Opinion

Countercyclical energy and climate policy for the U.S.

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Continuation of the U.S.'s historical pattern addressing energy problems only in times of crisis is unlikely to catalyze a transition to an energy system with fewer adverse social impacts. Instead, the U.S. needs to bolster support for energy innovation when the perceived urgency of energy-related problems appears to be receding. Because of the lags involved in both the energy system and the climate system, decarbonizing the economy will require extraordinary persistence over decades. This need for sustained commitment is in contrast to the last several decades, which have been marked by volatility and cycles of boom and bust. In contrast to the often-repeated phrase that one should 'never let a good crisis go to waste,' the U.S. needs to most actively foster energy innovation when aspects of energy and climate problems appear to be improving. We describe the rationale for a 'countercyclical' approach to energy and climate policy, which involves precommitment to a set of policies that go into effect once a set of trigger conditions are met.

How to cite this article:
WIREs Clim Change 2015. doi: 10.1002/wcc.369

INTRODUCTION

In addition to climate change, society faces an array of problems associated with current patterns of energy use, including energy poverty, local and regional air pollution, and international security issues. Developing lasting solutions to these problems—that simultaneously meet the social objectives of being affordable, clean, and reliable—has proven difficult. Even achieving consensus on what broad strategies to pursue has been elusive, in part because people value each of the various social objectives of an energy system differently. Choosing among affordable, clean, and reliable typically involves difficult trade-offs; implementing new policies creates winners and losers. Among this discord, one can still find a consensus among many of a need for a transition to a different, more modern, energy system, one in which the trade-offs among competing social objectives are less severe.[1]

THE NEED FOR A GOVERNMENT ROLE

A transition to an energy system that would adequately satisfy these multiple objectives requires a substantial government role for several reasons. First, multiple market failures affect the energy system.[2] Water and air are public goods shared across property lines and international borders; they are of value to the rich and poor alike. The dependence of our well-being on energy means that sudden changes in energy access can lead to macroeconomic shocks, such as recessions, and even to international conflicts. Competition may not be feasible due to what economists refer to as 'natural monopolies,' in which a single regulated entity is more efficient than competing

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The authors declare they have no conflicts of interest.

providers. Further, the intrinsic role of innovation in an energy transition involves spillovers of knowledge from one firm to another, as well as from one country to another. To keep incentives aligned with the multiple objectives, governments need to play a role in each of these areas; and to an extent, they do, at least partially. Examples include, pollution regulations, patrolling of sea-lanes, the patent system, and importantly, the approach to funding and valuing the research enterprise.

But even in the absence of market failures, a second set of reasons for government involvement may play an even more important role. A broad set of studies makes clear that increasing returns are pervasive in energy systems. Energy technologies exhibit massive economies of scale[3]; unit costs fall as output increases. One can see this in the size of energy supply technologies, such as nuclear, coal, and hydroelectric plants at gigawatt scale.[4] Unit costs also fall in the manufacturing of both energy supply and end-use technologies. The largest solar PV manufacturing facilities produce several gigawatts of panels per year and individual battery manufacturing plants involve several billion dollars of investment to produce dozens of gigawatt hours per year of capacity. Transmission and distribution networks too have scale economies. Moreover, load factors for them create network effects so that very large interconnected systems become more efficient by requiring less supply capacity than isolated small systems. We also know that there are substantial learning-by-doing effects in energy system components, particularly in small modular systems that involve orders of magnitude more construction iterations than large ones.[5,6] Beyond individual learning effects, studies show that learning—knowledge acquired through experience—flows between firms,[7] between technologies,[8] and between countries.[9,10] The outcome of this combination of mechanisms is a system in which increasing returns are pervasive. Instead of a system in which diminishing returns tend to support competition and diversity, the energy system has aspects that support concentration and dominant designs. Initial conditions loom large in determining outcomes and constrain the choices available to actors. One can see path dependence at multiple scales: in the evolution of individual technologies,[11,12] the development of the electric power system itself,[13] and even in modeling of climate-change mitigation scenarios.[14] Path dependence is especially important given the inherently uncertain and long-term aspects of the energy and earth systems discussed next. The array of mechanisms discussed above that fall under the rubric of increasing returns are powerful forces that can generate gains for society in terms of less costly and more substantial climate-change mitigation efforts. But they also constrain choices. Governments can play a role in designing institutions, enforcing rules, and creating incentives to preserve options that could become valuable in an inherently uncertain future.

