THE ENERGY ADVOCATE

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A Little Agreement

"Nuclear is no solution to climate change," bleats the Sierra Club [1], using the unfounded assumption that "climate change" somehow needs a "solution.

Otherwise, I have to agree. If we were to get 100% of our energy from nuclear (or Pixie Dust, for that matter), the effect on climate would be negligible. The climate will go on changing, just as it has done forever.

The Sierra Club is just one of many fervently anti-nuclear organizations. What is remarkable is just how rich these groups are. Robert Bryce [2], summarizing Capital Research's of anti-nuclear groups [3], emphasizes that the *annual* revenue of anti-nuclear NGOs is $2.3 *billion*. As shown in Bryce's nearby table, each of the top four anti-nuclear groups has a budget greater than the top ten pro-nuclear groups combined. Overall, the anti-nuclear groups have a combined budget that is 14 times the combined budget of all pro-nuclear groups combined. Bryce writes [2]:

> These numbers are relevant right now. On August 11, Illinois Gov. J.B. Pritzker vetoed a bill that would have lifted a moratorium on new nuclear reactors in his state. Pritzker vetoed the measure even though the bill had broad support in both houses of the Illinois Legislature. Who cheered Pritzker's veto? The Sierra Club, of course. So did the Illinois Environmental Council, which has a budget of about $1.6 million per year.
> ...
> A few days before Pritzker vetoed the bill, the Illinois Sierra Club and IEC sent the governor a letter urging him to spike the legislation. After Pritzker did their bidding, Sierra Club Illinois Director Jack Darin issued a press release saying new nuclear power plants in the state "<u>would have opened the door to increased risk</u>, negative environmental impacts, and higher costs for consumers." All of those claims, of course, are false.

Most of Ken Braun's Capital Research article tells how the organization went out of its way to avoid overcounting the budgets. The $2.3 billion total is therefore likely an underestimate. He says [3]

> The Sierra Club is far from alone. There may be as many as 1,000 groups in the United States with an agenda that includes opposition to the nation's largest source of carbon-free energy. More than 200 have recently been identified in the Capital Research Center's InfluenceWatch database.

Note that Braun evidently regards it important to have "carbon-free energy." This cudgel is taken up by all too many people (including some scientists and engineers) in the nuclear industry. Pro-nuclear people who persist in pushing the "climate-crisis" theme may well have regrets when the public finds out that there is no "climate crisis." The anti-nuclear groups will remember that the nuclear industry advertised that using nuclear power helps "battle" climate change.

Nuclear advocates should emphasize the positives. A nuclear plant that generates one billion watts of electricity around the clock for a year consumes one tonne of uranium and produces one tonne of radioactive waste that remains with the fuel. The casks containing 100% of the spent fuel and 100% of the radwaste from two such reactors for over twenty years sit out in the open on a concrete pad much smaller than your local WalMart at the Zion power plant in Illinois. The radiation exposure to somebody walking among the storage casks is nil. The reactors provided steady power around the clock.

Revenue Of Top 5 Anti-Nuclear NGOs Vs. Top 10 Pro-Nuclear NGOs

Top 5 Anti-Nuclear NGOs		Top 10 Pro-Nuclear NGOs	
World Wildlife Fund	$382	Nuclear Energy Institute	$50
World Resources Institute	$290	Clean Air Task Force	$32
Environmental Defense Fund	$285	Third Way	$27
Natural Resources Defense Council	$186	Manhattan Institute	$20
Sierra Club	$152	American Nuclear Society	$12
Total	**$1,295**	ClearPath	$9
		Breakthrough Institute	$5
		Ctr of the Nuclear Experiment	$5
		Nuclear Innovation Alliance	$1
		US Nuclear Industry Council	$1
		Total	**$162**

2021 revenue in $millions

Sources: Capital Research Center, ProPublica   © Robert Bryce

[1] https://www.sierraclub.org/maine/blog/2023/06/nuclear-not-climate-solution-maine

