May 24, 2013 (copy edited May 29)

Honorable Fred Upton
Chairman
Honorable Henry Waxman
Ranking Member
House Committee on Energy and Commerce
RFS@Mail.House.Gov

Dear Sirs,

This comment letter addresses Question 1(a) of your Renewable Fuel Standard (RFS) White Paper on Greenhouse Gas Emissions and Other Environmental Impacts, which asks: "Is the RFS reducing greenhouse gas emissions below that of baseline petroleum-derived fuels?"

Although not posed in the White Paper, a related question is whether the original energy security and climate change rationales for the RFS program are as sound or compelling as they appeared to be in 2007. I offer some thoughts on this topic in an addendum.

My main conclusions are as follows:

1. The RFS may be a net contributor to greenhouse gas emissions.
2. Even if ethanol does emit less carbon dioxide on a life-cycle basis than the gasoline it displaces, the RFS may still be an inefficient mitigation strategy.
3. The energy-security assumptions underpinning the RFS are dated and, arguably, false.
4. The scientific assumptions underpinning the RFS are dated and, arguably, false.

Thank you for the opportunity to provide comment on your timely and thoughtful reassessment of the RFS.

Sincerely,

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Question 1(a): Is the RFS reducing greenhouse gas emissions below that of baseline petroleum-derived fuels?

The RFS may actually be a net contributor to greenhouse gas emissions. What's more, even if ethanol does emit less carbon dioxide (CO_2) on a life-cycle basis than the gasoline it displaces, the RFS may still be an inefficient mitigation strategy.

Fargione et al. (2008) found that, "Converting rainforests, peatlands, savannas, or grasslands to produce food-based biofuels in Brazil, Southeast Asia, and the United States creates a 'biofuel carbon debt' by releasing 17 to 420 times more CO_2 than the annual greenhouse gas (GHG) reductions these biofuels provide by displacing fossil fuels."[1]

Similarly, Searchinger et al. (2008) found that when farmers worldwide "convert forest and grassland to new cropland to replace the grain (or cropland) diverted to biofuels," corn ethanol, "instead of producing a 20% savings, nearly doubles greenhouse emissions over 30 years and increases greenhouse gasses for 167 years." The researchers also found that cellulosic biofuel is not necessarily a 'climate-friendly' alternative to corn ethanol: "Biofuels from switchgrass, if grown on U.S. corn lands, increase emissions by 50%. This result raises concerns about large biofuel mandates and highlights the value of using waste products."[2]

The Fargione and Searchinger papers stirred up a controversy that simmers to this day. In a letter published in *Science* magazine,[3] Michael Wang of Argonne Laboratory's Transportation Technology Center and Zia Haq of the Department of Energy's Office of Biomass criticized Searchinger et al.'s assumptions and methods. In various rebuttals, Searchinger argued that his critics, who also included the California Air Resources Board (CARB) and the New Fuel Alliance (NFA), misrepresented the study, used inaccurate economics, and employed faulty logic.[4]

Hertel et al. (2010) found that the Fargione and Searchinger studies overestimated life-cycle CO_2 emissions associated with corn-ethanol production. Nonetheless, they concluded that corn ethanol offers no climate benefit compared to conventional gasoline:

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[1] Joseph Fargione, Jason Hill, David Tilman, Stephen Polasky, and Peter Hawthorne, "Land clearing and the biofuel carbon debt," *Sciencexpress*, Feb. 7, 2008, http://www.sjsu.edu/people/dustin.mulvaney/courses/envs133/s1/Fargione%20et%20al%202008%20Land%20Clearing.pdf

[2] Timothy Searchinger, Ralph Heimlich, R. A. Houghton, Fengxia Dong, Amani Elobeid, Jacinto Fabiosa, Simla Tokgoz, Dermot Hayes, and Tun-Hsiang Yu, "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change," *Sciencexpress*, Feb. 7, 2008, http://www.whrc.org/resources/publications/pdf/SearchingeretalScience08.pdf

[3] Available at http://www.bioenergywiki.net/images/2/2c/Wang_response_to_land_use.pdf

[4] Searchinger's response to Wang and Haq and the NFA is available at http://www.bioenergywiki.net/images/3/31/Searchinger_Response.pdf; his response to CARB is available at http://www.bioenergywiki.net/images/4/43/Searchinger_letter_re_letter_to_CARB.pdf.

> Factoring market-mediated responses and by-product use into our analysis reduces cropland conversion by 72% from the land used for the ethanol feedstock. Consequently, the associated GHG release estimated in our framework is 800 grams of carbon dioxide per megajoule (MJ); 27 grams per MJ per year, over 30 years of ethanol production, or roughly a quarter of the only other published estimate of releases attributable to changes in indirect land use. Nonetheless, 800 grams are enough to cancel out the benefits that corn ethanol has on global warming, thereby limiting its potential contribution in the context of California's Low Carbon Fuel Standard.[5]

Even if we assume, per Wang et al. (2007),[6] that corn ethanol achieves a 20% life-cycle reduction in greenhouse gas emissions compared to gasoline, the RFS may still be an inefficient mitigation strategy.

Consider a related biofuel policy, the volumetric ethanol excise tax credit (VEETC), which expired in December 2011. In July 2010, the Congressional Budget Office (CBO) analyzed the budgetary cost in foregone tax revenue of each ton of CO_2 avoided through the VEETC.[7] Citing Wang et al., CBO assumed that on a Btu-equivalent basis, corn ethanol emits 20% less CO_2 than does gasoline or diesel fuel.

CBO estimated that "taxpayers' costs for reducing greenhouse gas emissions through the ethanol tax credit are $754 per metric ton of CO2e (that is, per metric ton of greenhouse gases measured in terms of an equivalent amount of carbon dioxide), and about $300 per metric tons of CO2e for biodiesel." CBO noted that if the VEETC is responsible for only 15% of ethanol consumption, as Iowa State University researchers had estimated,[8] then "the costs to taxpayers of reducing emissions through the credits would be about $1,700 per metric ton of CO2e rather than roughly $750."

