COUNTERFLOW
BY STEVE HUNTOON

Alternative Facts and Global Warming

By Steve Huntoon


Huntoon

Everyone is entitled to their own opinions. But no one is entitled to their own facts.

IMHO, the facts are that climate change is happening, is man-made, and is a threat to mankind. How much of a threat, and how imminent the threat, are things we can talk about.

The big question is what to do about it. There are some who peddle the false hope that we can fix climate change on the cheap.

No Cheap Fix

No. Climate change is not going to be fixed on the cheap. Sugarcoating the requisite effort isn't doing us any favors.

Which brings us to the widely publicized 2015 claim by four academics from Stanford University's Department of Civil and Environmental Engineering and the Institute of Transportation Studies at the University of California, Berkeley that we can power the *entire* economy at "low cost" with just wind, water and solar (WWS) resources, using electricity and hydrogen as the delivery systems. The study was led by Stanford's Mark Jacobson, so let's call them the Jacobson Group.[1]

Their vision is not just electric generation powered with WWS resources, mind you: *everything* to be powered with WWS resources as the sole primary sources. Planes, trains and automobiles. Ships. Trucks. Industrial processes. All natural gas facilities — yes, your gas furnace, dryer, water heater and stove[2] — are torn out. All nuclear, gas and coal plants are shut down. Got the idea?

To put this staggering "low-cost" scenario in perspective, past analyses of deep decarbonization (80% reduction) of *only the electric sector* (and keeping nuclear plants) estimate increases of $23 to $53/MWh in average retail electric rates by the year 2050.[3] Whether one views a retail price increase of this magnitude as worthwhile can be debated, but it certainly can't be called "low cost."

Two years have gone by since the Jacobson Group paper was published, and thankfully the National Oceanic and Atmospheric Administration's Christopher Clack and 20 others (the Clack Group) have come forward to refute it.[4] The Jacobson Group replied, claiming their analysis was impeccable.[5] And the Clack Group has responded.[6]

Up to this point you may be thinking: "OK I read about this controversy in *The New York Times*, *Washington Post* and/or *The Economist*,[7] and there's probably some truth to each side."

Simply Wrong

You would be wrong. The Jacobson Group is in the realm of alternative facts. It is simply wrong.

Don't take my word on this. If you have the time and inclination, please read the Clack Group's detailed (and fascinating) "Supplemental Information," available here.[8] And then read the Jacobson Group response, available here.[9] You'll see that the Clack Group demolishes dozens of Jacobson Group claims; the Jacobson Group ignores most of the demolition and offers tweet-like replies for the rest.[10]

Why care? Right and wrong matter because wrong has tragic policy implications.

For example, the Jacobson Group claims that WWS resources can suffice for a low-cost carbon-free future, so it rules out other carbon-free sources like nuclear power. In the case of nuclear power, the Jacobson Group asserts a life-cycle mortality analysis that assumes nuclear wars occur on a 30-year cycle, which they haven't, and that civilian nuclear power somehow sustains military nuclear power, which it doesn't.[11]

The Jacobson Group also claims that all nuclear generation is uneconomic, relying on studies of *new* nuclear generation costs. As noted earlier, past analyses of electric sector deep decarbonization keep existing nuclear generation, the bulk of which *is* economic on a going-forward basis even with current low natural gas prices.[12]

Don't Abandon Energy Efficiency

Here's another tragic policy implication: Energy efficiency doesn't matter. If WWS resources can supply existing energy demand at low cost, why be more efficient? I've written before about how LED lighting has reduced demand by more megawatt-hours than rooftop solar has generated.[13]

That's how significant energy efficiency can be. Let's not abandon energy efficiency on the false hope that WWS resources can supplant all existing energy resources at low cost.

And how about reversing deforestation, which may be the cheapest way to fight climate change?[14] Or incenting India to take the most inefficient air-conditioning units off the market?[15]

Again, the Jacobson Group implicitly says "don't worry, be happy," we can stop climate change on the cheap with WWS resources.

I'm not going to take up a lot of your valuable time regurgitating the entire Clack Group demolition, but I do want to highlight some of the more outrageous Jacobson Group claims so you have a taste. And I'll do a little demo of my own.

Aviation. The Jacobson Group claims that all aviation fuel can be replaced with hydrogen created by electricity from WWS resources. Their support for this is an experimental four-seat airplane that runs on hydrogen.[16]

So … with a pilot, co-pilot and steward, the plane has room for one passenger. Luggage and toilet not included.

