The Critical Role of Energy Efficiency in Mitigating Global Warming

Robert Socolow
Princeton University
socolow@princeton.edu

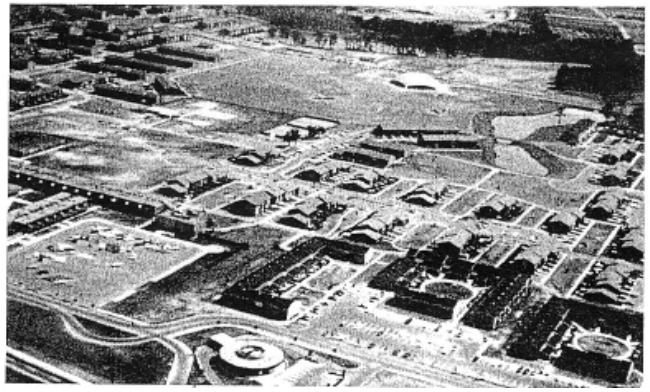
Housing into the Future:
Stepping toward Carbon Neutrality

A seminar of the Household Energy End-Use Project (HEEP)

Victoria University of Wellington
Wellington, New Zealand

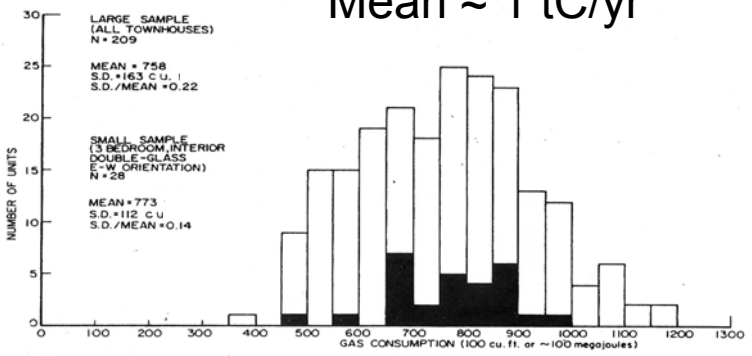
By video-conference
August 28, 2007

