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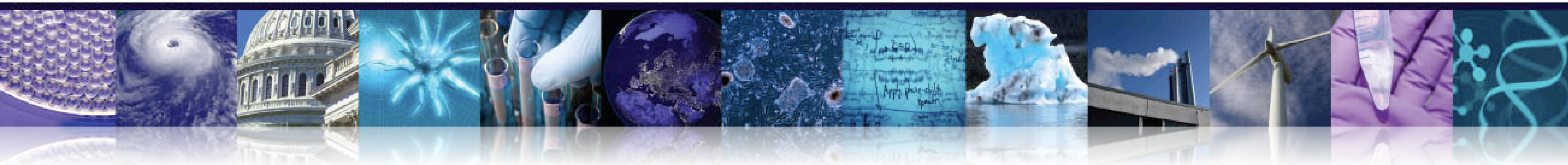
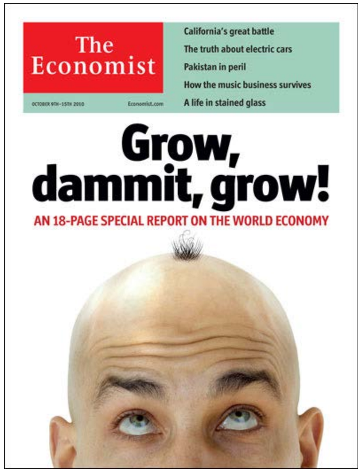
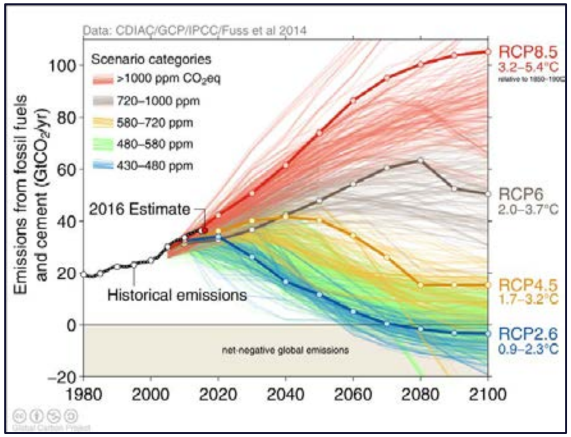


Misusing the Future

Roger A. Pielke, Jr.
University of Colorado

9 February 2018
ALPS Symposium
Tokyo, Japan





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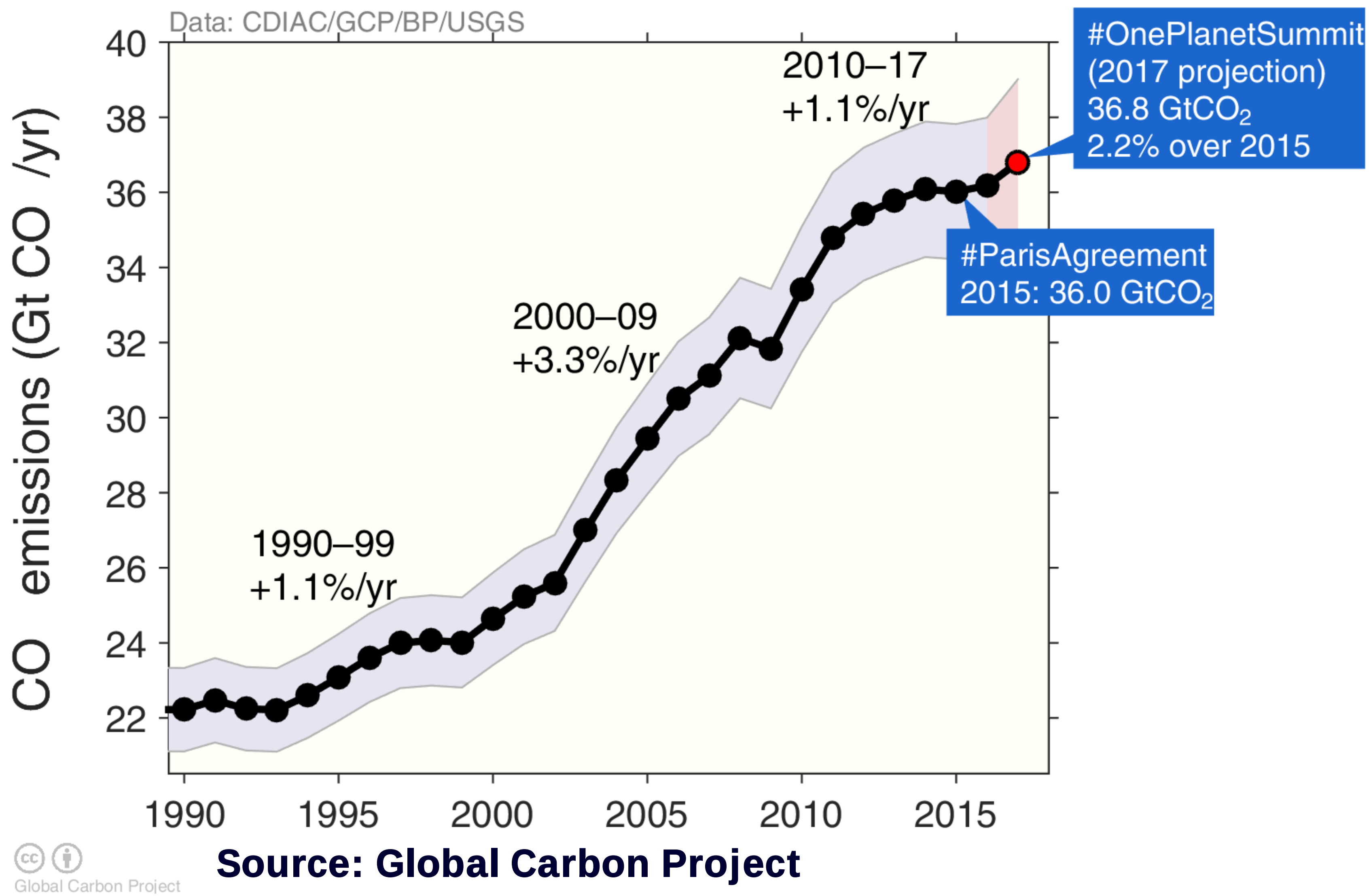
Overview of the talk

- This talk is about how we use the future to think about the present;
- Specifically, how we use scenarios of the future to focus attention on some policy options and lessen attention on others;
- Scenarios are important and necessary. Much excellent work has been done on climate and energy scenarios over decades, especially under the IPCC;
- But like any technology, scenarios can be well or poorly used in practice;

Outline: Three examples and an alternative

1. The magnitude of the challenge
   – Spontaneous decarbonization
2. The costs of inaction
   – RCP 8.5
3. Policy feasibility
   – BECCS
4. An alternative approach
   – Today-Forward planning
   – Focused on increasing the proportion of carbon-free energy consumption

The problem: emissions continue to increase



Source: Global Carbon Project

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Where do emissions come from?

People
engage in economic activity that
uses energy
from carbon emitting generation

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Where do emissions come from?

People	Population	P
Engage in economic activity that	GDP per capita	GDP/P
Uses energy from	Energy intensity of the economy	TE/GDP
Carbon emitting generation	Carbon intensity of energy	C/TE

Carbon emissions = C = ~~P~~ * ~~GD~~P / ~~P~~ * ~~TE~~ / ~~GD~~P * C / ~~TE~~

$$C = P \times \frac{GDP}{P} \times \frac{TE}{GDP} \times \frac{C}{TE}$$

The “Kaya Identity”

Where do emissions come from?

People	Population	P
Engage in economic activity that	GDP per capita	GDP/P
Uses energy from	Energy intensity of the economy	TE/GDP
Carbon emitting generation	Carbon intensity of energy	C/TE

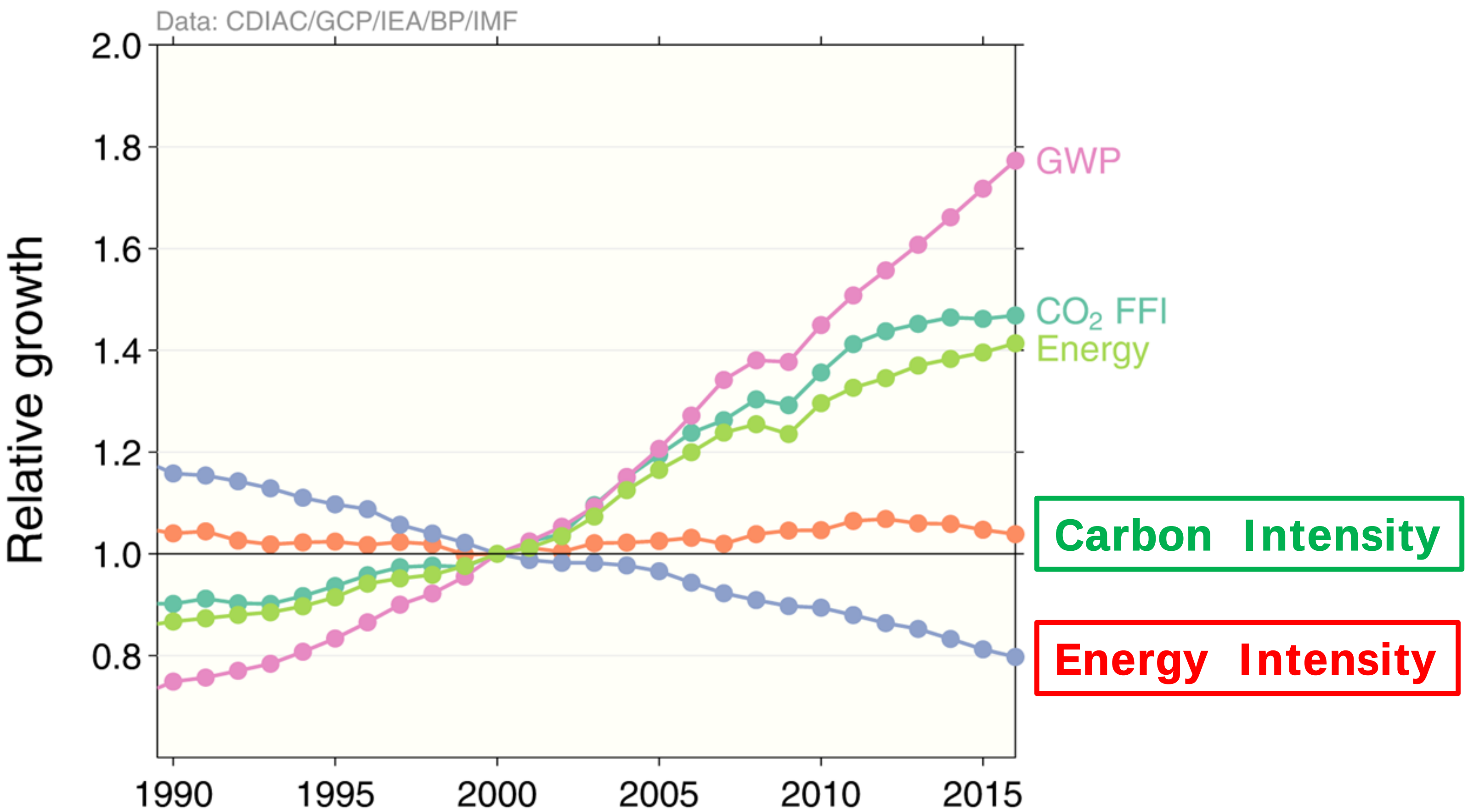
Carbon emissions = C =

$$C = P * \frac{GDP}{P} * \frac{TE}{GDP} * \frac{C}{TE}$$

energy intensity ($\frac{TE}{GDP}$)