[2] Robert Bryce, "The Anti-Nuclear Industry Is A $2.3B-Per-Year Racket," https://robertbryce.substack.com/p/the-anti-nuclear-industry-is-a-23b

[3] Ken Braun, "Annual Revenue of Opponents of Carbon-Free Nuclear Power Exceeds $2.3 Billion," August 9, 2023, https://capitalresearch.org/article/annual-revenue-of-opponents-of-carbon-free-nuclear-power-exceeds-2-3-billion/

War Against Natural Gas

When my dad returned from Europe at the end of WW-II, he was the manager of Arch Bean's coal yard. After a couple of years, he bought out the owner. Then he began putting himself out of the coal business by installing conversion burners—gas burners that were directly installed in existing coal furnaces.
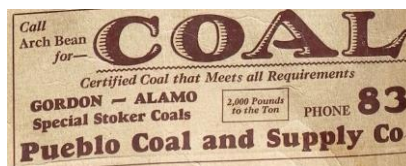
Homeowners no longer had to keep a coal fire going and take out the ash and the clinkers every day. There was a lot less smoke in the air, as Pueblo, Colorado converted from coal to gas.

It is virtually impossible to get a clean burn of coal in a home furnace. It can be done in huge coal-fired furnaces in power plants. The coal is pulverized and blown in with air so that each tiny piece of coal is surrounded by air and able to burn completely. Filters assure

that no ash goes up the chimney. Some chemical processes (that I do not pretend to understand) remove various contaminants in coal—mercury, sulfur, and others. Still, natural gas remains easier to use.

Coal-fired power plants use a steam cycle. The efficiency of converting heat energy into mechanical energy (hence to electrical energy) is higher when the steam is hotter. However, the hotter steam becomes, the more corrosive it is. So, the efficiency of coal-fired plants averages about 33%.

Natural gas fed into modern turbine engines produces electricity with approximately 44% efficiency. (Pulverized coal would be abrasive and detrimental to the operation of the turbine.) In large power stations, the very hot exhaust from gas turbines is ducted (in some cases with added heat) to run a steam cycle, so that overall efficiency of the plant is about 60% when the units are run continuously at full power.

The advent of hydraulic fracturing ("fracking") has suddenly made natural gas abundant, and far easier to get to market than coal.

On a per-kilogram basis, the combustion of coal releases about 1.5 times as much CO_2. Because the efficiency of a normal natural-gas plant is higher than that of a coal-fired plant, on a per-kWh basis, the coal plant produces close to twice as much CO_2 as the gas plant. Compared to a large combined-cycle plant, the coal plant produces about 2.7 times as much CO_2.

As shown at the figure from Our World in Data to the right, the switch from coal to natural gas has had a profound effect on CO_2 emissions in the US.
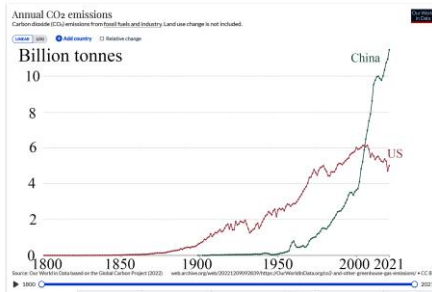
For climate worrywarts, the switch to natural gas should come as a big relief. "We're Battling Climate Change!" It seems instead to be a motivation to do more fanatical things. It took no more than a minute to find three news headlines about governmental moves to ban natural gas—the very thing that has caused the US to reduce its CO_2 emissions that are supposedly causing "climate change." As Stephen Moore puts it [4]:

An Oregon City Banned Natural Gas. The Gas Company Fought Back

Cities tried to cut natural gas from new homes. The GOP and gas lobby preemptively quashed their effort

San Francisco Becomes the Latest City to Ban Natural Gas in New Buildings, Citing Climate Effects

> What makes the Left's war against natural gas inexplicable is that the single biggest factor in reducing carbon emissions into the atmosphere has been the increased reliance on natural gas for electric power generation as we transition slowly away from coal.