Twin Rivers Energy-in-Buildings Research, 1971-1980

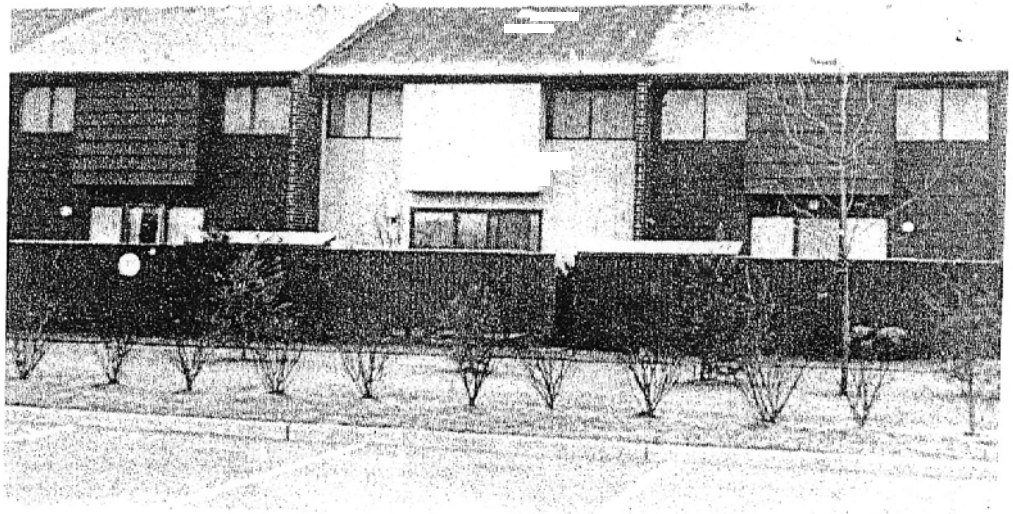


Twin Rivers, NJ, Quads I and II

Mean ≈ 1 tC/yr

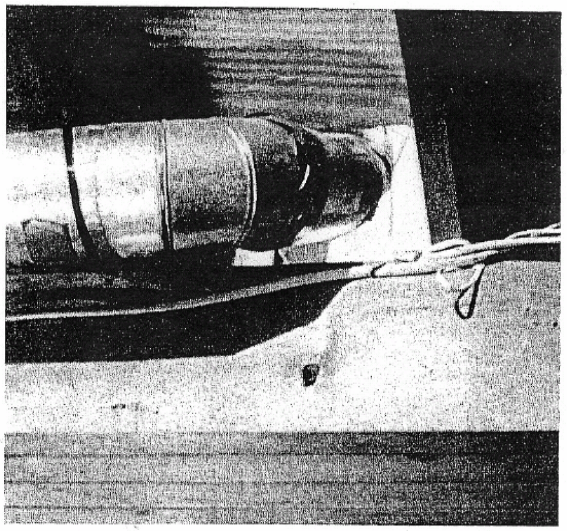


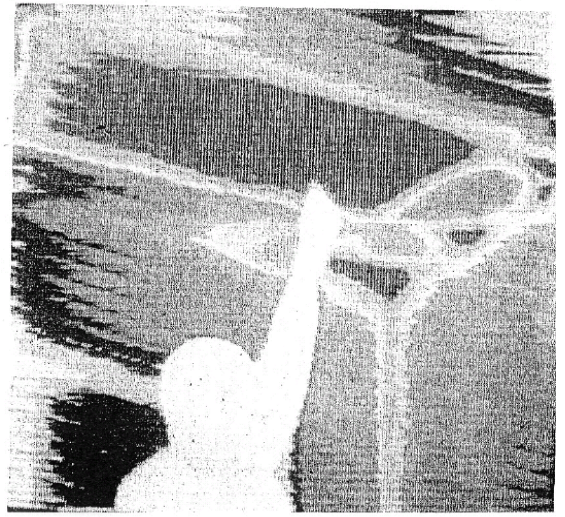
Gas consumption, average of two 6-month winters

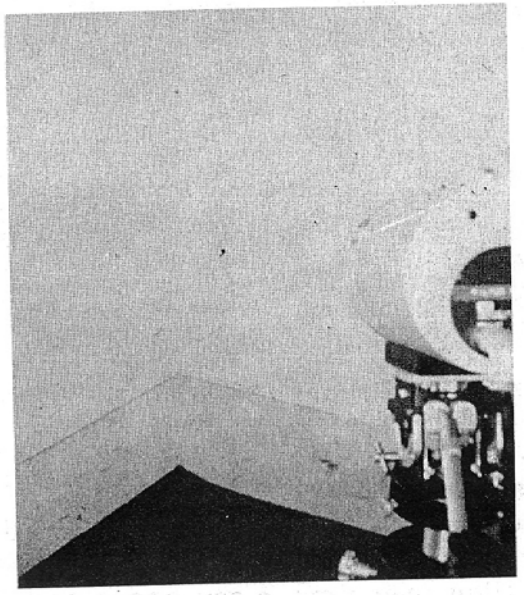


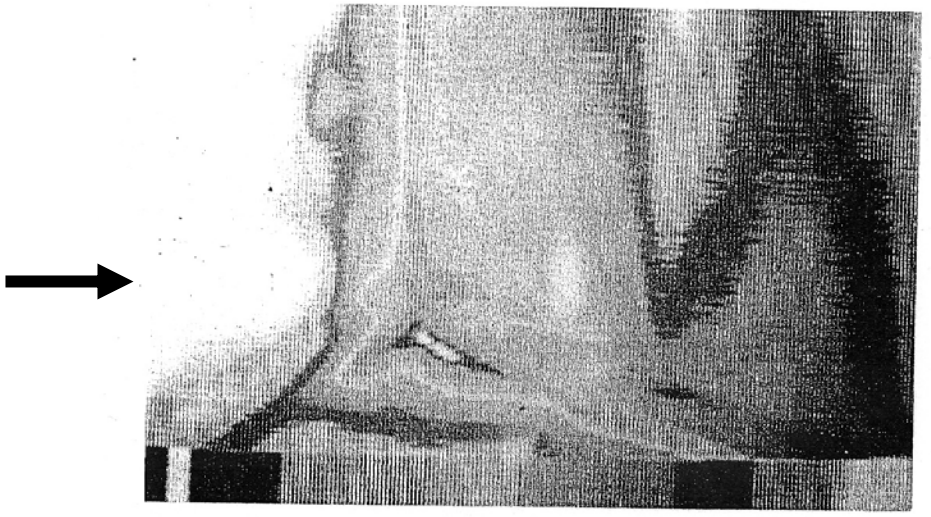
Frost shows Princeton has insulated two of three attics

