Why are we here? Why are we here? Why are we here?

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Pathways to Climate Solutions:
Assessing Energy Technology and Policy Innovation
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Why are we here?

Because we haven’t bent the curve, after five decades of trying. (Yes, it could have been worse.)

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# Four World Views

<table>
<thead>
<tr>
<th>Are fossil fuels hard to displace?</th>
<th>NO</th>
<th>YES</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td><strong>Are climate change an urgent matter?</strong></td>
<td><strong>NO</strong></td>
</tr>
<tr>
<td>NO</td>
<td>A nuclear or renewables world unmotivated by climate.</td>
<td>Most people in the fuel industries and most of the public are here. (5^\circ C).</td>
</tr>
<tr>
<td>YES</td>
<td>Environmentalists, nuclear advocates are often here. (2^\circ C).</td>
<td>OUR WORKING ASSUMPTIONS? (3^\circ C), tough job.</td>
</tr>
</tbody>
</table>
We may not all agree.

Those in the bottom left are here to plan the final attack and discuss victory – like Yalta.

Those in the bottom right are here to find a soft landing for “two degrees” – so we get to three degrees and not five.

My intent is to address all of us.
Committed CO$_2$ emissions from global power plants in 2012

Global view from 2012 view. Assumed 40-year life for power plants, updated for retirements and plant-life extensions. Remaining emissions are 307 GtCO$_2$.

Source: Davis and Socolow, to be published
Committed emissions as of each year, 1950-2012, by fuel, power sector only

The China-coal peak in 2005 is distinctive, but annual net new commitments of 6 to 10 GtCO$_2$ are seen throughout 2000-2102.

Source: Davis and Socolow, to be published
Committed emissions as of each year, 1950-2012, by region, power sector only

In 2012 China had half of the world’s commitments, other developing countries had more than half, and the U.S. was disinvesting. Note the U.S. “rush to gas,” 1998-2002.

Source: Davis and Socolow, to be published
Atmospheric CO$_2$ with 5600 GtC emissions

Warming $\approx 10^\circ$C

Source: Jeff Greenblatt
The below-ground frontier: a unified view of extraction and insertion of fluids, heat, and chemicals; rock manipulation; environmental impact – taking note of interesting departures from the mean (the Alberta oil sands, thermal hot spots, unusually connected porosity, exceptional isolation).

Shown here: After 10 years of operation of a 1000 MW coal plant, 60 Mt (90 Mm$^3$) of CO$_2$ have been injected, filling a horizontal area of 40 km$^2$ in each of two formations. Assume: 10% porosity, 1/3 of pore space accessed, 60 m total height for the formations.

Injection rate: 150,000 bbl(CO$_2$)/day. Lifetime injection (60 years): 3 billion barrels.
How low-carbon are wind and solar?

Natural gas is the dancing partner for intermittent renewables.

Assumptions:
- Wind: $2000/kW
- Gas: $1000/kW
- CCR: 15%
- Ignore running costs other than n.g. fuel

Source: Unpublished collaboration with Tom Kreutz
Fission power vs. climate change

Dry-cask storage: a 100-year “solution.”
No need to reprocess spent fuel.
It deserves awards, but no one loves it!

Meanwhile, nuclear power’s links to nuclear weapons grow stronger, and (it seems to me) the taboo against nuclear weapons use grows weaker.

To me, it’s a bad bargain.

Site: Surry station, James River, VA; 1625 MW since 1972-73, Credit: Dominion.
Acute vs. chronic use of geoengineering

**Acute**: Hold in reserve for an emergency. Its distinctive characteristic is that it works fast. But what is an emergency, and who will identify it?

**Chronic**: Compensate for some fraction of warming, starting soon. It is possibly very cheap, even after taking risks into account. Experience will increase the confidence to go further if desired.
Why are we here?

Because we are intrigued by Pasteur’s Quadrant: use-inspired, seeking powerful generalizations.

In Edison’s quadrant, a search for gadgets is enough.

In Bohr’s quadrant, truth and beauty for their own sake.
The operative systems boundary is always larger than the one under discussion.

*Principle*: You want A. You figure out that B will get us to A, and you like B. You foster B. But *there is always a C that someone else likes and you don’t like at all*, which also gets us to A. Unless you are alert, your efforts enable C.

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**Right**

You must mind each other’s business!
Conditionality example: biocarbon

What will go wrong if we move headlong to maximize either global biostocks or global biofuels without conditionalities?

Suppose you were a forester or an agronomist in a world where the carbon price was very high. You were told that storing carbon was your only objective. What would you do? Establish a monocrop? Pour on fertilizer? Be inventive....
Conditionality example: biocarbon

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Now, change roles. You are the policy maker in the same world. What conditionalities would you place on the carbon market for biostocks in the interest of eliciting actions you would welcome and deterring outcomes you would decry?
“Solutions” can bring serious problems of their own.

