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Designing Subsidies for Low-Carbon Energy

David Weisbach*

* This paper is a revision of remarks made by Professor David A. Weisbach of the University of Chicago on Friday, April 5, 2013, at the University of Missouri School of Law during the 2013 *Journal of Enviornmental and Sustainability Law* and Tax Law Society Symposium entitled "Promoting Sustainable Energy Through Tax Policy".

My topic today is the design of subsidies for renewable (i.e., low or zero carbon) energy. I want to investigate whether we can subsidize clean energy but not at the same time have to pick between types of clean energy or choose the overall mix of energy technologies. The goal should be to make sure that clean energy is not at a systematic disadvantage because users of fossil fuels can dump carbon pollution into the atmosphere for free but once that disadvantage is corrected, to allow the market to determine what mix of energy sources is best. While some people may feel confident that they or the government can pick the mix of energy sources that we should use, I'm confident that they or the government will guess incorrectly. Therefore, I want to investigate whether a subsidy can be neutral across the choice of technologies.

I was originally going to ask a different question, which is what a level-carbon playing field would look like. The reason for this original question was my belief that the tax system was tilted in favor of fossil fuels so that an easy way to level the playing field would be to eliminate tax subsidies for fossils. This belief turns out to be false: the tax system if anything currently "favors" clean energy over fossil fuels. ("Favors" is in scare quotes for reasons I will explain immediately below.)

Table 1 is a list of tax expenditures for energy for the year 2011 taken from the Administration's 2013 budget.[1] Clean energy tax expenditures are highlighted. A casual glance indicates that by any measure they dominate the list.

[1] Office of Mgmt. & Budged, Exec. Office of the President, Budget of the United States Government, Fiscal Year 2013, 249 (2012) (Estimates of Total Income Tax Expenditures for Fiscal Years 2011-2017) available at http://www.whitehouse.gov/sites/default/files/omb/budget/fy2013/assets/spec.pdf.

	Tax Expenditure (2011)	Cost in 2011 ($ millions)
1	Credit for energy efficient improvements to existing homes	4,370
2	Energy production credit	1,560
3	Percentage depletion	1,190
4	Credit for residential energy efficient property	840
5	Energy investment credit	700
6	50% expensing for equipment used in refining liquid fuels	670
7	Expensing of exploration and development costs	500
8	Alcohol fuel credits	500
9	Advanced energy property credit	430
10	Credit for clean coal	370

Table 1: 2011 Tax Expenditures for Energy

Table 2 is the same list projected out to the period from 2013 to 2017.[2] The same conclusion applies. A more sophisticated study by the National Academies that attempts to model the full macroeconomic effects of these tax expenditures confirms this.[3]

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[2] *Id.*

[3] *See* National Research Council, EFFECTS OF U.S. TAX POLICY ON GREENHOUSE GAS EMISSIONS (William D. Nordhaus, et al. eds., 2012).

	Tax Expenditure (2013-2017)	Cost in ($ millions)
1	Energy investment credit	12,210
2	Energy production credit	9,330
3	Percentage depletion	6,860
4	Credit for residential property efficiency	5,000
5	Expensing of exploration and development costs	2,950
6	Credit and deduction for clean-fuel burning vehicles	2,110
7	Credit for clean coal	1,710
8	Exclusion of utility conservation subsidies	1,020
9	Advanced energy property credit	700
10	50% expensing of equipment used in refining liquid fuels	(3,020)

Table 2: 2013-2017 Tax Expenditures on Energy

I also originally thought that the level playing field metaphor was helpful; that asking what a level playing field for energy would look like was a meaningful question. A cursory examination, however, shows that this metaphor gets in the way of thinking rather than helping it along. There is no way to determine what a level playing field would be without making a host of assumptions, and once you start making assumptions, the assumptions drive the conclusions and the metaphor is not doing any of the work except possibly making the assumptions less transparent. You have to analyze the policy choices and consider the resulting effects to determine the right policies toward clean energy.