Design and construction failures

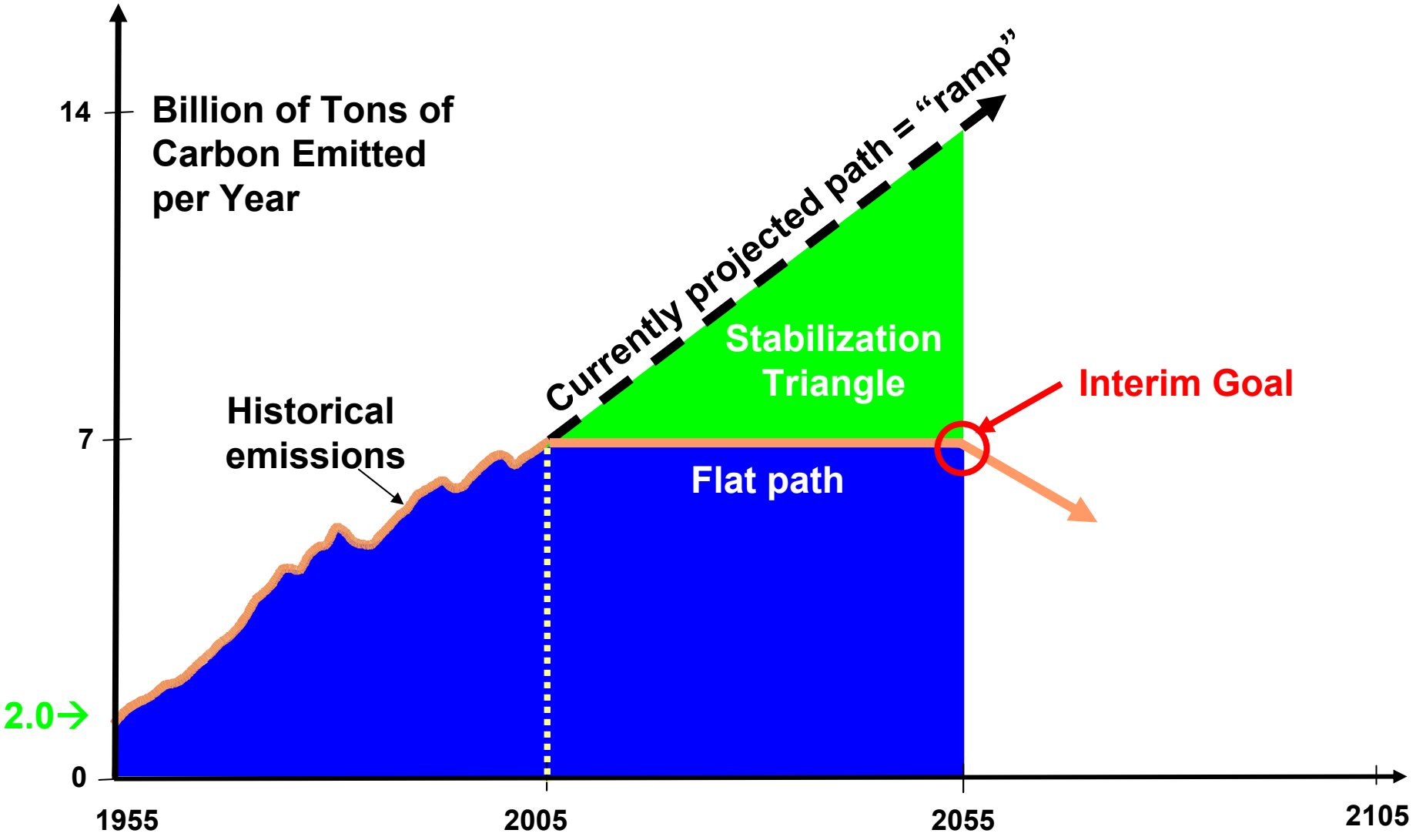








The Stabilization Triangle



Today and for the interim goal, global per-capita emissions are ≈ 1 tC/yr.

Four ways to emit 1 tonC/yr

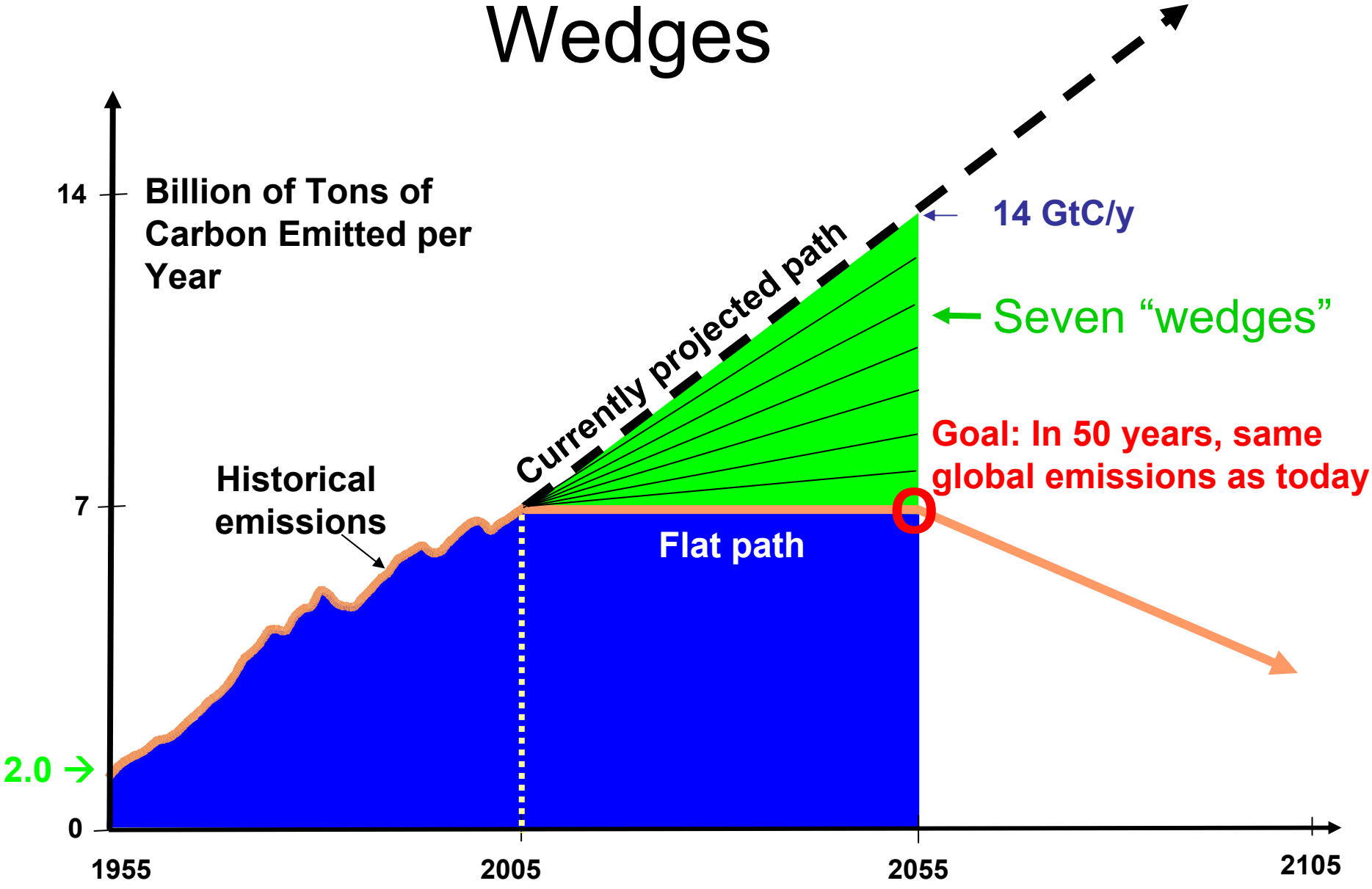
Activity	**Amount producing 1 ton carbon/yr emissions**
a) Drive	16,000 km/yr, 8 liters/100 km
b) Fly	16,000 km/yr
c) Heat home	Natural gas, average house, average climate
d) Appliances	300 kWh/month when all coal-power (600 kWh/month, natural-gas-power)

