Climate Changes. Do Policies?

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Trump Picks Top Climate Skeptic to Lead EPA Transition

Choosing Myron Ebell means Trump plans to drastically reshape climate policies

By Robin Bravender, ClimateWire on September 26, 2016
An epic Middle East heat wave could be global warming’s hellish curtain-raiser

Parts of the United Arab Emirates and Iran experienced a heat index — a measurement that factors in humidity as well as temperature — that soared to 140 degrees in July, and Jiddah, Saudi Arabia, recorded an all-time high temperature of nearly 126 degrees. Southern Morocco’s relatively cooler climate suddenly sizzled last month, with temperatures surging to highs between 109 and 116 degrees. In May, record-breaking temperatures in Israel caused a surge of heat-related illnesses.

The 28-year-old engineer at a government-run oil company in Basra said employees were ordered to stay home for several days in the past month. He and his family try not to go outside before 7 p.m.

“We’re prisoners,” Karim said.

Bassem Antoine, an Iraqi economist, said the weather has inflicted serious damage to the country’s economy. He estimates that Iraq’s gross domestic product — about $230 billion annually — has probably contracted 10 to 20 percent during the summer heat.
Land & Ocean Temperature Departure from Average Jul 2016
(with respect to a 1981–2010 base period)
Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0
Flooding of Coast, Caused by Global Warming, Has Already Begun

Scientists' warnings that the rise of the sea would eventually imperil the United States' coastline are no longer theoretical.
Rare Harmony as China and U.S. Commit to Climate Deal

By MARK LANDLER and JANE PERLEZ  SEPTEMBER 3, 2016
CLIMATE SCIENCE FOR FUTURE POLICYMAKERS
Planetary (inc. Earth) temperature is determined by interaction of sunlight warming Earth’s surface, and “greenhouse” gases that absorb infrared radiation (Fourier 1824, Tyndall 1861)

- CO$_2$ is a greenhouse warming gas and emitted from coal, oil, gas (Arrhenius 1896)

- Oceans can only take up a fraction of CO$_2$ produced by combustion (Revelle 1957)
• Atmospheric CO$_2$ increasing ~ 2 ppm/yr from fossil fuel combustion, with 50% going into land and ocean sinks (Keeling 1960, Tans 1990)

• Short and long term observed warming patterns are linked to greenhouse gases (Callendar 1938, Mann 1999)

• Significant warming in the 20$^{th}$ century is mostly explained by atmospheric CO$_2$ (Manabe 1967, Hansen 1984)
Atmospheric CO₂ at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
Congressionally mandated budget cuts force shutdown

NSF: warning on "routine monitoring"

NSF& NOAA coordinate terminate Scripps program

DOE rescues program

"Mandated convergence" w/ NOAA

DOE pulls out of global carbon research

Mauna Loa Record

<table>
<thead>
<tr>
<th>Year</th>
<th>CO2 Concentration (ppm)</th>
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<tbody>
<tr>
<td>1960</td>
<td>310</td>
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<tr>
<td>1964</td>
<td>315</td>
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<tr>
<td>1968</td>
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<td>2000</td>
<td>360</td>
</tr>
<tr>
<td>2004</td>
<td>365</td>
</tr>
</tbody>
</table>
World Energy Consumption

Figure 1 Greenhouse-gas emissions in 2000, by source

- Energy Emissions
  - Power (24%)
  - Industry (14%)
  - Transport (14%)
  - Agriculture (14%)
  - Buildings (8%)
  - Land use (18%)
  - Other energy related (5%)
  - Waste (3%)

Non-energy emissions

Total emissions in 2000: 42 GtCO₂e.
Energy emissions are mostly CO₂ (some non-CO₂ in industry and other energy related).
Non-energy emissions are CO₂ (land use) and non-CO₂ (agriculture and waste).

Source: Prepared by Stern Review, from data drawn from World Resources Institute Climate Analysis Indicators Tool (CAIT) on-line database version 3.0.
Global emissions from fossil fuel and industry: 35.9 ± 1.8 GtCO₂ in 2014, 60% over 1990
- Projection for 2015: 35.7 ± 1.8 GtCO₂, 59% over 1990

Estimates for 2012, 2013, 2014, and 2015 are preliminary
Source: CDIAC; Le Quéré et al 2015; Global Carbon Budget 2015
Atmospheric CO$_2$ records

Trend expected from fossil-fuel burning

Breakthroughs enabled:
- Regular seasonal cycle
- Airborne fraction quantification
- El Nino impact
- Need for significant land sink
- Increasing CO$_2$ amplitude
Callendar, 1938
Annual Global Average Temperature

Trend = 0.70 °C/Century
Base Line: 1981-2010 Average

Anomalies are deviation from baseline (1981-2010 Average).
The black thin line indicates surface temperature anomaly of each year.
The blue line indicates their 5-year running mean.
The red line indicates the long-term linear trend.