A simple example is the use of the word "favors" above. If the tax system had no special provisions for energy, clean, dirty, renewable, or something else, would it be a level playing field? Under one possible definition, yes, as it does not explicitly favor one form of energy over another. But users of fossil fuels would still be allowed to dump their carbon pollution into the atmosphere for free, so perhaps a level playing field can only be achieved if there is a carbon tax or an equivalent policy such as an auctioned cap and trade system.

Suppose we had a tax on carbon emissions. Would that get us to a level playing field? Perhaps not. There is a massive fossil fuel infrastructure. Now that it is built, the marginal cost of fossil fuel energy is low. This infrastructure was built with substantial subsidies. Although the history may be contested, the start-up fossil fuel industry arguably had help. It did not have to survive in the competitive marketplace. To have a level playing field, the start-up clean energy industry arguably should receive the same subsidies when building out its infrastructure. Determining the correct amount of help that would lead to a level-playing field, however, would be near impossible because most of those subsidies relate to now-depreciated infrastructure and the competitive marketplace looks completely different. To put clean energy on a level playing field, we have to determine the depreciated value of the subsidies and what the equivalent would be in a today's market, which would be a formidable and really impossible task. Even determining what a subsidy is would be near impossible: is a choice to build a road rather than a railroad a subsidy for automobiles and therefore a subsidy to the fossil fuel industry?

And even if we could do that, we still might not have a level playing field because clean energy is in its early stage of development, at a time when research into new ideas and approaches is vital. As we know from the last several decades of research into economic growth, we may need to subsidize new ideas because they create positive externalities in that they build the stock of knowledge which all can use.[4] That is, even with something like perfect markets and subsidies to offer the historical benefits to fossil fuels, we may want to subsidize R&D.

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[4] *See* PHILLIPPE AGHION & PETER HEWITT, THE ECONOMICS OF GROWTH [NEED PAGE NUMBER] (Mit Press, 2009); *See also* DARON ACEMOGLU, INTRODUCTION TO MODERN ECONOMIC GROWTH [NEED PAGE NUMBER] (Princeton Univ. Press 2009).

At this point, the level playing field metaphor has ceased any possible usefulness. We instead need to focus on policies that produce good results given the information constraints we face. Hence, it is better to focus on what sort of carbon pricing system we should have rather than the meaning of the term level. I've written about the design of a carbon tax in the past and still strongly support the idea.[5] I will focus here almost exclusively on the design of subsidies. This is partly because I think the chance of Congress enacting subsidies is much higher than the chances of a tax and also because we may want subsidies even if we have a tax for the reasons I just mentioned.

My core claim is that we cannot design a technology-neutral subsidy. Before exploring this claim, I will discuss the nature of the climate change problem to give a sense of how important it is to get our carbon pricing system right.

I. THE CLIMATE CHANGE PROBLEM AND ENERGY INFRASTRUCTURE

I will try to illustrate the climate change problem, widely viewed as one of the most complex problems we as a society face, using two pictures and a table. The goal is to simplify the problem as much as possible while capturing the core issues. There is, I should emphasize, massive uncertainty about what we should do given that we cannot predict how climate change will affect us and what the costs of avoiding those harms will be. Nevertheless, I think the core of the problem can be made quite simple and in doing so, some aspects of it that are otherwise hidden become transparent.

My first figure, Figure 1 shows the recent results from models that couple climate forcing with the carbon cycle.[6] The x-axis is cumulative

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[5] *See* Gilbert E. Metcalf & David Weisbach, *The Design of a Carbon Tax*, 33 HARV. ENVTL. L. REV. 499 (2009).

[6] Myles R. Allen et al, *Warming caused by cumulative carbon emissions towards the trillionth tonne*, NATURE, Apr. 30, 2009, at 1163; Malte Meinshausen et al, *Greenhouse-gas emission targets for limiting global warming to 2° C*, NATURE, Apr. 30, 2009, at

emissions, the simple sum of emissions in the past, not depreciating them or adjusting for whether they have been absorbed into the land or ocean or anything fancy. It is just the total amount we have emitted to date. The y-axis shows the expected temperature change from those emissions. The straight line shows the relationship between the total amount of carbon emitted to date and the expected temperature increase. The line is straight not for simplicity. It is supposed to be straight because current best estimates are that the relationship is roughly linear. Each additional ton of carbon emitted produces an additional unit of warming. The line is drawn to show the IPCC's central estimate of climate sensitivity: if we emit 1 trillion tons of carbon (not CO_2), we get 2° of warming. The light gray lines show the possibility of higher or lower climate sensitivity. The relationship is linear regardless but if the climate is more sensitive to carbon, it is steeper and if it less sensitive, it is shallower.

