DISCUSSION PAPER:
Update of Modeling for KCEC Short-Term Transition Planning
Runs with new KCEC Demand Data for 2014
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Introduction

This is a brief update of "Modeling for KCEC Short-Term Transition Planning," of 6 February 2015. The difference between these results and the earlier ones is that these are based on a complete year of KCEC demand data rather than the composite year data used earlier. The main difference between the data sets is that newer one has slightly smaller peak and average demands, and a slightly smaller total supply of electricity. This means that slightly smaller renewable energy (RE) systems are needed to meet the same levels of installed capacity and supply of total energy.

The New Data Sets

In May of 2015, KCEC gave Renewable Taos two data sets, one for system demand, and one for the output of PV systems. Both cover four calendar years: 2011 through 2014. The demand data for 2014 was modified by adjusting the anomalous low points shown in Figure 1. Each of these 59 points were adjusted to values similar to the values immediately before and after them. The total amount of these adjustments was 97.4 MWh, or 0.033% of the 298,463 MWh of total system demand. The purpose of these adjustments was to produce a more "normal" distribution of demand, without points caused by power failures or meter problems. The unadjusted minimum was zero, and the adjusted one is 22.20 MW. The average demand is 34.07 MW, and the peak is 64.94 MW.

The new PV data was not used because it appears to be the combined output of several arrays, the arrays that are included seem to change over time, and there is no indication of which arrays are included at any time. This makes the data unsuitable for projecting to larger arrays that may be installed in the future. Therefore, the same PVWatts® hourly simulations of fixed and tracking array output were used in the previous and updated models. The same wind data from Colorado were also used.

Results

KCEC11 Existing: The existing RE capacity in the KCEC service area consists of 4.75 MW of PV arrays, not including the approximately 1.18 MW of net metering customers. 4.75 MW is about 7% of peak demand, and the model indicates that it should supply about 9,377 MWh, or 3% of total electrical supply.

KCEC12 20% PV: 13 MW of PV arrays would be 20% of peak demand, and the model indicates they would supply about 24,040 MWh, or 8% of the total. As with the first model, all of the RE