For perspective, the Energy Information Administration (EIA) estimated that under the American Clean Energy and Security Act, emission allowances in the "basic case" would sell for

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[5] Thomas W. Hertel, Alla A. Golub, Andrew D. Jones, Michael O'Hare, Richard J. Plevin, and Daniel M. Kammen, "Global Land Use and Greenhouse Gas Emissions: Estimating Market-mediated Responses," *BioScience* Vol. 60, No. 3, March 2010, http://www.aibs.org/bioscience-press-releases/resources/Hertel.pdf

[6] Michael Wang, May Wu, and Hong Huo, "Life-Cycle Energy and Greenhouse Gas Emission Impacts of Different Corn Ethanol Plant Types," Environmental Research Letters, vol. 2, no. 2 (2007), http://iopscience.iop.org/1748-9326/2/2/024001/pdf/erl7_2_024001.pdf

[7] Congressional Budget Office, Using Biofuel Tax Credits to Achieve Energy and Environmental Policy Goals, July 2010, http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/114xx/doc11477/07-14-biofuels.pdf

[8] Bruce A. Babcock, Kanlaya Barr, and Miguel Carriquiry, *Costs and Benefits to Taxpayers, Consumers, and Producers from U.S. Ethanol Policies*, Staff Report 10SR-106, Center for Agricultural and Rural Development, Iowa State University, July 2010, http://www.card.iastate.edu/publications/DBS/PDFFiles/10sr106.pdf

$32 per metric ton in 2020 and $65 per metric ton in 2030.[9] Per ton of CO_2 avoided, the VEETC was about 11 to 24 times more costly than ACESA.

How does the RFS compare to ACESA on a bang-for-buck basis? To answer this question, we first need to estimate two quantities: (1) the total annual tons of CO_2 avoided through the RFS and (2) the total annual cost of such mitigation.

Here's my back-of-the-envelope, beginning with annual tons avoided. A Purdue University analysis found that even without the RFS, refiners would continue to blend ethanol as an octane booster and oxygenate at levels close to E10.[10] Similarly, the Iowa State University study referenced above estimated that in 2011, the RFS would increase ethanol production by 1.72 billion gallons.[11]

TABLE 1. Average results for ethanol policy scenarios in 2011

Ethanol Policies in Place	Corn Price ($/bu)	U.S. Ethanol Price[a] ($/gal)	Brazil Ethanol Price[b] ($/gal)	RIN Price ($/gal)	U.S. Ethanol Production (BG[c])	Imported Ethanol (MG[d])
Mandate, Tax Credit, Tariff	3.79	1.83	1.76	0.07	13.51	13
Mandate, Tax Credit	3.78	1.82	1.80	0.07	13.48	83
Mandate, Tariff	3.56	1.71	1.76	0.32	12.83	0
Mandate Only	3.55	1.71	1.78	0.32	12.80	37
Mandate, Tax Credit = Tariff	3.79	1.83	1.77	0.07	13.51	13
No Programs	2.98	1.55	1.76	0.0	11.08	11

[a]Average U.S. wholesale price. Includes any RIN price.
[b]Wholesale domestic Brazilian ethanol price for anhydrous ethanol. The exchange rate is set at 1.75 reals per dollar.
[c]Billion gallons.
[d]Million gallons.

Figure Source: *Babcock et al. (2010)*

On the other hand, U.S. ethanol production increased from 3.9 billion gallons in 2005, when Congress created the RFS, to 13.9 billion in 2011 (declining to 13.3 billion gallons in 2012 due to

[9] Energy Information Administration, E*nergy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009*, p. 12, http://www.eia.gov/oiaf/servicerpt/hr2454/pdf/sroiaf(2009)05.pdf
[10] Wallace E. Tyner, Farzad Taheripour, and Chris Hurt, *Potential Impacts of a Partial Waiver of the Ethanol Blending Rules*, Farm Foundation and Purdue University, August 16, 2012, pp. 3-4, http://www.farmfoundation.org/news/articlefiles/1841-Purdue%20paper%20FINAL%20%2010-17-12.pdf
[11] Babcock, Barr, and Carriquiry, *Ibid.*, Table 1, p. 16

the drought).[12] Was it just a coincidence that ethanol production more than tripled after Congress created the RFS in 2005 and expanded it in 2007? If so, the RFS – at least to date – has much less impact on the U.S. motor fuel market than either proponents or critics contend.

As a plausible starting point, let's assume that in recent years, the RFS is responsible for increasing ethanol consumption by at least 2 billion gallons annually above a no-RFS baseline and potentially by as much as 6 billion gallons. Since ethanol has two-thirds the energy content of gasoline,[13] it follows that the RFS displaces 1.3-4.0 billion gallons of gasoline per year. Since each gallon of gasoline emits 2.791 kilograms of CO_2,[14] the gasoline currently displaced by ethanol would if combusted emit between 3.6 million and 11.2 million metric tons of CO_2 annually. Finally, if we assume that ethanol emits 20% less CO_2 than the gasoline it displaces, the RFS avoids between 744,000 and 2,223,800 metric tons of CO_2 annually.

At what cost? The RFS imposes costs on refiners,[15] livestock producers,[16] restaurants,[17] domestic food consumers,[18] motorists,[19] and grain-import dependent developing countries.[20] Estimates of these costs are controversial, but they range in the billions of dollars. Tufts University researcher Timothy Wise estimates that U.S. ethanol production cost developing countries $6.6 billion in higher corn prices from 2005-6 to 2010-11. That averages out to more than $1 billion annually.[21] The recent surge in renewable identification number (RIN) credit prices could increase gasoline prices by 7 cents per gallon this year, imposing a hidden fuel tax of $11.5 billion on motorists.[22] The Congressional Research Service (CRS) projects that the RFS

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[12] Renewable Fuels Association, Statistics, http://www.ethanolrfa.org/pages/statistics#A

[13] Energy Information Administration, Frequently Asked Questions: How much ethanol is in gasoline and how does it affect fuel economy? http://www.eia.gov/tools/faqs/faq.cfm?id=27&t=4

[14] International Carbon Bank & Exchange, http://www.icbe.com/carbondatabase/CO2volumecalculation.asp.

