



Aspen Global Change Institute Energy Project March 2015 Quarterly Science Supplement

The Psychology of Sustainable Transitions

De Young, Raymond. 2014. "Some Behavioral Aspects of Energy Descent: How a Biophysical Psychology Might Help People Transition through the Lean Times Ahead." *Frontiers in Psychology* 5 (November): 1–16. doi:10.3389/fpsyg.2014.01255. <http://journal.frontiersin.org/article/10.3389/fpsyg.2014.01255/abstract>.

"Modern society, as a whole, does not have a settled pattern of voluntarily exploring and adopting alternative life patterns in advance of being forced into so doing." – De Young, 2014

What can be done to help people adjust to living within ecological and physical limits? A new paper by Raymond De Young in *Frontiers in Psychology* proposes a behavioral research agenda that would seek out answers to this question.

Given that climate change and other environmental realities impress upon society the need for speedy transitions in the resource intensity of lifestyles, particularly with respect to energy, De Young foresees the need to better understand how to stave off the psychological challenges associated with such shifts. Behavioral research could assist people on an individual level, as well as help uncover more about the kinds of policy and communication that would more effectively support sustained transitions to more sustainable futures. De Young argues that through studying examples of early experiments of individuals and communities doing well with less, we can "pre-familiarize" ourselves with behaviors needed to thrive in leaner times.

In presenting this argument, De Young takes note of the unique situation facing modern society: never before have we been faced with the challenge of intentionally and suddenly adopting new behaviors of consumption and lifestyle. While this situation could be viewed as alarming, De Young points out several silver linings. For one, inquiry into the individual process of coping with change can improve understanding of how to encourage the types of persistent behaviors required for transitions that help solve problems such as climate change. As an example, the so-called "stabilization wedges," popularized by Robert Socolow and Stephen Pacala, each require sustained and long-term commitment to a wide range of technological, industrial, and behavioral transitions. In addition, understanding the dimensions of behavioral shifts to more sustainable lifestyles also may illuminate "the best in people," where we uncover types of individual motivations that allow for collective action in support of common goals. De Young sees a critical opportunity and reason for hope in this line of behavioral exploration:

If we paused for a moment, and reflected on this social dilemma, it might be easy to despair of the human prospect. Yet the issue here may be one of mis-framing and thus lends itself to re-framing. An approach that might have promise is to help people to slowly build their own understanding of the newly emerging biophysical context while simultaneously helping them to explore behaviors that are meaningful to them now, while also pre-familiarizing them with behaviors that might be essential further on.

Plotting Future Socioeconomic Scenarios

O'Neill, B.C., et al., The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change* (2015, in press), <http://dx.doi.org/10.1016/j.gloenvcha.2015.01.004>

Global climate models project various possible future climates using a spread of greenhouse gas emissions scenarios, with higher emissions resulting in larger estimated increases in temperature. But, these scenarios don't make explicit the types of socioeconomic conditions that could generate such emissions pathways, nor the specific societal impacts and responses that occur as a result. Thus, to support research work into climate impacts and response options, a set of "Shared Socioeconomic Pathways" (SSPs) have been developed that each outline a set of hard to predict socioeconomic and geopolitical factors such as economic output, regional and global political and economic integration, and overall progress in basic human development.

The objective in creating the SSPs is to incorporate them across a set of integrated assessment models so that future strategies for energy transitions and climate adaptation can be considered within different plausible socioeconomic contexts.

As shown in the figure, the five SSP scenarios can be organized in a framework that considers the challenges to climate change adaptation and mitigation that would characterize society under any given pathway. This framework illuminates two important points. One, that progress on adaptation and mitigation may differ depending upon different socioeconomic conditions. And two, that a unique set of societal priorities and arrangements are necessary for joint forward momentum on both adaptation and mitigation (see SSP1, a pathway for sustainable development).

A summary of the five pathway storylines is provided here:

SSP1.

Sustainability: Taking the Green Road

Gradually shifting to more sustainable development with strong institutions locally to internationally that bolster commitments to environmental protection, improved resource efficiency, and human development.

SSP2. Middle of the Road

Social, economic, and technological trends continue much as before, but not fast enough to stave off some degradation to environmental systems. Fossil fuel dependency declines slowly, though unconventional fossil resources are still exploited.



Fig. 1. Five shared socioeconomic pathways (SSPs) representing different combinations of challenges to mitigation and to adaptation. Based on Fig. 1 from O'Neill et al. (2014), but with the addition of specific SSPs.