INERTIA IN ENERGY AND EARTH SYSTEMS

In addition to multiple market failures, addressing energy problems involves challenges due to distinct characteristics of the energy system, particularly its inertia. Foremost, capital stock in the energy sector lasts a long time. Much of it requires large investments, which are difficult to increase incrementally, due to pervasive economies of scale. Up-front capital costs comprise large portions of total costs, variable costs are low, and technology is upgradeable. As a result, substitution of new equipment for old is delayed; capital stock persists and is unlikely to be disposed of, even in the face of attractive substitutes.[15,16] Compare the 80-year-old power plants, transmission lines, and pipelines of today's U.S. energy system to: 10-year-old cars, 2-year-old phones, and 30-day pharmaceutical prescriptions. The shorter lifetimes of the latter provide frequent opportunities for iteration, innovation, and adoption of novel components. To be sure, the energy system has involved dramatic changes in the past 200 years, but the most fundamental changes have arrived slowly.[15,17]

These inertial aspects of the energy system are even more pronounced when one considers climate change. Once emitted, CO_2, and other greenhouse gases (GhGs) such as N_2O, remain in the atmosphere on time scales of decades to centuries, i.e., the same order of magnitude or even longer than energy infrastructure turnover. In contrast to these greenhouse gases, pollutants such as particulates and SO_2 mostly fall out of the atmosphere within weeks. Decarbonizing the energy system to address climate change is an especially daunting challenge in that it involves both the slow turnover of energy infrastructure and the slow removal of atmospheric greenhouses gases by land and oceans.

HISTORICAL VOLATILITY

A key implication of these characteristics of both energy and earth systems is that a transition to a less ecologically damaging and more socially equitable energy system will require extraordinary persistence over decades. Yet the history of energy policy, particularly in the U.S., reveals just the opposite. Over the last four decades, multiple disparate aspects of the U.S. energy system exhibit volatility: in prices, in policy intensity, in investment in R&D, and in technology deployment, and even in the amount of media attention devoted to energy and climate change[25–27] (Figure 1). These patterns do not fit with the nearly continuous growth over this period of the society that the U.S. energy system supports. Similar cycles also emerge in survey data on U.S. concerns about climate change.[28] In these cycles of interest and apathy, energy is at times a high national priority and then becomes a nonissue as other concerns take precedence. If it were not for the adverse social impacts of energy use, most would prefer that energy stay in the background, as a service we take for granted and can rely upon so that we can get on with daily life. But with climate change and other challenging problems to be addressed, the cycles of effort and indifference are damaging. One outcome is periods of overinvestment followed by periods of underinvestment. Cycles of 5–10 years, and often shorter, are out of sync with the time needed for innovation to progress, e.g., to train new researchers in universities who then develop experience so that they can play roles in driving innovations to market. The longer, 30 year cycles we see in Figure 1 affect perceptions and longer-term expectations that may have deeper effects on incentives. Both short and long cycles are certainly out of sync with the 50–100-year cycles characteristic of transitions in the global energy system. With inter-related business cycles and election cycles, long lags from investment decisions to payoffs may even amplify cycles. Further, the emergence of competing social priorities from other areas—such as employment, health, competitiveness, and national security—provides external contributions to volatility in energy.

Consider also that, in some situations, volatility is an inevitable effect of efforts to address energy and climate problems. At least part of the decline in several indicators in the first half of the 1980s in Figure 1 is attributable to an array of policies and other responses to the energy crises in the 1970s. For example, the doubling of miles-per-gallon of