Five ways to cut 1 tonC/yr by half

	1 ton carbon/yr	Cut in half	How?
a) Drive	16,000 km/yr 8 liters/100 km	4 liters/100 km	Lighter, less power(?)
b) Drive	16,000 km/yr 8 liters/100 km	8,000 km/yr	Live closer to work
c) Fly	16,000 km/yr	8,000 km/yr	Video-conference
d) Heat home	Nat. gas, av. house, av. climate	Insulate, double-pane windows, fewer leaks, condensing furnace,	
e) Appliances	300 kWh/month when all-coal power (600 kWh/month, NJ)	All-coal power: add CCS* at 60% of the plants, or permanently replace twenty 60W incandescent bulbs, lit 6 hrs/day, with compact fluorescents.	

*CCS = CO_2 capture and sequestration

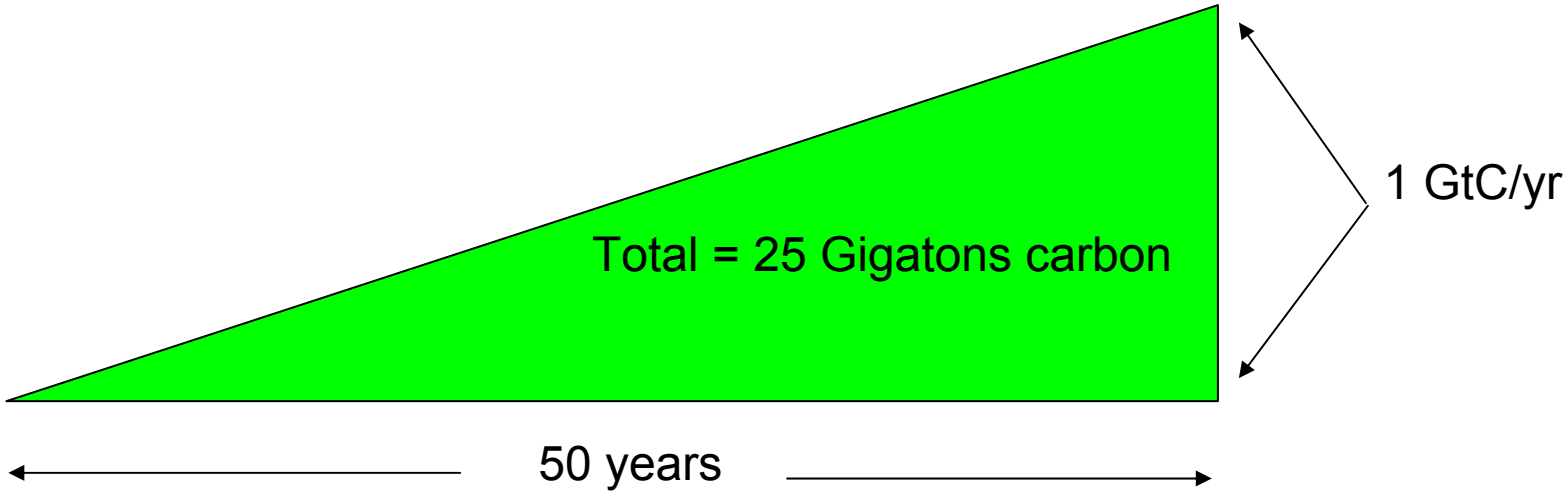
Wedges



Today and in 50 years, global *per-capita* emissions are ≈ 1 tC/yr.

