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CONGRESSIONAL TESTIMONY

Healthy Oceans and Healthy Economies: The State of Our Oceans in the 21st Century

Testimony before

Committee on Natural Resources

Subcommittee on Water, Oceans, and Wildlife

United States House of Representatives

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Chairman Huffman, Ranking Member McClintock, and other Members of the subcommittee, thank you for the opportunity to testify about healthy oceans and healthy economies. My name is Kevin Dayaratna. I am the Senior Statistician and Research Programmer at The Heritage Foundation. The views I express in this testimony are my own and should not be construed as representing any official position of the Heritage Foundation.

Energy is the fundamental building block of civilization from flipping on a light switch, to starting up our cars, to enabling this very hearing to operate. Unfortunately, however, many people take energy for granted. Over the course of the last decade, it has been a fundamental goal of policymakers in Washington to expand regulations across the energy sector of the economy. As a result, it is important to quantify the impacts of this fundamental building block both in terms of the economy as well as in terms of the climate. Over the course of my work at The Heritage Foundation, my colleagues and I have used the same models that the federal government has used to quantify these impacts ourselves. We have found in our work published both at Heritage and in the peer-reviewed literature, that these policies aimed at decarbonization are predicated on user-manipulated models. Moreover, we have found that these policies will result in devastating economic impacts along with negligible impacts on the climate. Policies aimed at taking advantage of our vast oil and gas supply, on the other hand, will grow the economy for years to come.

The Justfication Behind These Regulations

For much of the past decade, the federal government has sought to expand regulations across the energy sector of the economy. One of the primary justifications for doing so has been the social cost of carbon (SCC), which is defined as the economic damages associated with a metric ton of carbon dioxide (CO_2) emissions summed across a particular time horizon.[1]

There are three primary statistical models that the Interagency Working Group (IWG) has used to estimate the SCC—the DICE Model, the FUND model, and the PAGE model.[2]

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[1]The official definition of the social cost of carbon is the economic damages per metric ton of $C0_2$ emissions, and is discussed further in U.S. Environmental Protection Agency, "The Social Cost of Carbon," http://www.epa.gov/climatechange/EPAactivities/economics/scc.html (accessed September 14, 2013).

[2]For the DICE model, see William D. Nordhaus, "RICE and DICE Models of Economics of Climate Change," Yale University, November 2006, http://www.econ.yale.edu/~nordhaus/homepage/dicemodels.htm (accessed November 6, 2013). For the FUND model, see "FUND—Climate Framework for Uncertainty, Negotiation and Distribution," http://www.fund-model.org/ (accessed November 6, 2013). For the PAGE model, see Climate CoLab, "PAGE," http://climatecolab.org/resources/-/wiki/Main/PAGE (accessed November 6, 2013).
U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866," May 2013, revised November 2013, https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf .
U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analyses under Executive Order 12866: Application of Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide," August 2016, https://www.epa.gov/sites/production/files/2016-12/documents/addendum_to_sc-ghg_tsd_august_2016.pdf.

Over the last several years at The Heritage Foundation, my colleagues and I have used the DICE and FUND models, testing their sensitivity to a variety of important assumptions. Our research, published both as Heritage Foundation publications, in the peer reviewed literature, and discussed in my prior Congressional testimony, has repeatedly illustrated that although these models might be interesting academic exercises, they are extremely sensitive to very reasonable changes to assumptions.[3] These models can thus be manipulated by user-selected assumptions and are thus not legimate for guiding regulatory policy.

These models are estimated by Monte Carlo simulation. The general idea behind Monte Carlo simulation is that since some aspects of the models are random, the models are repeatedly estimated to generate a spectrum of probable outcomes. As a result of principles in probability theory, repeated estimation for a sufficient amount of time provides a reasonable characterization of the SCC's distributional properties.

As with any statistical model, however, these models are grounded by assumptions. In our work, my colleagues and I have rigorously examined three important assumptions: the choice of a discount rate, a time horizon, and the specification of an equilibrium climate sensitivity distribution.

Discount Rate

The concept of discount rates is best viewed by considering an expenditure today as a benefit in the future via an investment. Discounting future benefits of averting climate damage compares the rate of return from CO2 reduction to the rate of return that could be expected from other investments. In principle, discounting runs the compound rate of return exercise backwards, calculating how much would need to be invested at a reasonably expected interest rate today to result in the value of the averted future climate damage.[4]

U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "2010 Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866," February 2010, https://www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf.