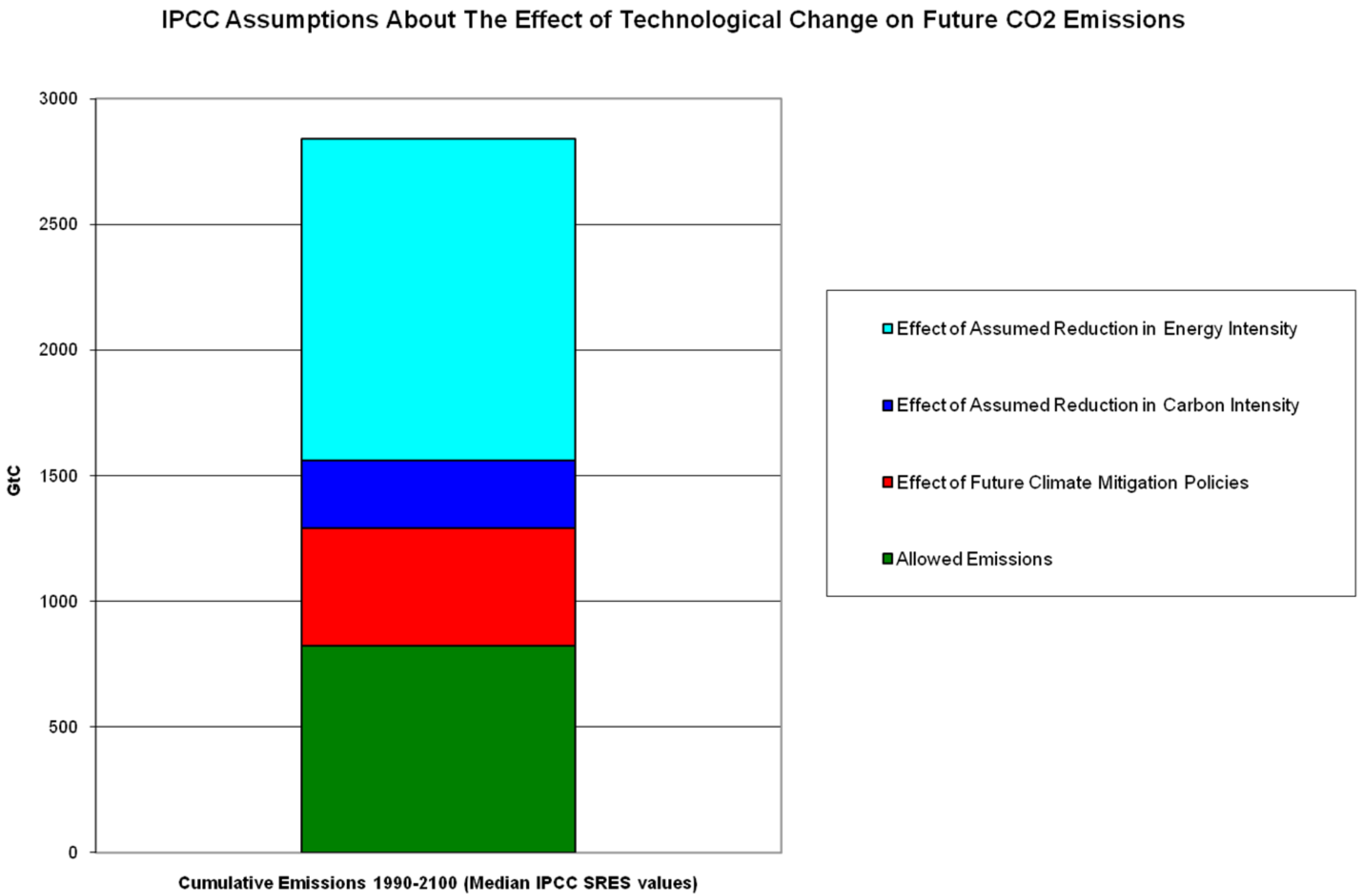
carbon intensity ($\frac{C}{TE}$)

No acceleration in rates of change of CI or EI



Source: Global Carbon Project 2017

Example 1. Spontaneous decarbonization



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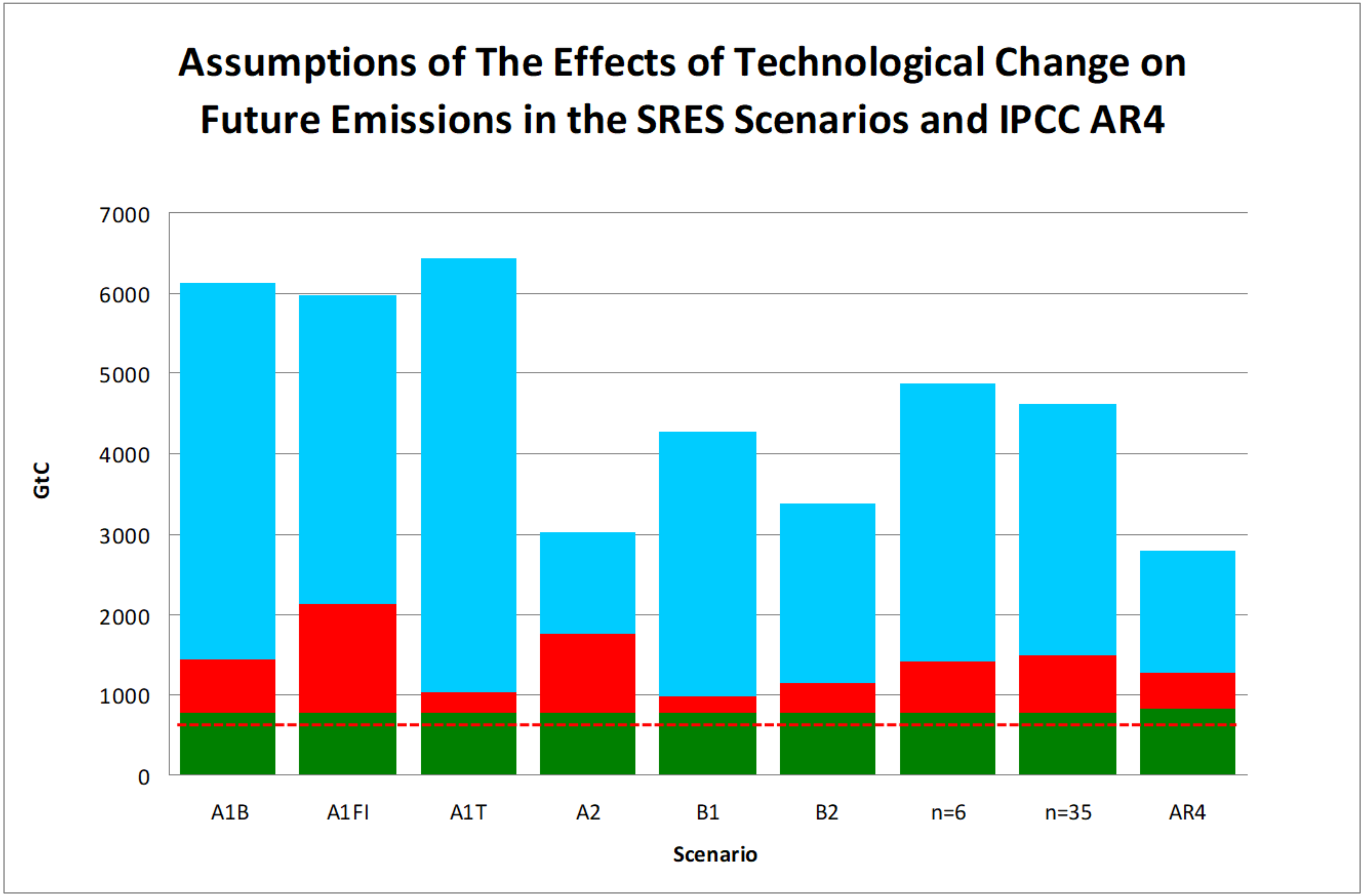
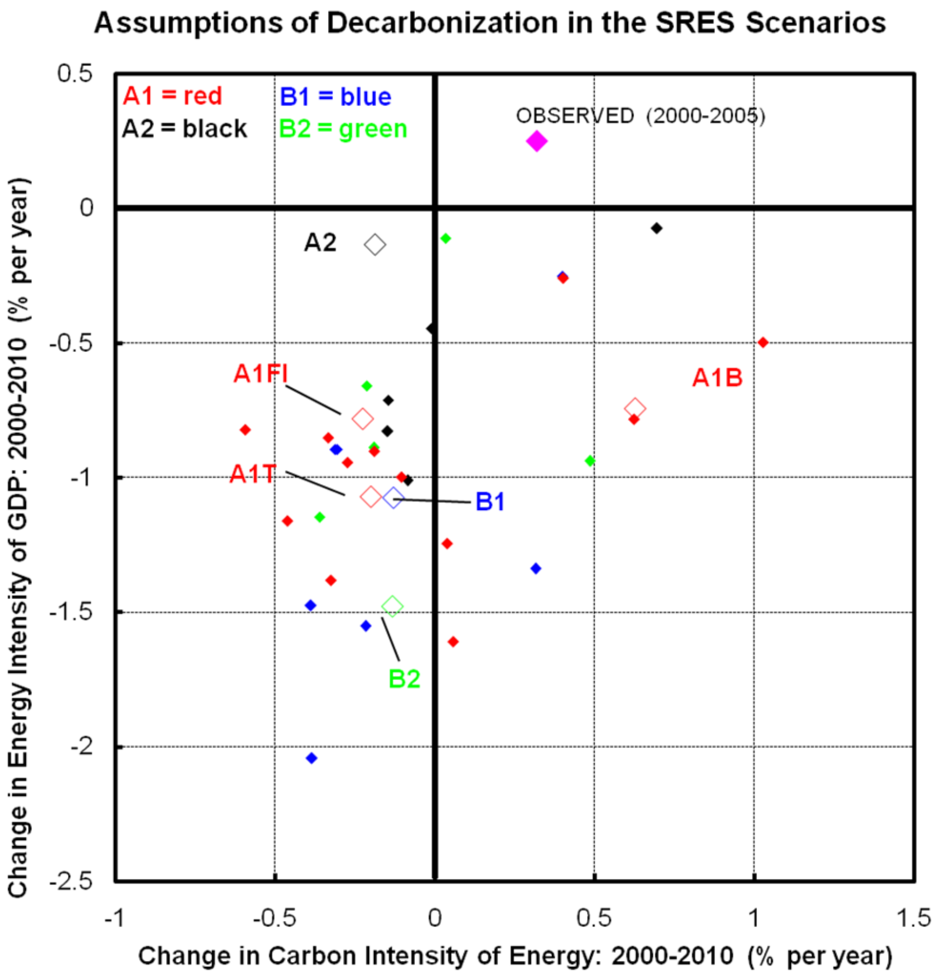
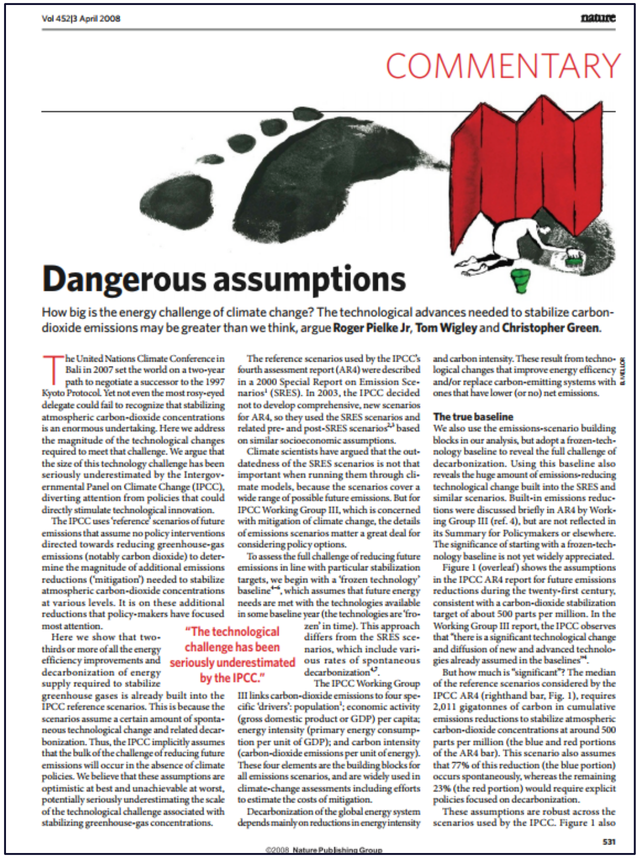
Spontaneous decarbonization does most of the work in the IPCC SRES scenarios



