Green New Deal: Carina’s (Informal) Opinion

July 2021

I have two opinions about the GND:

1. **It is absolutely needed.**
2. **Today's technology will make it near-impossible / insanely expensive.**

The GND referenced the 2018 IPCC Report, which I highly recommend everyone read to fully understand how exactly the word would change if there was a global warming of 1.5ºC above pre-industrial levels, and most of the grim predictions were statistically analyzed with a 95% confidence interval. Spoiler alert: it won't be a fun time, and the day to do something was yesterday. Often times, it is government regulation that can create significant positive environmental impacts (i.e. carbon tax, requirement of catalytic converters for vehicles, NOx/SOx scrubber requirements for coal power plants). The GND would address all the problems head-on, and I am ecstatic that many politicians agree that the problem of climate change needs to be addressed ASAP.

Unfortunately, it assumes that we have the current technology to go 100% renewable ASAP, and as much as I wished that was true, it's simply not.

The United States is power hungry. We can assume that our current consumption increases or even stays the same due to increased energy efficiency, but intermittent renewable energy will not sustain our power demand unless one or both of these things happen:

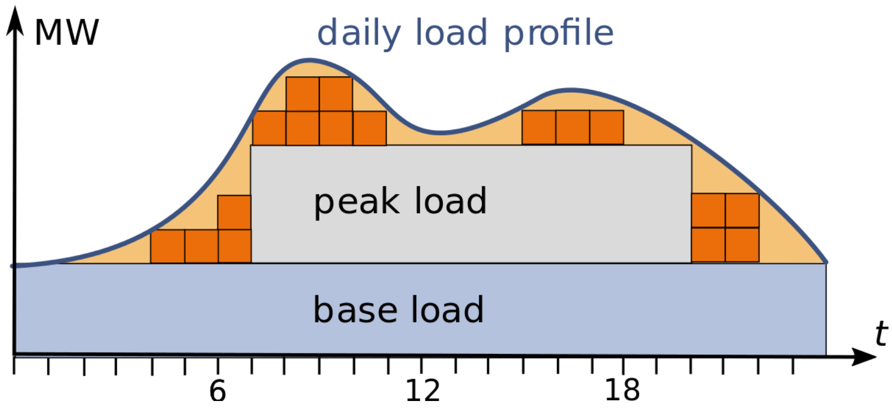
1. We completely overhaul the electric grid.
2. We invest in energy storage and energy diversification technologies.

Or, what I think the GND should say: **We include a bit of both.** But first, let's break this down into sections, just so we're all on the same page.

How does the electric grid work right now?

Right now, the grid is linear: power is generated at a power plant, it gets 'dumped' into a national grid (separated by three sectors [West, East, Texas... don't ask], but it's still connected), and then consumed by the user. I'll go into the technicalities if someone asks, but production *closely* matches demand , which you can see with Cal ISO's wonderful live graph in that link. Basically, there's an uptick of demand in the morning, then it goes down in the afternoon, then goes back up in the evening when people return from work and start to turn on the lights.

Right now, power plants are able to meet supply and demand pretty easily with baseload and peaking plants. Baseload would be nuclear and coal power plants since it's time-consuming to ramp/up down, and peaking would be natural gas-fired power plants since it can ramp up in minutes. Below is a graph of what this looks like with current supply and demand, as well as a visual for what peak and baseload power looks like.