SSP3. Regional Rivalry: A Rocky Road

Political fragmentation along national and regional lines leads to overall economic downturn and uneven global coordination on sustainable development. Inadequate progress is made towards international environmental agreements and strong environmental degradation occurs at least in some regions.

SSP4. Inequality: A Road Divided

Economic disparities grow unabated and lead to concentrations of power among a relatively small business and political elite. These concentrations enable a quick-acting and decisive effort to invest in low carbon energy, yet responding to environmental change is challenging for the large proportions of people under low development and low levels of access to effective institutions.

SSP5. Fossil-fueled Development: Taking the highway

General fear about tradeoffs between global economic growth and environmental protection leads world economies to continue to rely on returns from a fossil fuel-driven economy to make investments in health education and institutions. Resource and energy intensive lifestyles continue with the faith that economic and technological prowess will enable effective management of environmental change and degradation.

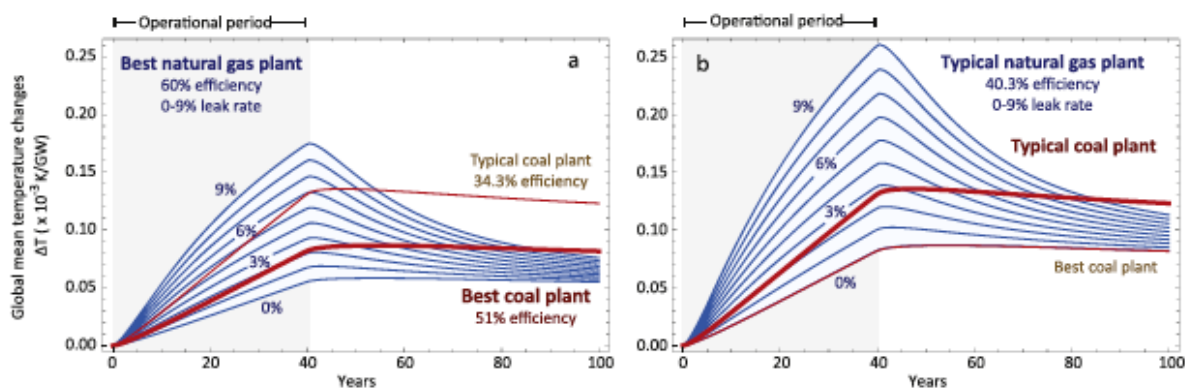
Natural Gas versus Coal: Comparing Climate Benefits Over Time

Zhang, X., N. P. Myhrvold and K. Caldeira. 2014. Key factors for assessing climate benefits of natural gas versus coal electricity generation. *Environmental Research Letters* 9(11): 114022.

Whether natural gas trumps coal-fired power plants as a bridge toward clean energy and minimizing impact to increasing temperature, depends on two critical factors: power plant efficiency and leakage rate of methane.

In the comparison of coal to natural gas-fired power plants, a common assumption is that natural gas is “cleaner” both in terms of air pollutants emitted per unit of energy delivered, but also because roughly half the carbon dioxide is emitted. For these reasons, energy policy has considered the use of natural gas replacing coal as a “bridge” toward a clean energy system where renewables play a larger role in primary power. Over the last several years, a number of research papers have considered complicating factors in the comparison, such as the leakage of methane, which by itself is a potent greenhouse gas. Leakage occurs at multiple points from drilling sites to other points in the natural gas infrastructure system. Actual leakage rates are hard to estimate because of the large variability between locations and spotty measurements; however at the time of this paper, an estimate for the leakage rate in the U.S. was 2.4 percent.

Zhang et al (2014) considers how the comparison plays out over time, taking into account two critical factors: 1) the efficiency of the natural gas and coal-fired power plants in producing a unit of energy; and 2) the assumed leakage rate of methane. Other factors were considered by the authors, but their research indicated these two factors as central to the comparison.



This figure from Zhang shows the time evolution of mean temperature change comparing the most efficient natural gas plant on the left with the a typical natural gas plant on the right. In both cases, the blue curves represent leakage rates from zero to nine percent and red indicates typical and theoretically best efficiencies for coal plants. Also in both, the power plants operate for 40 years. Methane has a relatively short lifetime in the atmosphere, hence the downward sloping curve following the 40-year operating period. If considering retiring a coal plant with a typical efficiency natural gas plant, the methane leakage rate would have to be below about two percent in the near-term to have less impact on increasing temperature than the coal plant it replaced. A replacement with the most efficient natural gas plant would have less near-term warming impact than coal with leakage rates closer to four percent.