Short-term reality fell outside all SRES scenarios for assumed spontaneous decarbonization





Vol 452|3 April 2008

nature

COMMENTARY

Dangerous assumptions

How big is the energy challenge of climate change? The technological advances needed to stabilize carbon-dioxide emissions may be greater than we think, argue **Roger Pielke Jr**, **Tom Wigley** and **Christopher Green**.

The United Nations Climate Conference in Bali in 2007 set the world on a two-year path to negotiate a successor to the 1997 Kyoto Protocol. Yet not even the most rosy-eyed delegate could fail to recognize that stabilizing atmospheric carbon-dioxide concentrations is an enormous undertaking. Here we address the magnitude of the technological changes required to meet that challenge. We argue that the size of this technology challenge has been seriously underestimated by the Intergovernmental Panel on Climate Change (IPCC), diverting attention from policies that could directly stimulate technological innovation.

The IPCC uses 'reference' scenarios of future emissions that assume no policy interventions directed towards reducing greenhouse-gas emissions (notably carbon dioxide) to determine the magnitude of additional emissions reductions ('mitigation') needed to stabilize atmospheric carbon-dioxide concentrations at various levels. It is on these additional reductions that policy-makers have focused most attention.

Here we show that two-thirds or more of all the energy efficiency improvements and decarbonization of energy supply required to stabilize greenhouse gases is already built into the IPCC reference scenarios. This is because the scenarios assume a certain amount of spontaneous technological change and related decarbonization. Thus, the IPCC implicitly assumes that the bulk of the challenge of reducing future emissions will occur in the absence of climate policies. We believe that these assumptions are optimistic at best and unachievable at worst, potentially seriously underestimating the scale of the technological challenge associated with stabilizing greenhouse-gas concentrations.

"The technological challenge has been seriously underestimated by the IPCC."

The reference scenarios used by the IPCC's fourth assessment report (AR4) were described in a 2000 Special Report on Emission Scenarios[1] (SRES). In 2003, the IPCC decided not to develop comprehensive, new scenarios for AR4, so they used the SRES scenarios and related pre- and post-SRES scenarios[2,3] based on similar socioeconomic assumptions.

Climate scientists have argued that the outdatedness of the SRES scenarios is not that important when running them through climate models, because the scenarios cover a wide range of possible future emissions. But for IPCC Working Group III, which is concerned with mitigation of climate change, the details of emissions scenarios matter a great deal for considering policy options.

To assess the full challenge of reducing future emissions in line with particular stabilization targets, we begin with a 'frozen technology' baseline[4–6], which assumes that future energy needs are met with the technologies available in some baseline year (the technologies are 'frozen' in time). This approach differs from the SRES scenarios, which include various rates of spontaneous decarbonization[4,7].

The IPCC Working Group III links carbon-dioxide emissions to four specific 'drivers': population[1]; economic activity (gross domestic product or GDP) per capita; energy intensity (primary energy consumption per unit of GDP); and carbon intensity (carbon-dioxide emissions per unit of energy). These four elements are the building blocks for all emissions scenarios, and are widely used in climate-change assessments including efforts to estimate the costs of mitigation.

Decarbonization of the global energy system depends mainly on reductions in energy intensity and carbon intensity. These result from technological changes that improve energy efficency and/or replace carbon-emitting systems with ones that have lower (or no) net emissions.

The true baseline

We also use the emissions-scenario building blocks in our analysis, but adopt a frozen-technology baseline to reveal the full challenge of decarbonization. Using this baseline also reveals the huge amount of emissions-reducing technological change built into the SRES and similar scenarios. Built-in emissions reductions were discussed briefly in AR4 by Working Group III (ref. 4), but are not reflected in its Summary for Policymakers or elsewhere. The significance of starting with a frozen-technology baseline is not yet widely appreciated.

Figure 1 (overleaf) shows the assumptions in the IPCC AR4 report for future emissions reductions during the twenty-first century, consistent with a carbon-dioxide stabilization target of about 500 parts per million. In the Working Group III report, the IPCC observes that "there is a significant technological change and diffusion of new and advanced technologies already assumed in the baselines"[4].

But how much is "significant"? The median of the reference scenarios considered by the IPCC AR4 (righthand bar, Fig. 1), requires 2,011 gigatonnes of carbon in cumulative emissions reductions to stabilize atmospheric carbon-dioxide concentrations at around 500 parts per million (the blue and red portions of the AR4 bar). This scenario also assumes that 77% of this reduction (the blue portion) occurs spontaneously, whereas the remaining 23% (the red portion) would require explicit policies focused on decarbonization.

These assumptions are robust across the scenarios used by the IPCC. Figure 1 also

R. MELLOR

531

Pielke Jr, R., Wigley, T., & Green, C. (2008). Dangerous assumptions. *Nature*, *452*(7187), 531.

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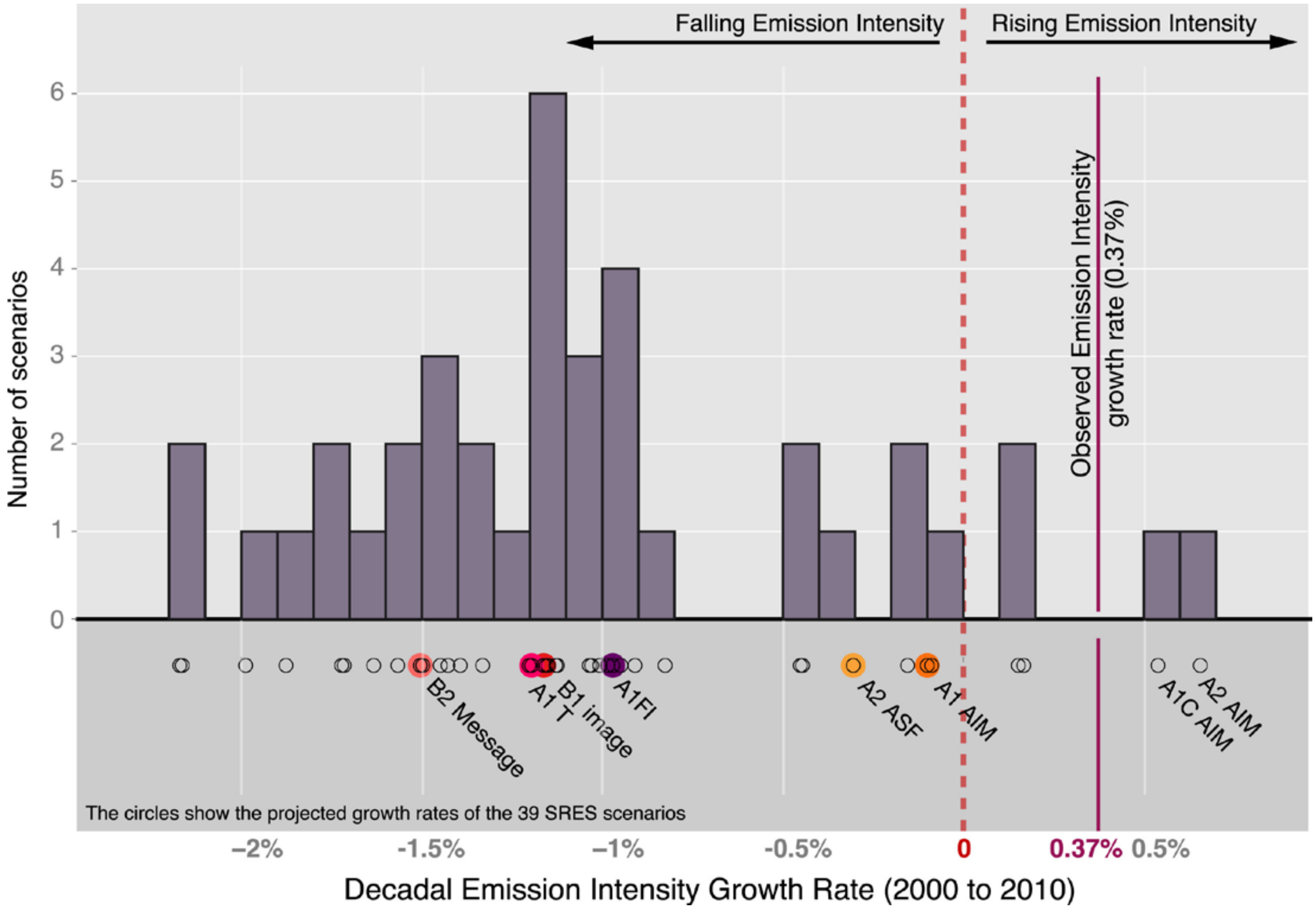
Also through 2010



Pretis, F., & Roser, M. (2017). Carbon dioxide emission-intensity in climate projections: Comparing the observational record to socio-economic scenarios. *Energy*, *135*, 718-725.