[3]Kevin D. Dayaratna and David W. Kreutzer, "Unfounded FUND: Yet Another EPA Model Not Ready for the Big Game," Heritage Foundation *Backgrounder* No. 2897, April 29, 2014, http://www.heritage.org/research/reports/2014/04/unfounded-fund-yet-another-epa-model-not-ready-for-the-big-game; Kevin D. Dayaratna and David W. Kreutzer, "Loaded DICE: An EPA Model Not Ready for the Big Game," Heritage Foundation *Backgrounder* No. 2860, November 21, 2013, 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, "Environment: Social Cost of Carbon Statistical Modeling Is Smoke and Mirrors," *Natural Gas & Electricity*, Vol. 30, No. 12 (2014), pp. 7–11;
Dayaratna, K., McKitrick, R., & Kreutzer, D. (2017). Empirically Constrained Climate Sensitivity And The Social Cost Of Carbon. *Climate Change Economics*, *8*(02), 1750006.
; Kevin D Dayarantna, "An Analysis of the Obama Administration's Social Cost of Carbon," testimony before the Committee on Natural Resources, U.S. House of Representatives, July 23, 2015. Kevin D Dayarantna, "At What Cost? Examining the Social Cost of Carbon," testimony before the Commitee on House, Sciences, and Techonology, U.S. House of Representatives, February 28, 2017

[4] Kreutzer, D.W., 2016. Discounting Climate Costs. *Heritage Found.* Issue Brief 4575.

The Environmental Protection Agency has run these models using 2.5 percent, 3 percent, and 5 percent discount rates despite the fact that the Office of Management and Budget guidance in Circular A-4 has specifically stipulated that a 7 percent discount rate be used as well.[5] In my research, we re-estimated these models using a 7 percent discount rate in a variety of publications. Below are our results published in the peer-reviewed journal *Climate Change Economics*:

	DICE Model Average SCC – Baseline, End Year 2300			
Year	**Discount Rate - 2.50%**	**Discount Rate - 3%**	**Discount Rate - 5%**	**Discount Rate - 7%**
2010	$46.58	$30.04	$8.81	$4.02
2020	$56.92	$37.79	$12.10	$5.87
2030	$66.53	$45.15	$15.33	$7.70
2040	$76.96	$53.26	$19.02	$9.85
2050	$87.70	$61.72	$23.06	$12.25

	FUND Model Average SCC – Baseline, End Year 2300			
Year	**Discount Rate - 2.50%**	**Discount Rate - 3%**	**Discount Rate - 5%**	**Discount Rate - 7%**
2010	$29.69	$16.98	$1.87	-$0.53
2020	$32.90	$19.33	$2.54	-$0.37
2030	$36.16	$21.78	$3.31	-$0.13
2040	$39.53	$24.36	$4.21	$0.19
2050	$42.98	$27.06	$5.25	$0.63

As the above talbes illustrate, the SCC estimates are drastically reduced under the use of a 7 percent discount rate. In fact, under the FUND model, the estimates are negative, suggesting that there are actually benefits to carbon dioxide emissions. These changes in the discount rate can cause the SCC to drop by as much as 80% or more.

Time Horizon

It is essentially impossible to forecast technological change decades let alone centuries into the future. Regardless, however, these SCC models are based on projections 300

[5]Office of Management and Budget, "Circular A-4," Obama White House, https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/ (February 22, 2017), and Paul C. "Chip. Knappenberger. "An Example of the Abuse of the Social Cost of Carbon." Cato-at-Liberty. http://www.cato.org/blog/example-abuse-social-cost-carbon (accessed September 14, 2013).

years into the future. In my work at Heritage, I have changed this time horizon to the significantly less, albeit still unrealistic, time horizon of 150 years into the future, and we obtained the following results for the DICE model in our work published in 2013:[6]

	DICE Model Average SCC - End Year 2150			
Year	**Discount Rate - 2.50%**	**Discount Rate - 3%**	**Discount Rate - 5%**	**Discount Rate - 7%**
2010	$36.78	$26.01	$8.66	$4.01
2020	$44.41	$32.38	$11.85	$5.85
2030	$50.82	$38.00	$14.92	$7.67
2040	$57.17	$43.79	$18.36	$9.79
2050	$62.81	$49.20	$22.00	$12.13

Clearly, the SCC estimates drop substantially as a result of changing the end year (in some cases by over 25 percent).