A key conclusion is that with high efficiencies and low leakage rates, natural gas is preferred; however, the authors state: *without carbon capture and storage natural gas power plants cannot achieve the deep reductions that would be required to avoid substantial contribution to additional global warming.*

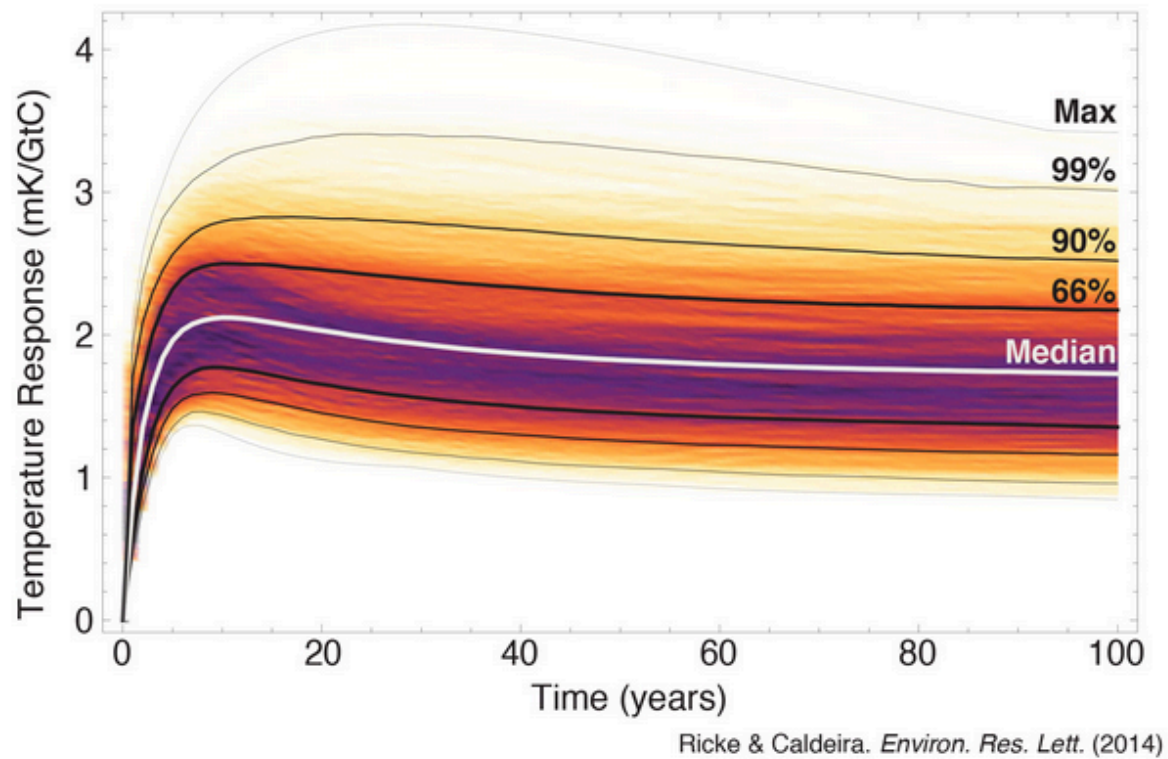
Timing of Benefit from Avoided CO2 Emissions

Ricke, K. L. and K. Caldeira (2014). "Maximum warming occurs about one decade after a carbon dioxide emission." *Environmental Research Letters* 9(12): 124002.

Surprisingly, until this analysis by Ricke and Caldeira, the estimate of the timing for the maximum warming from an assumed carbon dioxide pulse into the atmosphere had not been explicitly determined, taking into consideration climate sensitivity, carbon cycle, and ocean heat uptake (2014). In the case of this modeling experiment, a pulse of carbon dioxide explicitly looks at what would happen if 1 billion tons of carbon dioxide was released today and how long it would take for that carbon dioxide to have a maximum effect on the Earth's temperature. Rather than today's emissions affecting a distant future, Ricke and Caldeira found the maximum warming occurs at a median of 10.1 years from the pulse of carbon dioxide.

The finding is significant for climate research, the carbon cycle, and policy formation. Today's emissions have a direct effect on temperature within the lifetime of our current policymakers, rather than only on our future generations. It is also important to note that in the figure below, the decline after the peak at 10.1 years is very gradual and persists well past this century.

The following figure from Ricke and Caldeira is a time series of the marginal change in temperature per gigaton carbon pulse for the first 100 years peaking at a median of 10.1 years with a 90 percent probability range of 6.6 to 30.7 years.



The darker colors represent the density of 6000 modeling simulations, about the median represented as the white curve. While the resulting maximum temperature peaks at about 10 years, the increase in temperature from the pulse of CO₂ declines very gradually, affecting global temperature for centuries.