Japan Meteorological Agency
US per capita fossil fuel emissions exceed most of the world (DOE, GCP). China total emissions now exceeds the US (IEA).

Climate projections show a 3 C +/- 1.5 C response to doubling of CO$_2$ by 2100 with the primary uncertainty in range of emissions (IPCC 1990, 1995, 2001, 2007, 2013)

Modest warming (0-2 C) creates both winners and losers; warming above 2C or 550 ppm, losers > winners; warming above 4C, mostly losers (WMO, ExxonMobil, Stern Review, World Bank, NCA, WICCI, DOD 1979-present)
Total global emissions: 39.9 ± 3.8 GtCO₂ in 2014, 44% over 1990
Percentage land-use change: 36% in 1960, 19% in 1990, 10% in 2014

Three different methods have been used to estimate land-use change emissions, indicated here by different shades of grey.

Source: CDIAC; Houghton et al 2012; Giglio et al 2013; Le Quéré et al 2015; Global Carbon Budget 2015
Global CO₂ Emissions

Map showing countries resized according to their total CO2 emissions 2009
Data Sources: IWR (2009) & UNFCCC (2007)
Map created by Benjamin Hennig, Sasi Research Group, University of Sheffield - www.viewsoftheworld.net
Countries have a broad range of per capita emissions reflecting their national circumstances China’s per capita emissions have passed the EU28 and are 43% above the global average.

Source: CDIAC; Le Quéré et al 2015; Global Carbon Budget 2015
The emission pledges submitted to the Paris climate summit avoid the worst effects of climate change (red), most studies suggest a likely temperature increase of about 3°C (brown).

Over 1000 scenarios from the IPCC Fifth Assessment Report are shown.

Source: Fuss et al 2014; CDIAC; Global Carbon Budget 2015
Standard deviation ("normal") based on 1951-1980
Northern Hemisphere summer maximum temperatures
IPCC quotes in blue. Impacts start where text box begins. Edges of boxes and placing of text indicate the range of temperature change to which the impacts relate.

The impact chart omitted extreme weather events, that increase most impacts. The SPM impact chart was identical except it omitted the singular events.

Estimates are for the 2020s, 2050s and 2080s, (used by the IPCC Data Distribution Centre) and for the 2090s. Note that equilibrium temperatures would not be reached until decades or centuries after greenhouse gas stabilisation.

UNFCCC objective quoted in AR4..."prevent dangerous...interference with the climate system...within a time frame sufficient to allow ecosystems to adapt naturally to climate change, and to ensure that food production is not threatened."
Climate Change Impacts in the United States

Water Supplies Projected to Decline

Water Supply Sustainability Risk Index (2050)
- Extreme (29)
- High (271)
- Moderate (821)
- Low (2020)

http://nca2014.globalchange.gov/
Current & Developing Working Groups

- Water Resources
- Human Health
- Milwaukee
- Coldwater Fish
- Stormwater
- Wildlife
- Green Bay
- Coastal Communities
- Forestry
- Central Sands Hydrology
- Plants & Natural Communities
- Loss of Winter
- Agriculture
- Soil Conservation

Wisconsin Climate

http://www.wicci.wisc.edu/
What Are The Options?

- Adaptation
- Mitigation
What Are The Options?

• Adaptation
  – Economic/political (relocation, tech transfer, payments for damages, reduce poverty, educate)
  – Technological (resilient tech, seawalls, genetic hybrids, cure malaria, colonize new planet)

• Mitigation
What Are The Options?

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• Mitigation
  – Economic (taxes, cap and trade, R&D)
  – Regulatory (treaties, bans, compacts, fuel/energy standards, public transit, voluntary agreements)
  – Societal (sustainable development, education)
  – Technological (CO₂ capture, geoengineering, green tech, alternative energy, energy efficiency)
have we released to date? 1020 Gt added 1850-2000

more can we “safely” release? 500 our ‘carbon budget’

are left to release? 745 in fossil fuel reserves of the top coal, oil & gas companies + 2,050 in estimated remaining fossil fuel reserves

31 gigatons

13 years, average yearly emissions increase 3%

GLOBAL WARMING IF RELEASED

+0.8°C 1.4°F happened

+1.5°C 2.7°F inevitable

+2°C 3.6°F “safe” limit

+3-4°C 5.4-7.2°F tipping point

+5-6°C 9-10.8°F nightmare

* before 2050 and still have a chance of staying below 2°C warming

http://www.informationisbeautiful.net/2012/how-many-gigatons-of-co2/
KAYA IDENTITY

\[ F = P g e f \]