Equilibrium Climate Sensitivity Distribution

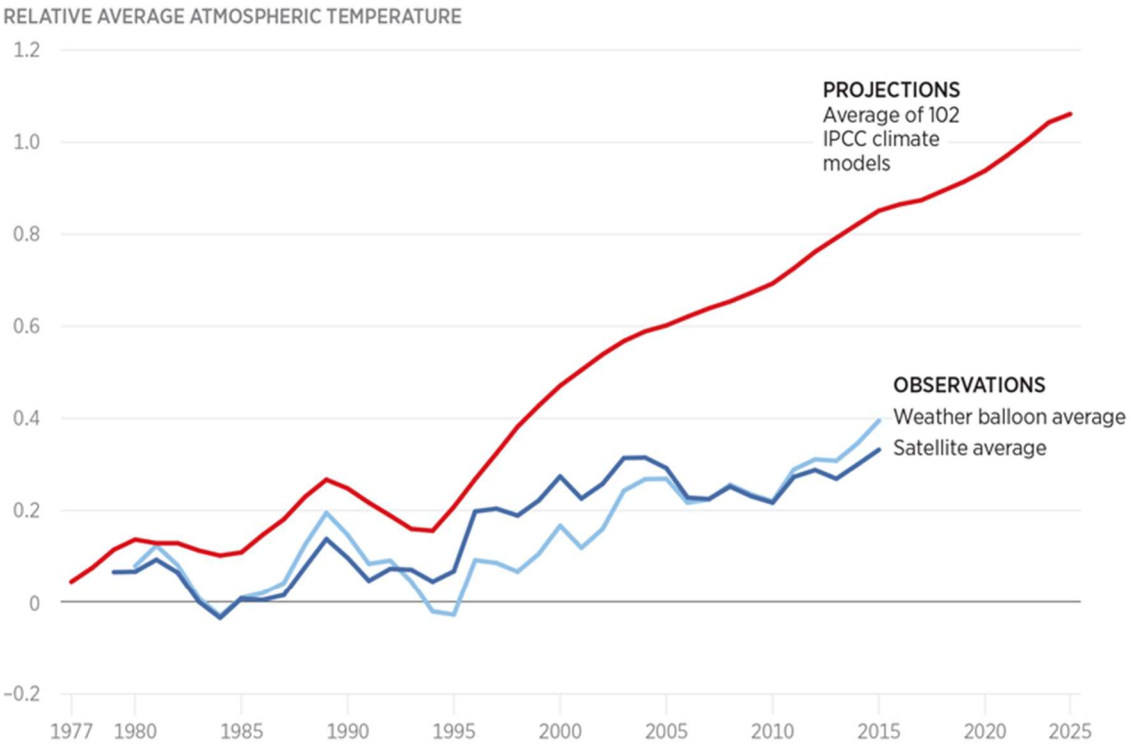
These models of course take into account assumptions regarding the planet's climate sensitivity. The real question, however, is the degree of accuracy statistical models have at doing so. Professor John Christy testified in both 2013 and 2016 regarding the efficacy of climate change projections and juxtaposed them against actual weather balloon and satellite data.[7] Christy has exposed the sheer inadequacy of the IPCC's models in forecasting global temperatures:

[6] Kevin D. Dayaratna and David W. Kreutzer, "Loaded DICE: An EPA Model Not Ready for the Big Game," Heritage Foundation *Backgrounder* No. 2860, November 21, 2013,

[7] John R. Christy, testimony before the Committee on Science, Space & Technology, U.S. House of Representatives, February 2, 2016.
John R Christy, "A Factual Look at the Relationship Between Climate and Weather," testimony before the Subcommittee on Environment, Committee on Natural Resources, U.S. House of Representatives, December 11, 2013.

CHART 2

Climate Models Predict Too Much Warming



NOTE: The starting value for each series is normalized so that a linear regression would pass the zero-degree mark at 1979.
SOURCE: U.S. House Committee on Science, Space and Technology, testimony by John R. Christy of University of Alabama in Huntsville, February 2, 2016, https://science.house.gov/sites/republicans.science.house.gov/files/documents/HHRG-114-SY-WState-JChristy-20160202.pdf (accessed April 12, 2016).