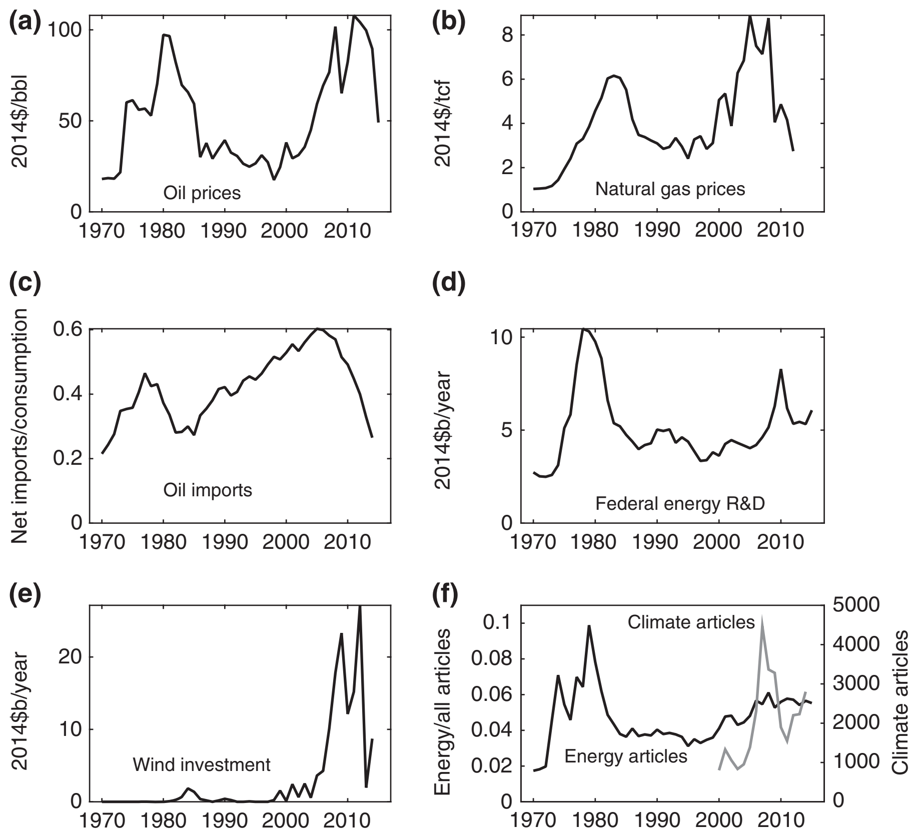

FIGURE 1 | Time series of selected aspects of the U.S. energy system 1970–2015: (a) crude oil prices,[18] (b) natural gas prices,[19] (c) crude oil imports,[20] (d) federal energy R&D investment,[21] (e) investment in new wind power,[22] and (f) 'energy'[23] and 'climate' articles in the media.[24]

U.S. passenger vehicles from 1975 to 1985 contributed directly to the fall in oil imports (panel C) and oil prices (panel A). It likely played an indirect role in the subsequent fading of public interest in energy (panel F) and decline in federal R&D appropriations in (panel D). Note also that miles-per-gallon barely changed for the next 20 years despite continued improvements in vehicle efficiency.[29] This scenario is a classic illustration of Downs'[30] 'issue-attention cycle,' in which efforts to respond to crises are sometimes difficult to sustain politically in part due to initial success removing a sense of urgency. In short, policies to address the 1970s energy 'crises' contributed to the subsequent bust. One can also imagine a quite similar outcome of efforts to improve energy efficiency and deploy low-carbon energy sources in response to climate change; fossil fuel prices will fall removing at least part of the motivation for pursuing climate policy, affordability of fossil fuels.

VOLATILITY WEAKENS INCENTIVES AND SLOWS INNOVATION

In addition to simply retarding progress, volatility is problematic in two additional critical ways. First, making a transition to a new energy system requires innovation, which both depends on, and must feed into further investment. Because payoffs to energy investments often take years to decades to accrue, investment depends on expectations—not in the next month or quarter, but on the 5–10 years or more over which large infrastructure or manufacturing facilities will pay off. Expectations are fragile—in part due to historical experience with booms and busts.[31] Even if we see overinvestment during the peak years of booms, the net effect over long-time periods is likely substantial underinvestment.[32] This effect extends across the innovation lifecycle, including technology deployment and back to the supply of trained scientists and engineers at the crucial stage at which they select their field of study.[33]

A second fundamental challenge has to do with the nature of innovation, which depends on the creation and use of new knowledge. While new knowledge can be created in many ways—via research, learning-by-doing, and serendipitous spillovers—it can also be lost.[34] Knowledge depreciates and is destroyed in busts—in part due to technological obsolescence and in part due to the tacit aspect of much of the knowledge created in booms.[7] The urgency of exploiting booms may even exacerbate knowledge destruction, with weak incentives to codify tacit knowledge during the scramble to scale up during a boom.[11] Moreover, knowledge is lost during cycles of hiring and firing, with little time or incentive to invest in training. When booms fade and layoffs increase, know-how is lost as workers, technicians, and entrepreneurs flee to seek opportunities in other sectors. In energy, particularly but not exclusively in the U.S., we have seen this happen again and again.[35] Note that many of these aspects are considerably more stable in other countries, e.g., R&D investment in Japan and renewables support in Germany. However, the rest of the world is not immune to what may appear to be peculiar and even perverse aspects of the U. S. energy system. In areas ranging from fusion energy, to solar energy, to natural gas, to an integrated view of nuclear energy science, engineering, and waste management, one can see clear evidence of the disproportionate role of the U.S. as an energy consumer and even more disproportionate role as a source and market for new energy technologies.[36]

