at https://www.jct.gov/publications.html?func=startdown&id=4415.

geologic formations; this tax treatment is available to all extractive industries.[32] It may or may not be the case that a particular legal depletion percentage is correct analytically---the allowance can result in a deduction in excess of the incurred capital costs---but the percentage depletion allowance as a method for the depreciation of an extractive capital asset conceptually is not a "subsidy."

The accelerated tax deduction for intangible drilling expenses allows expensing of labor and other drilling costs associated with exploration activities.[33] Since those costs are incurred in the creation of a capital asset, the basic analytics of income taxation require that such costs be capitalized and depreciated over time. This problem, however, does not represent a "subsidy" for conventional energy production, as this tax provision is very similar to the tax treatment of research and development costs in other industries. The allowed expensing of materials injected into declining wells so as to enhance extraction is appropriate, because the materials are consumed in the extraction process; they do not, therefore, help to create capital assets. Accordingly, this tax treatment is not a "subsidy."

The "Section 199" deduction of 9 percent of income is a tax preference given almost all U.S. producers of goods (but not services). This deduction for producers of goods may or may not be sound tax policy, but it is not specific to conventional energy producers---which receive only a 6 percent deduction---and so it is not a "subsidy" for such producers relative to other producers of goods. To the extent that goods producers with significant physical stocks of capital face some prospect of price controls during future wars or other emergencies, this deduction may be efficient in terms of inducing an optimal level of investment in such industries during peacetime.[34]

Finally, the foreign tax credit is a tax provision designed to avoid double taxation of U.S. firms operating both domestically and overseas. Whatever the issues inherent in the allocation of costs and revenues across operations in different geographic locales, or the possible classification of royalty payments as "income taxes", the tax credit is not a "subsidy" in principle, although it is the case that the foreign tax credit treats foreign income taxes more generously than other foreign taxes and business costs.

Adverse External Effects of Conventional Generation. A negative "externality" is an adverse effect of economic activity the full costs of which are not borne by the parties engaging directly in the activity yielding the adverse effect. A simple example is the emission of effluents into the air as a byproduct of such industrial processes as power generation. There is no dispute

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[32] Note that integrated oil companies---those that both produce and refine petroleum---are not allowed this tax benefit.

[33] This deduction is reduced for integrated oil companies, which are allowed to expense 70 percent of such costs, with the remainder deducted over the ensuing five years.

[34] The expectation (with some probability greater than zero) of future price controls would suppress investment below efficient levels because the presence of significant physical capital stocks specialized to specific production activities creates "quasi-rents" available for government to extract with price controls, without suppressing production in the short run. See Earl A. Thompson, "Taxation and National Defense," *Journal of Political Economy*, Vol. 82, No. 4 (July-August 1974), pp. 755-782; and Earl A. Thompson, "An Economic Basis for the 'National Defense Argument' for Aiding Certain Industries," *Journal of Political Economy*, Vol. 87, No. 1 (February 1979), pp. 1-30.

that power generation with fossil fuels imposes adverse environmental effects due to the emission of carbon monoxide, sulfur oxides, nitrogen oxides, mercury, particulates, lead, and other effluents. Accordingly, the EPA and the states have established detailed programs for defining emission standards and for implementing attendant investment and enforcement programs.

If the negative externalities yielded by conventional generation are not internalized fully by current environmental policies---that is, if buyers and producers are not confronted with the full costs of the adverse environmental effects that they impose on others---then the costs of conventional generation as perceived by the market would be (artificially) lower than the true social costs. At the same time, the unreliable nature of wind and solar generation imposes a requirement for costly backup capacity. And so the question to be addressed is as follows: Given the magnitude of those backup cost requirements---which are economic externalities imposed by renewables---as estimated in the technical literature, are the additional (or marginal) costs of backup capacity imposed by renewable generation sufficient to offset any artificial "externality" cost advantage enjoyed by conventional generation?[35]

A number of analyses of the environmental externality costs of U.S. electricity generation were conducted during the 1980s and 1990s.[36] These studies differ somewhat in terms of methodology and focus, but offer a range of estimates useful in terms of the question addressed here. In summary: The estimated externality costs for coal range from 0.1 cents to 26.5 cents per kWh. For gas generation, the range is 0.1-10.2 cents per kWh. For oil, nuclear, and hydro generation, the respective ranges are 0.4-16.5 cents per kWh, 0-4.9 cents per kWh, and 0-2.1 cents per kWh.

The highest estimated figure for coal generation is 26.5 cents per kWh, or $265 per mWh. A conservative estimate of the cost of backup capacity for existing wind and solar generation is about $368 per mWh, or roughly 37 cents per kWh.[37] Accordingly, if all conventional generation were coal-fired, existing wind and solar capacity imposes a backup cost "externality"

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[35] Note that because renewable generation---wind and solar power---are unreliable, the conventional backup generation must be cycled up and down in coordination with the availability of the renewable generation. In particular for coal-fired generation, but also for gas combined-cycle backup generation, this means that the conventional assets cannot be operated as efficiently as would be the case were they not cycled up and down in response to wind or solar generation conditions. Inefficient operation---a higher heat rate, that is, more btu of energy input per mWh generated---is the necessary result of such cycling. A recent study of the attendant emissions effects for Colorado and Texas found that requirements for the use of wind power impose significant operating and capital costs because of cycling needs for backup generation---particularly coal plants---and actually exacerbate air pollution problems. See Bentek Energy LLC, *How Less Became More: Wind, Power and Unintended Consequences in the Colorado Energy Market*, April 16, 2010, at http://docs.wind-watch.org/BENTEK-How-Less-Became-More.pdf.

[36] For a detailed discussion of that literature, see Zycher, *op. cit.*, fn. 4 *supra.*, at 41-46. Note that renewable power generation imposes its own set of problems, including noise, light flicker effects, deaths among possibly-large numbers of birds, pollution with heavy metals, consumption of large amounts of land with unsightly turbine farms or solar collection panels, and others. See Zycher, *op. cit.*, fn. 26 *supra.* Interestingly, new research finds that large-scale adoption of wind generation might cause an increase in surface temperatures. See C. Wang and R.G. Prinn, "Potential Climatic Impacts and Reliability of Very Large-Scale Wind Farms," *Atmospheric Chemistry and Physics*, Vol. 10, No. 4 (2010), pp. 2052-2061, at http://www.atmos-chem-phys.net/10/2053/2010/acp-10-2053-2010.pdf.