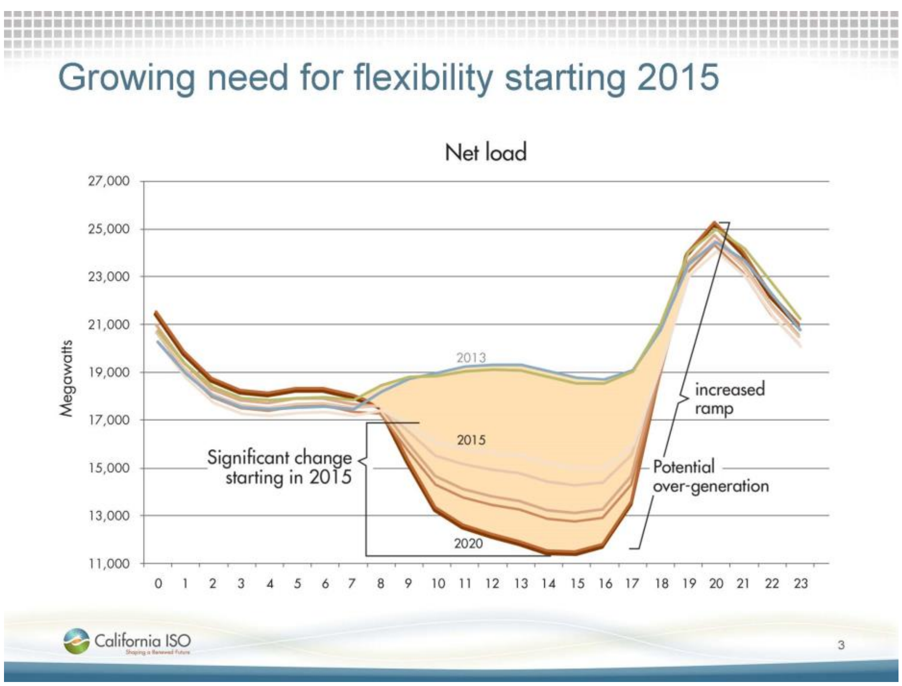
There are real-time grid analysts who carefully monitor supply and demand. If supply exceeds demand (overgeneration), then it goes to waste, and money is lost. If demand exceeds supply, (undergeneration), then blackouts could occur. The power grid is truly finicky sometimes, and the concept of it hasn't changed for 100+ years since its creation.

But with climate change, things need to change... which leads to my next point:

How can wind/solar energy match supply and demand?

The short answer? ... It doesn't. The sun is only shining so many hours a day, and the wind isn't always blowing. We may be able to predict tomorrow's or even next week's power demand output, but how can we match it if we can't predict the power supply input?

Here's a visual from Cal ISO called the "duck curve" which apparently, yeah, looks a bit like a duck.



Yes, solar power is more predictable than wind, but you can see that the hours the sun is shining the most are the hours that demand is low. So, solar panels will generate excess energy, and it goes nowhere.

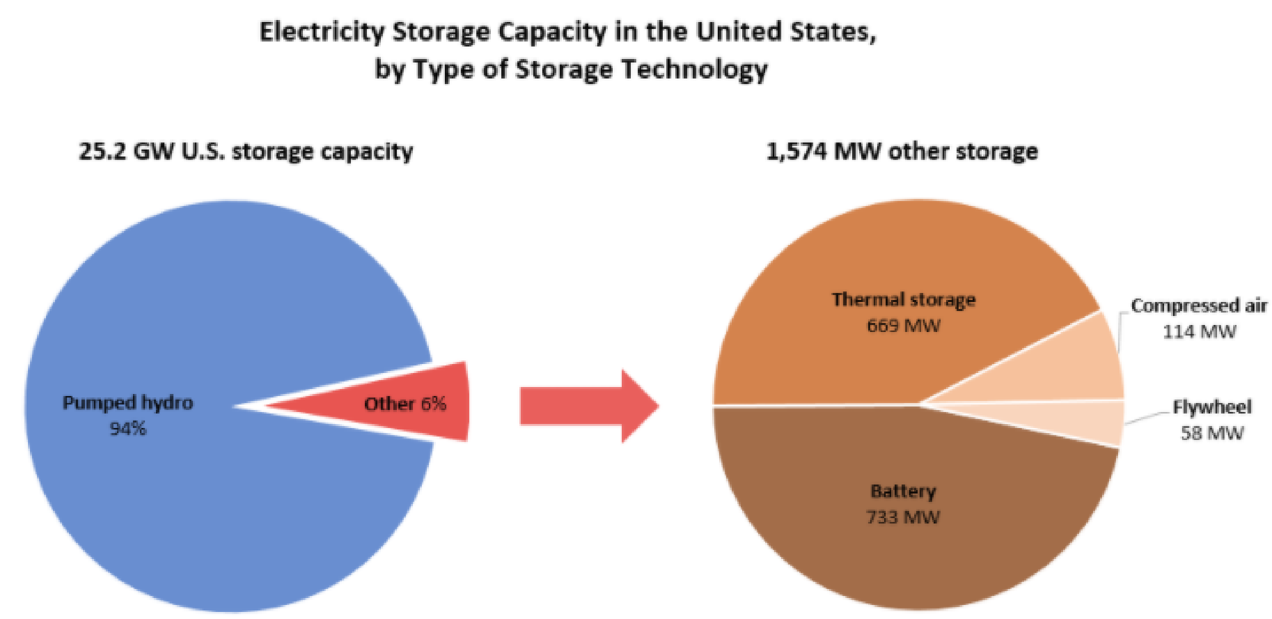
In fact, it's already happening! [Curtailment of renewable energy is not uncommon.] Ever see wind turbines not spinning? Either the wind isn't blowing, they're out of service, or they're being curtailed. This is because there is 'too much' electricity in the grid, and so they're turned off to save on costs.

