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The 100% solar, wind and water plan is broken and costs 3 to 5 times more than alternative clean energy

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2

The Solutions Project is an environmental group with a claim that the world can be powered with 100% renewable energy (wind, water and sunlight) and a simultaneous phase-out of fossil and nuclear power.

The all-renewables grid would have with no backup from fueled power plants, and practically no energy storage.

Mass energy storage plays a big role in most large-scale WWS strategies. Various scenarios range from powering the entire grid for 4 hours, up to an entire day.

In contrast, the tiny amount of storage in the Roadmap would only provide the equivalent of around 1.5 hours of nationwide power consumption.

Twenty-one top climate experts, led by Dr. Christopher Clack, formerly with CIRES (Cooperative Institute for Research in Environmental Sciences) at the University of Colorado, have reached the same conclusion, in an analysis called the Clack Evaluation.

The 100% WWS roadmap calls for

* A half million giant 5-MW wind turbines on acreage equal to New York state, Pennsylvania, Vermont and New Hampshire, and in open sea regions equal to West Virginia
* Billions of solar panels on land equivalent to Maryland and Rhode Island
* Concentrated Solar Power (CSP) on land equivalent to Connecticut
* Rooftop solar on 75 million homes and nearly 3 million businesses

In 2009, National Renewable Energy Laboratory (NREL) inspected 172 modern wind farms across the nation, and in 2013 they compiled land-use data for 66 of our large PV solar farms. According to their numbers, U.S. onshore wind will need 4X the land the Roadmap calls for and 2X the land that the Roadmap estimates for solar.

Wind and solar equipment can last from 10–40 years: about 10 years for offshore wind turbines, 25 years for onshore turbines, and up to 40 years for solar panels.

This means that nearly 500,000 giant wind turbines, both onshore and off-, will need a major overhaul before the Roadmap's 35-year buildout is even complete.

It also means that 5 years after completion, we'll have to start recycling and replacing the solar panels – all 18 billion square meters' worth. That's billions with a B.

A 40-year solar refurbishment schedule would mean the recycling and replacement of 1.23 million square meters of worn-out
panels, every single day, rain or shine – forever.

An all-nuclear grid composed of, say, 6,000 Small Modular Reactors (SMRs), each one generating 250 megawatts for a 7-year runtime, would require less than three reactor swap-outs per day (about 70 a month).

Think "nuclear battery": Factory-built SMRs will be fully sealed, self-contained units, about the size of a city bus and transportable by highway or rail. The fresh reactor is installed and the spent reactor is taken to a central facility for service and refueling.

Cost of the 100% WW

The $15.2 Trillion price for the bare-bones Roadmap leaves out the new transmission corridors required to connect its 50,000-plus wind and solar farms to the national grid.

This alone would kick up the price by an additional $0.5 Trillion or more, based on a rough average of 10 miles of new connector lines per farm to link the facility to the main trunk line (the actual grid), at the lowball price of $1 Million a mile.

Another thing left out of the Roadmap is a nationwide HVDC (high voltage / direct current) transmission network. It's something that most renewables advocates agree would be a key element in a national WWS grid.

An HVDC grid, in parallel with our ac grid, is actually quite feasible by running underground cables along existing state and federal rights-of-way, such as highways and railroads.

A national HVDC grid could probably be built for $100–$200 Billion, which is nothing to sneeze at. But in the $15 Trillion grand scheme of things, it's chump change.

In contrast, deploying the right reactors would require virtually no new transmission corridors, since many of the reactors would simply replace our existing fossil plants.

Molten Salt reactors can be drop in replacements for existing coal and natural gas power plants. Molten salt nuclear would be able to reuse turbines and electrical grid.

Generating all U.S. primary energy by 2050 with renewables
Land for photovoltaic solar equal to Maryland and Rhode Island
Land for concentrated solar power equal to Connecticut
Land for onshore wind larger than New York state, Pennsylvania, Vermont
and New Hampshire
An offshore wind region larger than West Virginia
Our existing hydroelectric dams (upgraded to 3% of grid)
Over 140 GWs of hydrogen production for heavy vehicles (problematic)
4.38% overbuild of all WWS systems (inadequate)
Our existing pumped hydro storage (inadequate)
Bare-bones cost: $15.2 Trillion

With 4 hrs of additional pumped hydro: $16.5 Trillion

Generating all U.S. primary energy by 2050 with nuclear power
Land equal to half of Long Island (including full security perimeters)
$9 Trillion with Generation III+ AP (Advanced Passive) Reactors
$6.7 Trillion with Generation III APR (Advanced Pressurized) Reactors based on South Korea's price for U.A.E.
$3 Trillion with Generation IV Molten Salt Reactors
Existing hydroelectric dams (upgraded to 3% of grid)
Existing pumped hydro (to match the Roadmap, but superfluous)
18 months (minimum) of all-grid storage, in the form of reactor fuel
Total cost (depending on the reactors used): $3 Trillion – $6.7 Trillion

Wind summary

Wind will comprise 50% of the Roadmap's 2050 grid: 30.9% from onshore, and 19.1% from offshore, for a 60-year price tag of $5.33 Trillion.

Even with a wind density factor of 0.089 km2 / MWp, it would take 489,600 km2 to generate the Roadmap's entire 1,591-GWs average with onshore wind.

That's acreage equal to Florida, Georgia, South Carolina, and half of North Carolina.

Solar Summary

With wind and solar's meager EROEIs (Energy Returned on Energy Invested), it's vitally important that no panel is ever in shadow and that every turbine's propeller can catch a fresh breeze.

In the world of solar energy, fixed-mount (stationary) PV panels need a little less room than single-axis track-mount panels, which are motorized to follow the sun.

Taking both mounting methods into account, the average solar packing factor for the continental U.S. is about 40%: One square kilometer (1 million square meters) of a solar field will have 400,000 square meters of panel surface.

The 100% WWS roadmap had a packing factor of 100%.

The Roadmap's utility PV solar breaks down as follows:

14.5 billion m2 of panels
Initial installation: $4.1 Trillion1
With one panel replacement and three inverter replacements: $7.4 Trillion
Minus 28% (NREL's utility PV future discount), 60-year cost = $5.3 Trillion

According to NREL, sloped-roof residential is $2.93 an installed watt (dc),17 which pencils out to $1.1 Trillion for the initial installation.18

Panels and inverters are only 38% of total price,19 because the BOS cost (racks, wiring, etc.) and the soft costs like permits, interest, and insurance are pricier for residential work.

One panel replacement and four inverter replacements add about 71% to the original cost.20
Since both commercial and residential rooftop systems must contend with shade from trees, buildings, and other obstructions, their inverters cycle more often and thus wear out faster.

The Roadmap's residential solar breaks down as follows:

2 billion m2 of panels
Initial installation: $1.1 Trillion
With one panel replacement and four inverter replacements: $1.9 Trillion
Minus 23% (NREL's rooftop future discount), 60-year cost = $1.5 Trillion
According to the Roadmap, rooftop residential would deliver 63.3 GWs, or 3.98% of the 1,591-GW grid, for 9.9% of the cost.

Residential PV quick numbers:
63 GWs
4% of grid
10% of cost

That same $1.5 Trillion, which would fund less than 4% of a 1,591-GW all-renewables grid, could fund half of an entire Molten Salt Reactor grid.