[37] See Zycher, *op. cit.*, fn. 4 *supra.*, at 26-31.

about 39 percent higher than the environmental externality costs of conventional generation under the implausible assumption that none of the conventional externalities have been internalized under current environmental policies.

But in fact coal generation is about 33 percent of total U.S. generation; gas generation is about 33 percent, nuclear generation is about 20 percent, hydroelectric generation is about 6 percent, and renewables and other miscellaneous technologies make up the rest.[38] If we use those figures and the highest estimates by fuel type noted above to compute a weighted-average externality cost for nonrenewable generation, the externality cost per conventional kWh is about 13.2 cents, or $132 per mWh. Relative to the backup cost "externality" ($368 per mWh) imposed by wind and solar investments alone, those figures are sufficiently low to cast substantial doubt upon the externality argument for tax expenditures on renewables: Current environmental regulation must internalize some substantial part of conventional externalities, and federal and state subsidies, both explicit and implicit, and requirements for minimum market shares for renewables also have the effect of offsetting any artificial cost advantage enjoyed by conventional generation as a result of uninternalized externalities.

The environmental problems caused by renewable power are substantial---noise, flicker effects, wildlife destruction, heavy-metals pollution, etc.---but represent a topic outside the scope of the discussion here.[39] In any event, note that in terms of economic efficiency, subsidies in the form of direct outlays or tax expenditures for renewables intended to offset the (assumed) uninternalized external costs of conventional generation are a "second-best" policy at best. Such subsidies would reduce the (inefficient) competitive advantage of conventional generation yielded by the presence of some social costs not reflected in prices; but they would not improve the efficiency of costs or prices for conventional generation. And by biasing the perceived costs and prices of renewable generation downward, the subsidies would result in a total electricity market that would be too large. In short: The externality argument in favor of tax expenditures or policy support for renewable electricity generation is exceedingly weak, far more so than commonly assumed.

The Resource Depletion or "Sustainability" Argument. "Renewable" energy has no uniform definition; but the (assumed) finite physical quantity of such conventional energy sources as petroleum is the essential characteristic differentiating the two in most discussions.[40] In a word, conventional energy sources physically are (assumed to be) depletable; but that would not yield a depletion problem as an economic reality under market processes, as discussed below. In contrast, each sunrise and geographic temperature differential yields new supplies of sunlight and wind flows, a central component of "sustainability," which perhaps is a concept broader than

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[38] See the EIA data at https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_1_1 and at https://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3.

[39] See fn. 36 *supra*.

[40] There is considerable discussion in the technical literature of non-biological sources of methane and petroleum. See James A. Kent, *Kent and Riegel's Handbook of Industrial Chemistry and Biotechnology*, 11th ed., New York: Springer, 2007, Ch. 20; and M. Ragheb, "Biogenic and Abiogenic Petroleum," at http://mragheb.com/NPRE%20402%20ME%20405%20Nuclear%20Power%20Engineering/Biogenic%20and%20Abiogenic%20Petroleum.pdf. To the extent that conventional energy resources are produced non-biologically, the "depletion" assumption underlying the sustainability argument may be incorrect even descriptively.

the depletion condition. Nonetheless, the definition of "sustainability" is highly elusive, as the Environmental Protection Agency discussion illustrates:

> Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. To pursue sustainability is to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations.[41]

This obviously is infantile blather, definitive proof that the EPA has no idea what "sustainability" means as an analytic concept. An international definition often cited is that from the *Report of the World Commission on Environment and Development: Our Common Future*:

> Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.[42]

This definition also is useless, as "needs" whether present or future are undefined, the evaluation of the inexorable tradeoffs among such needs is ignored, again whether in the present or the future or across time periods and generations, the effects of unknown but certain technological advances are not considered, *ad infinitum*.

In any event, the energy content of sunlight and wind is finite, regardless of whether new supplies of sunlight or wind flows emerge continually. They contain only so much convertible energy, which is not always available. Moreover, the same is true for the other resources---materials, land, etc.---upon which the conversion of such renewable energy into electricity depends. More fundamentally, the basic "sustainability" concept seems to be that without policy intervention, market forces will result in the depletion (or exhaustion) of a finite resource. Accordingly, subsidies and other support for renewable power generation are justified as tools with which to slow such depletion and to hasten the development of technologies that would provide alternatives for future generations.

That argument is deeply problematic. Putting aside the issue of whether government as an institution has incentives to adopt a time horizon longer than that relevant for the private sector, the profit motive provides incentives for the market to consider the long-run effects of current decisions. The market rate of interest is a price that links the interests of generations present and future. If a resource is being depleted, then its expected future price will rise, other things held constant. If that rate of price increase is greater than the market interest rate, then owners of the resource have incentives to reduce production today---by doing so they can sell the resource in the future and in effect earn a rate of return higher than the market rate of interest---thus raising prices today and reducing expected future prices. In equilibrium---again, other

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[41] See the EPA discussion at https://www.epa.gov/sustainability/learn-about-sustainability#what.

[42] See http://www.un-documents.net/our-common-future.pdf.

factors held constant---expected prices should rise at the market rate of interest.[43] Under market institutions, it is the market rate of interest, again, that ties the interests of the current and future generations by making it profitable currently to conserve some considerable volume of exhaustible resources for future consumption.[44] Because of the market rate of interest, market forces will never allow the depletion of a given resource.

Accordingly, the market has powerful incentives to conserve, that is, to shift the consumption of large volumes of finite (or depletable) resources into future periods. That is why, for example, not all crude oil was used up decades ago even though the market price of crude oil always was greater than zero, which is to say that using it would have yielded value. In short, the "sustainability" argument for policy support for renewable electricity depends crucially upon an assumption that the market conserves too little and that government has incentives to improve the allocation of exhaustible resources over time. That is a dual premise for which the underlying rationale is weak and with respect to which little persuasive evidence has been presented.[45]

"Green Jobs": Renewable Power As A Source of Expanded Employment. A common argument in support of expanded renewable power posits that policies (subsidies) in support of that goal will yield important benefits in the form of complementary employment growth in renewables sectors, and stronger demand in the labor market in the aggregate. Both of those premises are almost certainly incorrect.