[15] NERA Economic Consulting, *Economic Impacts Resulting from Implementation of RFS2 Program*, October 2012, http://www.api.org/~/media/Files/Policy/Alternatives/13-March-RFS/NERA_EconomicImpactsResultingfromRFS2Implementation.pdf

[16] Thomas Elam, *Ethanol Production: Impact on Meat and Poultry Consumption, Value, and Jobs*, FarmEcon LLC, October 30, 2012, http://www.farmecon.com/Documents/RFS%20Meat%20production%20impacts%20ELAM%2010-30-12.pdf

[17] PWC, *Federal Ethanol Policies and Chain Restaurant Food Costs*, November 2012, http://www.nccr.net/flipbook/index.html#/0

[18] Thomas Elam, *Food Costs Are Eating American Family Budgets*, FarmEcon LLC, January 8, 2013, http://www.farmecon.com/Documents/Food%20Spending%20Eating%20American%20Budgets%20ELAM%201-8-13.pdf

[19] Bill Lapp and Dave Juday, "Biofuels Policy Itself Is Warning That It's Near Breaking Point," GlobalWarming.Org, May 1, 2013, http://www.globalwarming.org/2013/05/01/biofuels-policy-itself-is-warning-that-its-near-breaking-point/#more-16668

[20] Timothy A. Wise, *The Cost to Developing Countries of U.S. Corn Ethanol Expansion*, Global Development and Environment Institute Working Paper No. 12-02, October 2012, http://www.ase.tufts.edu/gdae/Pubs/wp/12-02WiseGlobalBiofuels.pdf

[21] Wise, Ibid., p. 3

[22] Lapp and Juday, Ibid.

will lead "to an annual increase in the cost of food per capita of about $10 by 2022, or over $3 billion."[23] This may be a gross underestimate.

According to economist Thomas Elam, in current 2012 dollars, the average U.S. consumer paid a 2012 food bill that was $514 higher than the pre-2005 food-price trend. For the nation as a whole, the above-trend food bill in 2012 was $162 billion. Of that, about $71.3 billion, or 44%, is "due to 2005-2012 price increases for grains, soybean products, DDGS [distiller's dried grains with solubles, an ethanol byproduct] and hay." Although other factors also contribute to food-price inflation, the RFS was an important factor, Elam contends.[24]

The fact that the RFS bestows windfalls on corn farmers, increasing demand for their product and increasing the value of farm land, does not negate or cancel out the costs imposed on others. Cap-and-trade is the appropriate analogy here. Those who receive free emission allowances reap windfalls, as do producers of low- and-zero carbon energy. Nonetheless, to assess the efficiency of the program, the per-ton cost of emission reductions must be estimated.

Let's begin with the implausible assumption that the costs of the RFS are as low as $100 million annually. If, as crudely estimated above, the RFS avoids 744,000 to 2,223,800 metric tons of CO_2 annually, the RFS reduces CO_2 emissions at a cost of $44.78 to $134.40 per ton. The higher of those costs is more than double the EIA-estimated price of ACESA emission permits in 2030.

If, as seems more realistic, the combined burden on adversely affected interests ranges in the billions of dollars, then the RFS is grossly inefficient compared to ACESA. For example, if refiners, livestock producers, and consumers combined pay only an additional $500 million annually, then the RFS costs between $223.90 and $672.00 per ton of CO_2 avoided. If ACESA's projected emission allowances prices had been that high, it likely would not have passed in the House.

Recommendation: Ask CBO to assess the cost-effectiveness of the RFS as a mitigation program. The analysis should reflect the range of estimates in reputable studies regarding: (a) How much the RFS increases ethanol consumption above a no-RFS baseline; (b) the life-cycle carbon intensity of ethanol compared to gasoline; and (c) the economic impacts on refiners, livestock producers, restaurants, food consumers, motorists, developing-country grain importers, and others who bear the costs of the RFS program.

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[23] Congressional Research Service, *Renewable Fuel Standard (RFS): Overview and Issues*, March 14, 2013, p. 17, http://www.fas.org/sgp/crs/misc/R40155.pdf

[24] Elam, Ibid, p. 6

Addendum: What do recent developments in domestic energy production and climate science indicate about the original rationales for the RFS program?

Congress enacted the RFS in 2005 and expanded it in 2007. That period was a high watermark of U.S. oil import dependence. The expert consensus at the time held that America was fated to become ever more dependent on imported oil and natural gas.

During those same years, Vice President Al Gore's *An Inconvenient Truth*, the Bali Road Map[25] (anticipating the Copenhagen climate conference), the devastation of New Orleans by Hurricane Katrina, the *Stern Review* on climate change economics,[26] and the IPCC's *Fourth Assessment Report*[27] set the terms of national debate on climate change.

The tenor of the times was, in a word, one of alarm. Fear of peak oil merged with fear of climatic disruption to produce a policy – the RFS – that aimed both to reduce U.S. oil dependence and mitigate global climate change. A lot has happened since then.

Energy

In recent years, the national security rationale for regulating America 'beyond petroleum' has become less persuasive, as advances in unconventional oil and gas production rapidly transform North America into a major hydrocarbon producing region. Imports as a share of U.S. petroleum consumption declined from 60% in 2005 to 40% in 2012.[28]

By 2011, more than half the imports came from the Western hemisphere, with Canada's share more than twice that of Saudi Arabia. Petroleum products became America's leading export for the first time in 2011,[29] and again topped the list in 2012.[30]

Some experts now view the "shale revolution" as a source of U.S. global leadership and geopolitical influence. U.S. hydrocarbon exports, they contend, have the potential to undermine Russia's leverage over Europe, weaken OPEC, improve relationships with friendly