[4] Stephen Moore, "Biden Is Waging An Absurd War Against This Abundant Clean Energy," August 22, 2023, https://dailycaller.com/2023/08/22/stephen-moore-biden-is-waging-an-absurd-war-against-this-abundant-clean-energy/

Giga, Tera, Peta, ExaFlops

The heading of this article does not refer to Broadway shows that failed.

The mass of the sun is about 2,000,000,000,000,000,000,000,000,000,000 (= 2×10^{30}) kg. When that number is entered into a computer as "2E30" the 2 and the exponent 30 are stored together as a "floating-point" number. A calculation involving such a number is called a "floating-point operation," abbreviated *flop*.

By the early 1980s, supercomputers had achieved a billion (10^9) floating-point operations *per second*, or gigaflops. By the late 1990s, the speed had increased by a factor of 1,000 to teraflops—a trillion flops. By 2010, supercomputers were doing a quadrillion floating-point operations per second. Now, they are approaching exaflops status—a million-million-million (10^{18}) floating-point operations per second.

Climate models are run on supercomputers because they involve massive amounts of data and complicated equations.

Let us now slow things down a bit and look at a heat-balance diagram published by the IPCC (See Figure 1) but annotated with equations and arrows. A quick count reveals that there are 12 numbers in the original chart; all are expressed in W/m², averaged over the earth's sphere.

It is not a trivial task to make up a heat balance drawing like that of Fig. 1; some numbers are easy to obtain, and some are harder. For example, we do have direct measurements of solar intensity at our orbit, even dating back to the late 1800s, when it was inferred from ground measurements. The amount of reflected sunlight has long been measured by earthshine hitting the moon. The amount of earthly heat that goes into evaporation has been measured by averaging worldwide precipitation. The radiant heat leaving the surface is readily calculated from the Stefan-Boltzmann law, and the amount of IR leaving the planet (239 in the drawing) is measured three ways. (1) at equilibrium, it must equal the absorbed sunlight; (2) it has been measured by satellites flying well above the atmosphere; and (3) it has been calculated from the known spectral properties of the greenhouse gases.
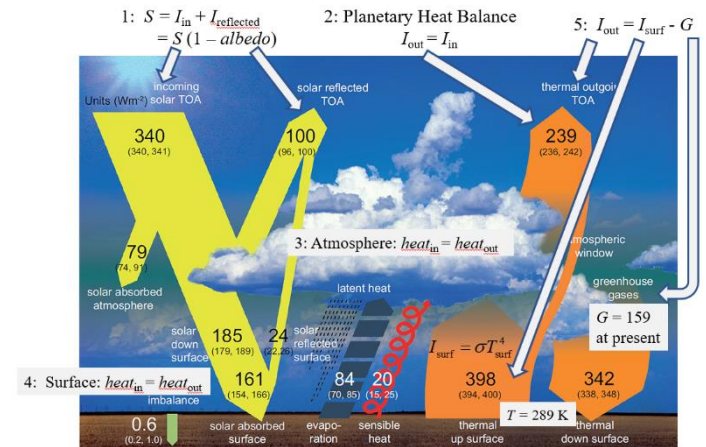

Figure 1: The heat balance drawing from IPCC's *Fifth Assessment Report*. All heat rates are in W/m² averaged over the sphere.

The two numbers that are hardest to measure with high accuracy are the "sensible heat" of 20 ± 5, and the "imbalance" of 0.6 ± 0.4 and the, because both involve subtraction of large numbers to obtain small differences, which is always dicey with imperfectly known numbers. The "sensible" heat value is the worldwide difference between heat transferred from the surface to the atmosphere by direct contact and the heat going to the surface, also by direct contact. The "imbalance" can in principle be measured by measuring the difference between absorbed solar heat and emitted IR but is more likely estimated from the rate at which the average temperature has been rising. A positive imbalance is consistent with a warming earth.