The employment in renewables sectors created by renewables policies actually would be an economic cost rather than a benefit for the economy as a whole. Suppose that policy support for renewables (or for any other sector) were to have the effect of increasing the demand for, say, high-quality steel. That clearly would be a benefit for steel producers, or more broadly, for owners of inputs in steel production, including steel workers. But for the economy as a whole, the need for additional high-quality steel in an expanding renewable power sector would be an economic cost, as that steel (or the resources used to produce it) would not be available for use in other sectors. Similarly, the creation of "green jobs" as a side effect of renewables policies is a benefit for the workers hired (or for those whose wages rise with increased market competition for their services). But for the economy as whole, that use of scarce labor is a cost because those workers no longer would be available for productive activity elsewhere.[46]

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[43] In reality the long run prices of most exhaustible natural resources have declined (after adjusting for inflation), in large part because of (unexpected) technological advances in discovery, production, and use.

[44] Strictly speaking, it is not the price of the resource that should rise at the market rate of interest; instead the total economic return to holding the resource for future use should equal the market rate of interest. That total economic return includes expected price changes and capital gains, expected cost savings, and the like. Current and expected prices are a reasonable first approximation of that total economic return.

[45] For a more detailed conceptual and empirical discussion of the market allocation of a depletable resource over time, see Benjamin Zycher, "World Oil Prices: Market Expectations, the House of Saud, and the Transient Effects of Supply Disruptions," monograph, *aei.org*, June 2016, at http://www.aei.org/wp-content/uploads/2016/06/World-Oil-Prices.pdf.

[46] Considerable employment would be created if policies encouraged ditch-digging with shovels (or, in Milton Friedman's famous example, spoons) rather than heavy equipment. Such employment obviously would be laughable, that is, an obvious economic burden. There is no analytic difference between this example and the "green jobs" rationale for renewables subsidies.

More to the point, an expansion of the renewable electricity sector must mean a decline in some other sector(s), with an attendant reduction in resource use there; after all resources in the aggregate are finite. If there exists substantial unemployment, and if labor demand in renewables is not highly specialized, a short-run increase in total employment might result. But in the long run---not necessarily a long period of time---such industrial policies cannot "create" employment; they can only shift it among economic sectors. In short, an expanding renewables sector must be accompanied by a decline in other sectors, whether relative or absolute, and creation of "green jobs" must be accompanied by a destruction of jobs elsewhere. Even if an expanding renewables sector is more labor-intensive (per unit of output) than the sectors that would decline as a result, it remains the case that the employment expansion would be a cost for the economy as a whole, and the aggregate result would be an economy smaller than otherwise would be the case.[47] There is no particular reason to believe that the employment gained as a result of the (hypothetically) greater labor intensiveness of renewables systematically would be greater than the employment lost because of the decline of other sectors, combined with the adverse employment effect of the smaller economy in the aggregate. There is in addition the adverse employment effect of the explicit or implicit taxes that must be imposed to finance the expansion of renewable power.

Because renewable electricity generation is more costly than conventional generation, policies driving a shift toward heavier reliance upon the former would increase aggregate electricity costs, and thus reduce electricity use below levels that would prevail otherwise.[48] The 2007 EIA projection of total U.S. electricity consumption in 2030 was about 5.17 million gigawatt-hours (gWh).[49] The latest EIA projection for 2030 is about 4.44 million gWh, a decline of about 14 percent.[50] The change presumably reflects some combination of assumptions about structural economic shifts, increased conservation, substitution of renewables for some conventional generation, and a projected price increase (in 2015 dollars) from about 9.3 cents per kWh to 11.6 cents, or almost 25 percent.[51] Because, in the EIA projections, consumption of electric power in 2030 falls by that 14 percent between the 2007 and 2015 analyses, the projected price increase is likely to be due to increases in costs rather than strengthened demand conditions.

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[47] Many advocates of renewables subsidies assert that solar and wind power is more labor intensive than conventional generation. The assumption of greater labor intensity for renewable power production is dubious: The operation of solar or wind facilities does not employ large amounts of labor, and it is far from clear that construction of solar or wind facilities is more labor intensive than construction of conventional generation facilities.

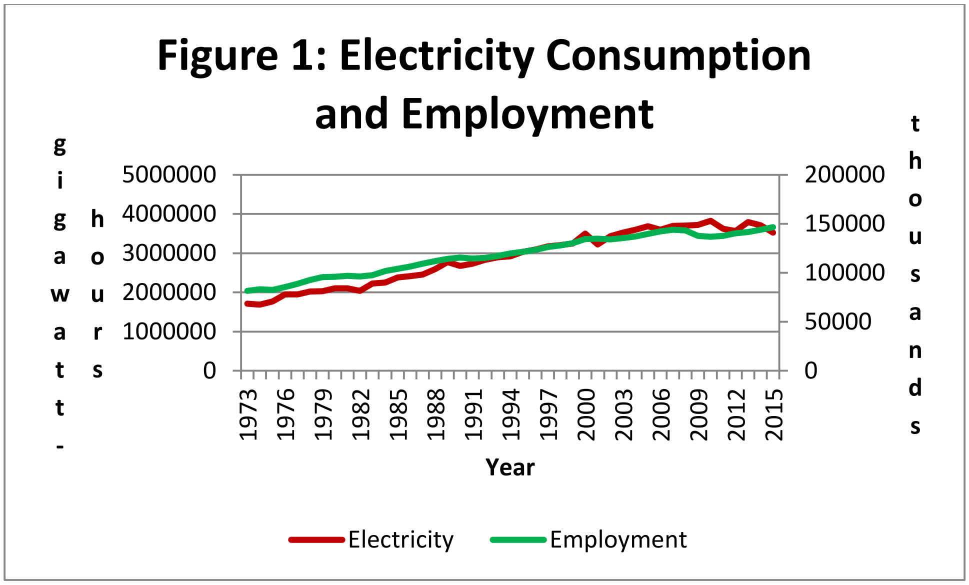
[48] See Zycher, *op. cit.*, fn. 4 *supra*.