[25] http://unfccc.int/key_documents/bali_road_map/items/6447.php
[26] *Stern Review on the Economics of Climate Change*, 2006, http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/sternreview_index.htm
[27] http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html
[28] Energy Information Administration, "How dependent are we on foreign oil?" http://www.eia.gov/energy_in_brief/article/foreign_oil_dependence.cfm
[29] AP, "In a first, gas and other fuels are top U.S. export," *USA Today*, December 31, 2011, http://usatoday30.usatoday.com/money/industries/energy/story/2011-12-31/united-states-export/52298812/1
[30] U.S. Census Bureau, *U.S. International Trade in Goods and Services December 2012*, February 8, 2013, http://www.bea.gov/newsreleases/international/trade/2013/pdf/trad1212.pdf

nations such as Japan and South Korea, and strengthen the U.S. bargaining position vis-à-vis our top creditor – China.[31]

Analyses by Citibank,[32] Wood McKenzie,[33] and IHS Global Insight[34] support the assessment of energy analyst Mark Mills that "unleashing the North American energy colossus" could create millions of new jobs by 2020 and provide hundreds of billions in cumulative new federal, state, and local tax revenues.[35]

In a study released this week, Mills makes the case that more than two-thirds of America's annual $750 billion trade deficit could be eliminated if Congress and the Obama administration remove political impediments to hydrocarbon energy development, approve all qualified entities seeking to export natural gas, and direct the Department of Commerce to approve exports of crude oil.[36]

In short, a bright future for hydrocarbon energy now competes in the public mind with yester-year's gloomy prognostications of depletion, dependency, and decline. In 2007, legislators did not know how rapidly advances in directional drilling and hydraulic fracturing would change the U.S. energy outlook. The energy security assumptions underpinning the RFS are dated and, arguably, false. For this reason, too, the Committee's reassessment is timely and commendable.

Climate

For many years, a constant refrain of carbon mitigation advocates has been that climate change is "even worse" than scientists previously believed – as if all news about the state of the climate must inevitably be bad news. This once-fashionable narrative is losing credibility and influence.

One reason is simply that "it's worse than we predicted" is hard to square with a 15-year period of no-net global warming. The long pause in global warming is a development IPCC-affiliated scientists did not predict and struggle to explain.[37] Whatever the underlying causes, what

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[31] Testimony of Amy Meyers Jaffe, Subcommittee on Energy and Power, "U.S. Energy Abundance: Exports and the Changing Global Energy Landscape," May 7, 2013, http://docs.house.gov/meetings/IF/IF03/20130507/100793/HHRG-113-IF03-Wstate-JaffeA-20130507.pdf

[32] Citibank, *Energy 2020: North America, the New Middle East?* March 20, 2012, http://fa.smithbarney.com/public/projectfiles/ce1d2d99-c133-4343-8ad0-43aa1da63cc2.pdf

[33] Wood McKenzie, U*.S. Supply Forecast and Potential Jobs and Economic Impacts (2012-2020)*, September 7, 2011, http://www.api.org/newsroom/upload/api-us_supply_economic_forecast.pdf

[34] IHS, *The Economic and Employment Contributions of Shale Gas in the U.S.*, http://www.ihs.com/info/ecc/a/shale-gas-jobs-report.aspx

[35] Mark P. Mills, *Unleashing the North American Energy Colossus: Hydrocarbons Can Fuel Growth and Prosperity*, Manhattan Institute Power & Growth Initiative Report, No. 1, July 2012, http://www.manhattan-institute.org/html/pgi_01.htm#notes

[36] Mark P. Mills, *The Case for Exports: America's Hydrocarbon Industry Can Revive the Economy and Eliminate the Trade Deficit*, Power & Growth Initiative Report No. 3 May 2013, http://www.manhattan-institute.org/html/pgi_03.htm

[37] Judith Curry, "Has Trenberth Found the Missing Heat?" March 29, 2013, http://judithcurry.com/2013/03/29/has-trenberth-found-the-missing-heat/

cannot be denied, NASA scientist Roy Spencer argues, is that the observed rate of warming over the past 15 years is lower than the IPCC's best estimate. [38]

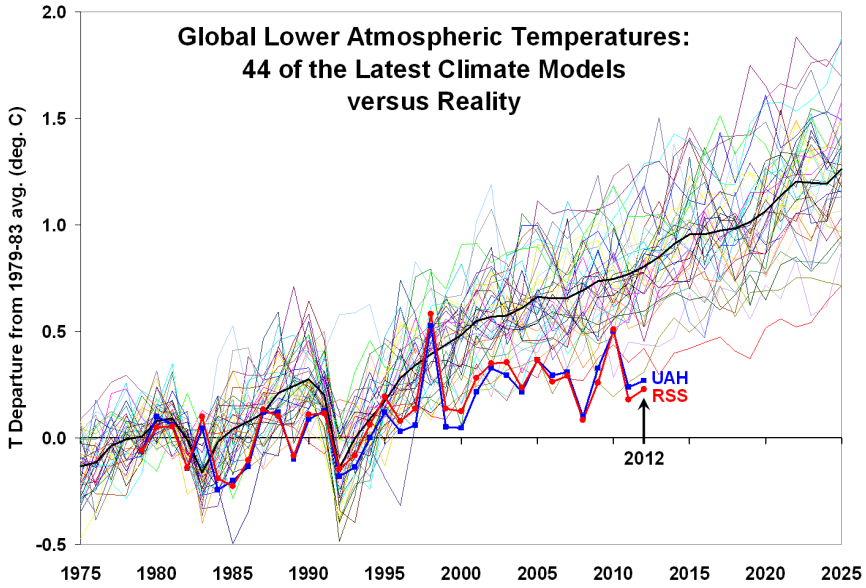

Figure Source: *John Christy and Roy Spencer. The thin colored lines are climate model projections of global temperature change. The black line is the IPCC best estimate. The thicker red and blue lines are satellite-based temperature observations.*

There are competing hypotheses but a plausible explanation, based on several 2012 studies summarized by Cato Institute climatologist Chip Knappenberger, is that the climate system is less sensitive to greenhouse forcing than "consensus" science had assumed.[39]

[38] Roy Spencer, "Global Warming Slowdown: The View from Space," April 13, 2013, http://www.drroyspencer.com/2013/04/global-warming-slowdown-the-view-from-space/

[39] Chip Knappenberger, "Global Lukewarming: Another Good Intellectual Year (2012 Edition)," MasterResource.Org, February 4, 2013, http://www.masterresource.org/2013/02/lukewarmers-2012-edition/