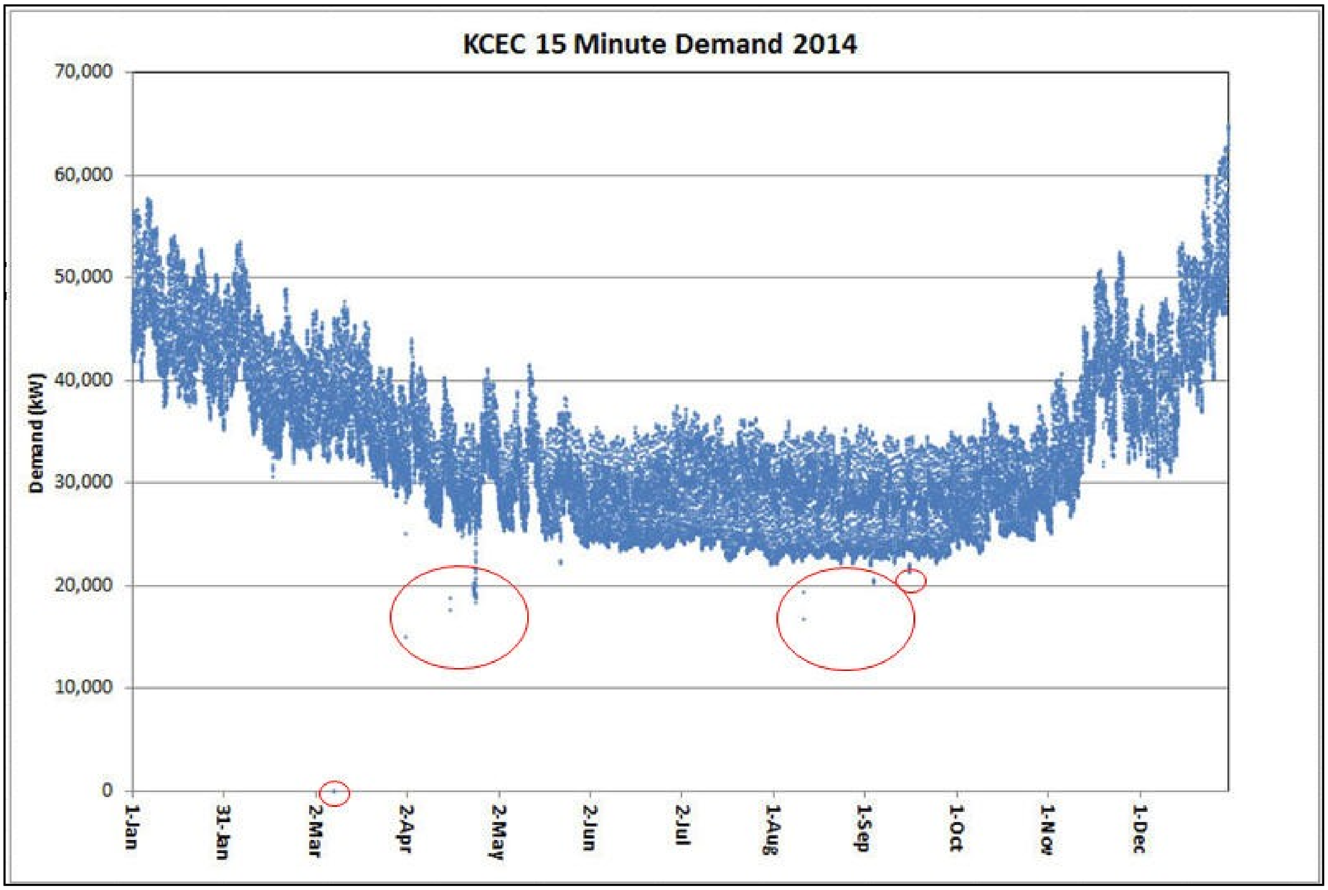

Figure 1. Adjusted Points in the New KCEC Demand Data for 2014.

generated can be directly used by KCEC customers, so there is no need to curtail, store, or sell excess energy.

KCEC13 50% PV: 32.5 MW of PV capacity would be 50% of peak demand. It would supply about 63,747 MWh, or 21% of the total. The model indicates that 1.4 MWh, or 0.0005% of this PV output could not be used directly. Thus, within the accuracy of the model, this is the level of installed PV capacity above which curtailment, storage, selling, or dumping of excess generation would be required.

KCEC14 PV, Wind: This model combines 16.2 MW of PV capacity with 16.2 MW of wind capacity for a total RE capacity of 51% of peak demand. This would supply about 75,077 MWh or 25% of the total. 1.2 MWh or 0.0004% of this RE would be excess generation. Thus, combining PV and wind allows a larger portion of total energy to be supplied without excess RE generation.

KCEC15 PV Wind+: This model increases the wind capacity to 20.7 MW, while keeping the PV at 16.2 MW. The combined 26.9 MW is 57% of installed capacity, and should supply about 87,102

MWh or 29% of the total. Excess generation would be 50 MWh or 0.017% of the total. This indicates that more wind could be added while keeping excess generation fairly insignificant.

KCEC16 PV+Wind++: In this final model both PV and wind are increased to 28.2 MW of installed capacity each, for a total of 56.4 MW, or 87% of peak demand. Together, they should produce about 131,317 MWh or 43% of the total. The model shows 2,928 MWh of excess generation, 1% of the RE total.

Conclusions

The last three models indicate that when using wind and PV, it may be possible to significantly increase the installed capacity, and the percentage of RE in the total, without producing significantly more excess RE generation. With both PV and wind, it may be possible to have around 40% of our energy produced renewably, without significant excess generation. However, producing wind energy in the KCEC service area, or purchasing it from elsewhere are still problematic. When only PV is used, the maximum that can be supplied without significant excess appears to be around 20% (with installed capacity equal to 50% of peak demand).

Is excess RE generation the new limit? Assuming that the FERC decision on the Delta-Montrose Coop and qualifying facilities holds, then KCEC will no longer be constrained by Tri-State's 5% limit. When KCEC can legally install or purchase as much RE as its members want it to, the next limit may be the economic, technical and legal issues concerning excess generation. Generation in excess of KCEC's demand at any given time can be curtailed, stored, sold to other utilities, or "dumped" on regional transmission lines for free. None of these are very satisfactory, and the last two may present technical or legal issues.