How do we fix this problem, you might ask? That leads me to one of my earlier points:

We need reliable energy storage, and that requires R&D.

Instead of curtailing solar/wind power and then 'ramping-up' when demand increases, what if we *store* the excess electricity, then use it when demand increases? This is exactly what energy storage does.

But first, what energy storage technology already exists? Below is a graph that details that.



Source: U.S. Department of Energy Global Energy Storage Database (accessed March 1, 2018).

Pumped-storage hydroelectricity takes up a whopping 94% of the total energy storage capacity in the US. The technology works wonders, but just like hydropower dams, it's hard to just "make more" due to infrastructure limits. (I won't go into more detail since it's not needed for this post, but I did do a mini thesis on this, so I can drone on and on about this topic if you want me to. :p)

Contrary to popular belief, batteries take up less than 3% of the total energy storage capacity in the US—and that includes *all* batteries, like lithium-ion and lead-acid. Yet, it is practically all we talk about when we hear the words 'energy storage', although that's likely because there have been leaps of development in the technology, and it works wonders.

Lithium-ion batteries work great, but there are fallbacks. The biggest one is that it's not renewable, and you have to admit, it's rather ironic to pair a rare-earth metal material next to a renewable power-generating source, knowing that it will only last ~2 years before efficiency declines. How can this be a long-term solution? Large-scale batteries are on the horizon, but will it work on a massive GWh utility-scale? Will it be sustainable? How long will it last? Can it actually be recycled? There is so much we don't know yet; it's all so new.

Here is a link that details the comparisons of existing energy storage technology, which are the following:

- Pumped Hydro
- Compressed air
- Molten salt
- Li-ion battery
- Lead-acid battery
- Flow battery
- Hydrogen
- Flywheel

Where is the R&D for the other options? Heck, I'm working in a national lab doing R&D for portable hydrogen applications (specifically light/heavy duty vehicles with a fuel cell, and also utility-scale hydrogen storage for data centers), and used to do lab work for a non-lithium flow battery. And let me tell you: *these projects are massively underfunded.* The GND is gaining traction, but where is the money and the attention for these energy storage topics?

And most of all, **where's the R&D for new energy storage technologies? Where is it in the GND?** We could just have a gazillion solar panels and wind turbines so that we don't have to worry about the supply/demand curve, but I cannot stress enough how that would be *insanely, insanely* expensive, like, the USA-might-as-well-be-bankrupt expensive. We can't realistically expect climate change to be fixed with *none* of these things.