Heroic assumptions were repeated in RCPs

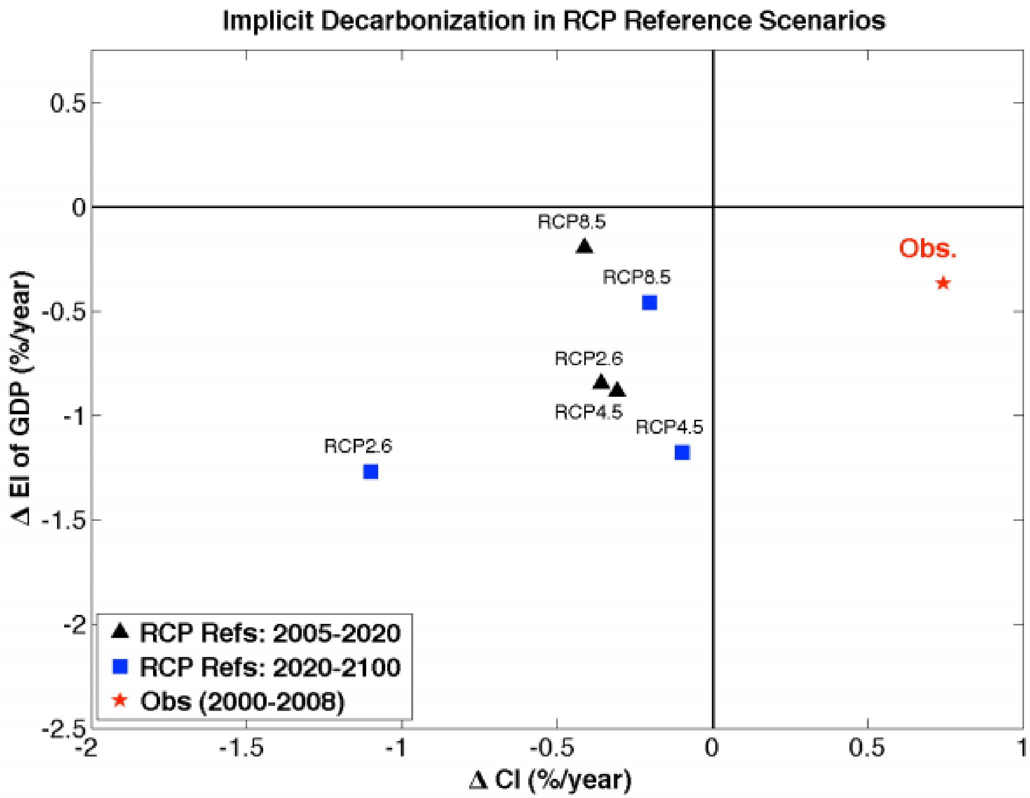


Figure 1: Rates of decarbonization in three of the RCP baseline scenarios for which data is available as compared with the observed rate. This figure is modeled after Figure 2 from [1]. Observations are from the World Bank database for 2000-2008.

Stevenson, S., & Pielke Jr, R. 2015. Assumptions of Spontaneous Decarbonization in the IPCC AR5 Baseline Scenarios. Center for Science and Technology Policy Research, University of Colorado.

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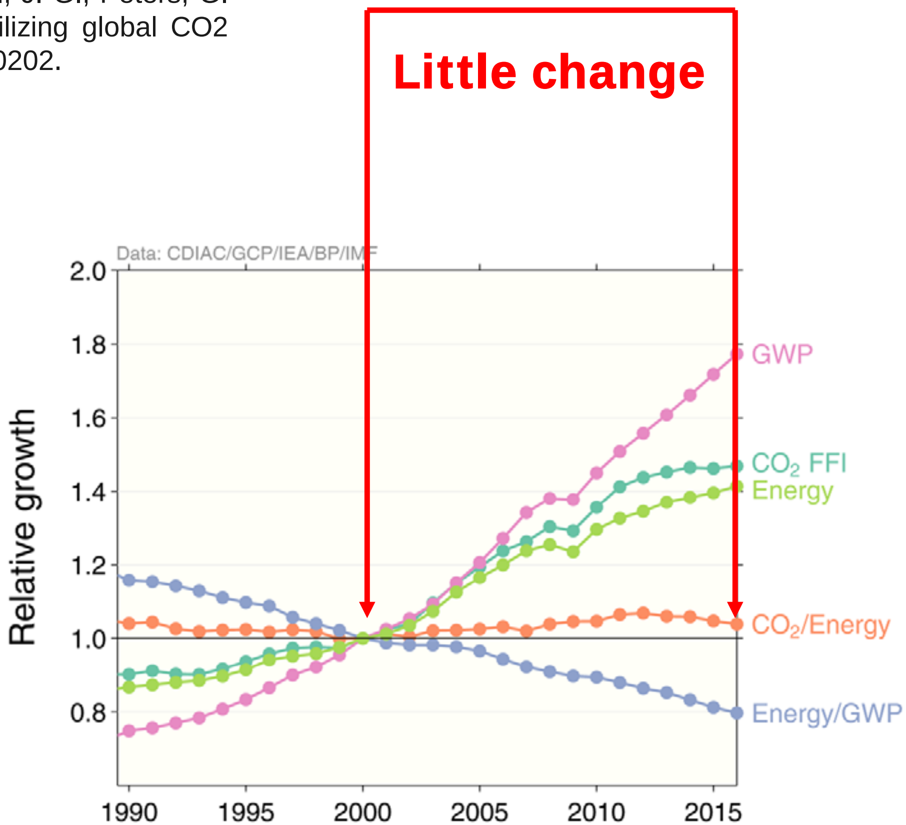
Surprise because reality didn't match assumptions

"One surprise over the past 15 years is how little change there has been in the CO_2 emissions per unit of primary energy consumption"

Jackson, R. B., Le Quéré, C., Andrew, R. M., Canadell, J. G., Peters, G. P., Roy, J., & Wu, L. (2017). Warning signs for stabilizing global CO2 emissions. *Environmental Research Letters*, *12*(11), 110202.



Source: Global Carbon Project 2017

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Projections continue to assume near-term historically unprecedented rates of decarbonization

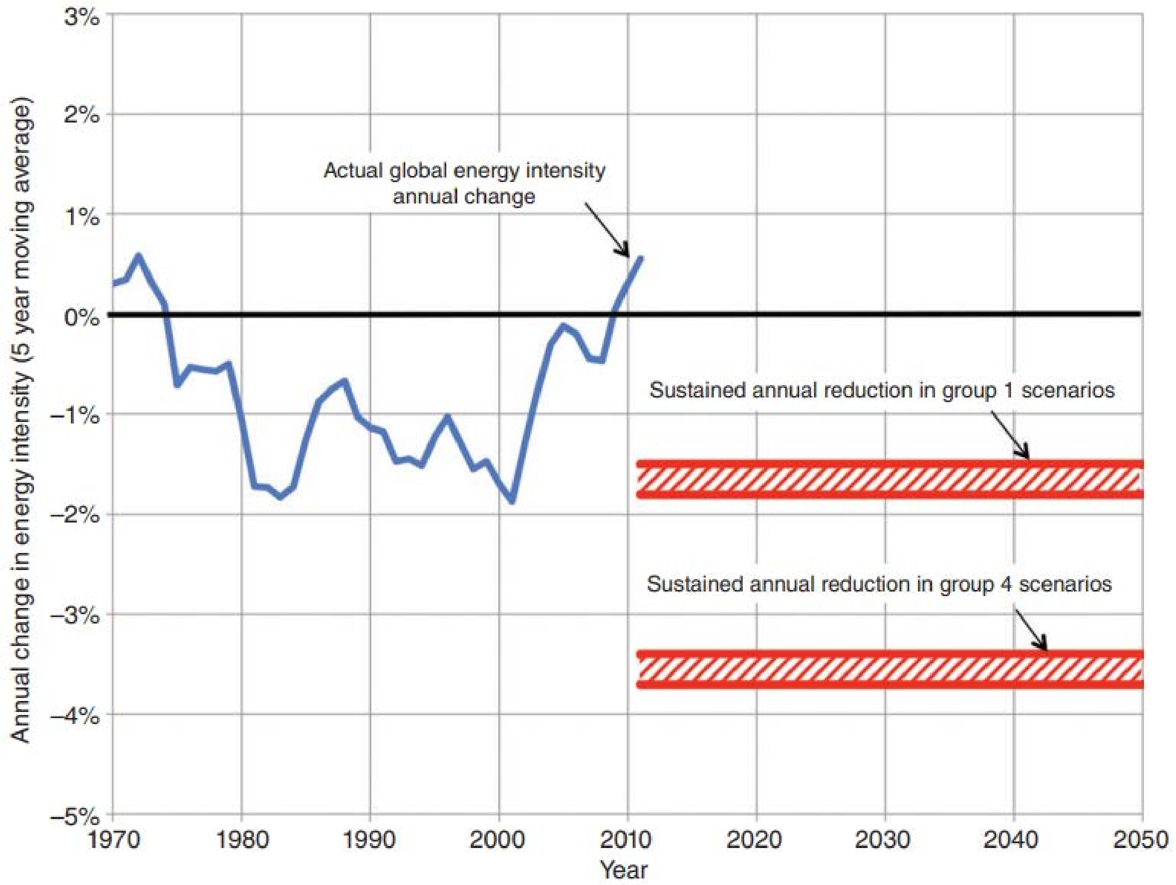
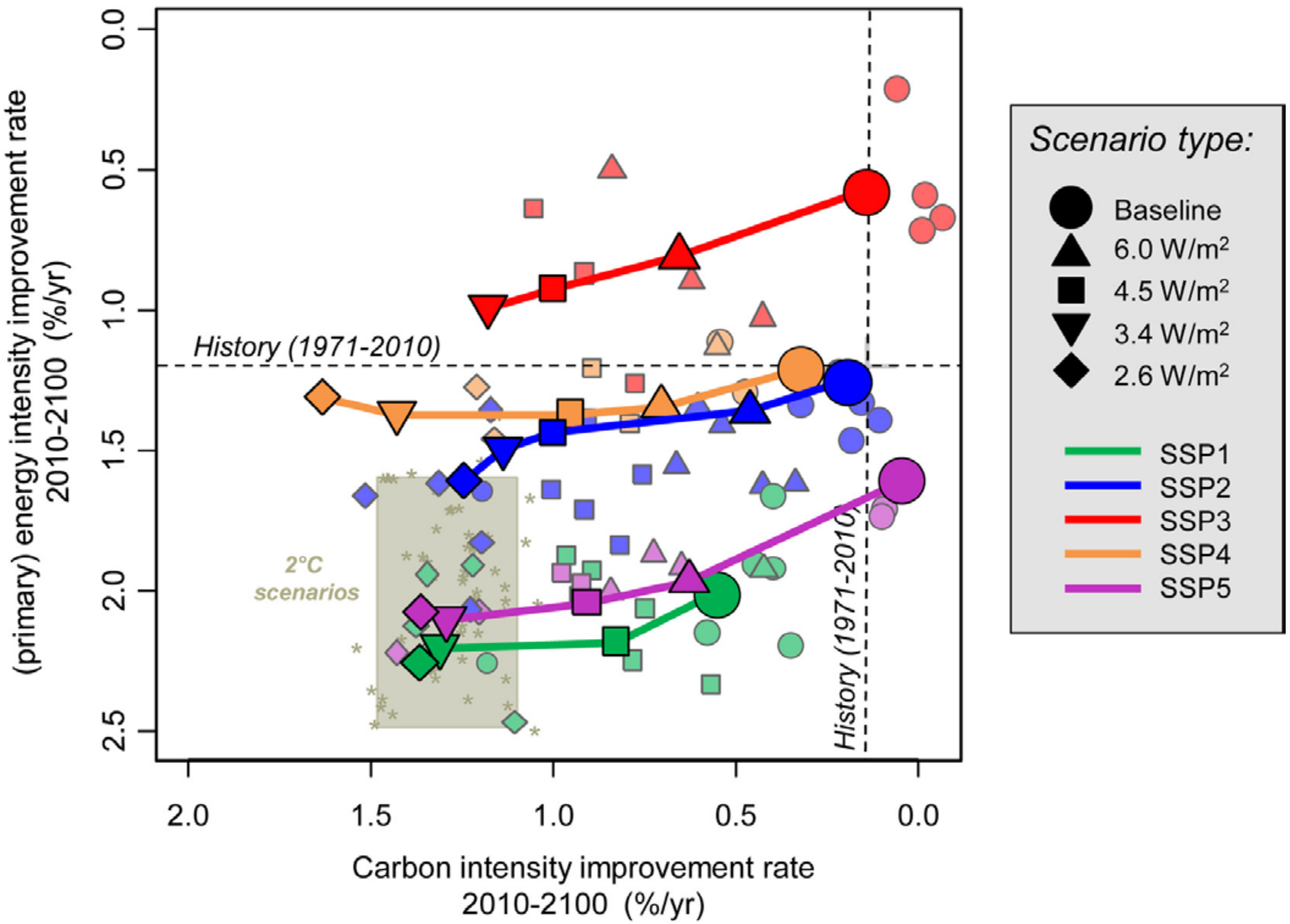