Children learn in grade school that energy can be neither created nor destroyed but can be converted from one form to another. Figure 1 shows five examples of the conservation of energy. For example, the surface receives 161 directly from the sun and 342 from the atmosphere, making a total of 503. The surface loses 84 through evaporation, 20 by sensible heat, 398 via infrared, for a total of 502, for a net absorption of 1, or to the best accuracy they can obtain, 0.6.

There is one number missing from IPCC's original drawing, and that is the one that most people think is the specialty of the IPCC: ***the greenhouse effect***. Finally, in the *Sixth Assessment Report*, the IPCC assigned a symbol (G) and a number (159 W/m²) to the greenhouse effect. The number is simply the numerical difference between the surface IR emission of 398 W/m² and the emission to space (239 W/m²). Of course, the self-realization did not cause the IPCC to include the greenhouse effect in their heat-balance diagram in that report.

A more serious omission, however, is that the climate *models so loved by the IPCC have never been used to construct heat-balance drawings for the future.* It's just too much to ask, when your supercomputers are limited to a few petaflops.

Climate Models

To predict tomorrow's weather, you begin with today's weather and then apply laws of physics. Small uncertainties in the data lead to small uncertainties in the prediction for tomorrow, but larger uncertainties in the prediction for the next day.

Now begin with the notion that CO_2 controls climate. To predict future climate, you must make assumptions about how much CO_2 will be released annually by burning coal, oil, and natural gas, and how much of that CO_2 will remain in the atmosphere. In IPCC's *Fifth Assessment Report* (*AR5,* 2014), they introduced the terminology *Representative Concentration Pathway* (RCP), and in *AR6* (2021) the *nom du jour* became *Shared Socio-economic Pathway* (SSP). That is, the notion that CO_2 controls climate is a *built-in assumption* of IPCC's climate models. Not surprisingly, the logicians at IPCC have concluded that CO_2 controls climate.

Let us have a look at IPCC's confused terminology.

Presently, sunlight averaged over the spherical shape of the earth is 340 watts per square meter (W/m²) and 30% of that is reflected to space so we absorb 239 W/m². (We use IPCC's numbers throughout.) Equilibrium demands that we radiate 239 W'm² to outer space. The surface radiates, on average, 398 W/m², and the atmosphere has a net absorption of 159 W/m² of that IR.

It would have been reasonable for the IPCC to refer to the net IR absorption of 159 W/m² as "radiative forcing F," and to *changes* in F with the symbology ΔF, where the "Δ" usually indicates a change. They did not do so. Confusingly, they refer to "Radiative forcing ΔF (W m⁻²)" in the *Third Assessment Report.* But things are even worse than that. IPCC's definition in the *Sixth Assessment Report* is shown in the box below.

If you needed further proof that IPCC does not understand basic science, it's right there in the box. The law of Planetary Heat Balance says that at equilibrium, the heat absorbed from the sun ("downward radiative flux") equals the heat radiated into space ("upward radiative flux"). At equilibrium, "downward minus upward" radiative flux is necessarily zero, regardless of the amount of sunlight at our orbit, the albedo, or the greenhouse effect. By IPCC's definition, the "radiative forcing" is zero at equilibrium. The eight (8) Coordinating Editors and the twenty-six (26) members of the Editorial Team that wrote the 40-page Glossary can't even define the most important term in IPCC's *Sixth Assessment Report.*

What IPCC is really trying to say is that there are three things that affect the visible and IR radiative quantities: the amount of sunlight, the albedo, and the greenhouse gases. If the amount of sunlight increases or the albedo decreases, the planet absorbs more solar energy. If the greenhouse effect increases, the net absorption of IR increases.

