Climate Threat to the Planet*
Implications for Energy Policy

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* Any statements relating to policy are personal opinion
Global Warming Status

1. Knowledge Gap Between
   - What is **Understood** (science)
   - What is **Known** (public/policymakers)

2. Planetary Emergency
   - Climate Inertia $\rightarrow$ Warming in Pipeline
   - Tipping Points $\rightarrow$ Could Lose Control

3. Good News & Bad News
   - Safe Level of CO$_2$ < 350 ppm
   - Multiple Benefits of Solution
Basis of Understanding

1. Earth’s Paleoclimate History
2. On-Going Climate Changes
3. Climate Models
Temperature Change at Seasonal Resolution

- Green Triangle = Volcano
- Red Box = El Nino
- Blue Semicircle = La Nina

Global

Low Latitudes (23.6°N-23.6°S)

Year: 1950 to 2000

Temperature Anomaly (°C)
United Nations
Framework Convention on Climate Change

Aim is to stabilize greenhouse gas emissions…

“…at a level that would prevent
dangerous anthropogenic interference
with the climate system.”
Metrics for “Dangerous” Change

Extermination of Animal & Plant Species
1. Extinction of Polar and Alpine Species
2. Unsustainable Migration Rates

Ice Sheet Disintegration: Global Sea Level
1. Long-Term Change from Paleoclimate Data
2. Ice Sheet Response Time

Regional Climate Disruptions
1. Increase of Extreme Events
2. Shifting Zones/Freshwater Shortages
Tipping Point Definitions

1. Tipping Level
   - Climate forcing (greenhouse gas amount) reaches a point such that no additional forcing is required for large climate change and impacts

2. Point of No Return
   - Climate system reaches a point with unstoppable irreversible climate impacts (irreversible on a practical time scale)
     Example: disintegration of large ice sheet
2007 Sea ice conditions in context

September Sea Ice Extent (1979–2007)

Extent (million sq km)

September 2007
4.28 million km²

Mark Serreze, Julienne Stroeve, Walt Meier, Ted Scambos, Marika Holland, Jim Maslanik, Stephanie Renfrow, Matt Savoie
Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)

Extent (millions of square kilometers)

- 2008
- 2007
- 1979–2000 Average

Mar | Apr | May | Jun | Jul

National Snow and Ice Data Center, Boulder CO
Global Ocean Heat Content Change: Above 700 m, 3-Year Mean

Arctic Sea Ice Criterion*

1. Restore Planetary Energy Balance
   → CO₂: 385 ppm → 325-355 ppm

2. Restore Sea Ice: Aim for -0.5 W/m²
   CO₂: 385 ppm → 300-325 ppm

Range based on uncertainty in present planetary energy imbalance (between 0.5 and 1 W/m²)

*Assuming near-balance among non-CO₂ forcings
Greenland Total Melt Area –
2007 value exceeds last maximum by 10%

Konrad Steffen and Russell Huff, CIRES, University of Colorado at Boulder
Melt descending into a moulin, a vertical shaft carrying water to ice sheet base.

Source: Roger Braithwaite, University of Manchester (UK)
Jakobshavn Ice Stream in Greenland

Discharge from major Greenland ice streams is accelerating markedly.

Source: Prof. Konrad Steffen, Univ. of Colorado
Greenland Mass Loss – From Gravity Satellite

-162 +/- 22 km³/yr
~0.4 +/- 0.1 mm/yr sea level rise

Velicogna and Wahr, 2005
Mass Balance of Greenland

Greenland ice-sheet: rate of change from airborne laser-altimeter surveys (green), airborne/satellite laser-altimeter surveys (purple), mass-budget calculations (red), temporal changes in gravity (blue).

Sources (corresponding to numbers on rectangles): 1 and 2 Krabill and others 2000; 16 and 2004; 3 Thomas and others 2006; 17; 4 Zwally and others 2005; 5 to 7 Rignot and Kanagaratnam 2006; 18; 8 and 9 Velicogna and Wahr 2005; and 2008b; 11 Chen and others 2006; 10 Ramillien and others 2008; 12 Luthke and others 2008
Sea Level Criterion*

1. Prior Interglacial Periods
   → $\text{CO}_2 \lesssim 300$ ppm

2. Cenozoic Era
   → $\text{CO}_2 \lesssim 300$ ppm

3. Ice Sheet Observations
   → $\text{CO}_2 < 385$ ppm

*Assuming near-balance among non-$\text{CO}_2$ forcings
Pier on Lake Mead.
Rongbuk Glacier

Rongbuk glacier in 1968 (top) and 2007. The largest glacier on Mount Everest’s northern slopes feeds Rongbuk River.