The figure offers us a very simple way of understanding the effects of emissions on temperatures. Add up total past emissions, find that spot on the x-axis and see the expected temperature increase.

It also shows something that, while perhaps known, is not as clear as it should be: as long as we keep emitting, cumulative emissions go up which means that temperatures keep going up just as fast. Every tick mark on the x-axis leads to an increase in temperatures.

1158; Myles R. Allen et al, *The exit strategy*, NATURE, Apr. 30, 2009, at 56; H. Damon Matthews et al, *The proportionality of global warming to cumulative carbon emissions*, NATURE, June 11, 2009, at 829.

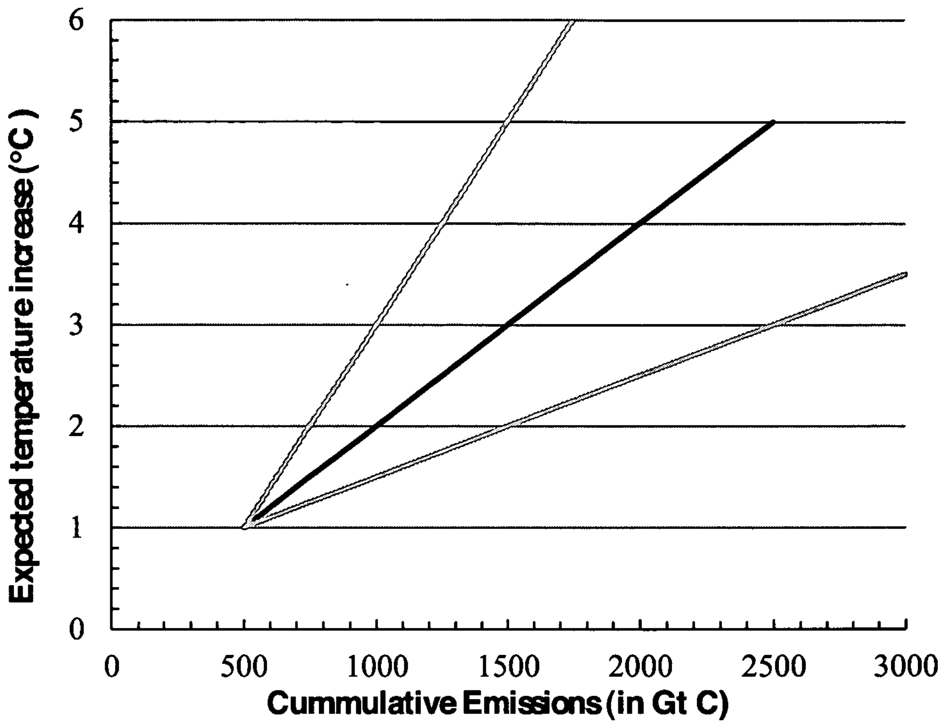

Figure 1: Relationship between cumulative emissions of carbon and expected temperature increase

The stark implication is that there is no safe level of emissions other than zero. Said another way, for any given temperature increase, there is a fixed carbon budget. For example, if we want to keep temperatures at, say two degrees, there is a cumulative amount of emissions that gives us that temperature increase. If we use the central climate sensitivity drawn on the graph, we can emit at most 1 trillion tons and have a fifty-fifty chance of the temperature increasing by two degrees or less. Anything more than that, and we should expect to get more than two degrees of warming. If we want to have better odds of staying below two degrees of warming, our budget is smaller.

The simple conclusion is this: the ultimate target of climate change policy has to be to reduce emissions to zero. Cutting a bit, conserving some, a bit of CO2 storage, a few windmills, and so forth, will not do it. Emissions have to go to zero. To be sure, cutting and conserving delays the time until zero so these may be highly desirable policies, by they do not change the real goal.