What is a “Wedge”?

A “wedge” is a strategy to reduce carbon emissions that grows in 50 years from zero to 1.0 GtC/yr. The strategy has already been commercialized at scale somewhere.

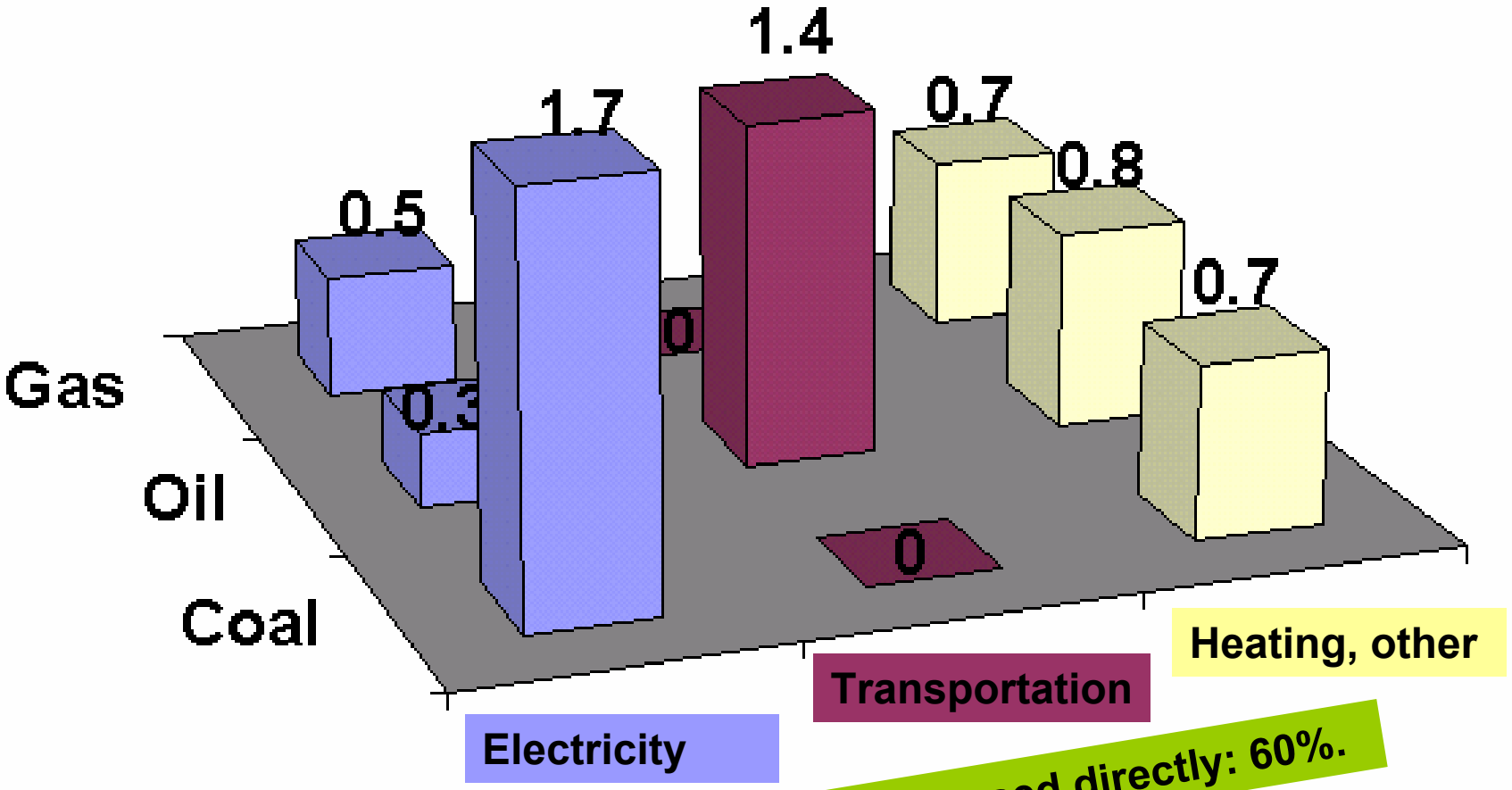


Cumulatively, a wedge redirects the flow of 25 GtC in its first 50 years. This is 2.5 trillion dollars at $100/tC.

A “solution” to the CO_2 problem should provide at least one wedge.

