

STATE OF THE TECH: CLEAN ENERGY GENERATION AND STORAGE

CLEAN ENERGY DILEMMA: INTERMITTENCY

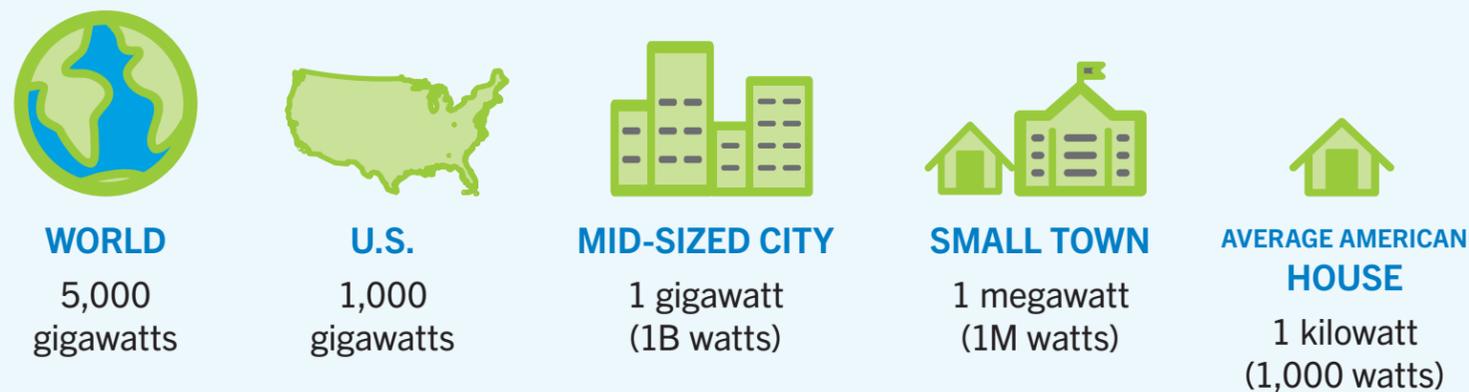
The sun and wind are intermittent sources of power, meaning they don't generate electricity 24 hours a day, 365 days a year like burning coal does. That's a problem for those dreaming of a 100% clean energy future. When we flip that light switch, we

expect the lights to come on. In a future where solar and wind power represent a big part of our electricity mix, we're going to need to store electricity in batteries to solve this intermittency issue and have power available around the clock.

BUT HOW MUCH POWER ARE WE TALKING ABOUT?

A watt is a joule per second. A joule is a bit of energy. A watt is a bit of energy every second. Remember, there is no such thing as watts per second or watts per hour. It's just watts. The definition of a watt already includes "per second." Think of it like this: if you were measuring the flow of water out

of your kitchen faucet, you count how many cups came out per second. Measuring power is similar, only you're measuring the flow of energy instead of water. Watts are equivalent to "cups per second." A watt is pretty small. A power plant might generate hundreds of millions of watts.



THE LIMITS OF BATTERY TECHNOLOGY

In his new book "How to Avoid a Climate Disaster," Bill Gates argues that battery systems large enough to power cities like Tokyo (that need something like 23 gigawatts on average, and up to 50 gigawatts at peak usage) are prohibitively expensive. He imagines a future where Tokyo gets all its electricity from wind power alone, but one day during cyclone season gets struck with

a massive storm. For the three days needed for the storm to pass, they'll need 14 million batteries. That's more storage capacity than the world produces in a decade. Purchase price: \$400 billion. It's just not a viable solution. Humbled by his research into the subject, Gates doesn't see battery technology improving by much more than a factor of 3.

CLEAN ENERGY SOLUTION: NUCLEAR POWER

Gates discusses the concept of power density, or the amount of land needed to generate a certain amount of electricity from the various energy sources. A solar farm needs between 5 and 50 times more land to generate as much electricity as an equivalent coal-powered plant, and a wind farm needs 10 times more than solar. That's why Gates has a hard time foreseeing a future where we decarbonize our electricity production

without using more nuclear power. No other clean energy source even comes close to what power from nuclear fission already provides today. It's the only carbon-free energy source that can reliably deliver power day and night, through every season, almost anywhere on earth that has been proven to work on a large scale. It also takes 10 to 15 times less materials to build versus wind and solar, respectively.