As stark as this conclusion is, there is worse news. If we continue on the path we are on now, and we adopt the two degree cap on temperatures that is widely used, we will hit the trillion ton limit in the immediate future – somewhere between 2040 and 2050. As of now, we have emitted about 570 billion tons of carbon.[7] We are currently emitting around nine billion tons of carbon each year, and the number has been going up. If we immediately stopped increasing emissions and held them constant, we would only have about fifty more years before we hit one trillion tons. To get a sense of that time period, the average life of a typical coal plant - as of today 1200 new ones are scheduled to be built - is 50 years. If instead of stabilizing emissions, we continue to increase at the same rate we have for the last twenty years, we will hit the trillionth ton in 2041.[8] This is a mere twenty-eight years from now or about half the life of the coal plants currently being constructed. If we start reducing emissions, we can push this date out perhaps to 2100 or 2150 depending on how much we reduce and how fast. Even so, if we hope to limit temperature increases to two degrees, we are rapidly approaching the point at which emissions have to be zero.

To get a sense of the size of the reductions needed in this short time period, consider President Obama's promise from his 2008 campaign which was to reduce emissions by eighty percent below 2005 levels by 2050. The EU has agreed to something similar. In 2005, the US emitted just under twenty tons of CO_2 per person, so a target reduction of eighty percent means that we can emit less than four tons per person.[9]

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[7] TRILLIONTHTONNE.ORG, http://www.trillionthtonne.org (last visisted July 23, 2013).
[8] *Id.*
[9] *Country GHG Emissions*, WORLD RESOURCES INSTITUTE (last visited July 24, 2013), http://cait2.wri.org/wri/CountryGHGEmissions (search "United States" for "Search for a

One way to get some perspective on this number is to consider when historically we emitted that amount. The relevant data is in Table 3. Before reading the table, take a guess. The answer, as you can see from the table, is sometime around 1875. This was before the invention of the light bulb, the Model T, the radio, and the airplane. It was before the modern economy and modern standards of living were developed. We need the energy use of today's economy with the emissions of 1875, just to get part way toward the ultimate goal.

Year	tCO_2/person[10]	Technology
1975	20	First PC (1980)
1950	16	First jet engine flight (1941)
1925	15	Frozen food (1929)
1910	14	Model T Ford (1908)
1900	8.7	Radio (1901), air conditioner (1902), airplane (1903), plastic (1907)
1890	6.4	Tesla's generator (1886), AC motor (1889), dishwasher (1886)
1880	4.0	Edison light bulb (1880), steam turbine (1884)
1870	2.6	Otto internal combustion engine (1876)

Table 3: Per capita emissions for selected years.

If you are not depressed enough, well, I'm not done. You might think since most emissions are from fossil fuel use, that all we have to do is cut our energy use and replace what is left with clean sources. That would be correct with the exception of the word "all".

My second figure, Figure 2, illustrates the connection between wealth and energy.[11] The x-axis shows per wealth, graphed on a

Country" and search "2005" for "Narrow by Year"; choose "Per Capita" from right side menu; choose "Emissions by Gas" from left side menu).

[10] *Country GHG Emissions*, WORLD RESOURCES INSTITUTE (last visited July 24, 2013), http://cait2.wri.org/wri/CountryGHGEmissions (search "United States" for "Search for a Country" and search "1870-1975" for "Narrow by Year"; choose "Per Capita" from right side menu; choose "Emissions by Gas" from left side menu).

logarithmic scale and the y-axis shows per capita energy use, also on a logarithmic scale, measured in a standard unit of kilograms of oil equivalents (basically it converts all energy use in the equivalent amount of oil needed to produce that energy). There is a remarkable connection between wealth and energy use. We simply do not know how to be wealthy without using large amounts of energy. Nobody does. No matter how green and nature loving a country is, nobody achieves wealth without massive use of energy. There is nobody in the bottom right hand corner.