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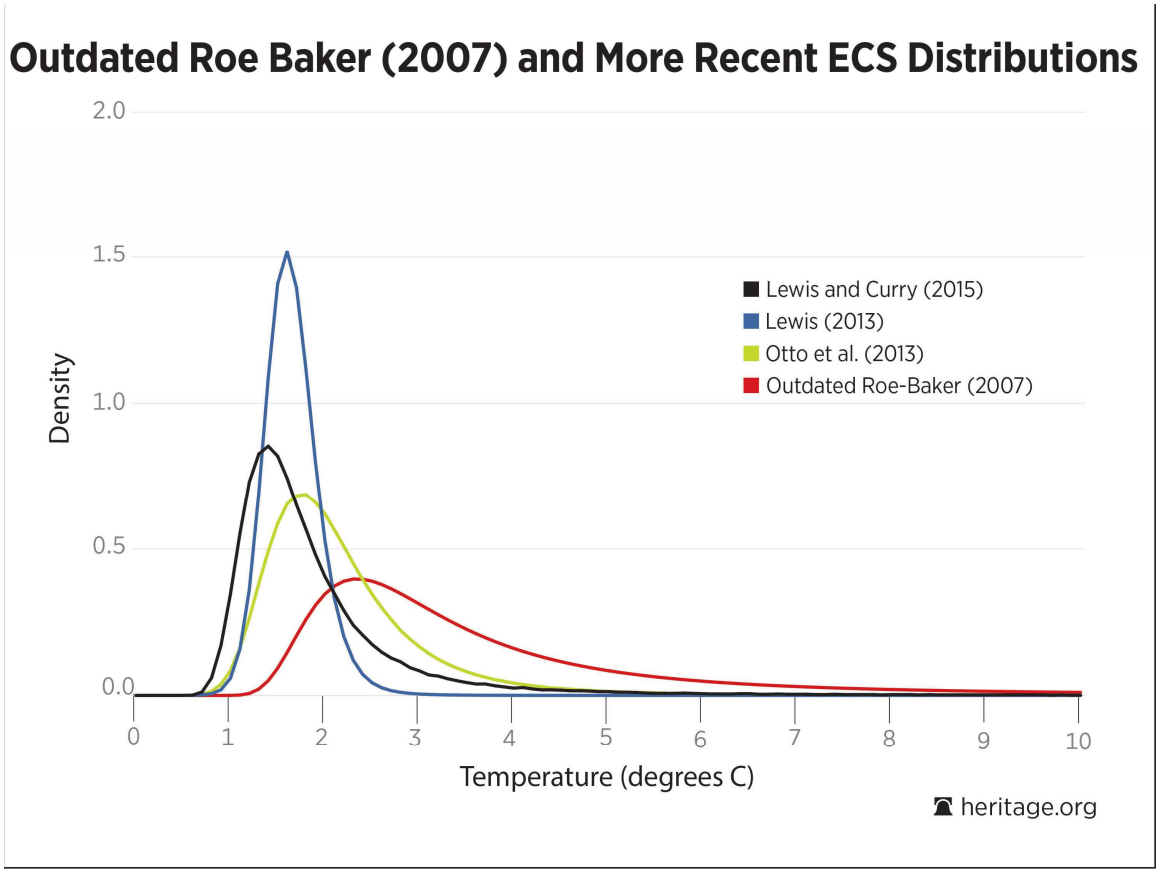
The climate specification used in estimating the SCC is that of an equilibrium climate sensitivity (ECS) distribution. These distributions probabilistically quantify the earth's temperature response to a doubling of carbon dioxide concentrations. The ECS distribution used by the IWG is based on a paper published in the journal *Science* twelve years ago by Gerard Roe and Marcia Baker. This non-empirical distribution, calibrated by the IWG based on assumptions that the group decided on climate change in conjunction with IPCC recommendations, has been deemed to be "no longer scientifically defensible."[8] Since then, a variety of newer and more up-to-date distributions have been suggested in the peer-reviewed literature. Many of these distributions, in fact, suggest lower probabilities of extreme global warming in response to carbon dioxide concentrations. Below are a few such distrubtions: [9]

[8] Patrick J. Michaels, "An Analysis of the Obama Administration's Social Cost of Carbon," testimony before the Committee on Natural Resources, U.S. House of Representatives, July 22, 2015, https://www.cato.org/publications/testimony/analysis-obama-administrations-social-cost-carbon.
[9]Gerard H. Roe and Marcia B. Baker, "Why Is Climate Sensitivity So Unpredictable?" *Science*, Vol. 318, No. 5850 (October 26, 2007), pp. 629–632; Nicholas Lewis, "An Objective Bayesian Improved Approach