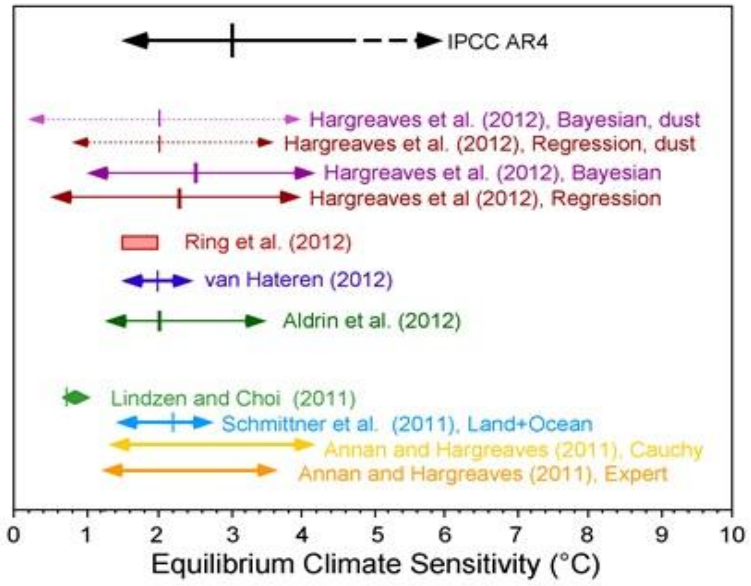

***Figure explanation**: Climate sensitivity estimates from new research published since 2010 (colored), compared with the range given in the IPCC Fourth Assessment Report (black). The arrows indicate the 5 to 95% confidence bounds for each estimate along with the mean (vertical line) where available. Ring et al. (2012) present four estimates of the climate sensitivity and the red box encompasses those estimates. The right-hand side of the IPCC range is dotted to indicate that the IPCC does not actually state the value for the upper 95% confidence bound of their estimate. The thick black line represents the IPCC's "likely" range.*

Otto et al. (2013), a study published this week in *Nature*, also indicates that climate sensitivity is at the low-end of the IPCC range.[40] "Using up-to-date data on radiative forcing, global mean surface temperature and total heat uptake in the Earth system," the researchers conclude that the "most likely value" for equilibrium climate sensitivity (ECS) is 2.0°C. In addition, based on observations of the most recent decade, they conclude that the "best estimate" for "the more policy-relevant" transient climate response (TCR)[41] is 1.3°C.

As noted by one of the co-authors, Nicholas Lewis, 14 of the researchers are lead or coordinating authors of IPCC AR5 WGI chapters, and two – Myles Allen and Gabi Hegerl – are

[40] Alexander Otto, Friederike E. L. Otto, Olivier Boucher, John Church, Gabi Heger, Piers M. Forster, Nathan P. Gillett, Jonathan Gregory, Gregory C. Johnson, Reto Knutti, Nicholas Lewis, Ulrike Lohmann, Jochem Marotzke, Gunnar Myhre, Drew Shindell, Bjorn Stevens and Myles R. Allen. Energy Budget Constraints on Climate Response, *Nature Geoscience*, May 19, 2013, http://www.nature.com/ngeo/journal/vaop/ncurrent/pdf/ngeo1836.pdf

[41] TRC is "The global average surface air temperature averaged over a 20-year period centered at the time of CO_2 doubling in a 1% yr–1 increase experiment." IPCC, Climate Change 2007, Working Group I: The Physical Science Basis, T.S.4.5 Climate Response to Radiative Forcing, http://www.ipcc.ch/publications_and_data/ar4/wg1/en/tssts-4-5.html

lead authors of the chapter discussing ECS and TCR estimates as constrained by observational evidence.[42] Lewis describes the significance of the study as follows:

> The take-home message from this study, like several other recent ones, is that the 'very likely' 5–95% ranges for ECS and TCR in Chapter 12 of the leaked IPCC AR5 second draft scientific report, of 1.5–6/7°C for ECS and 1–3°C for TCR, and the most likely values of near 3°C for ECS and near 1.8°C for TCR, are out of line with instrumental-period observational evidence.

Lower climate sensitivity means less warming, hence less damaging climate change impacts. That's good news.

But wait, there's more! In 2006-2007, Al Gore's *An Inconvenient Truth*,[43] Joseph Romm's *Hell and High Water*,[44] and Fred Pearce's *With Speed and Violence*[45] popularized scary climate change impact scenarios, such as ice sheet disintegration and catastrophic sea-level rise, dramatic increases in extreme-weather frequency and/or severity, and climate-destabilizing releases of CO_2 and methane from melting permafrost. Recent scientific studies undercut the credibility of those scenarios. A partial list follows:

- **King et al. (2012)**: The rate of Antarctic ice loss is not accelerating and translates to less than one inch of sea-level rise per century.[46]
- **Faezeh et al. (2013)**: Greenland's four main outlet glaciers are projected to contribute 19 to 30 millimeters (0.7 to 1.1 inches) to sea level rise by 2200 under a mid-range warming scenario (2.8°C by 2100) and 29 to 49 millimeters (1.1 to 1.9 inches) under a high-end warming scenario (4.5°C by 2100). [47]
- **Weinkle et al. (2012)**: There is no trend in the strength or frequency of land-falling hurricanes in the world's five main hurricane basins during the past 50-70 years.[48]
- **Chenoweth and Divine (2012)**: There is no trend in the strength or frequency of tropical cyclones in the main Atlantic hurricane development corridor over the past 370 years.[49]

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[42] Nic Lewis, "New energy-budget derived estimates of climate sensitivity and transient response in *Nature Geoscience*," Bishop Hill Blog, May 19, 2013, http://bishophill.squarespace.com/blog/2013/5/19/new-energy-budget-derived-estimates-of-climate-sensitivity-a.html

[43] Al Gore, *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It* (New York: Rodale, 2006)

[44] Joseph Romm, *Hell and High Water: Global Warming – the Solution and the Politics – and What We Should Do* (New York: William Morrow, 2007)