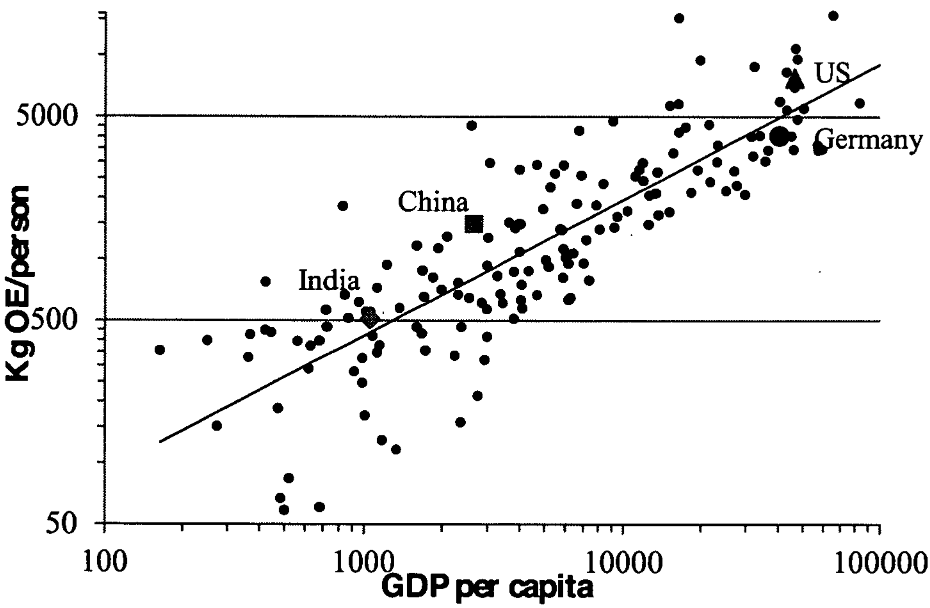

Figure 2: Relationship between wealth and energy use

The only way to stop climate change without being poor is to find massive amounts of clean energy. The problem of climate change is one of energy transformation, done as quickly as possible, before we hit the

[11] Kg OE/person values based on author's calculations. GDP per Capita values based on data obtained from World Bank, *see* THE WORLD BANK, http://data.worldbank.org/country/united-states (last visited July 24, 2013).

trillion-ton limit. It is a technology problem and an infrastructure problem. It is one of the great challenges of the twenty-first century.

II. TAXES AND SUBSIDIES

The tax system would seem to have a fairly obvious role to play. A tax on emissions creates incentives to reduce emissions by changing prices. With a carbon tax, energy prices overall would go up and fossil fuel energy would become relatively more expensive as compared to renewables. People will both reduce their energy use and substitute to cleaner forms of energy. There will also be to invest in R&D to develop cleaner energy because it can now compete against fairly priced fossil fuels. Moreover, a carbon tax is neutral across technologies and allows the private sector to choose winners and losers.[12]

A carbon tax is also relatively easy to implement. In prior work with Gib Metcalf, I showed that we can impose a tax on all emissions of carbon dioxide from fossil fuels in the US by taxing only 2,500 entities, all of them large sophisticated taxpayers.[13] The key is to impose the tax upstream on oil refiners, coal mines, and natural gas wells or processors. The tax is then embedded in the price that the ultimate customer sees.

Finally, a carbon tax has the potential to raise an incredible amount of money in times of great fiscal need. The US emits about five point five billion tons of carbon dioxide a year. If the tax were twenty dollars a ton, which is a relatively low starting point, it would raise about $1 trillion over the ten year budget window, even accounting for emissions

[12] A cap and trade system is roughly equivalent to a carbon tax. In a cap and trade system, we set a limit on emissions and sell the rights to emit up to that limit. People still see a price, just like in a tax, but it occurs via the need to buy permits rather than a direct payment to the government. If the cap is set so that the price is equal to the desired tax, the two are rough equivalents. For a discussion, *see generally* DAVID WEISBACH, U.S. ENERGY TAX POLICY 113-158 (Gilbert E. Metcalf, ed. 2011) (referring to a carbon tax).
[13] Gilbert E. Metcalf & David Weisbach, *The Design of a Carbon Tax*, 33 HARV. ENVTL. L. REV. 499 (2009).

reductions due to the tax. If the tax rate were to go up over time, as would be expected in most designs, the amount would be larger.