Curtailment: Curtailment means simply not producing excess energy. Rows of PV cells can be disconnected from their inverter, thus lowering the array's output. Wind turbine blades can be feathered, or a turbine can be stopped. Significant curtailment means significant loss of income from the facility, and real-time controls to prevent any excess generation will require extra technology, thus raising system costs.

Storage: Storage is expensive, and the cost of storage is added to the cost of generation. For example, if future storage technologies will cost 0.10 $/kWh (an optimistic assumption), and PV electricity cost 0.06 $/kWh, then stored PV energy would cost 0.16 $/kWh, far more than KCEC's wholesale cost of around 0.075 $/kWh. (If only a small percentage of RE were stored, then the blended cost would not be much more than 0.06 $/kWh, but the marginal benefit of adding storage would still be negative.)

Utility scale batteries may now be economic when used to cut a utility's peak demand charges. Storing excess RE when available, and using the stored energy to cut peak demand, would also increase the amount of RE that could be generated and used. How much more RE could be generated, and what the economics would be are beyond the model that Renewable Taos is now using (the EnergyShouldBe.org spreadsheets). Finding a way to answer these questions should be a priority for both KCEC and Renewable Taos.

Thermal Energy Storage (TES) is now by far the cheapest way to store electricity. For example, Lazard shows the cost of battery storage at 0.192 to 0.265 $/kWh, while the combined cost of solar thermal with storage is 0.102 to 0.118 $/kWh.[1] This implies that the combined cost of PV plus battery storage would be more than twice the cost of electricity from a concentrating solar facility with TES.

Selling: Excess renewable electricity will be significantly more intermittent, and probably harder to forecast, than electricity directly from an RE facility. So, it is extremely unlikely that any purchasing utility will pay as much for KCEC's excess as KCEC pays for the electricity to start with. This is especially true because the purchaser will have to pay to have the excess transmitted from KCEC to the purchaser's distribution lines. Transmission charges are around 0.015 $/kWh. So excess energy will almost certainly be sold at a loss, even assuming that a purchaser and the transmission lines can be found and contracted with.

Selling excess RE requires that the electricity be run "backward" through the sub-stations that connect KCEC's distribution lines to Tri-State's transmission lines. The available evidence suggests this is possible, but may require extra safety and control equipment.[2] This equipment will add to the costs of systems, but the extra costs may not be significant additions to systems in the tens of MW.

Dumping: Dumping excess RE onto transmission grids without getting paid for it could be the financial equivalent of curtailment and the technical equivalent of selling. It might be possible to "get away with" occasional dumping of small quantities, and this would have the effect of getting a little more RE onto the grid. But as installed RE capacity grows, and excesses become significant, then one or more of the others solutions will be needed.

Next Steps

Using the EnergyShouldBe Model: Model runs can be done for the other three years of KCEC demand data (2011, 2012, and 2013). This could tell us how much KCEC's load has changed, and may also indicate how much apparent excess generation is due to coincident high generation and low loads in a particular year, and how much is likely to occur in general. This work will be worth

[1] L A Z A R D ' S L E V E L I Z E D C O S T O F E N E R G Y A N A L Y S I S — V E R S I O N 8 . 0, Sept 2014, p. 13 http://www.lazard.com/insights/

[2] Sam Sciacca, "Designing substations and transformers for bi-directional power flow," November 27, 2012, Consulting-Specifying Engineer Website, http://www.csemag.com/blogs/insights-on-power/blog/designing-substations-and-transformers-for-bi-directional-power-flow/212b1d7da229ec50fc70ab9e36f1bf70.html

doing when KCEC supplies Renewable Taos with the same four years of PV output data from specific tracking and fixed PV arrays.

Estimating the Economics and Effects of Storage for Peak Load Reduction: This could be estimated "by hand," by analyzing the 15-minute demand data for a number of days in different seasons, estimating how much battery banks of different sizes would cost, and how much they could reduce peak demand charges, and how much "excess" RE they could absorb. At some point, this should be done using more sophisticated models that allow storage and release strategies to be simulated. HOMER is a possible model that Renewable Taos intends to acquire and learn.

The End

Summary of EnergyShouldBe runs for KCEC Short-Term Transition Planning
With new KCEC Demand Data, supplied May 2015

KCEC Annual Demand (MW): Peak: 64.94, Average: 34.07, Minimum: 22.20. Energy Supplied: 298,463 MWh.