The cruising speed of this plane is 102 mph. I guess commercial airlines — and the U.S. Air Force — will just have to make do with a plane barely faster than a car.[17]

Hydrogen Production. Here's a sleight of hand that us electric geeks will understand. Citing themselves, the Jacobson Group claims hydrogen production and storage will cost 4 cents/kwh-to-H2. But the Clack Group points out that this cost is based on a 95% capacity factor, while the capacity factor for hydrogen production in the Jacobson Group model is about 9%.

That means the capital cost for hydrogen production will be 1,000% more than the Jacobson Group claims. The Jacobson Group offers no defense.

Solar Thermal with Storage. Wow, another piece of work. The Jacobson Group says we

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can build massive networks of solar thermal panels that heat up glycol and then pump it underground to storage pools and then make withdrawals as needed. The Jacobson Group cites a residential housing project in Canada that involved 52 homes costing $134,000 each.[18]

Not 'Low Cost'

Mind you, that just gets space heating. Air conditioning, hot water, clothes drying, cooking — all extra. Not "low cost"!

The Jacobson Group claims underground thermal energy storage has a capital cost of $1,320/kW, but, as the Clack Group points out, its cited references don't provide any support. In another paper, the Jacobson Group said it relied on "Lazard's (2014) estimates with 18-hour storage"; that Lazard document says that solar thermal costs more than $9,000/kW.[19]

And where does the Jacobson Group account for the cost of facilities to convert excess electricity into heated glycol for injecting underground in the storage facilities? There is an assumed conversion capacity that is enormous, but I can't find any associated cost for such capacity in the modeling.

Back to the electric industry we know and love.

Water/hydropower. Let's start here with the Clack Group calling out the Jacobson Group's claim that U.S. hydropower capacity can be easily expanded from the current 87 GW to 1,300 GW (not a typo). This issue is the one that got the bulk of media attention.

The Jacobson Group asserted in reply to the Clack Group that it was assuming a feasible increase in capacity at existing hydro facilities.

The reality is that there is very limited hydropower expansion capability. A best-case scenario is an additional 13 GW by 2050, according to the U.S. Department of Energy's recent 407-page study of this subject — *which is hiding in plain sight on the DOE website.*[20]

Yes, the best case is *1%* of what the Jacobson Group claims. *One percent.*

And of course we couldn't release the water associated with 1,300 GW of hydropower without causing massive flooding across the U.S. A minor detail to be sure.

Fantasy

The Jacobson Group claim is a fantasy.

Flexible Electric Demand. In order for the intermittent WWS resources to "work," the Jacobson Group assumes 63% of industrial demand is flexible (totally controllable by system operators within eight-hour windows). We in the electric industry know that despite large economic incentives, only a small percentage of industrial load opts to participate in demand response programs (which involve only demand reduction, not demand increases on command).

In other words the Jacobson Group envisions a paradigm shift in which most industrial load conforms to intermittent resource output rather than the other way around. *Not going to happen at low cost, if at all.*

Offshore Wind. All of us in the industry know what a brutal slog it is. After many years there is all of 30 MW off Rhode Island at a cost of *$244/MWh.* The Jacobson Group makes the incredible claim that *750 GW* can be economically constructed, when the aggregate of all pending offshore proposals is 9.1 GW.[21]

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Electric Transmission. Despite changing virtually all sources of electric generation, and increasing the maximum electric generation the transmission system must handle by more than 500% from 977 GW to 5,271 GW,[22] the Jacobson Group assumes negligible incremental transmission system costs.

The Clack Group pointed out that the National Renewable Energy Laboratory estimated that a 90% renewable electric supply (just electricity not all other energy sources) would require doubling existing long-distance transmission capacity. That was being polite.