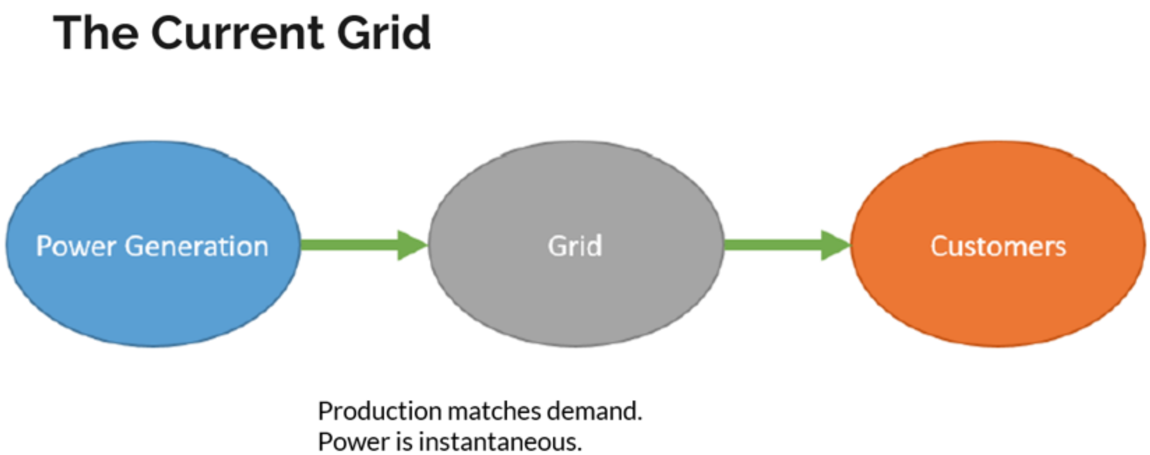
Unless we assume the following point:

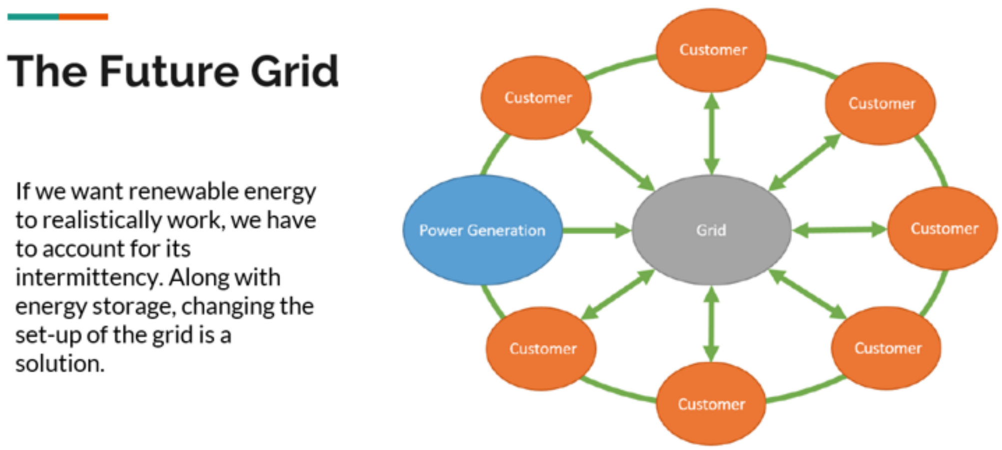
We completely overhaul the electric grid.

We could live in an ideal world and have an international power grid so that, when the sun isn't shining, Europe can send North America some of their excess sunshine power, and likewise to them. But again, that's an ideal scenario if money didn't exist, because an infrastructure like that would be an unrealistic amount of money. (We can't even fix our dang potholes, nevertheless an international grid!)

Instead, there have been propositions of a next-generation electric grid. This is a hot, very new topic with no real answer yet, unfortunately. But luckily, I'm super passionate with this topic, so here's a graphic of I made in school that I'm happy to share:

(Like I said, this is something I made, so please don't share this in the internet and say it came from an official source. I listened to a Stanford seminar that talked about this, and I simply put it into paper as a visual.)