[49] See EIA at http://www.eia.doe.gov/oiaf/archive/aeo07/aeoref_tab.html, at Table 2.

[50] See EIA at http://www.eia.gov/forecasts/aeo/pdf/tbla8.pdf.

[51] The EIA 2007 price projection for electricity in 2030 was $23.60 per million btu in year 2005 dollars, or about 8.1 cents per kWh at a conversion rate of 293 kWh per million btu (3413 btu per kWh); that is about 9.3 cents in year 2015 dollars. See EIA at http://www.eia.gov/oiaf/archive/aeo07/pdf/aeotab_3.pdf. The EIA projection in 2015 for 2030 was $33.97 per million btu, or 11.6 cents per kWh, in year 2015 dollars. See EIA at http://www.eia.gov/forecasts/aeo/data.cfm#summary (Table 3). The deflators are derived from the Council of Economic Advisers, *Annual Report of the Council of Economic Advisers*, February 2016, Table B-3, at https://www.whitehouse.gov/administration/eop/cea/economic-report-of-the-President/2016.

Accordingly, it would be surprising if that reduction in total U.S. electricity consumption failed to have some nontrivial employment effect. Figure 1 displays data on electricity consumption, and non-agricultural employment for the period 1973 through 2015.[52]



It is obvious from the aggregate trends that electricity use and labor employment are complements rather than substitutes; the simple correlation between the two series is 0.988, meaning, crudely, that a one-unit change in one tends to be observed with a 0.988 unit change in the other, in the same direction.

Correlation is not causation; but it is not plausible that an increase in electricity costs (or energy costs more broadly) would fail to have adverse effects on employment, if only by increasing the cost of using equipment and other such capital complementary with labor employment.[53] The determination (or refutation) of such economic relationships would require application (and statistical testing) of a conceptual model, a task outside the scope of the issues addressed here. But the data displayed in Figure 1 provide strong grounds to infer that the higher costs and reduced electricity consumption attendant upon expansion of renewable generation would reduce employment; at a minimum they provide strong grounds to question the common assertion that policies in support of expanded renewable electricity generation would yield

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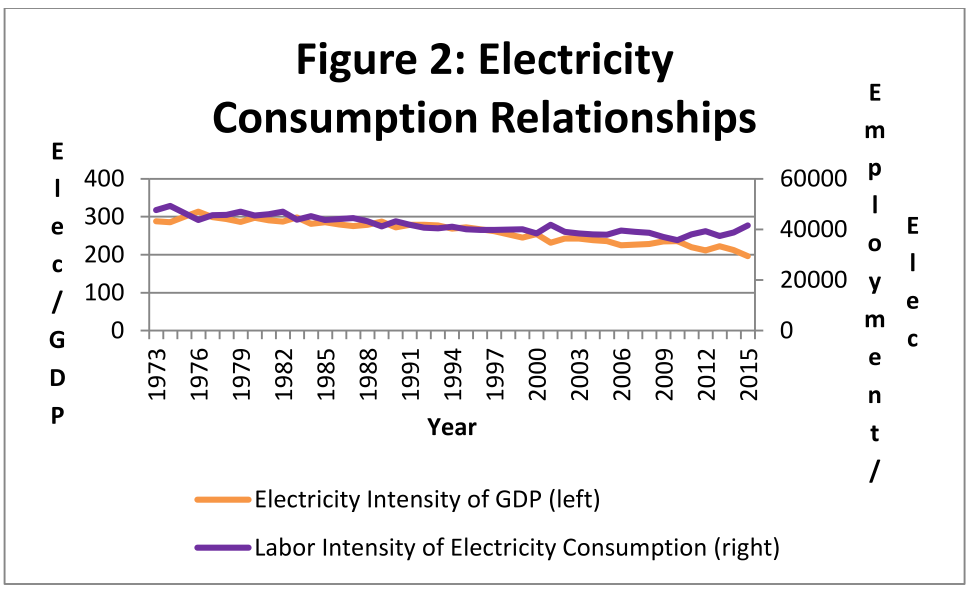
[52] For civilian employment, see the Bureau of Labor Statistics at http://www.bls.gov/cps/tables.htm. For electricity consumption, see EIA at http://www.eia.gov/totalenergy/data/annual/index.cfm#electricity (Table 8.9).

[53] It is important to keep clear the conceptual experiment under consideration. In the context here, we assume that government policies increase the substitution of renewable power in place of conventional electricity, and ask whether the aggregate data are consistent with the assertion that such "green" policies---explicitly an increase in energy costs (see Zycher, *op. cit.*, fn. 4 *supra*) ---can be predicted to yield an increase in aggregate employment. This is very different from, say, the effects of an aggregate recession, which can be predicted to reduce both energy costs (prices) and employment more-or-less simultaneously. Similarly, an economic boom would increase both energy prices and employment, while an increase in energy supplies would reduce energy prices and increase employment. Note that aggregate employment in any of these scenarios might fall in the short run as market forces reallocate labor (and other resources) in response to changes in relative prices.

increases in aggregate employment as a side effect, putting aside whether such increases would be a net economic benefit for the economy as a whole.

It certainly is possible that the historical relationship between employment and electricity consumption will change. Technological advances are certain to occur; but the prospective nature and effects of those shifts are difficult to predict.[54] The U.S. economy may evolve over time in ways yielding important changes in the relative sizes of industries and sectors, as it has continually over time; but, again, the direction of the attendant shifts in employment and electricity use is ambiguous.