FIGURE 3 | Global trends in energy intensity, past, and projected (sources: Refs 31, 32, and the various studies reviewed herein).

Loftus, P. J., Cohen, A. M., Long, J., & Jenkins, J. D. (2015). A critical review of global decarbonization scenarios: what do they tell us about feasibility?. *Wiley Interdisciplinary Reviews: Climate Change*, *6*(1), 93-112.

Heroic assumptions in the new IPCC SSPs?



Riahi, Keywan, et al. "The shared socioeconomic pathways and their energy, land use, and greenhouse gas emissions implications: an overview." *Global Environmental Change* 42 (2017): 153-168.

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Fudge factors are larger than policy impact

"as a practical matter the [assumed energy efficiency improvement] is a "fudge factor" which allows the results of climate-economy simulations to be tuned according to the analyst's sense of plausibility."

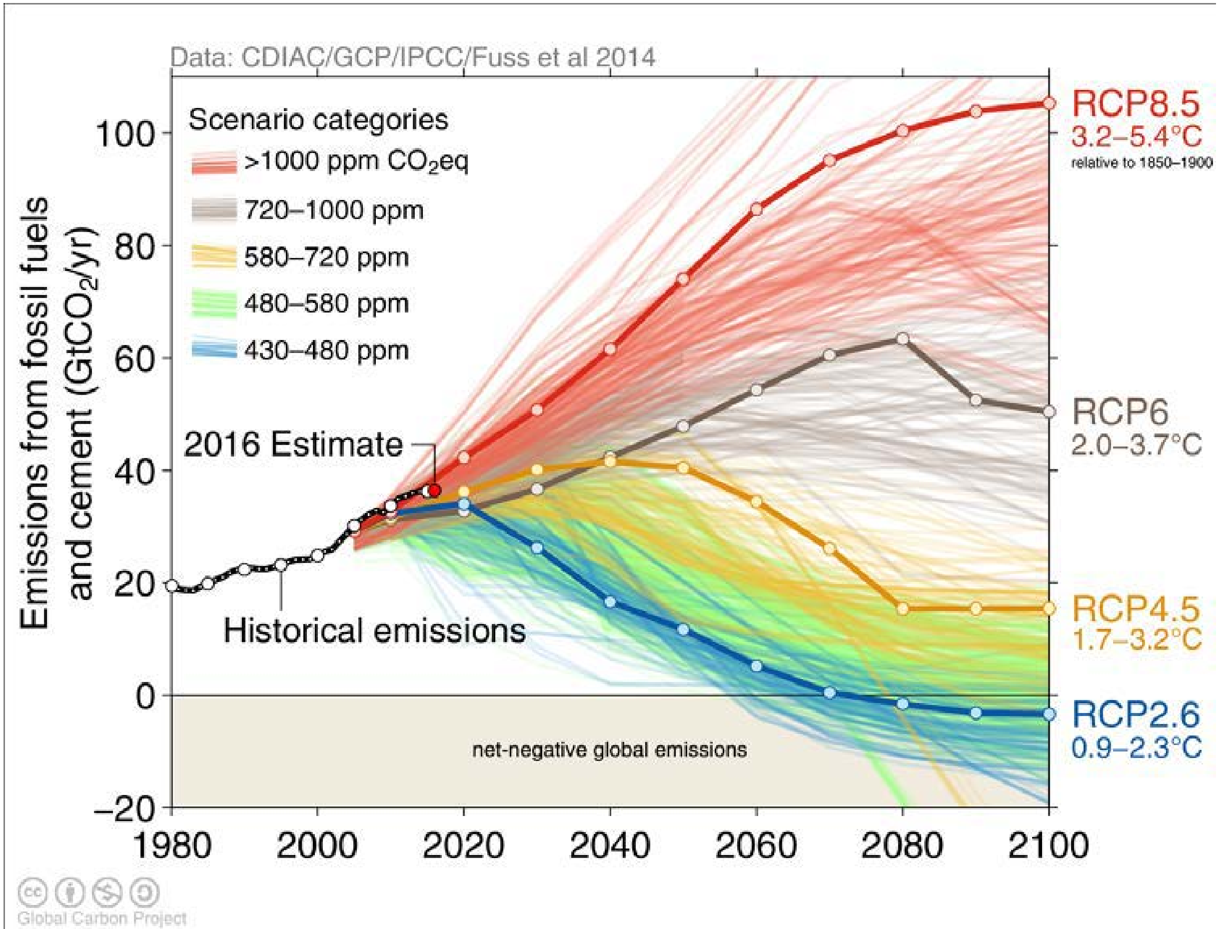
Sue Wing, I., & Eckaus, R. S. (2007). The decline in US energy intensity: Its origins and implications for long-run CO2 emission projections. *Energy Policy*, *35*(5267), U5286.

- Assumed spontaneous decarbonization generally has a larger impact on future emissions than do explicit climate policies;
- To produce scenarios assumptions must be made;
- Policy options should be generated to cover a broader scenario space in both short and long terms

Example 2. Costs of Inaction

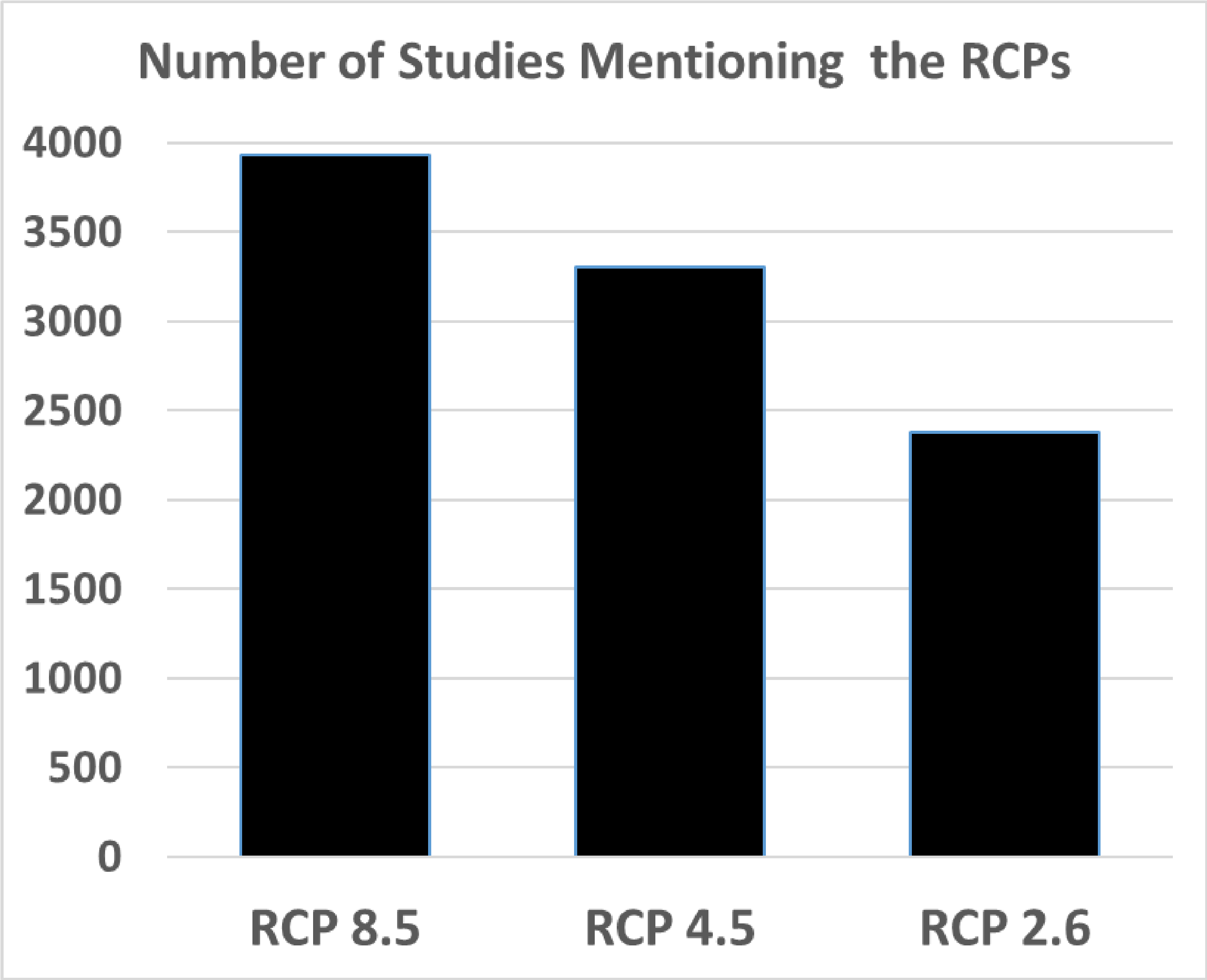
"[E]vidence indicates RCP8.5 does not provide a physically consistent worst case BAU trajectory that warrants continued emphasis in scientific research. Accordingly, it does not provide a useful benchmark for policy studies."