## Assessment of Target CO$_2$

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<th>Phenomenon</th>
<th>Target CO$_2$ (ppm)</th>
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<td>1. Arctic Sea Ice</td>
<td>300-325</td>
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<td>2. Ice Sheets/Sea Level</td>
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<td>3. Shifting Climatic Zones</td>
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<td>4. Alpine Water Supplies</td>
<td>300-350</td>
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<td>5. Avoid Ocean Acidification</td>
<td>300-350</td>
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→ Initial Target CO$_2$ = 350* ppm

*assumes CH$_4$, O$_3$, Black Soot decrease
Target $\text{CO}_2$: < 350 ppm

To preserve creation, the planet on which civilization developed
The fraction of CO₂ remaining in the air, after emission by fossil fuel burning, declines rapidly at first, but 1/3 remains in the air after a century and 1/5 after a millennium (Atmos. Chem. Phys. 7, 2287-2312, 2007).
Initial Target CO$_2$: 350 ppm

Technically Feasible
(but not if business-as-usual continues)

Quick Coal Phase-Out Critical
(long lifetime of atmospheric CO$_2$)
(must halt construction of any new coal plants that do not capture & store CO$_2$)
Fossil Fuel CO₂ Emissions

(a) 2007 Annual Emissions

- U.S.A.: 19.3%
- China: 20.6%
- Russia: 5.0%
- India: 5.0%
- Japan: 4.0%
- U.K.: 1.8%
- Grm.: 2.5%
- CanAus Ships/Air: 3.1%
- Rest of Europe: 11.8%
- Rest of World: 21.7%

(b) 1751-2007 Cumulative Emissions

- China: 8.5%
- Russia: 7.3%
- Germany: 6.4%
- U.K.: 5.9%
- Japan: 3.9%
- India: 2.5%
- CanAus Ships/Air: 3.1%
- Rest of Europe: 17.9%
- Rest of World: 13.3%
Per Capita Fossil Fuel CO₂ Emissions
(a) 2007 Annual Emissions
(Tons Carbon/Year/Person)
(b) 1751-2007 Cumulative Emissions
(Tons Carbon/Person)
Source of Fossil Fuel CO₂
(a) Today’s Emissions
(b) In the Air Today

(a) Fraction of each fossil fuel in 2007 CO₂ emissions
(b) Fraction of each in today’s airborne CO₂ amount
Coal Fraction of Fossil Fuel $\text{CO}_2$ Emissions

Fraction = Coal / (Coal + Oil + Natural Gas)
“Free Will” Alternative

1. Phase Out Coal CO$_2$ Emissions
   - by 2025/2030 developed/developing countries

2. Rising Carbon Price
   - discourages unconventional fossil fuels &
     extraction of every last drop of oil (Arctic, etc.)

3. Soil & Biosphere CO$_2$ Sequestration
   - improved farming & forestry practices

4. Reduce non-CO$_2$ Forcings
   - reduce CH$_4$, O$_3$, trace gases, black soot
Carbon Tax & 100% Dividend

1. Tax Large & Growing (but get it in place!)
   - tap efficiency potential & life style choices

2. Entire Tax Returned
   - equal monthly deposits in bank accounts

3. Limited Government Role
   - keep hands off money!
   - eliminate fossil subsidies
   - let marketplace choose winners
   - change profit motivation of utilities
   - watch U.S. modernize & emissions fall!
Key Elements in Transformation

Low-Loss Electric Grid
Clean Energy by 2020 (West) & 2030
Allows Renewable Energy Ascendancy

Carbon Tax and 100% Dividend
Tax at First Sale of Coal/Oil/Gas
Tax Can Rise & Spur Transformations
“100% or Fight! No Alligator-Shoes!”
Basic Conflict
Fossil Fuel Special Interests vs Young People & Nature (Animals)

Fossil Interests: God-given fact that all fossil fuels will be burned (no free will)

Young People: Hey! Not so fast! Nice planet you are leaving us!
What are the Odds?

Fossil Interests: have influence in capitals world-wide

Young People: need to organize, enlist others (parents, e.g.), impact elections

Animals: not much help (don’t vote, don’t talk)
The Challenge

We can avoid destroying creation! (+cleaner planet, + good jobs!)

We have to figure out how to live without fossil fuels someday...

Why not now?
What’s the Problem?*

1. No Strategic Approach
   %CO₂ Reduction Approach Doomed

2. No Leadership for Planet & Life
   Businesses Rule in Capitals

3. Greenwash Replaces Strategy

* Just my opinions, of course
Web Site

[www.columbia.edu/~jeh1](http://www.columbia.edu/~jeh1)

includes

Letter to Prime Minister Fukuda

Global Warming Twenty Years Later: Tipping Points Near (today’s statement)

Target Atmospheric CO₂: Where Should Humanity Aim?