The area under the cuve between two temperature points depicts the probability that the earth's temperature will increase between those amounts in response to a doubling of carbon dioxide concentrations. Thus, the area under the curve from 4 degrees C onwards (known as a "tail probability") provides the probability that the earth's temperature will warm by more than 4 degrees C in response to a doubling of carbon dioxide concentrations. Note that the more up to date ECS distributions (Otto et al 2013; Lewis 2013; Lewis and Curry 2015) have significantly lower tail probabiltiies than the outdated Roe-Baker (2007) distribution used by the IWG. In our research published in *Climate*

for Applying Optimal Fingerprint Techniques to Estimate Climate Sensitivity," *Journal of Climate*, Vol. 26, No. 19 (October 2013), pp. 7414–7429; and Alexander Otto et al., "Energy Budget Constraints on Climate Response," *Nature Geoscience*, Vol. 6, No. 6 (June 2013), pp. 415–416; Nicholas Lewis and Judith A. Curry, "The implications for climate sensitivity of AR5 forcing and heat uptake estimates", *Climate Dynamics*, Vol. 45, Issue 3, pp 1009-1923, http://link.springer.com/article/10.1007/s00382-014-2342-y; U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "2010 Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866," February 2010, https://www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf.

Change Economics, we re-estimated the SCC having used these more up-to-date ECS distributions and obtained the following results: [10]

	DICE Model Average SCC – ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300			
Year	**Discount Rate - 2.50%**	**Discount Rate - 3%**	**Discount Rate - 5%**	**Discount Rate - 7%**
2010	$23.62	$15.62	$5.03	$2.48
2020	$28.92	$19.66	$6.86	$3.57
2030	$33.95	$23.56	$8.67	$4.65
2040	$39.47	$27.88	$10.74	$5.91
2050	$45.34	$32.51	$13.03	$7.32

	FUND Model Average SCC – ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300			
Year	**Discount Rate - 2.50%**	**Discount Rate - 3%**	**Discount Rate - 5%**	**Discount Rate - 7%**
2010	$5.25	$2.78	-$0.65	-$1.12
2020	$5.86	$3.33	-$0.47	-$1.10
2030	$6.45	$3.90	-$0.19	-$1.01
2040	$7.02	$4.49	-$0.18	-$0.82
2050	$7.53	$5.09	$0.64	-$0.53

Again, we notice drastically lower estimates of the SCC using these more up-to-date ECS distributions. These results are not surprising—the IWG's estimates of the SCC were based on outdated assumptions that overstated the probabilities of extreme global warming, which artificially inflated their estimates of the SCC.

Negativity

When people talk about the social cost of carbon, they tend to think of damages. Not all of these models, however, suggest that there are always damages associated with carbon dioxide emissions. The FUND model, in fact, allows for the SCC to be negative based on feedback mechanisms due to carbon dioxide emissions. In my research at The Heritage Foundation, we computed the probability of a negative SCC under a variety of

[10] Dayaratna, K., McKitrick, R., & Kreutzer, D. (2017). Empirically Constrained Climate Sensitivity And The Social Cost Of Carbon. *Climate Change Economics*, *8*(02), 1750006.

assumptions. Below are some of our results published both at Heritage as well as in the peer-reviwed journal *Climate Change Economics*[11]*:*

	FUND Model Probability of Negative SCC – ECS Distribution Based on Outdated Roe–Baker (2007) Distribution, End Year 2300			
Year	**Discount Rate - 2.50%**	**Discount Rate - 3%**	**Discount Rate - 5%**	**Discount Rate - 7%**
2010	0.087	0.121	0.372	0.642
2020	0.084	0.115	0.344	0.601
2030	0.080	0.108	0.312	0.555
2040	0.075	0.101	0.282	0.507
2050	0.071	0.093	0.251	0.455

	FUND Model Probability of Negative SCC – ECS Distribution Updated in Accordance with Otto et al. (2013), End Year 2300			
Year	**Discount Rate - 2.50%**	**Discount Rate - 3%**	**Discount Rate - 5%**	**Discount Rate - 7%**
2010	0.278	0.321	0.529	0.701
2020	0.268	0.306	0.496	0.661
2030	0.255	0.291	0.461	0.619
2040	0.244	0.274	0.425	0.571
2050	0.228	0.256	0.386	0.517