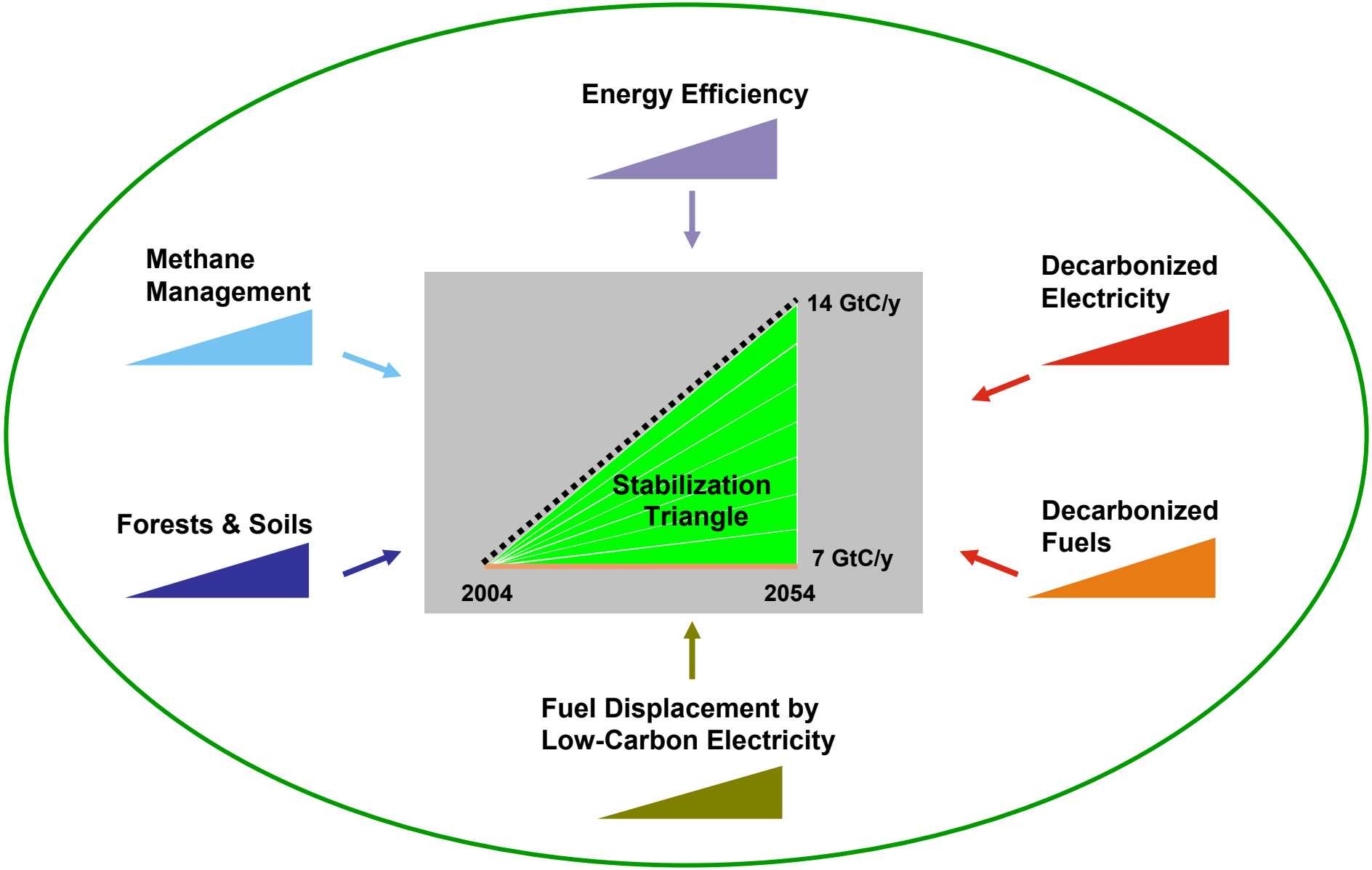
CO_2 Emissions by Sector and Fuel

Allocation of 6.2 GtC/yr 2000 global CO_2 emissions



Electricity: 40%; fuels used directly: 60%.

Fill the Stabilization Triangle with Seven Wedges



Priority #1: Invent a smart-carbon post-industrial society

The post-industrialized age features unprecedented private consumption. In industrialized countries more than 60% of oil is used in vehicles, more than 60% of electricity in buildings.

The CO2 mitigation challenge is a challenge to both energy supply systems and the energy end-use systems.

