How Much Renewable Energy Can the SunZia Southwest Transmission Project Actually Carry?

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Introduction

It is questionable how much renewable power the SunZia Project will actually carry. The project has been touted as carrying "primarily renewable energy," but open-access laws prohibit limiting the transmission system to any particular type of generation. The Southwestern Power Group intends to use part of the transmission capacity for its 1,000-MW natural gas-fired Bowie power plant, and the project is well positioned to allow several natural gas generation plants in southwestern New Mexico to use the system. This suggests that a significant part of SunZia's transmission capacity will be used to deliver power from nonrenewable sources.

The following is a rudimentary attempt to quantify the amount of renewable and nonrenewable energy the system would carry using several basic scenarios. This quantification is very simplistic, and it is apparent that many additional possible combinations of use need to be modeled to understand how the system would best be used. Every megawatt of SunZia transmission capacity sold to carry nonrenewable energy prevents that capacity from being used for wind generation. This reduces the renewable power that the system can carry in unexpected ways because the capacity factors of wind and natural gas differ so greatly.

Four Generation Components to the SunZia System

The following four power generation types must be considered in using the SunZia transmission system to carry wind power and to stabilize wind power fluctuations. These four types must all be balanced to maintain reliability and system efficiency.

- Renewable (wind) generation
- Nonrenewable dispatchable generation attached to the transmission system to compensate for wind power fluctuations
- Nonrenewable dispatchable generation sited outside the transmission system to compensate for wind power fluctuations
- Nonrenewable generation attached to the transmission system but not used to compensate for wind power fluctuations. This would be used to serve base loads or to augment other generation outside the system

The Percent Renewable Energy Carried by SunZia – Five Scenarios to Consider

The following are five hypothetical scenarios used to illustrate the problems with using SunZia for primarily renewable energy. The first two are end-member cases and not realistic, but they serve as reference points. These five scenarios are summarized in Table 1. The total transmission capacity of the system is 3,000 MW, and it is assumed that all renewable energy generated will be fully used by displacing nonrenewable generation in order to reduce carbon emissions.

Table 1. Comparison of transmission capacity allotted, average power carried, and percent of total power for each generation type for four mixes of generating capacity.

	Scenario				
	1	**2**	**3**	**4**	**5**
Renewable transmission capacity (MW)	3,000	1,500	1,500	1,800	2,000
Dispatchable transmission capacity (MW)	0	1,500	0	600	0
Base load transmission capacity (MW)	0	0	1,500	600	1,000
Total transmission capacity (MW)	3,000	3,000	3,000	3,000	3,000
Average renewable power carried (MW)	1,200	600	600	720	800
Average dispatchable power carried (MW)	0	900	0	360	0
Average base load power carried (MW)	0	0	1,275	510	850
Average total power carried (MW)	1,200	1,500	1,875	1,590	1,650
% renewable power carried by system	100.0	40.0	32.0	45.3	48.5
% nonrenewable power carried by system	0.0	60.0	68.0	54.7	51.5
% system utilization	40.0	50.0	62.5	53.0	55.0

1. **All transmission capacity reserved for wind generation.** All dispatchable non-renewable generation used to stabilize wind output would be sited outside the transmission system, and no base-load nonrenewable generation would be connected to it. A total of 3,000 MW of wind capacity would be connected to the system, and an equivalent nonrenewable power capacity would be used outside the system to maintain this power level. With a gross New Mexico wind capacity factor of 0.40, the system would carry 1,200 MW of power on average, while 1,800 MW of nonrenewable power on average would be used from outside the system to maintain power reliability. In this case, 100% of the energy in the transmission system would be from renewable sources, and system utilization would be 40%.

   Note that the capacity factor for New Mexico wind in the peak load season of July and August would be 36% (this is probably high), which would reduce average power output to a maximum of 1,080 MW. Both of these capacity factors are calculated and not confirmed by actual operating data. Operational data from California wind plants indicate that both are likely to be significantly lower when actually measured.

2. **All nonrenewable generation used to compensate for wind power variability is sited within the system.** No nonrenewable base load generation would be connected to the system. System transmission capacity must be split evenly between renewable and nonrenewable generation to maintain a constant power output. Thus 1,500 MW of transmission capacity must be reserved independently for both renewable and nonrenewable sources. Total system power capacity will thus be limited to 1,500 MW because transmission capacity must be sold separately for each type of generation. The average power produced by wind energy will be 1,500 MW x 0.40, or 600 MW. The remaining 900 MW of power in the system will be generated by nonrenewable sources. Thus 40% of the power in the system would be renewable and 60% would be nonrenewable, with a system utilization of 50%.

3. **50% of capacity used for renewable energy, 50% for nonrenewable base-load generation**. All dispatchable nonrenewable generation used to compensate for wind power variability would be sited outside the system. The capacity factors of each type of generation are 40% for New Mexico wind and ~85% for natural gas. Using these capacity factors, 1,500 MW of wind-generating capacity will produce an average of 600 MW of power, and 1,500 MW of natural gas generating capacity will produce an average of 1,275 MW of power, yielding a total average generation of 1,875 MW. In this scenario, 32.0% of the power in the system would be from renewable sources and 68.0% from nonrenewable sources, resulting in an average system utilization of 62.5%. At times each form of generation will reach 1,500 MW of output, and each must separately reserve 1,500 MW of transmission capacity, using the full 3,000 MW available.