	FUND Model Probability of Negative SCC – ECS Distribution Updated in Accordance with Lewis (2013), End Year 2300			
Year	**Discount Rate - 2.50%**	**Discount Rate - 3%**	**Discount Rate - 5%**	**Discount Rate - 7%**
2010	0.390	0.431	0.598	0.722
2020	0.375	0.411	0.565	0.685
2030	0.361	0.392	0.530	0.645
2040	0.344	0.371	0.491	0.598

[11]Kevin D. Dayaratna and David W. Kreutzer, "Unfounded FUND: Yet Another EPA Model Not Ready for the Big Game," Heritage Foundation *Backgrounder* No. 2897, April 29, 2014, http://www.heritage.org/research/reports/2014/04/unfounded-fund-yet-another-epa-model-not-ready-for-the-big-game;
Dayaratna, K., McKitrick, R., & Kreutzer, D. (2017). Empirically Constrained Climate Sensitivity And The Social Cost Of Carbon. *Climate Change Economics*, *8*(02), 1750006.

2050	0.326	0.349	0.449	0.545

	FUND Model Probability of Negative SCC – ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300			
Year	**Discount Rate - 2.50%**	**Discount Rate - 3%**	**Discount Rate - 5%**	**Discount Rate - 7%**
2010	0.416	0.450	0.601	0.730
2020	0.402	0.432	0.570	0.690
2030	0.388	0.414	0.536	0.646
2040	0.371	0.394	0.496	0.597
2050	0.354	0.372	0.456	0.542

As the above statistics illustrate, under a very reasonable set of assumptions, the SCC is overwhelmingly likely to be negative, which would suggest the government should, in fact, subsidize (not limit) carbon dioxide emissions. Of course, we by no means use these results to suggest that the government should actually subsidize carbon dioxide emissions, but rather to illustrate the extreme sensitivity of these models to reasonable changes to assumptions and can thus be quite easily fixed by policymakers.

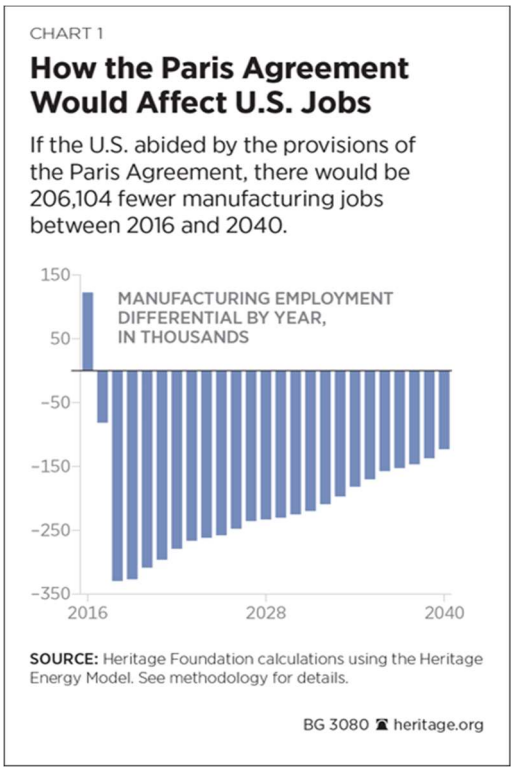
Economic Impact

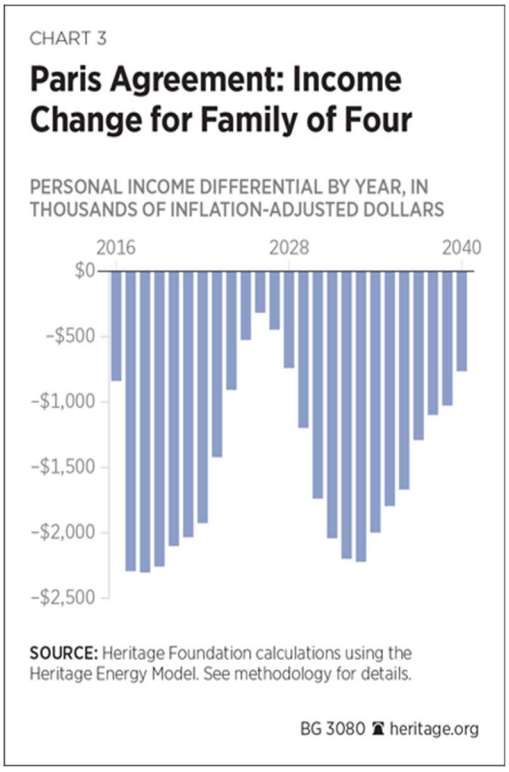
In our research at The Heritage Foundation, we used the Heritage Energy Model, a clone of the Department of Energy's National Energy Modeling System to quantify the economic impact of both implementing further carbon based regulations as well as repealing existing ones. One policy we analyzed was the Clean Power Plan, a policy initiated by the Obama administration to regulate carbon based emissions. We found that by 2035, the policy would result in an average employment shortfall of over 70,000 lost jobs, a loss of income of more than $10,000 for a family of four, and up to 5% increase in household electricity expenditures, and an aggregate $1 trillion loss in GDP. I discussed these facts during Congressional Testimony for the House, Sciences, and Technology Committee in June 2016.[12]