The Jacobson Group simply ignored the staggering cost and staggering siting issues involved with a 500%+ increase in transmission system capability.[23]

Electric Distribution. In its critique, the Clack Group left out a huge problem in the Jacobson Group modeling: the electric distribution system. The Jacobson Group's assumptions of net injections from 652 GW of rooftop solar (more than 100 times what currently exists) — and increased electric demand from eliminating retail natural gas, propane and oil use, and from making all cars electric — would require a massive expansion of the distribution system at a staggering cost.[24] How much did the Jacobson Group allow for that? *Zero.*

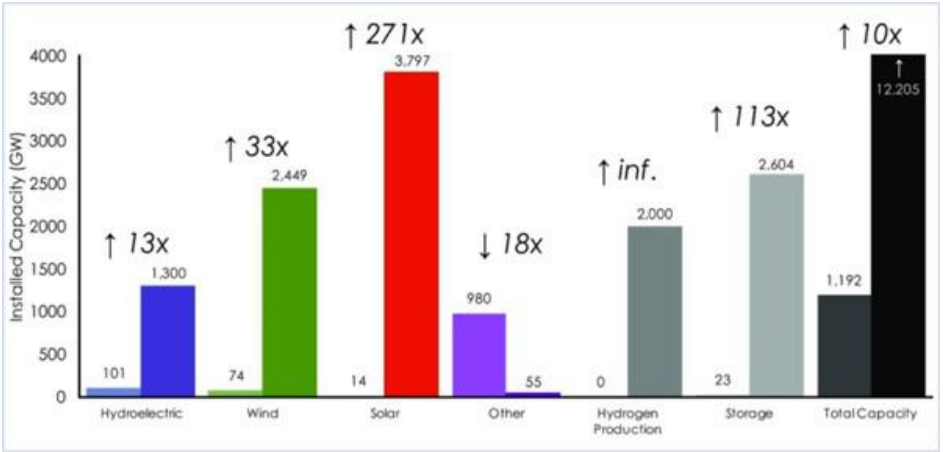
System Modeling. Frequency regulation and operating reserves are ignored by the Jacobson Group. Congestion is avoided by assuming unlimited transmission capability. The Clack Group laid out the problems with all this, and the Jacobson Group simply ignored it.

Cost of Capital/Discount Rate. Saving the best for last because so much money is involved. The Jacobson Group forecasts a cost per kilowatt-hour of its WWS scenario in 2050 based on a "discount rate" of 3%. The Clack Group rightly points out that the true cost of capital is more than twice that.

The Jacobson Group replies that the 3% "is a well-referenced social discount rate for a social cost analysis of an intergenerational project." Whatever that may mean, it is irrelevant.[25]

Electric utility customers — which we'll all be for almost all the energy we use — will pay the weighted average cost of capital of those utilities, which right now is about 7.4% plus an income-tax allowance.[26]

Because virtually all WWS resource costs are capital costs, this element by itself means that the overall cost of the Jacobson Group vision will be 200 to 300% more than it claims (and before correcting for everything else discussed earlier).



Installed capacity values for 2015 (left column in each pair) and those used in the Jacobson studies (right column in each pair). The 100% wind, solar and hydroelectric studies propose installing technologies at a scale equivalent to or greater than the entire capacity of the existing electricity generation infrastructure. The other category includes coal, natural gas and nuclear, all of which are removed by 2050. | Clack, *et al.*

Bottom line, the Jacobson Group's analysis is deeply flawed. It would be a terrible mistake to base public policy on any of its claims.

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[1] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4679003/

[2] On the subject of stoves, I know a lot of cooks who will give up gas cooking when their frying pan is pried from their cold dead fingers. Don't get them started.

[3] http://www.nrel.gov/docs/fy13osti/52409-ES.pdf (Table ES-10 on page 28). NREL has a fascinating future scenarios viewer here. Other modeling is more optimistic, projecting no increase in electricity costs from 80% decarbonization, http://www.nature.com/nclimate/journal/v6/n5/full/nclimate2921.html.

[4] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5495221/. Christopher Clack is now the CEO of Vibrant Clean Energy.

[5] http://web.stanford.edu/group/efmh/jacobson/Articles/I/CombiningRenew/PNASReplyClack.pdf

[6] https://www.dropbox.com/s/n8oxg2xykc8j3dx/ReplyResponse.pdf

[7] https://www.nytimes.com/2017/06/20/business/energy-environment/renewable-energy-national-academy-matt-jacobson.html; https://www.washingtonpost.com/news/energy-environment/wp/2017/06/19/a-bitter-scientific-debate-just-erupted-over-the-future-of-the-u-s-electric-grid/?utm_term=.7587c607d0d0; https://www.economist.com/news/finance-and-economics/21725011-transition-away-fossil-fuels-necessary-it-will-not-be-painless-can

[8] http://www.pnas.org/lookup/suppl/doi:10.1073/pnas.1610381114/-/DCSupplemental

[9] http://web.stanford.edu/group/efmh/jacobson/Articles/I/CombiningRenew/PNASReplyClack.pdf

[10] Oh, and in the media making *ad hominem* attacks on Clack Group contributors such as having "conflicts of interests" to favor other energy resources. These attacks on distinguished academics and scientists are utterly without merit.