IPCC's Own Numbers

In *AR6*, we read, "Human-caused radiative forcing of 2.72 [1.96 to 3.48] W m⁻² in 2019 relative to 1750 has warmed the climate system." By "radiative forcing" of 2.72 W/m², the IPCC means that the increase in the *net* absorption of IR has been 2.72 W/m²: a change from 156.28 W/m² to 159 W/m². One would not expect that 1.7% change to have much effect on global temperature.

IPCC says on page 191 of *AR6* that the temperature rise since 1850 is 1.26ºC, and (elsewhere) that the temperature rise between 1750 and 1850 is about 0.1ºC, so they are saying that a total of 1.36ºC temperature rise is caused by an increase in the greenhouse effect of 2.72 W/m². What they fail to do is to apply the Stefan-Boltzmann law to their results. A temperature rise of 1.36ºC would cause the surface to radiate 7.4 W/m² more than it did in 1750. How could this possibly be caused by a "radiative forcing" of only 2.72 W/m²?

Answer: it can't. 0.5ºC is more like it. The earth may well have warmed 1.36ºC since 1750, but the greenhouse gases are responsible for no more than 0.5ºC of that rise.

SSPs

IPCC has Shared Socio-economic Pathways (SSPs) numbered 1 through 5, with attached estimates of the total "radiative forcing" expected by the year 2100. For example SSP3-7.0 refers to CO_2 emissions scenario given by the next-to-top line in the adjacent graph, with an expected "radiative forcing" of 7.0 W/m² by the year 2100. SSP1 and SSP2 represent various scenarios by which CO_2 emissions decrease with time, reaching zero late in the century.

Fig. SPM 4 (a) from *AR6 WGI 2021*
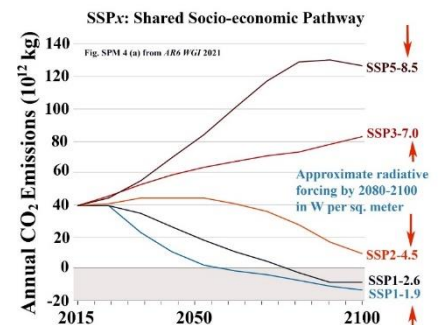
For any given SSP, there are many additional assumptions: how much snow will melt, thereby removing reflective snow and exposing light-absorbing earth, how much water will evaporate, how much sulfate will go into the atmosphere to change the albedo, and so forth. The figure to the right shows IPCC's predictions of temperature rise 0.5ºC to 5ºC. for many scenarios (SSP3-7.0 in pink; SSP1-2.6 in blue.) The dots along the 2ºC line show when the temperature reaches the dreaded 2ºC increase that "climate scientists" have said is to be avoided.

(a) Global mean temperature in CMIP6
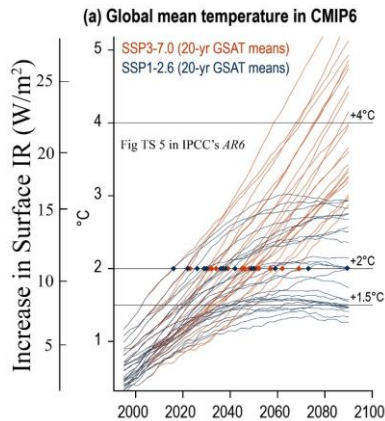
I have appended a secondary scale, showing the increase in surface radiation I in W/m² calculated from the Stefan-Boltzmann radiation law.[1] For example, a temperature increase of 2ºC would cause the surface to radiate about 11 W/m² more than it does now.

Here is a challenge to any and all "climate scientists" who produce or use climate models:

- Choose an SSP. Any SSP.
- Choose a scenario. Any scenario.
- Choose a time in the future. Any time 20 or more years into the future.
- Use the results of the supercomputer code for that SSP, scenario, and time to make a heat balance diagram.
- You must include the number that is missing from other heat-balance diagrams—the greenhouse effect G.
- You must show how G is calculated from the "radiative forcing."