[45] Fred Pearce, *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change* (Boston: Beacon Press, 2007)

[46] Matt A. King, Rory J. Bingham, Phil Moore, Pippa L. Whitehouse, Michael J. Bentley & Glenn A. Milne, 2012. Lower satellite-gravimetry estimates of Antarctic sea-level contribution. *Nature*, Vol. 491, 586–589, http://www.nature.com/nature/journal/v491/n7425/full/nature11621.html

[47] Faezeh M. Nick, Andreas Vieli, Morten Langer Andersen, Ian Joughin, Antony Payne, Tamsin L. Edwards, Frank Pattyn & Roderik S. W. van de Wal, 2013. Future sea-level rise from Greenland's main outlet glaciers in a warming climate. *Nature*, Vol. 497, 235-238, http://www.nature.com/nature/journal/v497/n7448/full/nature12068.html

[48] Jessica Weinkle, Ryan Maue, Roger Pielke, Jr., 2012. Historical Tropical Cyclone Landfalls. *Journal of Climate*, Vol. 25, 4729-4735, http://sciencepolicy.colorado.edu/admin/publication_files/2012.04.pdf

- **Bouwer (2011)**: There is no trend in hurricane-related damages since 1900 once economic loss data are adjusted for changes in population, wealth, and the consumer price index.[50]
- **NOAA**: There is no trend since 1950 in the frequency of strong (F3-F5) U.S. tornadoes.[51]
- **National Climate Data Center**: There is no trend since 1900 in U.S. soil moisture as measured by the Palmer Drought Severity Index.[52]
- **Hirsch and Ryberg (2011)**: There is no trend in U.S. flood magnitudes over the past 85 years.[53]
- **Dmitrenko et al. (2011)**:[54] Even under the most extreme climatic scenario tested, permafrost thaw in the Siberian shelf will not exceed 10 meters in depth by 2100 or 50 meters by the turn of the next millennium, whereas the bulk of methane stores are trapped roughly 200 meters below the sea floor.[55]
- **Kessler et al. (2011):** Microbes digested the methane released during the 2010 BP Deepwater Horizon oil spill. Any future warming-induced "large-scale releases of methane from hydrate in the deep ocean are likely to be met by a similarly rapid methanotrophic response."[56]
- **Sistla et al. (2013)**: Over the past two decades, warming increased net eco-system carbon storage in the Arctic tundra as the growth of woody biomass outpaced the increase in CO_2 emissions from subsoil microbial activity.[57]
- **Goklany (2009)**: Global deaths and death rates related to extreme weather have declined by 93% and 98%, respectively, since the 1920s.[58]

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[49] Michael Chenoweth and Dmitry Divine, 2012. Tropical cyclones in the Lesser Antilles: descriptive statistics and historical variability in cyclone energy, 1638–2009. *Climate Change*, vol. 113, issue 3, 583-598 http://econpapers.repec.org/article/sprclimat/v_3a113_3ay_3a2012_3ai_3a3_3ap_3a583-598.htm

[50] Laurens M. Bouwer, 2011. Have Disaster Losses Increased Due to Anthropogenic Climate Change? *Bulletin of the American Meteorological Society*, January 2011, http://www.ivm.vu.nl/en/Images/bouwer2011_BAMS_tcm53-210701.pdf

[51] NOAA, U.S. Tornado Climatology, U.S. Annual Count of Strong to Violent Tornadoes (F3+), 1954-2012, http://www1.ncdc.noaa.gov/pub/data/cmb/images/tornado/clim/EF3-EF5.png

[52] "Hansen Is Wrong," *World Climate Report*, August 14, 2012, http://www.worldclimatereport.com/index.php/2012/08/14/hansen-is-wrong/#more-551

[53] R. M. Hirsch & K. R. Ryberg, 2011. Has the magnitude of floods across the USA changed with global CO2 levels? *Hydrological Sciences Journal*, DOI:10.1080/02626667.2011.621895, http://www.tandfonline.com/doi/abs/10.1080/02626667.2011.621895

[54] Igor A. Dmitrenko1, Sergey A. Kirillov, L. Bruno Tremblay, Heidemarie Kassens1, Oleg A. Anisimov, Sergey A. Lavrov, Sergey O. Razumov, Mikhail N. Grigoriev, 2011. Recent changes in shelf hydrography in the Siberian Arctic: Potential for subsea permafrost instability. *Journal of Geophysical Research: Oceans*, DOI: 10.1029/2011JC007218, http://onlinelibrary.wiley.com/doi/10.1029/2011JC007218/abstract

[55] Colin Schultz, "Siberian shelf methane emissions not tied to warming," EOS, DOI: 10.1029/2011EO490014, http://onlinelibrary.wiley.com/doi/10.1029/2011EO490014/abstract

[56] John D. Kessler, David L. Valentine, Molly C. Redmond, Mengran Du1, Eric W. Chan, Stephanie D. Mendes, Erik W. Quiroz, Christie J. Villanueva, Stephani S. Shusta, Lindsay M. Werra, Shari A. Yvon-Lewis, and Thomas C. Weber, 2011. A Persistent Oxygen Anomaly Reveals the Fate of Spilled Methane in the Deep Gulf of Mexico. *Science*, Vol. 331 no. 6015, 312-315, http://www.sciencemag.org/content/331/6015/312.abstract

[57] Seeta A. Sistla, John C. Moore, Rodney T. Simpson, Laura Gough, Gaius R. Shaver & Joshua P. Schimel, 2013. Long-term warming restructures Arctic tundra without changing net soil carbon storage. *Nature* doi:10.1038/ http://www.nature.com/nature/journal/vaop/ncurrent/pdf/nature12129.pdf

- **Range et al. (2012)**: There is no evidence of CO_2-related mortalities of juvenile or adult mussels "even under conditions that far exceed the worst-case scenarios for future ocean acidification."[59]

Notwithstanding such studies, the paradigm of climate disruption still has plenty of fight in it – more so than the paradigm of peak oil. In part, that is because *climate* risk is easily confused with climate *change* risk. Due to their sheer magnitude and terror, natural catastrophes have an almost super-natural aspect. People by nature are prone to imagine that natural disasters have non-natural causes. Thus, each time natural disaster strikes, pundits – especially those with scientific credentials – can plausibly blame fossil fuels and declare "it's worse than we predicted."

