SDP

JULY 2022 BRAIN TEASER & SOLUTION

Lalaland Power Grid

This country has been merrily oblivious to the energy challenges around the world, blessed with a very stable economy and reliable sources of energy and power generation for many decades, without the need to add renewables. Their power generation grid has been fine with a 20% reserve margin, but their power generation fleet is aging with many plants about to reach useful life. They are under pressure to reduce nuclear and fossil fuels internally and from the international community. It's decision time and they are evaluating four alternatives: 1.) replace aging plants like-for-like per current state; 2.) add 20% wind and 20% solar, while eliminating coal and decreasing nuclear and natural gas; 3.) same as Alt 2 but increasing reserve margin to achieve 100% ability to meet demand load; 4.) similar to Alt 2 keeping reserve margin at 20%, while equally enhancing wind and solar beyond desired 20% to achieve 100% ability to meet demand load.

To help Lalaland evaluate alternatives, your job is to estimate the ability to meet demand load Alt 2 and capacity additions for Alts 3 and 4, essentially: A, B and C per table below. Also summarize the key learning in "one sentence" no more the 50 words.

Note: As you can imagine electric grids are highly complex, but the objective of this Brain Teaser is to keep it simple and not get very technical. Capacity factor is defined as plant actual energy delivery, relative to plant running at full installed capacity all the time. This teaser is intended as a pencil and paper exercise, or simple Excel. You can simulate if you wish, but it is not the intent.

Lalaland Power Grid SDP Brain Teaser Jun-2022				**Installed Capacity Expressed as Percent of Demand Load**			
				Alt 1	Alt 2	Alt 3	Alt 4
						Future	Future
					Future	Desired	Desired
Generation	Intended	Generation	Performance	Today's	Desired	w/Enhanced	w/Enhanced
Type	Operations	Capacity Factor	Limiting Factor	State	State	Reserve	Wind & Solar
Nuclear	Base Load	95%	Mechanical	25%	20%	20%	20%
Natural Gas	Base Load	90%	Mechanical	25%	15%	15%	15%
Coal	Base Load	85%	Mechanical	25%	0%	0%	0%
Hydro	Base Load	80%	Seasonal	25%	25%	25%	25%
Wind	As Available	30%	Wind Speed	0%	20%	20%	C
Solar	As Available	30%	Night / Cloud Cover	0%	20%	20%	C
Reserve	Peaking	100%	Assume Infallible	20%	20%	B	20%
Total Capacity				120%	120%	100% + B	80% + 2C
		System Ability to Meet Demand Load		100%	A	100%	100%

The answer to the July 2022 Brain Teaser - Lalaland Power Grid

With some simple math the boxes in yellow can be completed to fulfill the Brain Teaser request for a simple and fully correct answer.

This simple answer is quite insightful. You will note that with lower capacity factors for wind and solar replacing generation with higher capacity factors results in significantly lower grid reliability. Increasing the infallible reserve (whatever this nondescript reserve may be) is one way to address; the other way is to add significantly more wind and solar. The problem is that solar is guaranteed not to work at night, while wind speeds are guaranteed to be occasionally low, with steep reduction in wind power output. This statistically ensures that frequently there will be precious little of both wind and solar, hence adding a ton of wind and solar does not solve the grid reliability issue. Taking it a step further, a second table has been added below grouping the power into base load and wind and solar. This confirms Alt 2 is unreliable, however shows Alt 3 and 4 are to the limit and ready to fail whenever both wind and solar are off, which means the reserve for Alts 3 and 4 needs to be higher, i.e., at least 47%. Clearly a 47% infallible reserve would be prohibitively expensive, meaning that some high-capacity factor base load generation is needed and should not be eliminated. This problem originated as substitution of old generation capacity but can easily creep in slowly over time when exclusively adding wind and solar to meet demand growth. The key learning is that a diverse mix of generation capacity both existing and additions is the way to go to keep the grid reliable.

As Decision Professionals, isn't this something to sink your teeth into?

Lalaland Power Grid SDP Brain Teaser Jun-2022				**Installed Capacity Expressed as Percent of Demand Load**			
				Alt 1	**Alt 2**	**Alt 3**	**Alt 4**
Generation Type	Intended Operations	Generation Capacity Factor	Performance Limiting Factor	Today's State	Future Desired State	Future Desired w/Enhanced Reserve	Future Desired w/Enhanced Wind & Solar
Nuclear	Base Load	95%	Mechanical	25%	20%	20%	20%
Natural Gas	Base Load	90%	Mechanical	25%	15%	15%	15%
Coal	Base Load	85%	Mechanical	25%	0%	0%	0%
Hydro	Base Load	80%	Seasonal	25%	25%	25%	25%
Wind	As Available	30%	Wind Speed	0%	20%	20%	**46%**
Solar	As Available	30%	Night / Cloud Cover	0%	20%	20%	**46%**
Reserve	Peaking	100%	Assume Infallible	20%	20%	**36%**	20%
			Total Installed Capaci	120%	120%	136%	172%
			System Ability to Meet Demand Load	100%	**85%**	100%	100%

Lalaland Power Grid - Baseload Analysis	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
Total Baseload Reliable Capacity (Cap x CF)	88%	53%	53%	53%
Wind and Solar Reliable Capacity (Cap x CF)	0%	12%	12%	28%
Reserve Infallible Capacity	20%	20%	36%	20%
Total Reliable Capacity	108%	85%	100%	100%