But there exists no evidence with which to predict that a reduction in electricity consumption would yield an increase in employment. Like all geographic entities, the U.S. has certain long-term characteristics---climate, available resources, geographic location, trading partners, legal institutions, *ad infinitum*---that determine in substantial part the long-run comparative advantages of the economy in terms of economic activities and specialization. Figure 2 presents the historical paths of the electricity intensity of U.S. GDP (electricity consumption per dollar of output) and of the labor intensity of U.S. electricity consumption (employment per million gWh of power consumption).[55]



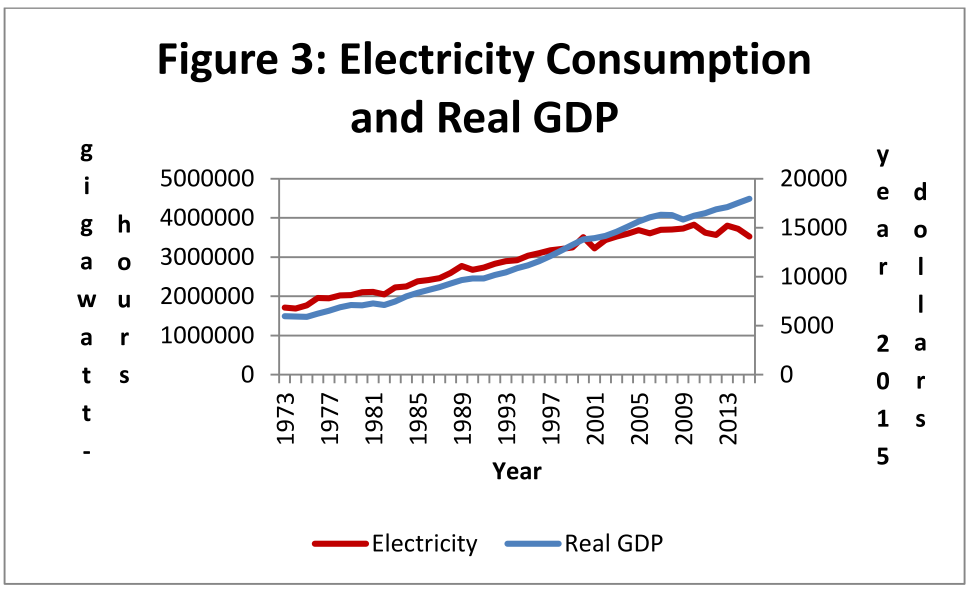
[54] Note that greater energy "efficiency" in any given activity can yield an increase in actual energy consumption, if the elasticity of energy demand with respect to the marginal cost of energy use is greater than one. If, for example, air conditioning were to become sufficiently "efficient" in terms of energy consumption per degree of cooling, it is possible that air conditioners would be run so much---or that so many additional air conditioners would be installed---that total energy consumption in space cooling would increase. A tax, on the other hand, whether explicit or implicit, increases the price of energy use, and so unambiguously reduces energy consumption.

[55] Sources: See BLS and EIA, *op. cit.* fn. 52 *supra.*; and for GDP, Bureau of Economic Analysis at http://www.bea.gov/national/index.htm#gdp, Federal Reserve Bank of St. Louis at https://research.stlouisfed.org/fred2/series/GDPDEF, and author computations.

During 1973-2015, the electricity intensity of GDP has increased and declined over various years, but for the whole period has declined slightly at a compound annual rate of about 0.9 percent. The labor intensity of U.S. electricity consumption---in a sense, the employment "supported" by each increment of electricity consumption---has declined over the entire period at an annual compound rate of about 0.3 percent. This may be the result largely of changes in the composition of U.S. GDP (toward services), and perhaps the substantial increase in U.S. labor productivity in manufacturing.

But these data are not consistent with the premise that a reduction in electricity consumption driven by an increase in energy costs would yield an increase in aggregate employment; instead, they suggest the reverse strongly. In short, while the electricity/output and employment/electricity relationships may have declined over time, there is no evidence that they are unimportant in an absolute sense, and they are far from negative. An increase in the cost of electric power will reduce electricity consumption and employment, notwithstanding ubiquitous assertions about the "green jobs" attendant upon an expansion of wind and solar power.

Finally, Figure 3 presents the crude relationship between electricity consumption and real GDP; the simple correlation between these two parameters is 0.977 for 1973-2015. This relationship makes it difficult to believe that an artificial increase in electricity costs would fail to erode GDP growth and thus employment.



<u>III. The "Social Cost of Carbon" Rationale for Renewables Subsidies</u>

The newest application of the externality rationale is the "social cost of carbon" (SCC) analysis conducted by an interagency working group of the Obama Administration.[56] The

[56] See *op. cit.*, fn. 17, *supra*.

overall purpose of this estimate of the SCC is the application of benefit/cost analysis to policies proposed to mitigate the asserted effects of increasing atmospheric concentrations of greenhouse gases (GHG), that is, "climate" policies. The SCC analysis is deeply flawed, for three central reasons: the use of "global" benefits in the benefit/cost calculation, the failure to apply a 7 percent discount rate to the stream of (asserted) future benefits and costs, and the use of ozone and particulate reductions as "co-benefits" of climate policies.[57]

Before turning to those analytic issues, it is important to note as an aside that carbon dioxide---the most important anthropogenic GHG---is not "carbon." "Carbon" is soot, or in the language of environmental policy, particulates; carbon dioxide is a colorless, odorless GHG, a certain minimum atmospheric concentration of which is necessary for life itself. It is, therefore, not a "pollutant." By far the most important GHG in terms of the radiative properties of the troposphere is water vapor; do the proponents of renewables subsidies believe that water vapor is a "pollutant?"[58] The "social cost of GHG" would be a wise replacement for "the social cost of carbon," as the former has the virtue of scientific accuracy without assuming the answer to the underlying policy question. More generally, the terms "carbon" and "carbon pollution" are political propaganda, designed to end debate before it begins by shunting aside the central policy questions.

With respect to the first of the three flaws in the SCC analysis by the Obama administration, Office of Management and Budget Circular A-4 is explicit: Only the benefits and costs of regulations enjoyed or borne domestically are to be used in benefit/cost analysis.[59] International effects are to be reported separately. The reason for this is obvious: If domestic costs and global benefits are used in benefit/cost analysis, then the U.S. would be driven to bear all of the regulatory burdens for the entire world.[60] Not only would other economies have

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[57] Note that these three problems are independent of the climatology assumptions underlying the analysis of the costs of increasing atmospheric concentrations of GHG. Notwithstanding ubiquitous assertions that "the science is settled," in reality it is not: The issue of the climate sensitivity of the atmosphere is hotly (!) debated, as noted below, and the existing body of evidence on temperature and other climate phenomena are not consistent with the argument that climate impacts both visible and serious already are visible. See Benjamin Zycher, Paris In the Fall: COP-21 vs Climate Evidence," *aei.org*, November 30, 2015, at http://www.aei.org/publication/paris-in-the-fall-cop-21-vs-climate-evidence/. How rising temperatures might affect such phenomena as weather patterns, ice sheet dynamics, sea levels, agriculture, *ad infinitum* simply is not known. Moreover, scientific "truth" is not majoritarian; it never can be "settled" because new evidence emerges constantly. These observations are not relevant to the benefit/cost critique presented here; but it is important to note that the *policy* issues raised by the GHG/climate question would remain difficult even if there existed both unanimity and certainty on the underlying *scientific* issues.