Efficient Use of Electricity

motors

lighting

cogeneration

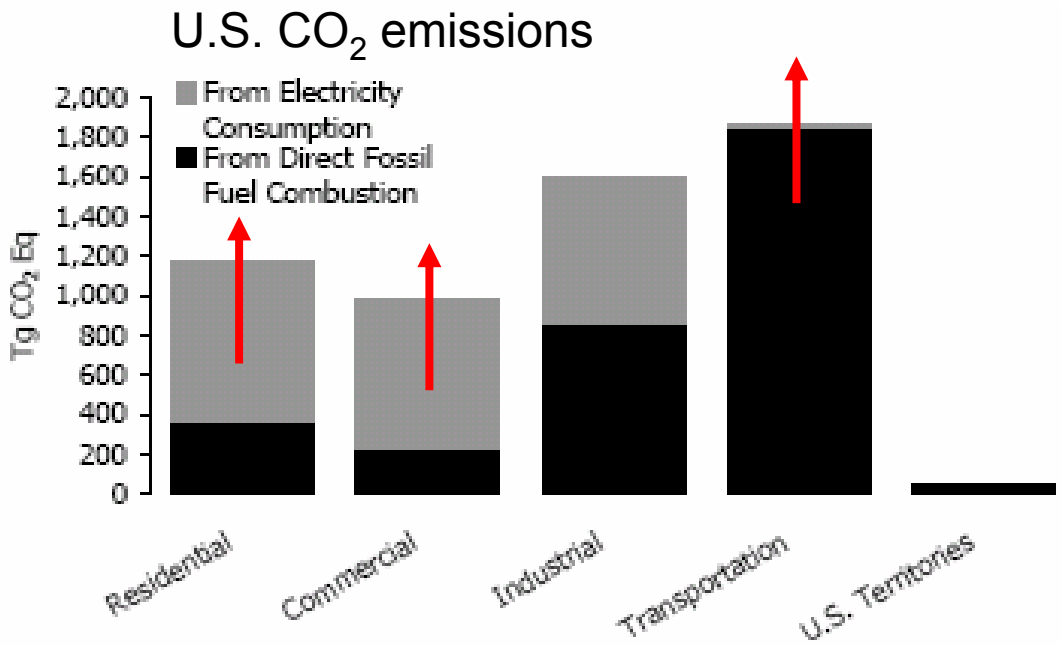
Effort needed by 2055 for 1 wedge:

25% reduction in expected 2055 electricity use in commercial and residential buildings.

Assumes: 40% of global CO2 continues to be emitted at power plants and 70% of electricity is used in buildings.

Target: Commercial and multifamily buildings, worldwide.

At the power plant, CO_2 heads for the sky, the electrons head for buildings!



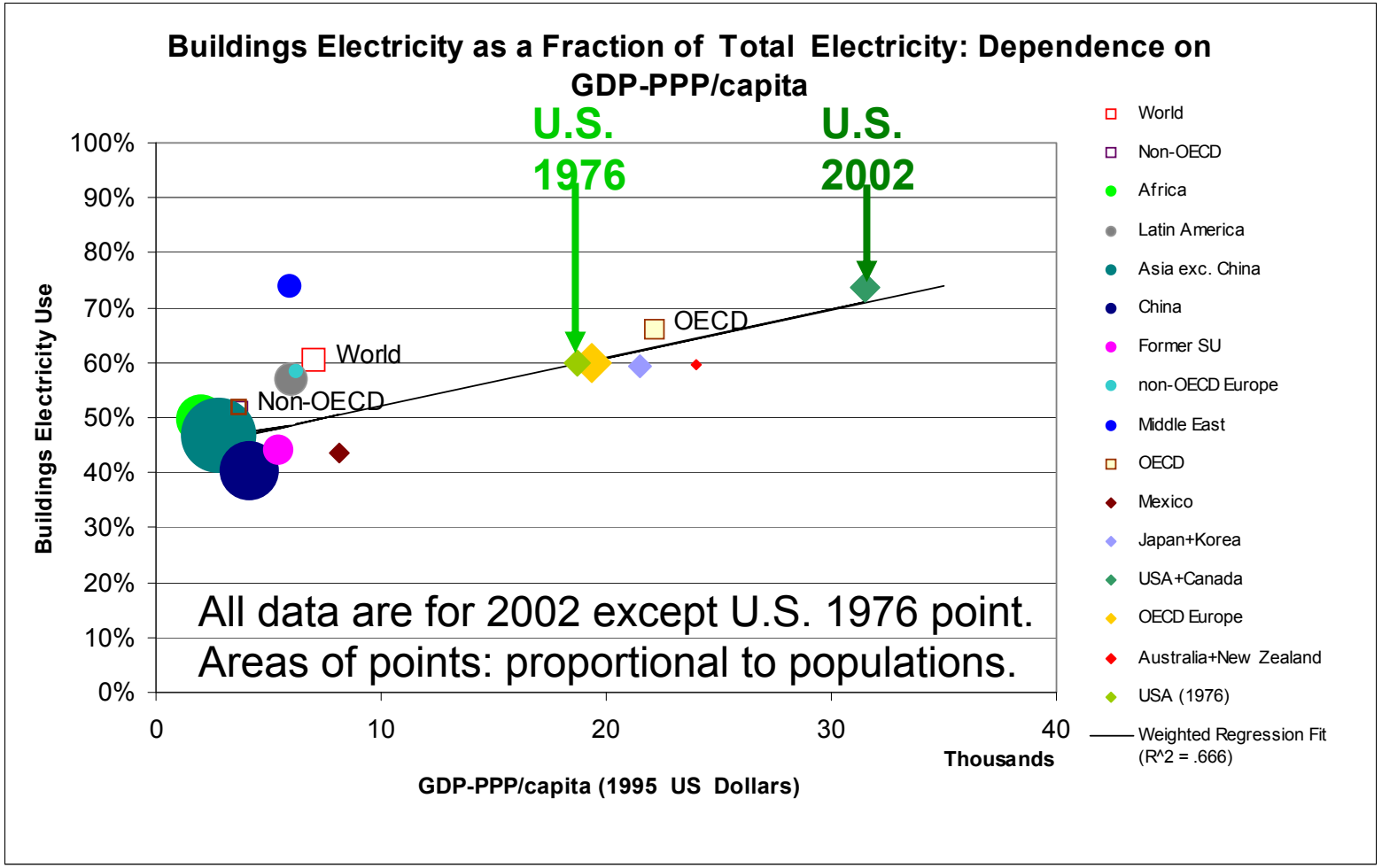
1) Electricity in buildings, and 2) all forms of transport are the components of CO_2 emissions that rise in a post-industrial society.