TOWARD A COUNTERCYCLICAL ENERGY POLICY

These characteristics of the carbon cycle, the energy system, and of innovation systems require a sustained commitment to incentives for investments in innovation. These incentives must be aligned, balanced, credible, and durable,[35,37] which is a particular challenge in periods where general public and policy interests in energy wane due to competing concerns or complacency on energy issues. Thus, we argue for a countercyclical approach to energy and climate policy, much as the U.S. does now for monetary and fiscal policy. The Strategic Petroleum Reserve and related commitments by the International Energy Agency member states are the closest examples we have within energy[38]; prepare in good times for the bad times.

Multiple factors support the rationale for governments to be more active during the lulls in energy problems, that is, when a crisis appears most distant. For example, the past has shown that the private sector will invest in new technology, in efficiency, and in new sources when prices are high and when other factors, such as policy and public sentiment, are aligned. But the private sector has also shown tremendous agility in disinvesting in innovation when prices fall; firms have disincentives to sustain investments in alternatives, including employing those with specialized knowledge, when the outlook for the legacy system is benign.[25] Sustaining knowledge creation and required investments is crucial, as these lull periods typically last several years. Similarly, the public has tended to demand better environmental protection when it feels its health or important ecosystems are threatened, which is most pronounced in the wake of regulatory failures and when 'focusing events' catalyze concern and action.[39] Temporary improvement, or even gradual deterioration in environmental quality, may not provide sufficient motivation to assemble necessary political coalitions. Yet, the long-lived aspects of the related systems require persistent progress under varying degrees of urgency. Indeed in energy, as nearly every U.S. President over the past 40 years has learned, inertia, as well as the truly global aspects of the system, severely constrain the avenues available for governments to effectively address energy-related crises in the short term.

We define countercyclical policies as having two components: (1) a set of trigger mechanisms in place ahead of time and (2) a set of policies that would be put in place once the trigger conditions are met. Both would ultimately need to be quite specific in order for them to have meaningful effects on incentives and ultimately on the energy and climate systems. This paper is intended primarily to lay out the rationale and structure for this type of approach. Still, some examples exist and would help clarify what is involved in these two policy components.

First, a countercyclical policy would need to have rules, or guidelines, in place ahead of time to be implemented once conditions are met. For example, one could use oil price declines as a trigger for a set of policies. Just to illustrate, an arbitrary rule could be that a counter cyclical period is triggered if the average annual oil price is below the levels of the past 3–6 years. Figure 2 shows there are three periods that meet this rule: 1977–1978, 1984–1999, and 2012–2014. The levels shown in gray in these periods are simply the oil price at the beginning of the period and perhaps provide an indication of the stringency of policies needed to address incentives.

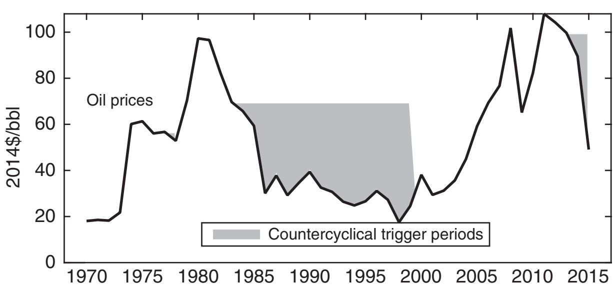

FIGURE 2 | Example of periods when conditions trigger countercyclical policies.

Note that in this case the rule would not trigger policies in 2000–2004, even though prices were historically low then, because prices were rising. The specifications of the trigger rules would need to be worked out, but the main point is that having them in place before the periods is crucial given the low political salience during these periods.

Second, the countercyclical approach needs specific policies to go into place once the trigger conditions are met. This might involve a single important policy mechanism or could involve a bundle of policies intended to address a broad set of sectors or related incentive problems. One can imagine a number of policies that would be especially appropriate during countercyclical trigger periods, that is, when incentives are most needed. For example, one could implement a gasoline tax that rises as the gas price falls, which would have the effects of smoothing out after-tax prices.