In addition, we also used the Heritage Energy Model to quantify the economic impact of the Paris Agreement on the American economy. In our research published in 2016, we found that the economic impacts would be quite devastating – in particular by 2035, the country would see an average employment shortfall of nearly 400,000 lost jobs, a loss of

[12] Kevin D Dayarantna, "The Economic Impact of the Clean Power Plan," testimony before the Committee on House, Science, and Technology, U.S. House of Representatives, June 24, 2015 https://www.heritage.org/testimony/the-economic-impact-the-clean-power-plan

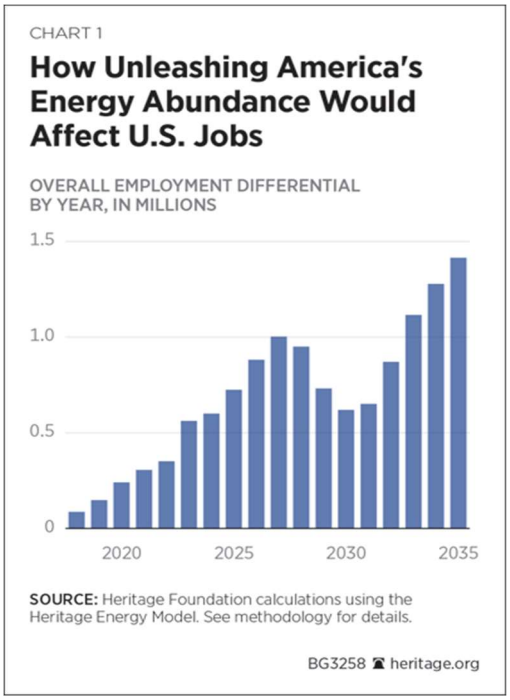
income of more than $20,000 for a family of four, an up to 20% increase in household electricity expenditures, and an aggregate $2.5 trillion loss in GDP.

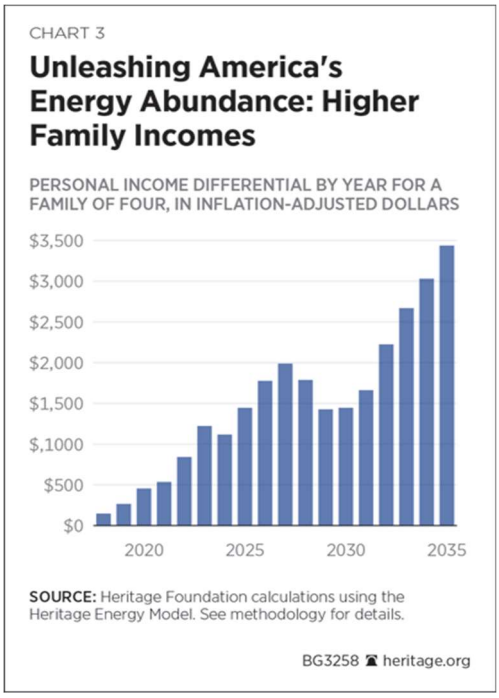




In other research at the Heritage Foundation, we considered the impact of taking advantage of the significant shale oil and gas supply available here in the States. The Institute for Energy Research has noted that in North America alone has over 1.4 trillion barrels of oil and 2.2 quadrillion cubic feet of natural gas. My colleagues and I have used the Heritage Energy Model to look into the impact of actually taking advantage of these resources. Our research found that if this vast supply were actually utilized that by 2035, the country would see an average employment gain of nearly 700,000 jobs, an increase in over $27,000 for a family of four, a marked reduction in household electricity expenditures, and an aggregate $2.4 trillion increase in GDP. [13]