Many commentators and even some scientists, for example, implied or asserted that Hurricane Sandy, or its immense devastation, would not have occurred but for global warming. There was, however, no real science to support that narrative.

Roughly 95 tropical storms have hit New York since the 18th century. The strongest on record was the New England Hurricane of 1938, a category 3 storm that killed upwards of 600 people.[60]At the time, global CO_2 concentrations were 310 parts per million[61] – well below the 350 ppm concentration deemed the maximum safe level by former NASA scientist James Hansen.[62]

Sandy was a category 1 storm before making landfall in the Northeast.[63] What made Sandy a "super storm" was its merging with a winter, frontal storm. Some commentators insinuated that any such "frankenstorm" must, like the monster in Mary Shelley's novel, be man-made (anthropogenic). MIT's Kerry Emanuel cautioned that scientists "don't have very good theoretical or modeling guidance on how hybrid storms might be expected to change with climate." He added: "I feel strongly about that. I think that anyone who says we do know that is not giving you a straight answer."[64]

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[58] Indur Goklany, Death and Death Rates from Extreme Weather Events: 1900-2008, *Journal of American Physicians and Surgeons*, Vol. 14, No. 4, Winter 2009, http://www.jpands.org/vol14no4/goklany.pdf

[59] Range, P., Pilo, D., Ben-Hamadou, R., Chicharo,M.A., Matias, D., Joaquim, S., Oliveira, A.P. and Chicharo, L. 2012. Seawater acidification by CO2 in a coastal lagoon environment: Effects on life history traits of juvenile mussels Mytilus galloprovincialis. *Journal of Experimental Marine Biology and Ecology* 424-425: 89-98, http://www.co2science.org/articles/V16/N4/C3.php

[60] Wikipedia, List of New York Hurricanes, http://en.wikipedia.org/wiki/List_of_New_York_hurricanes

[61] Center for the Study of Carbon Dioxide and Global Change, CO2 Concentrations, The Last 1,000 Years, http://co2science.org/subject/other/data/lawdome_co2.php

[62] J. Hansen, M. Sato, P. Kharecha, D. Beerling (3), R. Berner, V. Masson-Delmotte, M. Pagani, M. Raymo, D. L. Royer, and J. C. Zachos, 2008. Target atmospheric CO2: Where should humanity aim? Open Atmos. Sci. J., Vol. 2, 217-231, http://arxiv.org/abs/0804.1126

[63] Willie Drye, "A Timeline of Hurricane Sandy's Path of Destruction," *National Geographic*, November 2, 2012, http://newswatch.nationalgeographic.com/2012/11/02/a-timeline-of-hurricane-sandys-path-of-destruction/

[64] Lisa Palmer, "Hybrid Hell Entry 1: Hurricane Sandy is a kind of storm scientists don't understand well," *Slate*, October 29, 2012,

New York Times columnist Andrew Revkin commendably points out that societal factors determine the magnitude of devastation from extreme weather events to a far greater degree than any possible modification of the climate system. In a column on the recent Oklahoma tornado, he writes:

> I'll add a final thought about the persistent discussion of the role of greenhouse-driven climate change in violent weather in Tornado Alley. . . .It's an important research question but, to me, has no bearing at all on the situation in the Midwest and South — whether there's a tornado outbreak or drought. The forces putting people in harm's way are demographic, economic, behavioral and architectural. Any influence of climate change on dangerous tornadoes (so far the data point to a moderating influence) is, at best, marginally relevant and, at worst, a distraction.[65]

James Hansen is probably the most influential purveyor of the alarm narrative. During the height of last year's drought, he published an op-ed in the *Washington Post* titled "Climate change is here – and worse than we thought." [66] Hansen's evidence was a study that he and two colleagues published in *Proceedings of the National Academy of Sciences*.[67] He contended that the worst hot spells of recent years – the European heat wave of 2003, the Russian heat wave of 2010, the Texas-Oklahoma drought of 2011, and the Midwest drought of 2012 – were "a consequence of climate change" and have "virtually no explanation other than climate change."

There was just one problem. The Hansen team did not examine any of those events to assess the relative contributions of natural variability and global warming. They provided no event-specific evidence that the particular heat wave or drought would not have occurred, or would have been less than record-breaking, in the absence of climate change.

Other scientists did undertake meteorological analyses of those events, and in each case they attributed the event principally to natural variability.

Chase et al. (2006)[68] found "nothing unusual" in the 2003 European heat wave that would indicate a change in global climate. The global temperature map included in the study is telling.

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http://www.slate.com/articles/health_and_science/science/features/2012/hurricane_sandy_and_climate_change/hurricane_sandy_hybrid_storm_kerry_emanuel_on_climate_change_and_storms.html

[65] Andrew Revkin, "A Survival Plan for America's Tornado Disaster Zone," *New York Times*, May 21, 2013, http://dotearth.blogs.nytimes.com/2013/05/21/a-survival-plan-for-americas-tornado-danger-zone/

[66] James Hansen, "Climate change is here – and worse than we thought," *Washington Post*, August 3, 2012, http://www.washingtonpost.com/opinions/climate-change-is-here--and-worse-than-we-thought/2012/08/03/6ae604c2-dd90-11e1-8e43-4a3c4375504a_story.html

[67] James Hansen, Mikako Sato, and Reto Ruedy, 2012. Perception of climate change. *Proceedings of the National Academy of Sciences*, doi/10.1073/pnas.1205276109, http://www.globalwarming.org/wp-content/uploads/2012/08/Hansen-PNAS-Extreme-Heat.pdf

[68] Thomas N. Chase, Klaus Wolter, Roger A. Pielke Sr., Ichtiaque Rasool, 2006. Was the 2003 European Heat Wave Unusual in a Global Context? Geophysical Research Letters, Vol. 33, Issue 23, http://onlinelibrary.wiley.com/doi/10.1029/2006GL027470/abstract

During June, July, and August 2003, more than half the planet was cooler than the mean temperature from 1979 through 2003. Europe – a tiny fraction of the Earth's surface – was the only place experiencing high heat. Europe's anomalous heat was due to local meteorology – atmospheric blocking. There was no discernible link to global climatic factors.