[58] That the dominant source of tropospheric water vapor by far is ocean evaporation, a natural process, is irrelevant. Volcanic eruptions also are natural, but no one would deny that the massive amounts of particulates, mercury, and other effluents emitted by volcanoes are pollutants.

[59] See Office of Management and Budget at https://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/a-4.pdf (p. 15): "… analysis should focus on benefits and costs that accrue to citizens and residents of the United States. Where you choose to evaluate a regulation that is likely to have effects beyond the borders of the United States, these effects should be reported separately." See also https://www.whitehouse.gov/sites/default/files/omb/inforeg/regpol/circular-a-4_regulatory-impact-analysis-a-primer.pdf.

[60] In this case, U.S. policies would equate marginal domestic costs with marginal global benefits. In other words, the U.S. would reduce emissions of a given effluent to the point that such emissions would be optimal for the entire world, with only the U.S. bearing the costs. If U.S. benefit/cost analysis were to incorporate both global benefits and global costs, the enormous cost calculation would reduce the domestic political viability of any such U.S. policy, and the U.S. cannot enforce regulatory requirements on other nations in an effort to spread the costs. At the

incentives to allow the U.S. to bear all of the attendant costs (that is, to engage in "free riding" on U.S. policies), it would be *economically efficient* for them to do so; if they were to reduce emissions further, global emissions would be lower than optimal, because the global marginal cost of emissions reductions would exceed the global marginal benefits.[61] This also is inconsistent with the standard theory of efficient emissions reductions, under which the marginal cost of those reductions is equated across emitters. Accordingly, the global benefits orientation is inconsistent with the current objective, implicit but clear, under the Clean Power Plan of regionalizing emissions reductions, ostensibly to equate the marginal costs of reducing GHG emissions across states, but actually to force most states into regional cap-and-trade wealth transfer systems, the dominant feature of which would be payments from red states to blue ones.[62]

OMB Circular A-4 requires also that federal agencies apply both 3 percent and 7 percent discount rates to the streams of benefits and costs of proposed regulations in order to allow a comparison of the respective present values.[63] The Obama Administration used 2.5 percent, 3 percent, and 5 percent discount rates, but not 7 percent. The reason for this is obvious: At 7 percent, the social cost of carbon becomes small or negative. In the DICE integrated assessment model, the social cost of carbon declines by 80 percent relative to the case of a 3 percent discount rate, from $61.72 per ton to $12.25. In the FUND model, the social cost of carbon for 2010-2050 at a 7 percent discount rate declines to approximately zero or becomes negative. In the 2015 IWG revision, the 2050 social cost of carbon is $26 per ton at a 5 percent discount rate, $69 at 3 percent, and $95 at 2.5 percent. It is clear that the effect of changes in the assumed discount rate is very substantial, and the failure of the Obama administration to adhere to the requirements of OMB Circular A-4 is driven by imperatives heavily political rather than analytic.[64]

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same time, if all nations were to adopt a global benefit approach, the efficient level of effluents would be achieved, but this ignores the individual incentives to obtain a free ride on the efforts of others, and so is not a reasonable underlying analytic assumption.

[61] This problem is separate from the industry relocation incentives yielded by the adoption of such policies only by the U.S. Note that in the 2010 Interagency Working Group analysis, the domestic SCC is about 7-23 percent of the global value, or about $2-7 per ton of GHG emissions if we apply the 2015 IWG estimate of the SCC of $31 for 2010. See the IWG 2010 analysis at https://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf; and the 2015 revision at *op. cit.*, fn. 17 *supra*.

[62] See "'Summary of Key Points' in Testimony of Anne E. Smith, Ph.D. at a Hearing on *EPA's Final Clean Power Plan Rule* by the Committee on Science, Space, and Technology," United States House of Representatives, Washington D.C., November 18, 2015, at http://docs.house.gov/meetings/SY/SY00/20151118/104182/HHRG-114-SY00-Wstate-SmithA-20151118.pdf.

[63] A-4 allows a 3 percent discount rate in addition to the 7 percent rate if a consumption displacement model is deemed appropriate. That obviously is not solely the case for climate policies, which would affect investment flows substantially; but A-4 (p. 34) requires the use of both 3 percent and 7 percent discount rates so as to account for both the consumption and investment effects of proposed regulations, and to allow for sensitivity analysis.

[64] For the DICE and FUND models, see, respectively, http://www.econ.yale.edu/~nordhaus/homepage/documents/DICE_Manual_103113r2.pdf and http://www.fund-model.org/. See Kevin D. Dayaratna and David Kreutzer, "Environment: Social Cost of Carbon Statistical Modeling Is Smoke and Mirrors," *Natural Gas and Electricity*, Vol. 30, Issue 12 (July 2014), pp. 7-11; Kevin D. Dayaratna and David Kreutzer, "Loaded DICE: An EPA Model Not Ready for the Big Game," Heritage Foundation Backgrounder #2860, November 21, 2013, at http://www.heritage.org/research/reports/2013/11/loaded-dice-an-epa-model-not-ready-for-the-big-game; and Kevin D. Dayaratna and David Kreutzer, "Unfounded FUND: Yet Another EPA Model Not Ready for the Big Game," Heritage Foundation Backgrounder #2897, at http://www.heritage.org/research/reports/2014/04/unfounded-fund-yet-another-epa-model-not-ready-for-the-big-

Note that it is not appropriate to use a low discount rate as a means of increasing the weight given the interests of future generations. This is because future generations are interested not in receiving a bequest of, say, maximum environmental quality, but instead in an inheritance of the most valuable possible capital stock in all of its myriad dimensions, among all of which there are tradeoffs that cannot be avoided. Consider a *homo sapiens* baby borne in a cave some tens of thousands of years ago, in a world with a resource base virtually undiminished and environmental quality effectively untouched by mankind. That child at birth would have had a life expectancy on the order of ten years; had it been able to choose, it is obvious that it willingly would have given up some resources and environmental quality in exchange for better housing, food, water, medical care, safety, *ad infinitum*.[65] That is, it is obvious that people willingly would choose to give up some environmental quality in exchange for a life both longer and wealthier.