[13]Kevin D. Dayaratna, Nicolas D. Loris, and David W. Kreutzer, "The Obama Administration's Climate Agenda: Will Hit Manufacturing Hard," Heritage Foundation *Backgrounder* No. 2990, November 13, 2014, http://www.heritage.org/research/reports/2014/11/the-obama-administrations-climate-agenda-underestimated-costs-and-exaggerated-benefits; Kevin D. Dayaratna, Nicolas D. Loris, and David W. Kreutzer, "The Obama Administration's Climate Agenda: Underestimated Costs and Exaggerated Benefits," Heritage Foundation *Backgrounder* No. 2975, November 13, 2014, http://www.heritage.org/research/reports/2014/11/the-obama-administrations-climate-agenda-underestimated-costs-and-exaggerated-benefits; Nicholas D. Loris, Kevin Dayaratna, and David W. Kreutzer, "EPA Power Plant Regulations: A Backdoor Energy Tax," Heritage Foundation *Backgrounder* No. 2863, December 5, 2013, http://www.heritage.org/research/reports/2013/12/epa-power-plant-regulations-a-backdoor-energy-tax; David W. Kreutzer, Nicholas D. Loris, and Kevin Dayaratna, "Cost of a Climate Policy: The Economic Impact of Obama's Climate Action Plan," Heritage Foundation *Issue Brief* No. 3978, June 27, 2013, http://www.heritage.org/research/reports/2013/06/climate-policy-economic-





Negligible Environmental Benefits

In our research at The Heritage Foundation, we have also estimated the environmental impact of a number of pertinent policies using the Model for the Assessment of Greenhouse Gas Induced Climate Change. In one exercise, we simulated the impact of reducing carbon dioxide emissions from the United States by 80%. Assuming a climate sensitivity of 4.5 degrees Celsius, we found that by 2100, the earth would incur a temperature reduction of 0.135 degrees Celisus and 1.35 cm sea level rise reduction. In a second exercise, we simulated the impact of eliminating all carbon dioxide emissions from the United States completely. We found a similarly trifling change of 0.2 degree Celsius temperature reduction and 2 cm of sea level rise reduction. In a third exercise, we modeled the climate impact of taking advantage of the oil/gas resources discussed in Dayaratna et al (2017). We again found a neglible impact of less than 0.003 degree Celsius change in temperature and 0.02 cm of sea level rise increase.[14]

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impact-and-cost-of-obama-s-climate-action-plan; David W. Kreutzer and Kevin Dayaratna, "Boxer–Sanders Carbon Tax: Economic Impact," Heritage Foundation *Issue Brief* No. 3905, April 11, 2013, http://www.heritage.org/research/reports/2013/04/boxer-sanders-carbon-tax-economic-impact; "Consequences of Paris Protocol: Devastating Economic Costs, Essentially Zero Environmental Benefits," Heritage Foundation *Report*, April 13, 2016, http://www.heritage.org/environment/report/consequences-paris-protocol-devastating-economic-costs-essentially-zero; Institute for Energy Research, *North American Energy Inventory*, December 2011, https://www.instituteforenergyresearch.org/wp-content/uploads/2013/01/Energy-Inventory.pdf ; and Kevin Dayaratna and Nicholas Loris, "Turning America's Energy Abundance into Energy Dominance," Heritage Foundation *Report*, November 3, 2017, https://www.heritage.org/energy-economics/report/turning-americas-energy-abundance-energy-dominance

[14]Kevin Dayaratna and Nicholas Loris, "Turning America's Energy Abundance into Energy Dominance," Heritage Foundation *Report*, November 3, 2017, https://www.heritage.org/energy-

Conclusions

Policies aimed at "decarbonizing" the American economy are predicated on faulty models that are prone to user-selected manipulation. These policies will raise the cost of energy, thus resulting in devastating economic impacts. On the other hand, policies that are aimed at taking advantage of fossil-based fuels have tremendous potential to grow the economy. And moreover, either policy – regulatory or de-regulatory – will have negligible impact on the climate.

economics/report/turning-americas-energy-abundance-energy-dominance University Corporation for Atmospheric Research, "MAGICC/SCENGEN," http://www.cgd.ucar.edu/cas/wigley/magicc/ (accessed January 9, 2017);

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