4. **A intermediate scenario: 60% of capacity used for renewable sources, 20% for nonrenewable dispatchable sources, 20% for nonrenewable base-load sources.** Neither of scenarios 1 and 2 is realistic, and this scenario would better approximate system usage, although this is yet speculative. In this scenario, 60% of transmission capacity would be used by wind, or 1,800 MW. With a wind capacity factor of 0.40, on average the system would carry 720 MW of renewable power. A total of 600 MW of capacity would be reserved for nonrenewable dispatchable power linked to wind generation. The additional 1200 MW of dispatchable power required to stabilize wind generation would be sited outside the transmission system.

   This dispatchable capacity would be used 60% of the time, as it would be directly coupled to wind generation, and it would thus contribute 360 MW of power to the system on average. The remaining 600 MW of transmission capacity would be reserved for nonrenewable base-load generation. Using an 85% capacity factor for this would result in the production of 510 MW of power on average. Thus 720 MW of power in the system would be renewable and 870 MW would be nonrenewable, or 45.3% and 54.7%, respectively. The average total power in the system would be 1,590 MW, resulting in a system utilization rate of 53%.

5. **Bowie power plant connected to the system.** An additional scenario to consider is the connection of the Bowie power plant to the system without other generation connections except for wind power generation. This would result in up to 1,000 MW of system capacity being used by the Bowie plant and 2,000 MW by wind generation. Using the wind capacity factor of 0.40, average wind power in the system would be 800 MW. If the Bowie power plant has a capacity factor of 0.85 (this would be high if part of the plant's capacity were used to meet peak demand rather than base load), the Bowie plant would on average contribute 850 MW of power to the system. The percent contribution of each type of energy would be 48.5% for renewable power and 51.5% for non-renewable power. The total average system capacity used would be 1,650 MW, and system utilization would average 55%.

Economic Considerations for Transmission Systems and Optimum System Utilization

The lower average generating capacity for renewable energy resulting from wind power's low capacity factor has important implications for the economic viability of a transmission system. It is not economic for up to two-thirds of the system's capacity, on average, to be idle, as would be the case if all of SunZia's capacity were devoted to renewable power (scenario 1 above). The High Plains Express Project recognized this and did economic modeling to determine how much non-renewable energy was required to optimize the system's economics. They determined that a 50:50 mix of renewable to nonrenewable energy achieved the best results.

One of the inherent problems in the above scenarios is the low system utilization. Each of these scenarios reflects the maximum generation for that mix of power sources, and transmission use cannot be increased without changing the mix of generation sources. System utilization can be increased to an optimum level only by significantly reducing renewable generation and increasing nonrenewable generation.

HPX considers a 75% utilization of transmission capacity to be optimal, and achieving this requires that nonrenewable energy strongly dominate the system. Overbuilding of wind generation capacity (i.e., building more capacity than the transmission system can accommodate when the wind speed allows a wind turbine to reach full generating capacity) can help increase the utilization rate, but it cannot achieve this rate. The problem is roughly illustrated in the following calculations, which determine the mix of renewable and nonrenewable generation required to achieve a 75% utilization level when all nonrenewable generation is devoted to meeting base load. Using transmission capacity for base load nonrenewable generation is the most efficient way of achieving a 75% utilization rate.

x = megawatts (MW) of installed renewable generating capacity
y = megawatts (MW) of installed nonrenewable of generating
0.40 = capacity factor of New Mexico wind
0.85 = capacity factor of natural gas generation
0.75 = utilization level

For 3,000 MW of transmission capacity, the total of x and y generating capacity must equal 3,000:

$$x + y = 3000 \text{ MW}$$

75% utilization would be calculated as follows:

$$(0.40x + 0.85y) = (0.75 \text{ x } 3000 \text{ MW}) = 2250 \text{ MW}$$

This provides two equations with which to solve for x, the amount of renewable generation needed, and y, the amount of nonrenewable generation needed:

$$x = 3000 - y$$
$$x = (2250 - 0.85y)/0.40$$

Solving for y by equating the right sides of these two equations:

$$3{,}000 - y = 5625 - 2.125y$$
$$1.125y = 2625$$

$$\boldsymbol{y = 2333\ \mathrm{MW}}$$

and solving for *x*:

$$\boldsymbol{x = (3000 - y) = 667\ \mathrm{MW}}$$

In this scenario, 22.2% of the power in the system would be renewable. To keep the system in balance, when renewable power generation falls to 0 MW, nonrenewable generation would have to rise to the full 2,250 MW, and when renewable generation rose to its full generation level of 1,667 MW, nonrenewable generation would have to fall to 1,333 MW. Some coupling between the two would have to occur. This calculation has significant flaws, but it demonstrates the difficulty with achieving an adequate utilization level for a transmission system when renewable energy is involved. Only by using predominantly nonrenewable energy is it possible to achieve the desired level.

As noted above, overbuilding of wind capacity can increase the utilization of the transmission system by wind energy, and it is also unlikely that the nonrenewable power level in the system would be kept at an average value of 2,333 MW. It would likely fall below it at times, increasing the percentage of renewable energy in the system. Nevertheless, this illustrates how use of a transmission system to carry renewable energy must be limited to optimize use of transmission capacity.