I have offered some "climate scientists" a $1,000 wager to make such a heat-balance drawing: "$1,000 says you can't do it. Agree to the wager now, and you have two weeks to do the work."

Exeunt stage left.

To see why this wager is safe, it helps to look at the increase in surface emission caused by temperature rise, and compare it with the **_total radiative forcing expected by 2100._** For example, the SSP1-2.6 designation means that IPCC expects 2.6 W/m² increased radiative forcing by 2100 (the reference date is 1850-1900.) All of those models (blue lines in the drawing) would result in increased surface IR emission in the range of 6-to-10 W/m². How is it possible to block an additional 6-to-10 W/m² with an increase in the "radiative forcing" of only 2.6 W/m²?

Similarly, the SSP3-7.0 models show 15-to-30 W/m² being blocked by only 7.0 W/m² of increased IR-blocking ability.

STEM Notes

Everybody can subtract 99 from 100. But suppose that both of those two numbers are accurate to 1%. That is, we now

must subtract 99 ± 1% from 100 ± 1%, or 99 ± 1 from 100 ± 1. In principle we could be subtracting 98 from 101 to get 3. Alternatively, we might wind up subtracting 100 from 99 to get −1. So, the "obvious" answer of 1 is not so obvious. The correct answer could be anywhere in the range of −1 to +3. So, we should write the answer as 1 ± 2.

The numbers we started with were accurate to 1%, but the result of subtraction is 1 ± 200%. (A more sophisticated technique would put the uncertainty at 1.4, or 140%).

This little arithmetic lesson should serve as a reminder that it is far better to measure differences directly than to subtract large numbers to find small differences.

USGS Fanaticism on NPR

NPR can't get through a news broadcast without blaming something on "climate change." On 8/22/2023, they interviewed Sean Vitousek of the USGS in Santa Cruz, CA about sea rise. As you know, the weighted average of sea rise from tidal stations around the world is 1.8 mm/year, whereas the satellites put the rise at 3 mm/year (one foot per century).

To make sea rise sound dangerous, Vitousek said that sea rise of one meter would wash away the beach for 30 meters inland, "So, when you get into three meters of sea-level rise …". Maybe he's confusing 3,000 mm with 3 mm. The chart to the right shows sea rise from 1950 to 2010 ("Data" 10 cm—4 inches—in 50 years) with Vitousek's 3-meter delusion drawn to scale.

In any case, the next interviewee was Kathleen Treseder (U. Cal, Irvine, now in some political office in Irvine), who said that Vitousek's conclusions were "robust."

NPR seeks (and receives) donations to support their Climate Desk. The Associated Press admits to receiving support of "climate and environmental coverage." It would be interesting to see just how much money is funneled to various news outlets, "climate" NGOs, and other organizations from private foundations and the government.

In other words, follow the money.

Qui Bono?
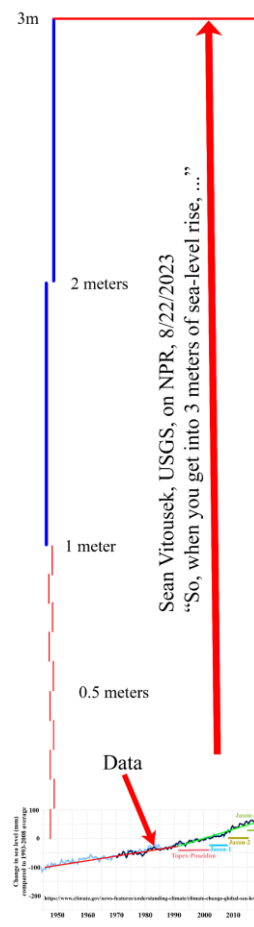
Associated Press climate and environmental coverage receives support from several private foundations.

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[1] $I = \varepsilon\sigma T^4 = \varepsilon\left(5.67\times10^{-8} \ \dfrac{W}{m^2 K^4}\right)T^4$, where the emissivity ε is usually taken as 1.0, although 0.95 would be better.