Aol Energy.

When a Megawatt Isn't a Megawatt

Rating power facilities is largely a matter of simple math, but advocates and opponents of renewable power facilities face challenges communicating exactly how much capacity they will need to build to satisfy retirements of existing fossil fuel and nuclear generation. Here AOL Energy examines the rating math.

The U.S. electricity system is the world's largest, generating some 4 billion megawatt-hours (MWh) of power every year to run everything from hospitals, police stations and traffic lights to home entertainment systems.

But it remains heavily dependent on fossil fuels—70% of power last year came from fossil fuels—coal (45%), natural gas (23.8%) and petroleum products (1.2%). Another 19.6% came from nuclear. That means only 10.2% came from the renewables environmentalists favor, and 6.2% of that was from hydropower dams. Only 2.3% came from wind and 0.03% from solar.

Why not more electricity from renewables?

The answer may lie in the output rate of renewable technology currently available. It takes many more megawatts (MW) of wind or solar to generate the same amount of electricity as conventional sources.

Variability

Moreover, renewables vary with the weather, which fossil and nuclear sources don't. Without utility-scale electricity storage—giant batteries that many researchers are seeking, and say will come eventually—renewables can't be relied on 24/7.

> All commercial electric generators – regardless of fuel type – are rated in megawatts. That rating says how much electricity the generator can reliably put out under ideal operating conditions – in other words, what the facility *can* do.

But what it *will* do varies wildly, according to performance statistics gathered by the U.S. Energy Information Administration (EIA).

Any generator is really just an electricity factory. Every MW of capacity produces a MWh of electricity every hour – so a 500 MW plant running for 5 hours generates 2,500 MWh. The average U.S. homeowner uses a bit less than 1 MWh a month.

Operators assess how well their factories are working by looking at "capacity factor," a percentage comparing the actual output to the estimated output if ideal conditions existed at all times.

Cost Effectiveness

A 500 MW plant operating for a year (8,760 hours) could produce as much as 4,380,000 MWh. If it actually produces only 3,500,000 MWh, its capacity factor is 80%. The more electricity generated, the more cost-effective the factory. And all plants need some maintenance downtime, so no plant runs 100% all the time.

Nuclear plants can run the longest at their rated output – in the U.S., 18-24 months between maintenance outages. EIA says the average annual nuclear capacity factor is around 90% in the five years 2005-09. Data for 2010 has not yet been released.

Coal and natural gas plants also provide baseload power, but can be cycled to produce less than their maximum MW when the grid doesn't need all their power. Some gas-fired units can start up rapidly and are cut in quickly when demand rises, like hot days when everyone cranks up the air-conditioning. Cycling for lower output and "peaking power" lowers plant capacity factors. Coal's annual average is a bit over 70%, while natural gas is only about 25% – some baseload units have far higher capacity factors, some peaking units, lower.

Renewables like wind and solar differ fundamentally because they can't be turned on when needed, so they are not baseload. And like hydro, which depends on mountain snowpacks, overall wind and solar performance varies year-to-year with weather.

The Ratability Challenge

Except for the latest solar thermal designs that can capture excess daytime heat, solar doesn't work at night, and all solar produces below the official rated MW when it's cloudy. EIA numbers show solar averages about 15% capacity – but that's higher for solar thermal, often lower for photovoltaic (PV) panels.

Wind turbines typically need wind blowing around 9 miles per hour to get rotating, produce some fraction of their rated MW up to around 30 mph, and generate at the rated level over 30 mph. At some top speed, usually around 55 miles per hour, they have to be braked.

EIA figures show U.S. wind averages about 25% annual capacity factor. U.S. Department of Energy figures for 2010 indicate wide differences among turbines depending on age and location, with a few plants topping 40% capacity, and some still below 20%. The American Wind Energy Association says turbines typically achieve capacity factors between 25% and 40%.

What It Means

What does all this mean when it comes to supplying a town of, say, 100,000 homes?

EIA says the average U.S. household uses 10.9 MWh per year. So 100,000 homes would need 1,090,000 MWh annually.

The different capacity factors mean the town needs 139 MW of nuclear to provide that power, or 176 MW of coal, or 498 MW of wind. Assuming a better-than-average wind factor of, say, 35%, cuts that to 356 MW. With a solar PV facility the same town would need 830 MW of capacity to satisfy the same amount of electricity demand.

The question then is: what does it take to replace a 1,000 MW nuclear plant with wind or solar? Advocates often say 1,000 MW of a renewable will do the trick—but it won't.

That nuke, at 90% capacity factor, puts out 7.884 million MWh in a year. Replacing that with average wind capacity requires 3,600 MW, which means erecting 2,034 average (1.77 MW) turbines. A solar PV project requires 6,000 MW of replacement power.

Raise the assumed wind capacity factor to the 38% cited by several recent Midwestern projects with more efficient turbines and high-quality wind resources? The MW needed drop to 2,369, and the number of required turbines to 1,338.

And renewables still require backup from the grid, to balance when the wind gusts or the sun flickers through clouds. But backup power still depends on the on-demand fuels—mostly fossil, and—where they're lucky enough to have dams built long ago—hydropower.

The game-changer for the renewables sector is broadly held to be large-scale, cheap storage that lets grids smooth out the variability of wind and solar. Battery technology and compressed air storage has been of little use on a large scale so far, but research and development efforts are continuing across the industry.