Ritchie, J., & Dowlatabadi, H. (2017). Why do climate change scenarios return to coal?. *Energy*, *140*, 1276-1291.



RCPs are the most recent scenarios. RCP 8.5 is the most popular for use in climate impact studies.

Studies citing each RCP scenario



Source: Google Scholar

How to misuse RCP 8.5 in climate impact studies

1. Project future climate impacts from 2000 to 2100 using RCP 8.5
2. Document large climate impacts in 2100 under RCP 8.5
3. Divide impacts by 6 (2017 is $1/6^{th}$ of the way until 2100), the impacts will still be large
4. Publish in a journal
5. Get headlines
6. Watch this questionable scientific work become routinely cited by other climate researchers, in the media and in policy debates

Example of the (mis)use of RCP 8.5

PNAS Proceedings of the National Academy of Sciences of the United States of America

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NEW RESEARCH IN Physical Sciences

Assessing the present and future p[...] of Hurricane Harvey's rainfall

Kerry Emanuel

PNAS 2017; published ahead of print November 13, 2017, https://doi.org/10.1073/pnas.1[...]

Contributed by Kerry Emanuel, October 4, 2017 (sent for review September 15, 2017; re[...] Foufoula-Georgiou, and James A. Smith)

Article | Figures & SI | Authors & Info

Significance

Natural disasters such as the recent Hurricanes Harvey, Irma, and M[...] for quantitative estimates of the risk of such disasters. Statistically ba[...]

"For each model, 100 events were run for each of the years 1981–2000 from the historical climate simulations, and again for the period 2081–2100 under Representative Concentration Pathway RCP 8.5"

November 2017

The threat of 'Biblical' rainfall over Texas has soared sixfold in just 25 years due to global warming, experts warn

- **From 1981 to 2000, probability of 20 inches of rain was 1 in 100 or even less**
- **Now it's 6 in 100 and by 2081, those odds will be 18 in 100**

By ASSOCIATED PRESS

PUBLISHED: 15:10 EST, 13 November 2017 | **UPDATED:** 06:06 EST, 14 November 2017

Share 31 shares 145 View comments

The chances of a hurricane flooding parts of Texas, like Harvey did, have soared sixfold in just 25 years because of global warming and will likely triple once again before the end of the century, a new study says.

Emanuel, K. (2017). Assessing the present and future probability of Hurricane Harvey's rainfall. *Proceedings of the National Academy of Sciences*, 201716222.

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Why use RCP 8.5 as a primary scenario?

PNAS Proceedings of the National Academy of Sciences of the United States of America

Keyword, Author, or

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NEW RESEARCH IN Physical Sciences | Social Sciences

Assessing the present and future probability of Hurricane Harvey's rainfall

Kerry Emanuel

PNAS 2017; published ahead of print November 13, 2017, https://doi.org/10.1073/pnas.1716222114

Contributed by Kerry Emanuel, October 4, 2017 (sent for review September 15, 2017; reviewed by Cindy L. Bruyere, Efi Foufoula-Georgiou, and James A. Smith)

Article | Figures & SI

Significance

Natural disasters such as the recent ... for quantitative estimates of the risk ... suffers from short records of often po... from the fact that the underlying clim... developed physics-based risk assess... probabilities of extreme hurricane rai... flooding risks in all locations affected ... of historical hurricane records.

"For each model, 100 events were run for each of the years 1981–2000 from the historical climate simulations, and again for the period 2081–2100 under Representative Concentration Pathway RCP 8.5"

November 2017

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Global Environmental Change

Volume 42, January 2017, Pages 153-168

The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview

Keywan Riahi [a], Detlef P. van Vuuren [b], Elmar Kriegler [c], Jae Edmonds [d], Brian C. O'Neill [e], Shinichiro Fujimori [f], Nico Bauer [c], Katherine Calvin [d], Rob Dellink [g], Oliver Fricko [a], Wolfgang Lutz [a], Alexander Popp [c], Jesus Crespo Cuaresma [a], Samir KC [a, h], Marian Leimbach [c], Leiwen Jiang [e], Tom Kram [b], Shilpa Rao [a] ... Massimo Tavoni [i, j, o]

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January 2017

"As the SSPs systematically cover plausible combinations of the primary drivers of emissions, this finding suggests that 8.5 W/m2 can only emerge under a relatively narrow range of circumstances."
(in only 1 of >100 scenarios)

Emanuel, K. (2017). Assessing the present and future probability of Hurricane Harvey's rainfall. *Proceedings of the National Academy of Sciences*, 201716222.

Riahi, Keywan, et al. "The shared socioeconomic pathways and their energy, land use, and greenhouse gas emissions implications: an overview." *Global Environmental Change* 42 (2017): 153-168.

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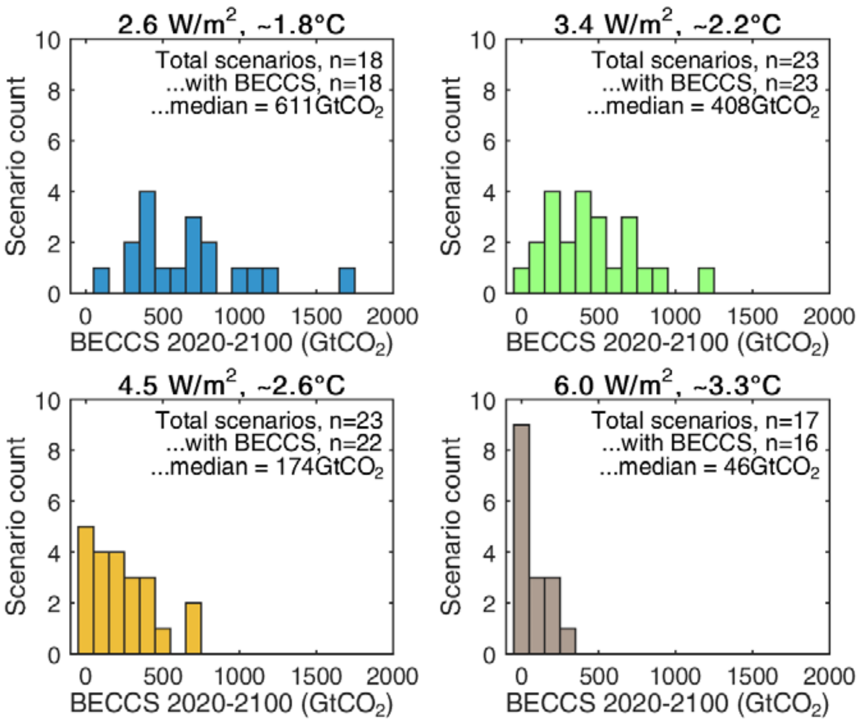
Example 3. Policy feasibility and BECCS

"**[Bioenergy with carbon capture and storage] is explicitly being put forth as an important mitigation option by the majority of integrated assessment model (IAM) scenarios** aimed at keeping warming below 2° C in the IPCC's fifth assessment report (AR5). Indeed, in these scenarios, IAMs often foresee absorption of CO2 via BECCS up to (and in some cases exceeding) 1,000 Gt CO_2 over the course of the century, **effectively doubling the available carbon quota**."



http://cicero.uio.no/no/posts/klima/love-it-or-hate-it-heres-three-reasons-why-we-still-need-ccs

Fuss, Sabine, et al. "Betting on negative emissions." *Nature Climate Change* 4.10 (2014): 850.

Policy lock-in based on a constrained scenario space

1. The costs of action are reasonable
   – Spontaneous decarbonization
2. The costs of inaction are high
   – RCP 8.5
3. Policy action is feasible
   – BECCS

But what if these assumptions are wrong?