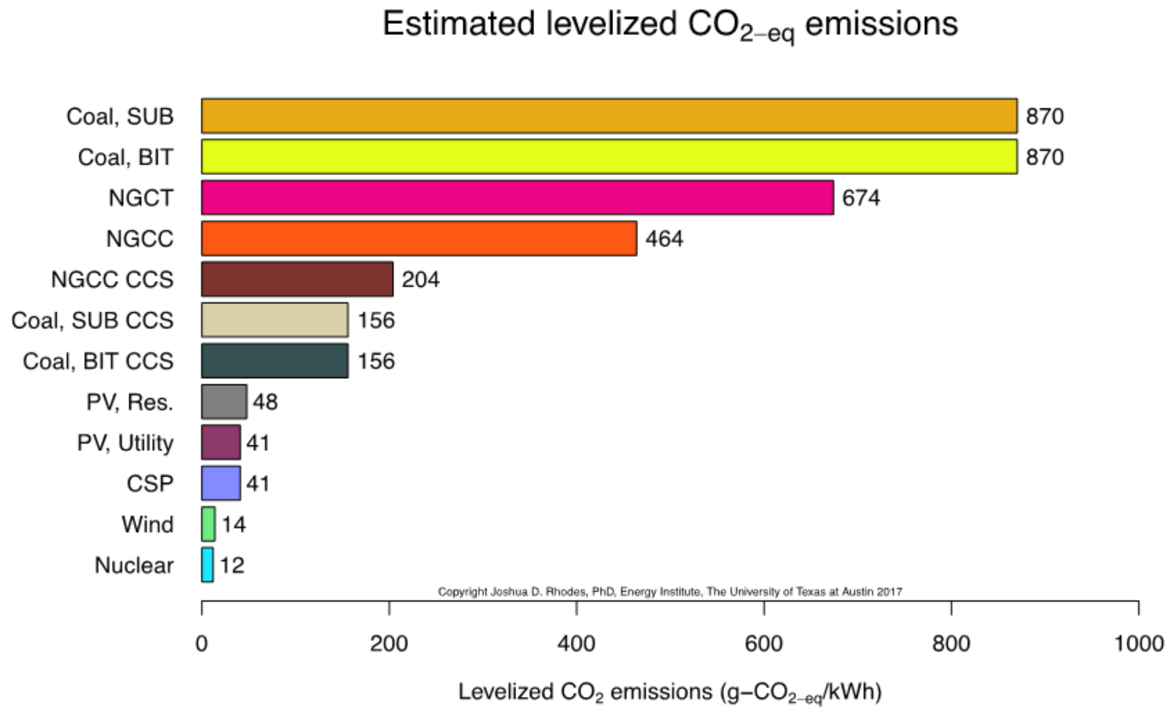
Basically, the grid doesn't have to be linear anymore. **We can have a series of micro-grids**, created by communities rather than giant sections of the nation. For example, one micro-grid community might have every residential house have a solar panel on their roof, and have everyone drive an electric car. When demand is low, the solar panels will charge up the battery connected to each house (as opposed to utility-scale battery), so nothing needs to be curtailed. Additionally, the electric cars can work as portable batteries, since it can charge when demand is low (during work hours or nighttime) and decharge when demand is high (when car is away from home and in use).

More modeling work needs to be done to determine if this will work, but it's just an idea. The infrastructure hasn't changed for the past century, and if we want renewable energy to be a key player, the design of it *has* to change.

I think a combination of energy storage + grid infrastructure needs to change for the GND to realistically happen, but before I give my closing remarks, I just want to add on one thing:

Nuclear power is the future.

Unfortunately, the GND does not mention nuclear power, yet it has the [lowest overall carbon emissions of *all* energy sources] if you consider transportation, mining, manufacturing, etc.



Yes, nuclear power seems scary, but [it is very safe], contrary to popular belief. Yes, nuclear power does generate radioactive waste, but [if you were to use 100% nuclear power up to age 80, all the waste you generated will be enough to fit in a soda can].