- **F**: Global CO₂ emissions
  - Includes combustion, flaring of natural gas, cement production, oxidation of nonfuel hydrocarbons, and transport.
  - 28.56 gigatons CO₂

- **P**: Global population
  - Total number of human beings—call it 6 billion.
  - 6.8 billion people

- **g**: Consumption per person
  - \( \frac{\text{Gross world product}}{\text{Population}} \)
  - \$10,000

- **e**: Energy intensity of gross world product
  - \( \frac{\text{Global energy consumption}}{\text{Gross world product}} \)
  - 7,000 BTUs per dollar

- **f**: Carbon used to make all that energy
  - \( \frac{\text{Global CO₂ emissions}}{\text{Global energy consumption}} \)
  - 60 tons of CO₂ per billion BTUs

http://climatemodels.uchicago.edu/kaya/
U.S. Emissions

- Carbon Capture & Storage

After Pacala and Socolow, 2004; ARI CarBen3 Spreadsheet

- Electricity end-use efficiency
- Other end-use efficiency
- Passenger vehicle efficiency
- Other transport efficiency
- Renewables
- CCS
Why is climate policy so hard?
1990

SO, THIS CLIMATE CHANGE THING COULD BE A PROBLEM...

1995

CLIMATE CHANGE: DEFINITELY A PROBLEM.

2001

TEP, WE SHOULD REALLY BE GETTING ON WITH SORTING THIS OUT PRETTY SOON...

2007

LOOK, SORRY TO SOUND LIKE A BROKEN RECORD HERE...

2013

WE REALLY HAVE CHECKED AND WE'RE NOT MAKING THIS UP.

2019

IS THIS THING ON?

TAP TAP TAP

（THE AUSTRALIAN 26/10/13）
• “I am not a scientist myself, but my best assessment of the data is that the world is getting warmer, that human activity contributes to that warming, and that policymakers should therefore consider the risk of negative consequences.”
  – Sept. 2012

http://www.sciencedebate.org/debate12/
“Higher temperatures and less-predictable weather would hurt poor farmers, most of whom live on the edge and can be devastated by a single bad crop. [...] It would be a terrible injustice to let climate change undo any of the past half-century’s progress against poverty and disease—and doubly unfair because the people who will be hurt the most are the ones doing the least to cause the problem.”
How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming

Merchants of Doubt

Naomi Oreskes & Erik M. Conway
“If you look at global warming alarmists, they don't like to look at the actual facts and the data. The satellite data demonstrate that there has been no significant warming whatsoever for 17 years. [...] I read this morning a Newsweek article from the 1970s talking about global cooling. And it said the science is clear, it is overwhelming, we are in a major cooling period... Now, the data proved to be not backing up that theory. So then all the advocates of global cooling suddenly shifted to global warming [...] and the solution interestingly enough was the exact same solution -- government control of the energy sector and every aspect of our lives.”

Washington Post, 2 Aug 2015
UNFCCC and Kyoto Protocol and the Paris Agreement

- **Signed and Ratified**
- **Signed with intent to Ratify**
- **Signed with no intent to Ratify**
- **Non-Signatory**
Informationisbeautiful.net

The Visual Mescellaneum

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Despite Kyoto, the EU's CO2 emissions will increase by 1% by 2012
source: European Environment Agency
Major flows from production to consumption

Flows from location of generation of emissions to location of consumption of goods and services

Values for 2011. EU is treated as one region. Units: MtCO$_2$

Source: Peters et al 2012
Major flows from extraction to consumption

Flows from location of fossil fuel extraction to location of consumption of goods and services

Values for 2011. EU is treated as one region. Units: MtCO₂

Source: Andrew et al 2013
Paris

• Refocuses goal on temperature below 2°C limit (global emissions will need to peak in <20 years, sources must balance sinks by 2050)
• Lets countries determine their contribution
• $100 billion fund for developing countries
• Is set to be in force, now that > 55% of emissions included in ratified countries*
• Compliance and monitoring will be a key challenge
The future?

- Climate scientists will continue to refine projections of future change and impacts in response to emissions and/or policy.
- Global treaty progress will likely be slow, but there are successes in deforestation reduction, developing country support, and renewal energy infrastructure.
- Bi- or Multi- lateral agreements (e.g., US-China) and within country “energy arms race” may end up having the biggest bang for buck.
- Fossil fuel reserves are getting scarcer, but not running out anytime soon. Given lags in climate response, some level of adaptation is inevitable.
- The US election just threw a really big monkey-wrench into the whole thing.
DISCUSSION?