4. An alternative approach: Back to Kaya

	Factor	Lever	Approach to Policy
P	Population	Less people	Population management
GDP/P	GDP per capita	Smaller economy	Limit generation of wealth
TE/GDP	Energy intensity	Increase efficiency	Do same or more with less energy
C/TE	Carbon intensity	Switch energy sources	Generate energy with less emissions

$$\text{Carbon emissions} = C = P * \frac{GDP}{P} * \frac{TE}{GDP} * \frac{C}{TE}$$

GDP **Technology**

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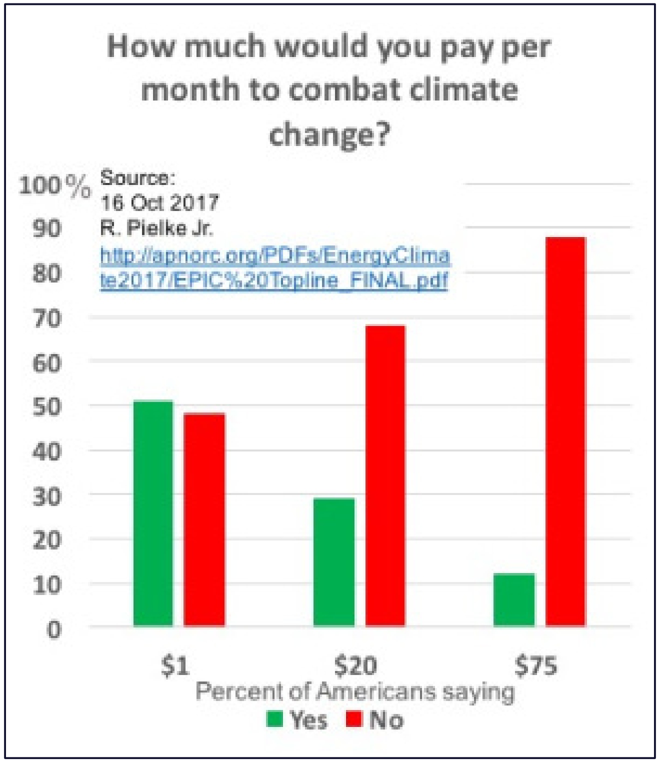
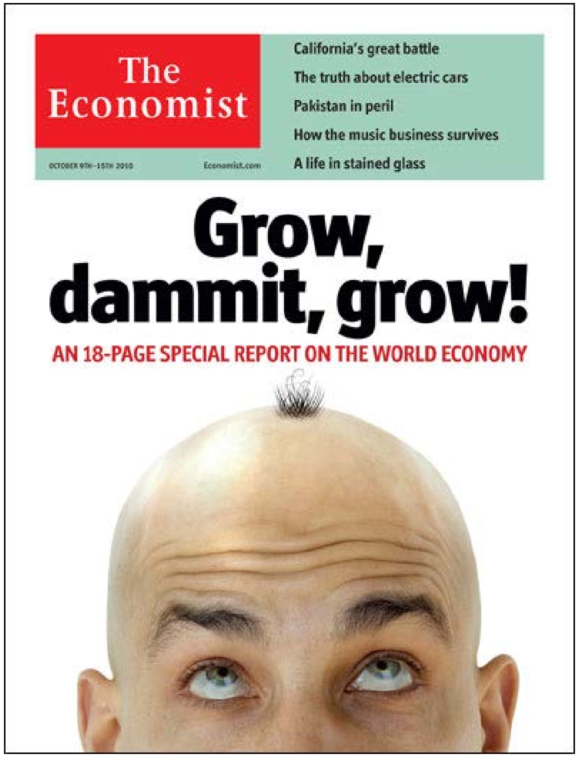
The Iron Law of climate policy





A Boundary Condition for Policy Design: Climate policies must not cost too much, better yet, they should foster economic growth

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If we focus only on emissions, we have already lost

$$\text{Carbon emissions} = C = \boxed{P * \frac{GDP}{P}} * \boxed{\frac{TE}{GDP} * \frac{C}{TE}}$$

$$\text{Emissions} = \text{GDP} \times \text{Technology}$$

$$\frac{\text{Emissions}}{\text{GDP}} = \text{Technology}$$

A reduction in this ratio is decarbonization

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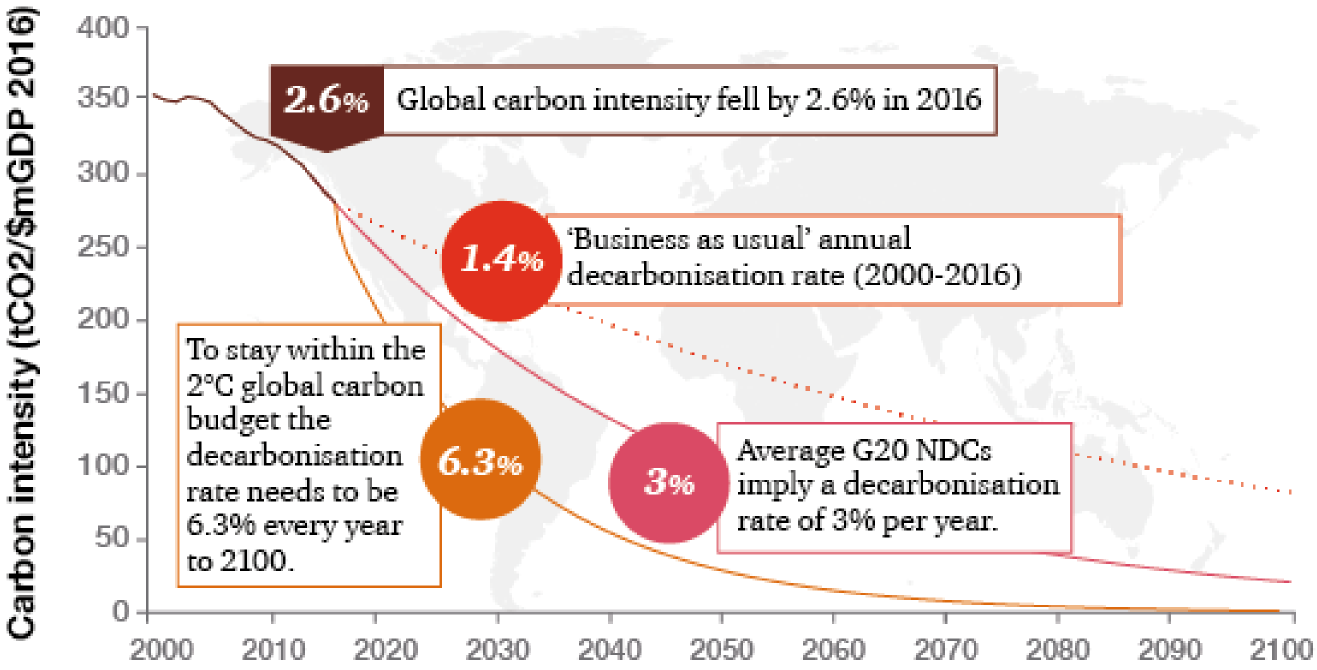
How are we doing? (from PwC 2017)



https://www.pwc.co.uk/services/sustainability-climate-change/insights/low-carbon-economy-index.html

The Index

Our Low Carbon Economy Index tracks the rate of the low carbon transition in each of the G20 economies and compares this with their national targets.

Top performers in 2016 are the UK and China, who reduced their carbon intensities by 7.7% and 6.5%. Both exceeded their NDC targets and the annual global decarbonisation rate required to limit warming to two degrees. However, these countries are the exceptions rather than the rule – the rest of the G20 didn't do so well.

Table 1:
Low Carbon Economy Index – country summary

Country	Change in carbon intensity 2015–16	Paris target annual change in carbon intensity 2015–2030	Annual average change in carbon intensity 2000–2016	Change in energy related emissions 2015-2016	Real GDP growth (PPP) 2015-2016	Carbon intensity (tCO2/$m GDP) 2016
World	-2.6%	-3.0%	-1.4%	0.4%	3.1%	281
G7	-2.9%	-3.6%	-2.2%	-1.4%	1.5%	237
E7	-4.2%	-1.7%	-1.6%	0.5%	4.9%	337
UK	-7.7%	-3.2%	-3.7%	-6.0%	1.8%	142
China	-6.5%	-3.4%	-2.7%	-0.2%	6.7%	431
Mexico	-4.6%	-2.4%	-0.7%	-2.4%	2.3%	197
Australia	-3.8%	-4.5%	-2.0%	-1.2%	2.8%	339
Brazil	-3.8%	-2.9%	0.1%	-7.2%	-3.6%	156
US	-3.4%	-3.9%	-2.5%	-1.8%	1.6%	284
Japan	-2.4%	-4.2%	-1.0%	-1.5%	1.0%	228
Canada	-2.1%	-4.5%	-1.9%	-0.7%	1.5%	344
Russia	-1.7%	0.7%	-3.1%	-2.0%	-0.2%	443
EU	-1.7%	-3.2%	-2.3%	0.2%	1.9%	170
India	-1.6%	-1.9%	-1.7%	5.4%	7.1%	261
Korea	-1.0%	-4.3%	-1.3%	1.8%	2.8%	409
Germany	-0.6%	-3.2%	-1.9%	1.3%	1.9%	188
Italy	-0.4%	-3.2%	-1.9%	0.5%	0.9%	143
Saudi Arabia	0.2%	0.7%	1.4%	1.9%	1.7%	397
France	0.4%	-3.2%	-2.4%	1.6%	1.2%	118
South Africa	0.7%	-2.7%	-1.8%	1.0%	0.3%	555
Turkey	2.5%	1.9%	-1.4%	5.4%	2.9%	179
Argentina	2.7%	-1.6%	0.0%	0.4%	-2.3%	215
Indonesia	3.4%	-3.9%	-1.1%	8.5%	5.0%	171

Key: Top 5 in Index | Bottom 5 in Index

***Sources:** BP, Energy Information Agency, World Bank, IMF, UNFCCC, National Government Agencies, PwC data and analysis*