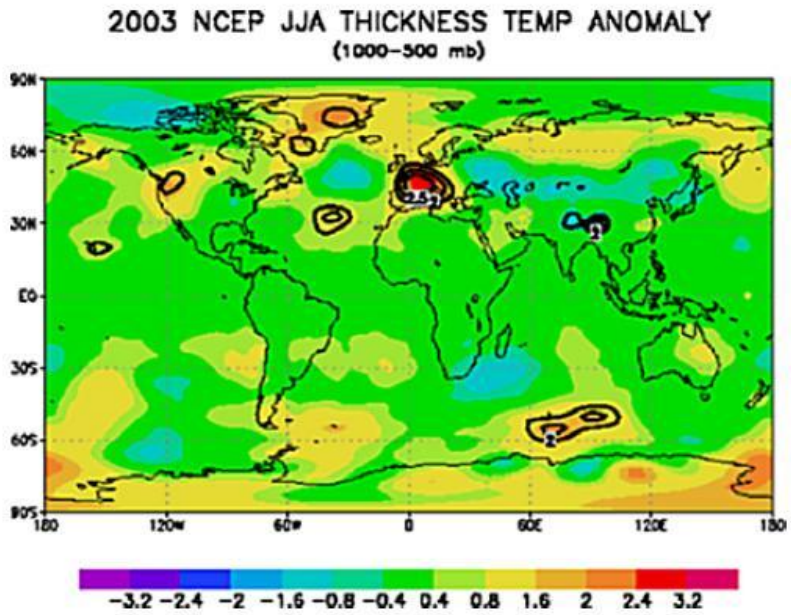

Figure explanation *(courtesy of World Climate Report[69]): 1000–500 mb thickness temperature anomaly for June, July, and August 2003. Green and blue tones indicate below-normal temperature anomalies.*

Similarly, NOAA scientists[70] found that the 2010 Russian heat wave "was mainly due to natural internal atmospheric variability." The study specifically addressed the question of a possible linkage to anthropogenic climate change:

> Despite this strong evidence for a warming planet, greenhouse gas forcing fails to explain the 2010 heat wave over western Russia. The natural process of atmospheric blocking, and the climate impacts induced by such blocking, are the principal cause for this heat wave. It is not known whether, or to what extent, greenhouse gas emissions may affect the frequency or intensity of blocking during summer. It is important to note that observations reveal no trend in a daily frequency of July blocking over the period since 1948, nor is there an appreciable trend in the absolute values of upper tropospheric summertime heights over western Russia for the period since 1900.

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[69] European Heat Wave of 2003: A Global Perspective, *World Climate Report*, January 31, 2007, http://www.worldclimatereport.com/index.php/2007/01/31/european-heat-wave-2003-a-global-perspective/

[70] Dole, R. M. Hoerling, J. Perlwitz, J. Eischeid, P. Pegion, T. Zhang, X. Quan, T. Xu, and D. Murray, 2010. Was There a Basis for Anticipating the Russian 2010 Heat Wave? *Geophysical Research Letters*, 38, L06702, doi:10.1029/2010GL046582, http://www.esrl.noaa.gov/psd/csi/events/2010/russianheatwave/papers.html

The Texas-Oklahoma drought of 2011 broke heat and drought records in several climate divisions in Texas, Oklahoma, and New Mexico. The world is experiencing a period of climatic warmth, and greenhouse gas concentrations keep rising. However, correlation does not prove causation. A complicated analysis is required before one could detect and, if possible, quantify the contribution of climate change to this regional anomaly.

Texas State Climatologist John Nielsen-Gammon conducted a "preliminary analysis" of the role of global warming in the Texas drought.[71] Although not definitive, the study is probably the most thorough analysis to date. Nielsen-Gammon estimates that climate change contributed 0.9°F of the 5.4°F above-average warmth, which was chiefly caused by drought (lack of evaporative cooling). The drought, in turn, has no discernible link to climate change. From 1895 to 2010, precipitation in Texas increased overall by more than 10%, and Texas precipitation variability has not changed since 1920.

Nielsen-Gammon concluded that "even without global warming," the hot spell in Texas "would have broken the all-time record for summer temperatures," and the drought would have been "an outlier and record-setter."

As for the Midwest drought of 2012, NOAA scientists attribute it chiefly to natural variability.[72] From the agency's Web site:

> The central Great Plains drought during May-August of 2012 resulted mostly from natural variations in weather.
>
> - Moist Gulf of Mexico air failed to stream northward in late spring as cyclone and frontal activity were shunted unusually northward.
> - Summertime thunderstorms were infrequent and when they did occur produced little rainfall.
> - Neither ocean states nor human-induced climate change, factors that can provide long-lead predictability, appeared to play significant roles in causing severe rainfall deficits over the major corn producing regions of central Great Plains.

Based on the foregoing discussion of extreme heat events and the studies cited above, I conclude that "worse than we thought" assessments of climate change are not consistent with the best available science. To the contrary, the climate change outlook is better than we have long been told.

In 2007, most legislators did not know that the world was warming more slowly than feared, that long-term hurricane behavior was not changing, that runaway warming from permafrost

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[71] John Nielsen-Gammon, Texas Drought and Global Warming, *Climate Abyss*, September 9, 2011, http://blog.chron.com/climateabyss/2011/09/texas-drought-and-global-warming/

[72] NOAA, An Interpretation of the Origins of the 2012 Central Plains Drought, http://drought.gov/media/pgfiles/DTF%20Interpretation%20of%202012%20Drought%20FINAL%202%20pager.pdf

melting and methane releases was wildly implausible, and that the great ice sheets were more likely to contribute inches rather than feet to sea-level rise.

The scientific assumptions underpinning the RFS are dated and, arguably, false. For this reason, too, the Committee's reassessment of the RFS program is timely and commendable.