Every “solution” has a dark side.

<table>
<thead>
<tr>
<th>Conservation</th>
<th>Reglementation</th>
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<tbody>
<tr>
<td>Renewables</td>
<td>Competing uses of land</td>
</tr>
<tr>
<td>“Clean coal”</td>
<td>Mining: worker and land impacts</td>
</tr>
<tr>
<td>Nuclear power</td>
<td>Nuclear war</td>
</tr>
<tr>
<td>Geoengineering</td>
<td>Technological hegemony</td>
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*Risk management*: We must take into account both the risks of disruption from climate change and the risks of disruption from mitigation. We must not privilege the atmosphere. Climate change is just one aspect of “fitting on the earth.”
Patient Earth

“I will apply, for the benefit of the sick, all measures that are required, avoiding those twin traps of overtreatment and therapeutic nihilism.”

Hippocrates

“Emissions budgets” mean choices

Connecting 2°C to the carbon-budget idea is a distraction. The idea is more general. We are going to leave carbon in the ground. What matters, beyond counting carbon atoms?

Regarding the fossil fuel that we choose to burn:

When? Better options someday?
Whose? Geopolitical stability
Used where? “Fairness”
For what? Who judges?

Which fossil fuels? Those with the most attached hydrogen?

Buried CH_n has a range of n. Should we extract so as to maximize n? Extract gas (even methane hydrates), leave tars and coal behind, develop NG-CCS.
Surrogate Goals (1 of 3)

Definition of a surrogate goal

A person who holds Goal A strongly and Goal B weakly, but believes that achieving Goal B will also achieve Goal A, can pursue Goal B as a surrogate for Goal A.

Usually, Goal A will be revealed only in special circumstances. Recognizing that a multiplicity of surrogate goals is at play has considerable explanatory power.
Surrogate goals and climate change

In the formulation of policy to deal with climate change, the general objective of slowing the rate of climate change is often a surrogate for more strongly held goals, such as:

- Augmenting financial transfers to developing countries
- Bringing the fossil fuel era to a close
- Curtailing consumerism and human centeredness
- Promoting self-sufficiency, autonomous communities
- Diminishing the power of technological elites
- Promoting environmental science
- Encouraging entrepreneurship
Surrogate Goals (3 of 3)

A problem arises when an action in support of the surrogate goal negates the person’s more strongly held goal.

- Capturing and storing CO$_2$ prolongs the fossil fuel era.
- Large and distant solar arrays and windfarms do not promote local self-reliance.
Destiny Studies

In the past 50 years we have become aware of the history of our Universe, our Earth, and life.

Can we achieve a comparable understanding of human civilization at various future times: 50 years ahead – vs. 500 years and vs. 5000 years?

A new field, Destiny Studies, will emerge. It will produce disciplined thinking about future time. It will address planning horizons, infrastructure, waste management, whose destiny matters to us, ....
Who is not here?

National CO₂ Emissions, 2009

Source: EIA data; Guardian.co.uk “atlas of pollution”
Beyond per capita

We can’t solve the climate problem without moving beyond “per capita” – looking inside countries.

What if “common but differentiated responsibilities” refers to individuals instead of nations?

In 2030, over half of the “high-emitters” will live outside the OECD.

Three bins: Estimated emissions of individuals in 2030, tons CO$_2$/year

<table>
<thead>
<tr>
<th>Bin emissions (GtCO$_2$), population (billion)</th>
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<tbody>
<tr>
<td>USA</td>
</tr>
<tr>
<td>2003</td>
</tr>
<tr>
<td>2030</td>
</tr>
<tr>
<td>2003</td>
</tr>
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<td>2030</td>
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</table>

Total emissions and population

<table>
<thead>
<tr>
<th>Year</th>
<th>Billion people</th>
<th>GtCO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>6.2</td>
<td>26</td>
</tr>
<tr>
<td>2030</td>
<td>8.2</td>
<td>41</td>
</tr>
</tbody>
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Indoor air pollution: the global energy system’s largest negative health effect

Why are we here?

Because Aspen is a place of extraordinary beauty which cultivates “active liberty” (Justice Breyer’s phrase – an engaged public).

Aspen is home to the Aspen Institute, the Ideas Festival, the Aspen Global Change Institute (our host), and the Aspen Center for Theoretical Physics. It has developed traditions of truth telling, communicating at a non-technical level, and taking on big issues.
Is the signal already emerging from the noise in extreme events?

The example here: heat waves. The nastiest heat waves will arrive much more frequently.

If so, will “active liberty” kick in? If it does, are we ready?

Source: S. Pacala, private communication
“Madmen in authority who hear voices in the air are distilling their frenzy from an academic scribbler of a few years back.”

John Maynard Keynes

We must imagine success and leaders who take us seriously. To guard against frenzy, we must promote active liberty and undermine zealotry.