[11] But to play out this assumption of periodic nuclear wars *ad absurdum*, they would cause global cooling offsetting to a greater or lesser extent than global warming. So the Jacobson Group's own assumption about nuclear wars is inconsistent with the need to battle global warming. What an intellectual mess.

[12] "In 2016, approximately three quarters of [PJM] nuclear plants covered 100% or more of going forward costs." http://monitoringanalytics.com/reports/Reports/2017/IMM_Post_Technical_Conf_Comments_Docket_No_AD17-11_20170622.pdf (page 3).

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[13] http://www.energy-counsel.com/docs/LED-Kills-the-Edison-Star-2017-01-24%20RTO-Insider-Individual-Column.pdf

[14] https://www.nytimes.com/2017/07/20/climate/a-cheap-fix-for-climate-change-pay-people-not-to-chop-down-trees-uganda.html?emc=edit_ne_20170720&nl=evening-briefing&nlid=39266840&te=1

[15] https://energyathaas.wordpress.com/2017/07/24/cooling-india/

[16] https://phys.org/news/2016-09-world-seater-fuel-cell-plane-germany.html

[17] I won't get into replacement of gasoline and hybrid cars with all-electric cars because I discussed back in February how much the fundamental economics would have to change before electric cars would be cheaper. http://www.energy-counsel.com/docs/Electric-Cars-Three-Ugly-Facts-2017-02-14-RTO-Insider-Individual-Column.pdf. Thankfully a couple obscure studies I cited got much deserved exposure in a *Wall Street Journal* story on July 12, 2017. https://www.wsj.com/articles/electric-cars-are-the-future-not-so-fast-1499873064.

[18] http://www.hme.ca/presentations/Drake_Landing_Solar_Community--AAPT.pdf

[19] https://www.lazard.com/media/1777/levelized_cost_of_energy_-_version_80.pdf (slide 11).

[20] https://energy.gov/sites/prod/files/2016/10/f33/Hydropower-Vision-10262016_0.pdf (pages 1 and 17). This includes installing hydropower capacity at dams without any at present. This study is by advocates of hydropower within DOE, supporting its "Hydropower Vision."

[21] https://www.wsj.com/articles/plans-for-u-s-wind-farms-run-into-headwinds-1499605200. It is also worth noting that the Jacobson Group assumes the capital cost of offshore wind is $3,770/kw, while the real-world costs of the U.S. Wind and Skipjack projects are reported to regulators as $5,544/kw and $6,000/kw, respectively, http://www.offshorewindhub.org/sites/default/files/resources/Order-No.-88192-Case-No.-9431-Offshore-Wind_0.pdf. Presumably these are the most economic projects so others would be more costly.

[22] The existing transmission system interconnects 977 GW of resources per NERC's State of Reliability Report 2016, Table 4.1 (removing Canadian resources). The Energy Information Administration reports a slightly larger 1,064 GW of "Net Summer Capacity" in its Electric Power Outlook, Table 4.3.

The Jacobson Group hypothesizes 5,271 GW of off-site resources in its "Supporting Information," Table S2 (starting with total of 6,390 GW and removing on-site PV and solar thermal resources). All these resources have to be deliverable under its model because "zero electricity shedding occurs."

[23] A note about the ultimate cost to customers: Regulated cost-of-service rates provide a utility a regulated return based on depreciated original cost of the specific facilities, and a depreciation expense based on that original cost. An essentially new and vastly larger transmission system would entail a utility return on the undepreciated full cost of the new system, and a depreciation expense based on the full cost.

Modeling this transmission system cost, along with the distribution system cost discussed below, is beyond the capability of this writer. But the cost would be staggering.

[24] California utilities already claim to need billions of dollars for new distribution facilities in order to handle a relatively small amount of rooftop solar.

[25] Irrelevant, as in "The Treasure of the Sierra Madre" when Tim Holt says, "Not so far as the crow flies," and Humphrey Bogart replies, "But we ain't crows."

[26] http://pjm.com/~/media/committees-groups/committees/teac/20160609/20160609-market-efficiency-update.ashx (slide 17). To the extent WWS resources are provided by merchant companies the cost of capital will tend to be greater than that of regulated utilities.