As another example: low natural gas prices have many benefits, but undermine incentives for a broad set of low-carbon technologies such as nuclear power, energy efficiency, and renewables. Countercyclical conditions triggered by low natural gas prices could be offset with incentives for these other technologies. The U.S. currently supports some of these other technologies with a production tax credit (PTC) of $22/MWh. This tax credit is in place for 18 months at a time, but is often left to expire and remain at zero for many months until it is reauthorized. A countercyclical approach would be to preset the value of the PTC so that it inversely tracks the price of natural gas.

On R&D spending, guidelines might implement an increase in energy R&D once the triggers are met. This would offset likely declines in private R&D and in any case would help smooth investment in new knowledge, which can improve its value over time. It might even be appropriate to have secondary policies, that is, policies that are made more stringent when other policies weaken. Such a policy could be an investment in R&D when carbon prices get low enough to trigger countercyclical conditions.[40]

Given the lengthy time periods involved, some flexibility in the policies to be implemented would surely be helpful. But an essential aspect of the countercyclical approach is precommitment, that is, policy makers do not have complete discretion over whether to implement these policies once trigger conditions are met.

A countercyclical approach would provide several benefits. In addition to sustaining knowledge creation and innovation, it would build reserves, resilience, and buffer capacity against inevitable future shocks. It would build long-term credibility in government targets, create a more stable policy environment, and hence would render a valuable public good to markets; it would enhance, rather than undermine, the predictability of future conditions. A countercyclical approach is also likely to be less expensive because governments need not compete with the private sector for resources, capital, and especially talented scientists and engineers, during these slack periods. One need not worry about governments crowding out private investment when the private sector is disinvesting. Moreover, governments borrow at much lower rates than does the private sector, allowing them to take a longer-term view.

The policy alternative to which we are primarily comparing our countercyclical approach is the status quo. The status quo in the U.S. is, and has been, quite similar to the prototypical policy response in the Downs article we cite above: 'alarmed discovery' of the problem, followed by 'enthusiastic response,' and 'gradual decline.' Another policy alternative would be to target a commitment to a 'stable' set of policies that are sustained over many years. For example, a carbon price that reflects the social costs of carbon and rises at a social discount rate. That type of policy would be preferable to the status quo. But there are reasons a 'stable' policy approach would be less preferable than a countercyclical approach: it would not be able to respond to new information about the problem; it would not be able to take advantage of inexpensive resources available during lulls; and it would not respond to the incentives to backtrack on policy commitments during lulls in public interest, a pattern we have seen repeatedly.[31]

To be sure, such a strategy would encounter challenges, most prominently in its political feasibility. Government efforts would need to be most active when public salience of energy problems is low. But, in the longer term, the advantages of more substantively addressing fundamental climate and energy challenges are large. The political challenges need not be insurmountable given the magnitude of benefits, as shown by other countries' approaches to energy and even those by the U.S. in diverse areas of social concern, such as social security, highways, and fiscal policy. Familiarity with the efforts to address these problems can itself facilitate support.[41] In short, we need the government most when prices are low, when a crisis appears furthest away, when energy problems appear to be getting better, and when competing social priorities, such as health, education, and the economy, demand attention.

CONCLUSION

We may be on the cusp of just such a regime of benign energy challenges in the U.S. Oil prices are down 50% from their peak; many project natural gas prices to stay low for 10–20 years; imports of oil have declined for several years and discussion of energy independence is widespread. Indeed, many see the recent emergence of plentiful domestic fossil fuel production as a linchpin of a return to international competitiveness for energy intensive sectors of the U.S. economy. Similarly, greenhouse gas emissions have fallen in part due to substituting gas for coal, which will also improve local air quality and the associated health impacts. Even global temperature rise appears to have slowed over the past 15 years, if for not well understood and likely temporary reasons.[42] In short, several aspects of energy problems give the appearance of improving for the first time in 30 years. If this current outlook remains in place long enough to dampen perceptions about the urgency of energy problems, this juncture is exactly when we need to more seriously address energy problems, which are unavoidably long term. We need energy policy most not when there is a crisis, but when things appear to be getting better and the opportunities for sound planning and long-term vision are in greatest supply. A counter cyclical energy policy—including a precommitment to a set of policies once trigger conditions are met—would provide a basis for institutionalizing farsightedness that is robust to the vagaries of near term social priorities.

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