While it would seem that imposing a carbon tax or the equivalent cap and trade system is the obvious approach, it is apparently a pipe dream. It violates two central beliefs of Republicans, who currently control the House: It is a tax and it is designed to stop what they claim is a mere hoax, climate change. It also raises the single most transparent price that consumers face: the price of a gallon of gasoline. While this position is unreasoned and unreasonable, without the House, we cannot have a carbon tax.

The alternative taxing fossil fuels is subsidize clean energy. As noted, we might want subsidies for clean energy even if we have a carbon tax because of the positive externalities from R&D. If we cannot have a tax or an equivalent such as a cap and trade system, the argument for subsidies is much simpler. Subsidies for clean energy are needed because users of fossil fuels get the implicit subsidy of dumping their carbon pollution into the atmosphere for free. A subsidy for clean energy is needed simply to level the playing field, if I can get away with using that phrase.

Even if we could design the best possible subsidy for clean energy, it would still be clearly inferior to a carbon tax. A tax does two things: it raises the price of energy and it tilts the prices away from fossil fuels. In response to a tax, people will reduce overall energy use and shift to clean energy. A subsidy only does the latter. It gets the choice between energy types correct but does not address the choice between energy use and all other goods. Energy would still be too cheap relative to the climate change costs it imposes, so people would still use too much energy. Subsidies are no substitute for a tax.

If we must use subsidies instead of a tax, the subsidy should at least be neutral with respect to technology choice, both with respect to which fossil fuels are replaced and which renewable technology replaces them. There is simply so much uncertainty about energy technology that it is hard to believe that we can successfully pick the right mix by fiat. Do we really know, for example, whether battery technology will evolve sufficiently to make electric vehicles a workable solution for transport or whether a better approach is to use hydrogen fuel cells? Solar has the potential to have much higher energy density than wind – solar energy has far greater watts per square meter than wind does – but do we know whether the technology will develop to capture that higher density? The relative advantage of gas over coal in terms of emissions depends on the price of implementing carbon capture and storage at scale which we do not know. The goal of a subsidy should be to make the choice between renewables and fossil fuels reflect the emissions costs from fossil fuels, not to choose what energy mix we use.

A carbon tax achieves this automatically because it adjusts the price of fossils, not renewables. Gasoline cars, for example, would bear an additional cost. Hydrogen and electric vehicles would then compete with neither of them getting a preference. Coal-generated and gas-generated electricity would be more expensive, and by different amounts reflecting their relative emissions. Wind and solar would have to compete. The government does not need to decide the mix if it imposes a carbon tax. Can we achieve the same thing with a subsidy?

My thesis is that we cannot. The reason is that the amount of a subsidy is the price of the avoided emissions. The avoided emissions, however, depend on the technology that is being replaced. If we replace coal with a renewable energy source we have different avoided emissions than if we replace gas or petroleum. And if we replace inefficient systems of whatever fuel, we should get more of a subsidy that if we replace efficient systems because the avoided emissions per unit of energy would be higher.

An illustration may help. The production tax credit ("the PTC") provides a credit of about 2 cents/kWh for the use of wind.[14] This is about

[14] 26 U.S.C.§ 45 (2013).

the same as a \$25/ton carbon tax on the use of coal.[15] Therefore, if a reasonable carbon tax would be \$25/ton, which is in the range often mentioned, we can argue that PTC gets the wind price right in the absence of such a tax. It allows consumers to choose between wind and coal fully taking into account the emissions from coal. Both are subsidized by the same amount: coal through the free dumping of emissions that should cost \$25/ton and wind through the tax credit.

Suppose, however, that the wind energy replaces electricity from natural gas. Gas has about half of the carbon per kilowatt of electricity as coal. If we do the same calculation for gas, the subsidy for wind is too big by a factor of two. The PTC is equivalent to approximately a \$45/ton carbon tax on gas. If the carbon tax is only \$25/ton CO_2, the PTC gives wind too much of an advantage over gas. The PTC cannot get the trade-offs of both wind for coal and wind for gas correct. If it gets one correct, it gets the other one wrong. If we lower the PTC to 1¢/kWh so that we get the tradeoff between wind and gas correct, wind would be at a disadvantage relative to coal.