Accordingly, the central interest of future generations is a bequest from previous generations of the most valuable possible capital stock, of which the resource base and environmental quality are two important dimensions among many, and among which there always are tradeoffs. That requires efficient resource allocation by the current generation. If regulatory and other policies implemented by the current generation yield less wealth currently and a smaller total capital stock for future generations, then, perhaps counterintuitively, some additional emissions of effluents would be preferred (efficient) from the viewpoint of those future generations.[66]

The IWG benefit/cost analysis of the Clean Power Plan (CPP)---the central "climate" policy proposal from the Obama administration---includes "co-benefits" in the form of reductions in ozone and emissions of fine particulates. Indeed: These co-benefits in 2030 are half or more of the benefits (evaluated at a 3 percent discount rate) asserted for the CPP.[67] This "co-benefit" approach is deeply problematic because the Clean Air Act explicitly requires the EPA, upon making an "endangerment" finding for a given effluent, to promulgate a National Ambient Air Quality Standard that "protects the public health" with "an adequate margin of

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game. Another problem is presented by the reality that the economic costs of climate policies---increased energy costs and attendant effects---are substantially more certain than the benefits, that is, the future impacts of those policies in terms of temperatures and other such phenomena as storms and sea levels. This means that the assumed benefit stream of such policies over time should be subjected to a state-options analysis, or at a minimum to a crude application of a discount rate higher than that applied to the cost stream. See e.g., Daniel A. Graham, "Cost-Benefit Analysis Under Uncertainty," *American Economic Review*, Vol. 71, No. 4 (September 1981), pp. 715-725.

[65] The source for this life expectancy estimate is a telephone discussion February 16, 2011 with Professor Gail Kennedy, Department of Anthropology, University of California, Los Angeles. Note here the implicit normative assumption that the "interests" of any individual or group are those that they would define for themselves or, more important, reveal through choice behavior.

[66] The capital stock includes both tangible capital and such intangibles as the rule of law, the stock of knowledge, culture, and the like. Greater wealth for the current generation yielded by resource consumption yields conditions allowing the expansion of other dimensions of the capital stock defined broadly.

[67] This is true for both the "rate-based" and "mass-based" regulatory approaches of the CPP. In the regulatory impact analysis for the CPP, the "climate" and "air quality" benefits of the CPP can be compared only with the 3 percent discount rate, because EPA does not provide that direct comparison for other discount rates, interestingly enough. See Tables ES-9 and ES-10 in Environmental Protection Agency, *Regulatory Impact Analysis for the Clean Power Plan Final Rule*, October 23, 2015, at https://www.epa.gov/sites/production/files/2015-08/documents/cpp-final-rule-ria.pdf.

safety."[68] Accordingly, it must be the case that the existing ozone and particulate standards fail to satisfy the requirements of the law, *or* the EPA is double- (or more) counting the benefits of reductions in ozone and fine particulates in its analysis of the CPP, *or* the CPP will reduce ozone and fine particulate emissions to levels that are inefficiently low, that is, to levels at which marginal costs exceed marginal benefits. *At least one of those three conditions must be true.* Note that the EPA uses the same assumed particulate reductions to justify the CPP, the new ozone rule,[69] the new particulate rule,[70] and the Utility Mercury and Air Toxics Standards.[71] Note also that the IWG uses the assumed global benefits of reductions in GHG emissions as the basis for the SCC analysis, while the CPP net benefits in substantial part are created by assumed reductions in ozone and fine particulates, which are domestic pollutants, as just discussed. This is an inconsistency that has gone largely unnoticed in the Washington policy community.

It is important to note that even in the context of the climate model used by the EPA,[72] the future temperature effects of U.S. and international climate policies are small at most and trivial for the most part. The Obama administration Climate Action Plan calls for a 17 percent reduction below 2005 levels in U.S. GHG emissions by 2020.[73] In addition, the U.S.-China Joint Announcement on Climate Change calls for an additional 10 percent reduction by the U.S. by 2025.[74] The 17 percent reduction would reduce temperatures by the year 2100 by fifteen one-thousandths of a degree. The additional 10 percent reduction yields another one one-hundredth of a degree. Given that the standard deviation of the temperature record is about 0.1 degrees, these effects would be too small even to be measured, let alone to affect sea levels and cyclones and all the rest.[75] If we assume an additional 20 percent emissions cut by China by 2030, that adds 0.2 degrees; and another 0.2 degrees if we assume a 30 percent emissions cut by the rest of the industrialized world, by 2030. If we assume also a 20 percent reduction by the less-developed world by 2030, temperatures would be reduced by another one tenth of a degree. The total: a bit more than 0.5 degrees.

Note that these model predictions use underlying parameters highly favorable to the policies under examination, that is, assumptions that increase the predicted effects of the policies. The most important is a "climate sensitivity" (the temperature effect in 2100 of a doubling of GHG concentrations) assumption of 4.5 degrees, a number 50 percent greater than the median

[68] See the relevant language at https://www.law.cornell.edu/uscode/text/42/7409.
[69] See EPA at https://www.gpo.gov/fdsys/pkg/FR-2015-10-26/pdf/2015-26594.pdf.
[70] See EPA at https://www.gpo.gov/fdsys/pkg/FR-2015-03-23/pdf/2015-06138.pdf.
[71] See EPA at https://www3.epa.gov/mats/pdfs/20160317fr.pdf.
[72] This model was developed at the National Center for Atmospheric Research, with funding provided by the EPA. See http://www.cgd.ucar.edu/cas/wigley/magicc/.
[73] See https://www.whitehouse.gov/sites/default/files/docs/cap_progress_report_final_w_cover.pdf.
[74] See https://www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change. See also Benjamin Zycher, "Observations on the U.S.-China Climate Announcement," *The Hill*, November 14, 2014, at http://thehill.com/blogs/pundits-blog/energy-environment/224076-observations-on-the-us-china-climate-announcement; and Benjamin Zycher, "The U.S.-China Climate Agreement Hangover," *The Hill*, December 8, 2014, at http://thehill.com/blogs/pundits-blog/energy-environment/226272-the-us-china-climate-agreement-hangover.
[75] See Judith Curry's analysis at https://judithcurry.com/2015/11/06/hiatus-controversy-show-me-the-data/.