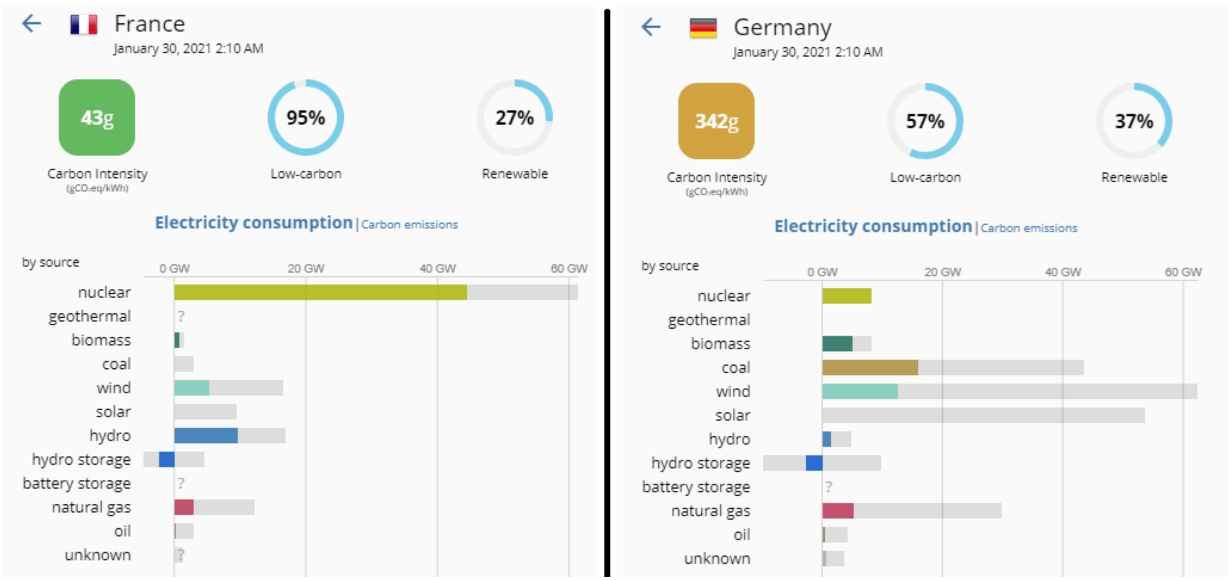
Yes, nuclear power is expensive. And yes, that soda can I mentioned will take thousands of years to safely decay. But both of these points assume that we continue to use the 1950s Rankine-cycle PWR design (because let's face it, BWR design sucks) with ~5% uranium-enriched ore.

Supercritical coal plants exist, yet nuclear power has basically been unchanged. How come the Gen III+ design mainly comes with safety features, and not anything new with the technology? The short answer is because there's no funding for it. Since Three Mile Island and Fukushima, there just isn't demand for it, and oil/gas became cheap, thereby making nuclear look like an unprofitable alternative that everyone is afraid of.

But if we want to live in a world without climate change ASAP, nuclear power is the best thing we have to make this happen. Just like new energy storage sources, I think there needs to be immediate R&D funding efforts to modernize/design small-scale, modular, thorium-powered nuclear reactors. I say small-scale/modular because it supports the micro-grid plan, and it also makes it affordable. And finally, I pitch thorium over uranium because it is much safer (less likely to meltdown) and the waste takes ~100 years to decompose rather than thousands. (I'd source this, but I've memorized this from my college lectures; I am not a nuclear engineer, so the numbers may be off.)

And finally: [check out this cool electric map!]() It tells you the power source and carbon intensity of each country/grid in *real-time*. Smart grids are nifty!

I specifically mention this because I want to call attention to Germany (population 83M) and France (population of 67M). They're two neighboring countries with the same time zone, somewhat similar populations, and about the same land size. I screenshotted the two electricity consumption data breakdowns below.



You can see that because France is vastly powered by nuclear, the carbon intensity is in the green (low). But look at Germany's gray bar under solar and wind. It's unclear whether I'm looking at this in my time (2AM) or their time (8AM), but either way, you can see that the bar is low, and carbon intensity is *eight times* the amount of France. Germany is technically more renewable since they have a higher capacity, but when the sun isn't shining and the wind isn't blowing, they resort to fossil fuels to power the country by buying it from other countries or producing it within the country, both options not being renewable at all.

~~Food~~ Data for thought. Below are my closing thoughts that also function as a tldr.

> **The GND is needed, but it fails to mention energy storage, grid infrastructure changes, and nuclear power. Without mentioning these things, how can we expect this to work in a realistic manner? I think the GND is rushing to solve social/climate issues by deploying technology that isn't quite ready yet, and I fear that this will cause more harm than good. If the GND funnels money into R&D of the grid/nuclear/energy storage, then it can be coupled with the goals it already has.**

Links:

1. https://www.caiso.com/TodaysOutlook/Pages/default.aspx
2. https://www.sciencedirect.com/science/article/abs/pii/S0301421517307115
3. https://www.eesi.org/papers/view/energy-storage-2019
4. https://energy.utexas.edu/news/nuclear-and-wind-power-estimated-have-lowest-levelized-co2-emissions
5. https://ourworldindata.org/safest-sources-of-energy
6. https://www.ne.anl.gov/About/open_house/2012/factoids2.pdf
7. https://www.electricitymap.org/map