The problem is not unique to the PTC. It is general. There is no way to design a subsidy for clean energy that is neutral across technologies. The reason is that clean energy competes with three fossils and each has different emissions per unit of energy. Moreover, even within a fossil fuel, there are different efficiencies (and therefore, different levels of emissions) for different systems. The right subsidy for renewables when competing with petroleum is not the same as the subsidy when competing with gas or coal.

Said another way, we want to raise price of different fossil fuels by different amounts because each fuel has different emissions. The correct subsidy is the avoided emissions. A single subsidy for renewables cannot reduce the price of renewables by three (or more) different amounts so it

[15] There are 860 grams of CO_2 per kilowatt for typical coal power. Some manipulation of this figure produces the \$25/ton value.

cannot match avoided emissions for three different fuels. A subsidy cannot have the neutrality properties of a tax.

What can we do in the face of this problem? Perhaps we can get close. The idea would be to have a different subsidy for different renewable technologies depending on which fossil fuel it primarily competes with. If a technology replaces petroleum it would get one subsidy and if it replaces goal, it gets another and gas a third.

Getting such a system even within the ballpark of right would be tricky and perhaps not possible, although it may be our only choice. The problem is determining what fuel is the marginal source of energy that a given renewable competes with. To illustrate, suppose we are designing a subsidy for clean energy such as wind which is used to produce electricity. To determine the correct subsidy, we must determine which fuel the clean energy source is competing with. Sometimes we may know this, but often it will not be clear. Most new electricity in the US is from gas so perhaps the correct subsidy should be based on emissions from gas. But wind may instead compete with old coal plants: the choice might be to retire an old coal plant and replace it with wind turbines or keep it online for a few more years and to forget the wind turbines. If this is so, the correct subsidy should be based on emissions from coal, not gas. Maybe the best thing to do is to use some sort of average emission from a given sector and understand that it is just a rough number. We have a problem to solve. The perfect may be the enemy of the good.

What is the correct subsidy for transportation technologies? This might seem easy because currently all transportation relies on various forms of petroleum, such as gasoline or diesel. The energy for the alternative transportation technology, however, has to come from somewhere. For example, the electricity used to charge a battery comes from the grid and the ultimate source may be coal, nuclear, hydro, gas, or really a mix of whatever feeds into the grid at the instant that the battery is plugged in. The subsidy for transportation technologies has to consider this substitute fuel and determining which substitute fuel is used involves the same sorts of calculations needed to determine the subsidy for wind or solar electricity. If we add a large number of electric vehicles to the fleet, power-generation capacity has to be increased, so we need to know the marginal source of this additional capacity and this could be from either coal or gas (even when all new generation comes from gas because the marginal source of power might be keeping old coal plants online).

Perhaps I'm thinking about this the wrong way. Maybe the key thing we need is a technological breakthrough. After all, a glance at Figure 2 shows that we need massive amounts of clean energy, not just incremental improvements. If so, then maybe we should be thinking of the right level of subsidy as the one that can produce the breakthrough. It does not matter what fuel the renewable competes with today. What matters is achieving a breakthrough.

I do not think this is right for two reasons. First, reducing the cost of clean energy is largely one of gradual field-level improvements. While we cannot rule out a breakthrough – cold fusion or dilithium anti-matter drives might be in our future – but we should not hold our breath. Instead, energy improvements tend to come in incremental change as we improve the conversion technologies. Second, even if we think there might be a breakthrough, its value depends on avoided emissions, so we still have to set it based on what types of fuels are avoided.

It seems clear that a carbon tax or an equivalent cap and trade system is superior to subsidies for clean energy. A carbon tax gets all marginal correct – both intensive and extensive – and is automatically neutral on technology choice. A subsidy does not fix the incentive to use too much energy. My thesis here is that it also cannot easily be made neutral with respect to the choice of technology. It unfortunately seems clear that a carbon tax is unlikely, and we may be stuck with subsidies for renewables. The best we can do in this case is to approximate a neutral subsidy by considering the avoided emissions from a particular technology.