adopted by the Intergovernmental Panel on Climate Change in its latest assessment report.[76] And even the latter is about 40 percent higher than the median of the estimates published in the recent peer-reviewed literature.[77]

For obvious reasons, these trivial temperature benefits of "climate" policies have not been publicized extensively. EPA has published such an estimate in its regulatory rule for GHG emissions and fuel efficiency standards for medium- and heavy-duty engines and vehicles, and it is revealing:[78]

> The results of the analysis, summarized in Table VII-37, demonstrate that relative to the reference case, by 2100… global mean temperature is estimated to be reduced by 0.0026 to 0.0065 °C, and sea-level rise is projected to be reduced by approximately 0.023 to 0.057 cm…

EPA then states that "the projected reductions in atmospheric CO_2, global mean temperature, sea level rise, and ocean pH are meaningful in the context of this action." And so we arrive at the benefit/cost conclusion:

> [We] estimate that the proposed standards would result in net economic benefits exceeding $100 billion, making this a highly beneficial rule.

Can anyone believe that a temperature effect by 2100 measured in ten-thousandths of a degree, or sea-level effects measured in thousandths of a centimeter could yield over $100 billion in net economic benefits?[79] This conclusion is possible only because of the assumptions and approach underlying the SCC analysis; as discussed above, they are deeply problematic.

In short: The climate change/GHG emissions/"social cost of carbon" rationale for renewables subsidies is fatally flawed analytically, and should be reformed in a serious fashion by policymakers.

IV. Concluding Observations

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[76] See the summary of the recent peer-reviewed evidence presented by Patrick J. Michaels and Paul C. Knappenberger at http://www.cato.org/blog/collection-evidence-low-climate-sensitivity-continues-grow. See the IPCC 5th Assessment Report at https://www.ipcc.ch/report/ar5/.

[77] On the recent estimates in the peer-reviewed literature, see https://judithcurry.com/2015/11/30/how-sensitive-is-global-temperature-to-cumulative-co2-emissions/#more-20572, https://judithcurry.com/2015/03/23/climate-sensitivity-lopping-off-the-fat-tail/, and Michaels and Knappenberger, *op. cit*., fn. 76 *supra*.

[78] See https://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2014-0827-0002,

[79] Marlo Lewis, *et. al.* provide a detailed analysis of the fuel efficiency standards for medium- and heavy-duty engines and vehicles at http://www.globalwarming.org/wp-content/uploads/2015/10/Marlo-Lewis-Competitive-Enterprise-Institute-and-Free-Market-Allies-Comment-Letter-on-Phase-2-EPA-NHTSA-greenhouse-gas-fuel-economy-HDV-rule-Oct-1-2015-Final.docx.pdf.

From "energy independence" through the "social cost of carbon," the modern rationales for energy subsidies have varied in prominence over the decades, but none has been broadly discredited in the public discussion despite the reality that each suffers from fundamental analytic weaknesses.

Energy "independence"---the degree of self-sufficiency in terms of energy production---is irrelevant analytically, particularly in the case of such energy sources as petroleum traded in international markets, an economic truth demonstrated by the historical evidence on the effects of demand and supply shifts from the 1970s through the present.

Capital markets can sustain promising industries or technologies in their infancy---the early period during which technologies are proven and scale and learning efficiencies are achieved---so that the "infant industry" rationale for renewables subsidies is a *non sequitur*. Moreover, there is little evidence that there exist additional learning or scale cost reductions remaining to be exploited in wind and solar generation in any event.

There is no analytic evidence that renewables suffer from a subsidy imbalance relative to competing conventional energy technologies---the data suggest the reverse strongly---and the conventional "subsidies" that are purported to create a disadvantage for renewables are not "subsidies" defined properly as a matter of economic analysis.

Wind and solar power create their own set of environmental problems, and even in terms of conventional effluents and GHG it is far from clear that they have an advantage relative to conventional generation, particularly because of the up-and-down cycling of conventional backups units needed to preserve system reliability in the face of the intermittency (unreliability) of renewable power. And those backup costs---an economic externality caused by the unreliability of renewable power---are substantially larger than the externality costs of conventional power even under extreme assumptions.

The "sustainability" or resource depletion arguments for renewables subsidies make little sense analytically---the market rate of interest provides powerful incentives to conserve resources for consumption during future periods---and are inconsistent with the historical evidence in any event.

Nor does the "green jobs" employment rationale for renewables subsidies make analytic sense, as a resource shift into the production of politically-favored power must reduce employment in other sectors---resources, after all, are limited always and everywhere---and the taxes needed to finance the subsidies cannot have salutary employment effects. Moreover, the historical evidence on the relationships among GDP, employment, and electricity consumption does not support the "green jobs" argument.

The newest environmental rationale for renewables subsidies---the SCC---is an argument deeply flawed both conceptually and in terms of the quantitative estimates now underlying a large regulatory effort. Moreover, the policies being proposed to reduce emissions of greenhouse gases would have temperature effects trivial or unmeasurable even at the international level, under assumptions highly favorable to the policy proposals. More generally, the terms "carbon" and "carbon pollution" are political propaganda, as carbon dioxide and "carbon" are very different physical entities, particularly given that some minimum atmospheric concentration of the former is necessary for life itself.

It would be hugely productive for the U.S. economy writ large were policymakers to adopt a straightforward operating assumption: Resource allocation in energy sectors driven by market prices is roughly efficient in the absence of two compelling conditions. First: It must be shown that some set of factors has distorted those allocational outcomes to a degree that is substantial. Second: It must be shown that government actions with high confidence will yield net improvements in aggregate economic outcomes. Given the weak history of analytic rigor and policy success in the context of energy subsidies, greatly increased modesty on the part of policymakers would prove highly advantageous.