Run	Description
KCEC10 No RE	Kit Carson Electrical Cooperative (KCEC) Hourly Demand with No Renewable Energy
KCEC11 Existing	KCEC Demand with existing large scale PV – 4.25 MW of Tracking Arrays, 0.5 MW of Fixed Arrays. Not including behind the meter. Supplies 3.1% of Annual Energy.
KCEC12 20% PV	KCEC Demand with PV equal to 20% of Peak Demand = 13.0 MW. Supplies 8.4% of Annual Energy.
KCEC13 50% PV	KCEC Demand with PV equal to 50% of Peak Demand= 32.5 MW. Supplies 21.4% of Energy. Max PV with insignificant selling.
KCEC14 PV, Wind	KCEC Demand with 25% PV & 25% Wind = 16.2 + 16.2 MW. Supplies 25% of Energy. Insignificant selling.
KCEC15 PV Wind+	KCEC Demand with 25% PV & 32% Wind = 16.2 + 20.7 MW. Supplies 29% of Energy. Insignificant selling.
KCEC16 PV+Wind++	KCEC Demand with 43% PV & 43% Wind = 28.2 + 28.2 MW. Supplies 43% of Energy. “Maximum” with 1% selling.

Run	PV Installed Capacity			PV Output		Wind Installed Capacity			Wind Output	
	MW	% of Peak	% of Min	MWh	% of Total	MW	% of Peak	% of Min	MWh	% of Total
KCEC10 No RE	0	0%	0%	0	0%	0	0%	0%	0	0%
KCEC11 Existing	4.75	7%	21%	9,377	3%	0	0%	0%	0	0%
KCEC12 20% PV	13.0	20%	59%	25,040	8%	0	0%	0%	0	0%
KCEC13 50% PV	32.5	50%	146%	63,747	21%	0	0%	0%	0	0%
KCEC14 PV, Wind	16.2	25%	73%	31,792	11%	16.2	25%	73%	43,825	15%
KCEC15 PV Wind+	16.2	25%	73%	31,792	11%	20.7	32%	93%	55,310	19%
KCEC16 PV+Wind++	28.2	43%	127%	55,965	19%	28.2	43%	127%	75,352	25%

Run	RE Installed Capacity			RE Output		Batteries		Cost ($/kWh)			
	MW	% of Peak	% of Min	MWh	% of Total	MWh	M$/y	PV	Wind	Purchased	Total
KCEC10 No RE	0	0%	0%	0	0%	0	0	-	-	0.060	0.1103
KCEC11 Existing	4.7	7%	21%	9,377	3%	0	0	0.060	-	0.060	0.1103
KCEC12 20% PV	13.0	20%	59%	25,040	8%	0	0	0.060	-	0.060	0.1103
KCEC13 50% PV	32.5	50%	143%	63,747	21%	0	0	0.060	-	0.060	0.1103
KCEC14 PV, Wind	33.0	51%	143%	75,077	25%	0	0	0.060	0.0450	0.060	0.1081
KCEC15 PV Wind+	36.9	57%	166%	87,102	29%	0	0	0.060	0.0450	0.060	0.1075
KCEC16 PV+Wind++	56.4	87%	254%	131,317	43%	0	0	0.060	0.0450	0.060	0.1068

Run	Annual Demand minus RE (MW)			Annual Energy (MWh)		Sold Energy		
	Peak	Mean	Min	Purchased	Renewable	MWh	% of RE	M$
KCEC10 No RE	64.9	34.1	22.2	298,463	0	0	0%	0
KCEC11 Existing	64.9	33.0	20.4	289,086	9,377	0	0%	0
KCEC12 20% PV	65.9	31.2	14.1	273,423	25,040	0	0%	0
KCEC13 50% PV	65.9	26.8	-0.5	234,716	63,747	1.4	0.0005%	0
KCEC14 PV, Wind	59.4	25.5	-1.2	223386	75,077	1.2	0.0004%	0
KCEC15 PV Wind+	59.2	24.1	-4.9	211,361	87,102	50.0	0.017%	0.0015
KCEC16 PV+Wind++	59.1	19.1	-20.2	170,074	128,389	2,928	1.0%	0.088