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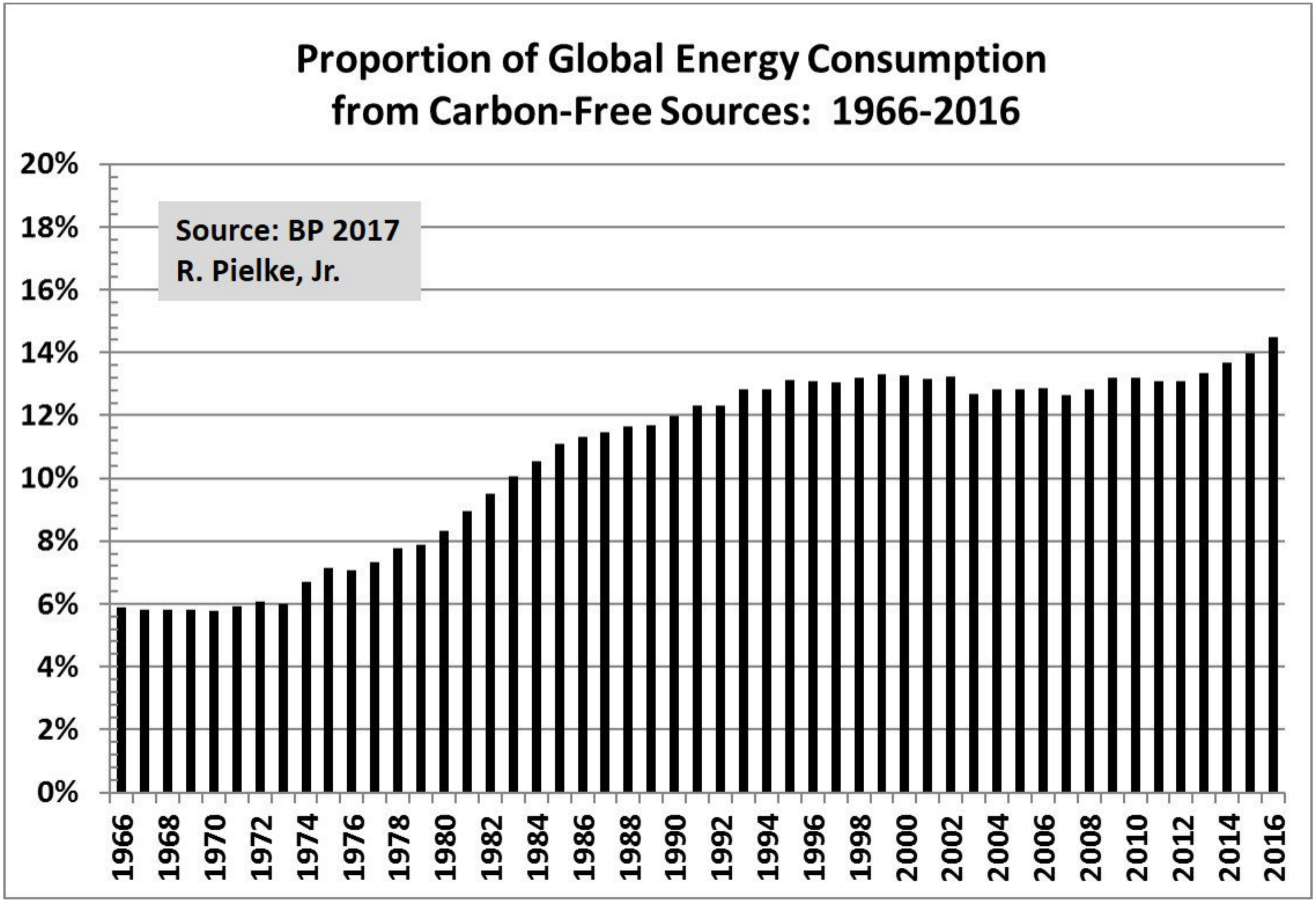
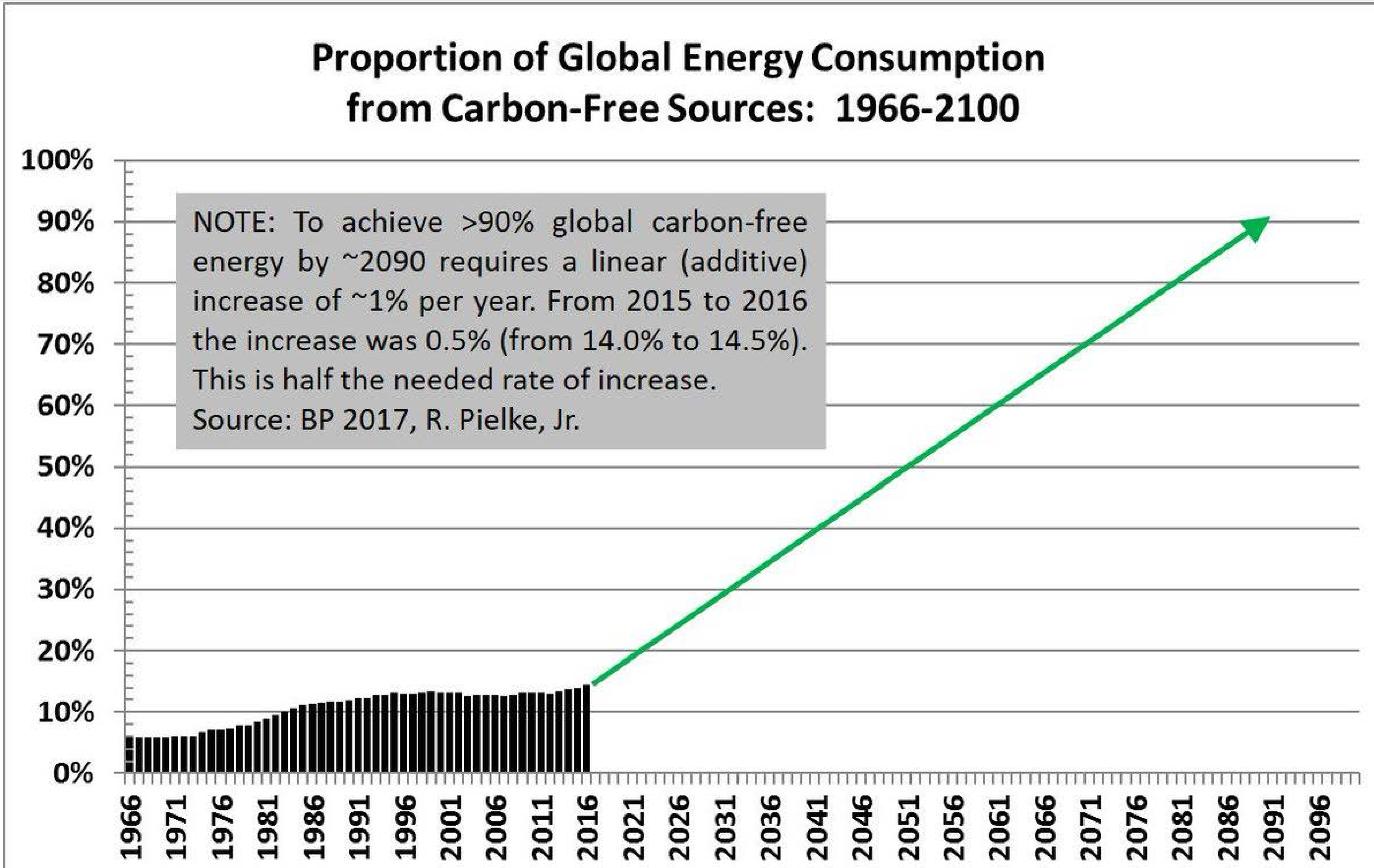
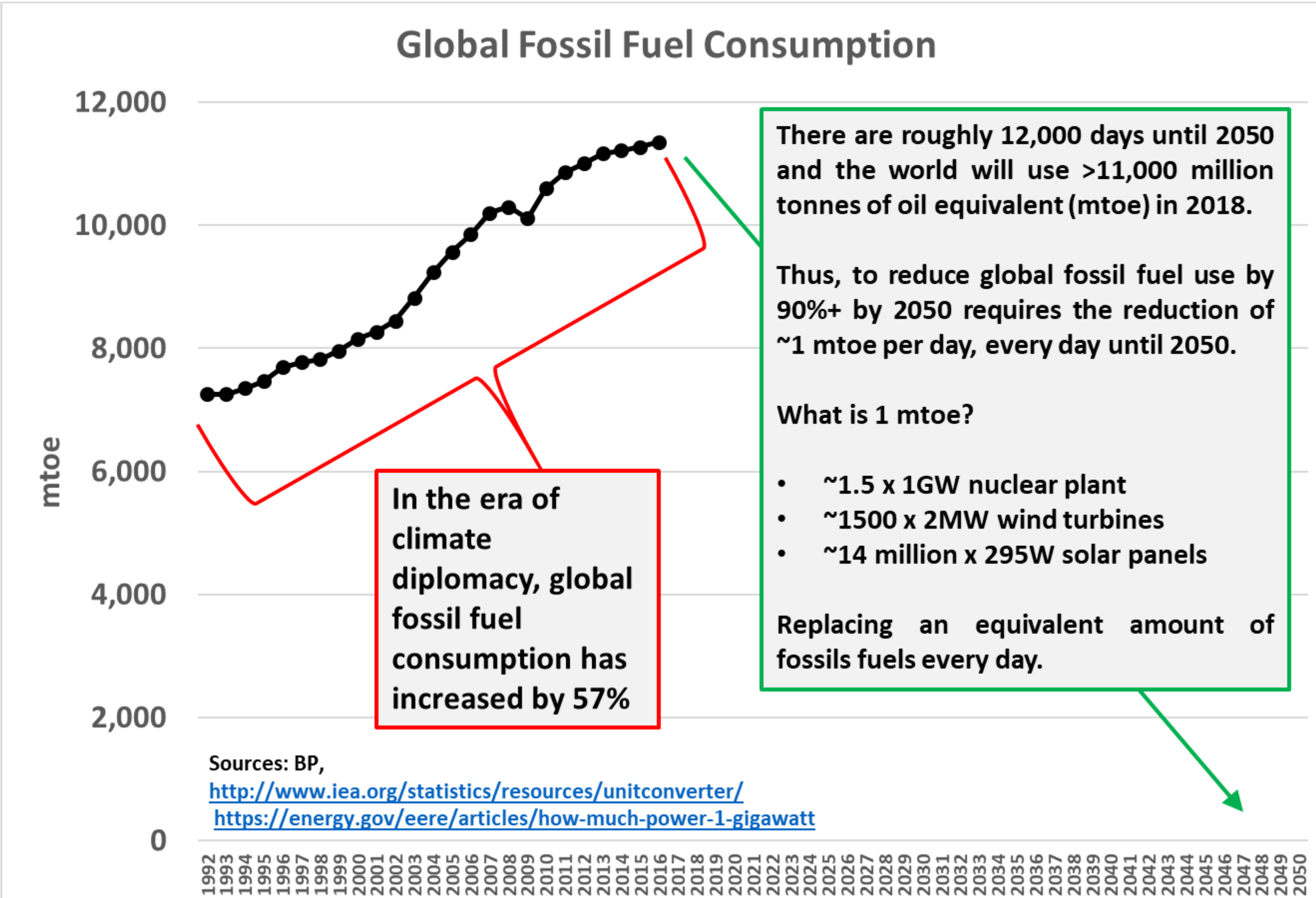
Global carbon-free energy



How do we go from here to there?



The scale of the challenge

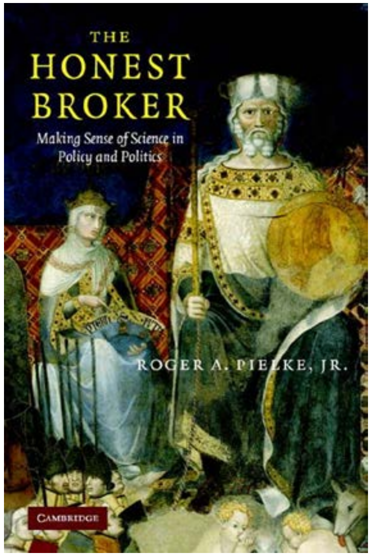


Final words: A need to open up climate policy

- Scenarios of the future have the power to open up possibilities and close them down;
- The use of climate scenarios has arguably helped to reinforce a climate policy status quo, characterized by very little progress;
- An alternative is to focus on today-forward planning
  - We are at 16% carbon-free global energy consumption, how do we get to >90%?
  - We consume 11,000 mtoe of fossil fuels per year, how do we get close to zero?
- Climate policy needs more options, more debate

How to provide feedback!

- pielke@colorado.edu
- Papers etc. can be downloaded from: http://sciencepolicy.colorado.edu
- http://theclimatefix.wordpress.com



Thank you!

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