They are the two top places to look for wedges.

Figure 2-9: 2004 End-Use Sector Emissions of CO_2 from Fossil Fuel Combustion

Source: U.S. EPA

A larger fraction of electricity goes to buildings in rich countries



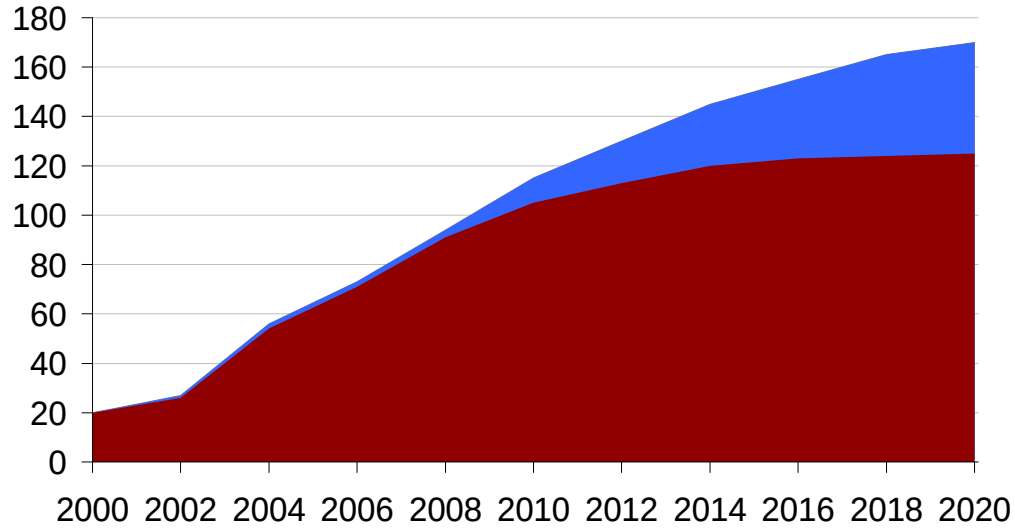
"Buildings Electricity" = 100% Commercial and Residential + 15% Industrial + 10% Agricultural.

Data provided by Paul Waide, graphics by Shoibal Chakravarty

China Appliance Standards

Business as Usual: CO_2 emissions from air conditioners in 2020 are 9x those in 2000.

New Air Conditioner Standard: Down 25% (45 $MtCO_2$/yr) in 2020.



50 million new, efficient air conditioners per year in 2020

Lessons from the 1970s

Measure, measure, measure (institutionalize skepticism: trust, but verify)

For existing buildings, go building by building

For new buildings, anticipate the undoing of good intentions (e.g., interior design and the aesthetics of daytime mood lighting)

Use policy:

- Performance standards (appliance efficiency, interior temperature, light levels)
- Bounty for old stuff (cars, appliances)
- Time-of-day pricing and congestion charges(!)
- Lifeline rates

Utility economics: decouple revenue from sales

New: Anticipate increases in kWh consumption via shifts from fuel to power (hybrid vehicle, heat pump)

Every wedge strategy can be implemented well or poorly

Every wedge has a dark side, generating opposition that thwarts implementation.

Conservation	Regimentation
Renewables	Competing uses of land
Nuclear power	Nuclear war
“Clean coal”	Mining: worker and land impacts

“Solution science” is emerging: the study of the environmental and social costs and benefits of stabilization strategies.

Can We Do It?

People (we!) are becoming increasingly determined to lower the risk that we and our children will experience major social dislocation and environmental havoc as a result of rising CO_2 in the atmosphere

…and we are learning that there are many ways of changing how we live, what we buy, and how we spend our time, that will make a difference.

We are in the midst of a discontinuity:

What once seemed too hard has become what simply must be done.

Precedents include abolishing child labor, addressing the needs of the disabled, and mitigating air pollution.

Further Reading

Two papers on “wedges” by Steve Pacala and Rob Socolow:

1) “Stabilization Wedges: Solving the climate problem for the next 50 years with current technologies,” *Science*, **305** (5686), August 13, 2004, 968-972 (and its Supporting Online Material).

2) “A plan to keep carbon in check,” *Scientific American*, September 2006, 50-57.

Twin Rivers research:

R. H. Socolow, ed., *Saving Energy in the Home: Princeton’s Experiments at Twin Rivers*. Cambridge, MA, USA: Ballinger Publishing Company, 1978.