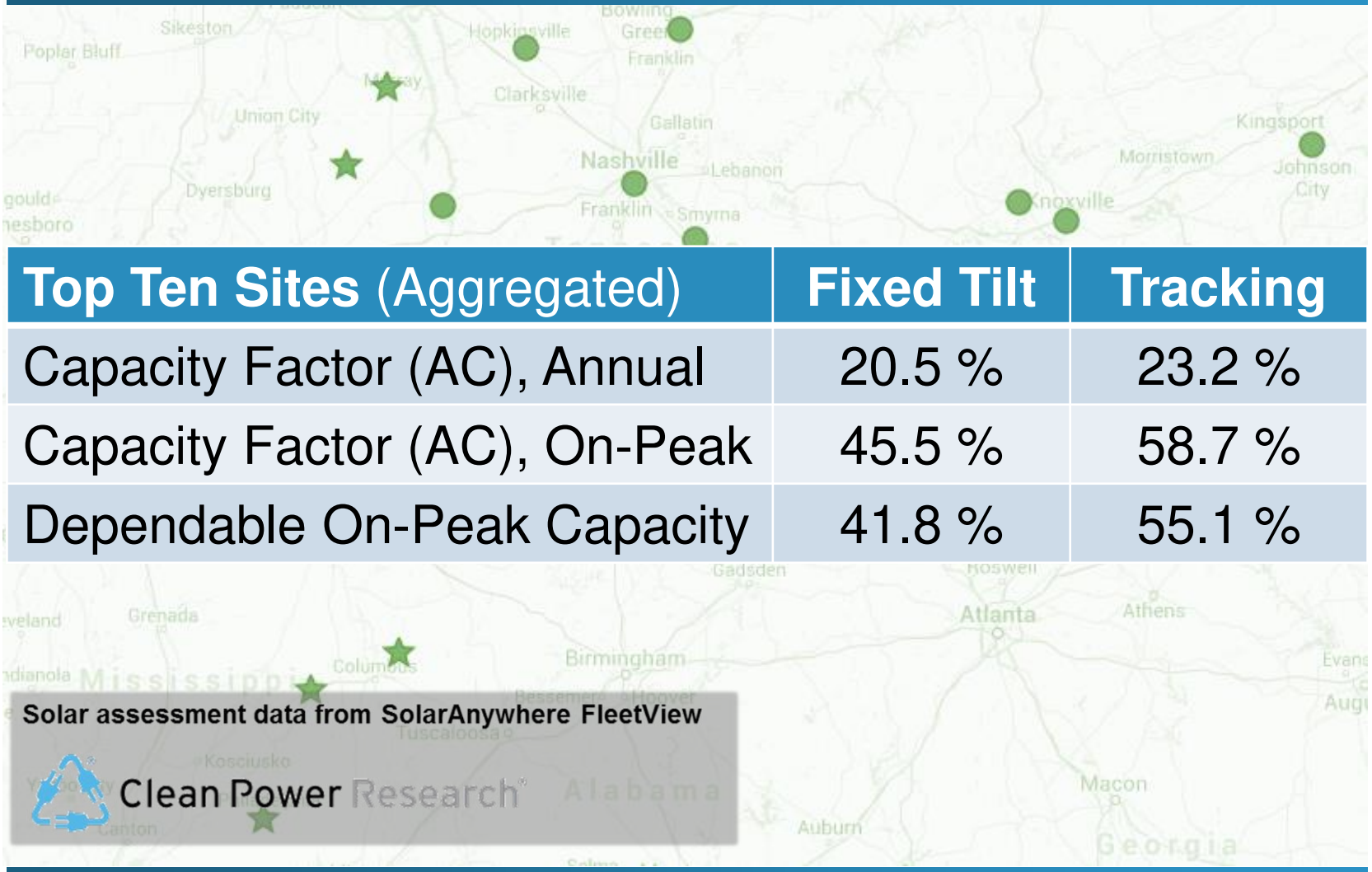
Tennessee Valley Utility-Scale Solar Assessment

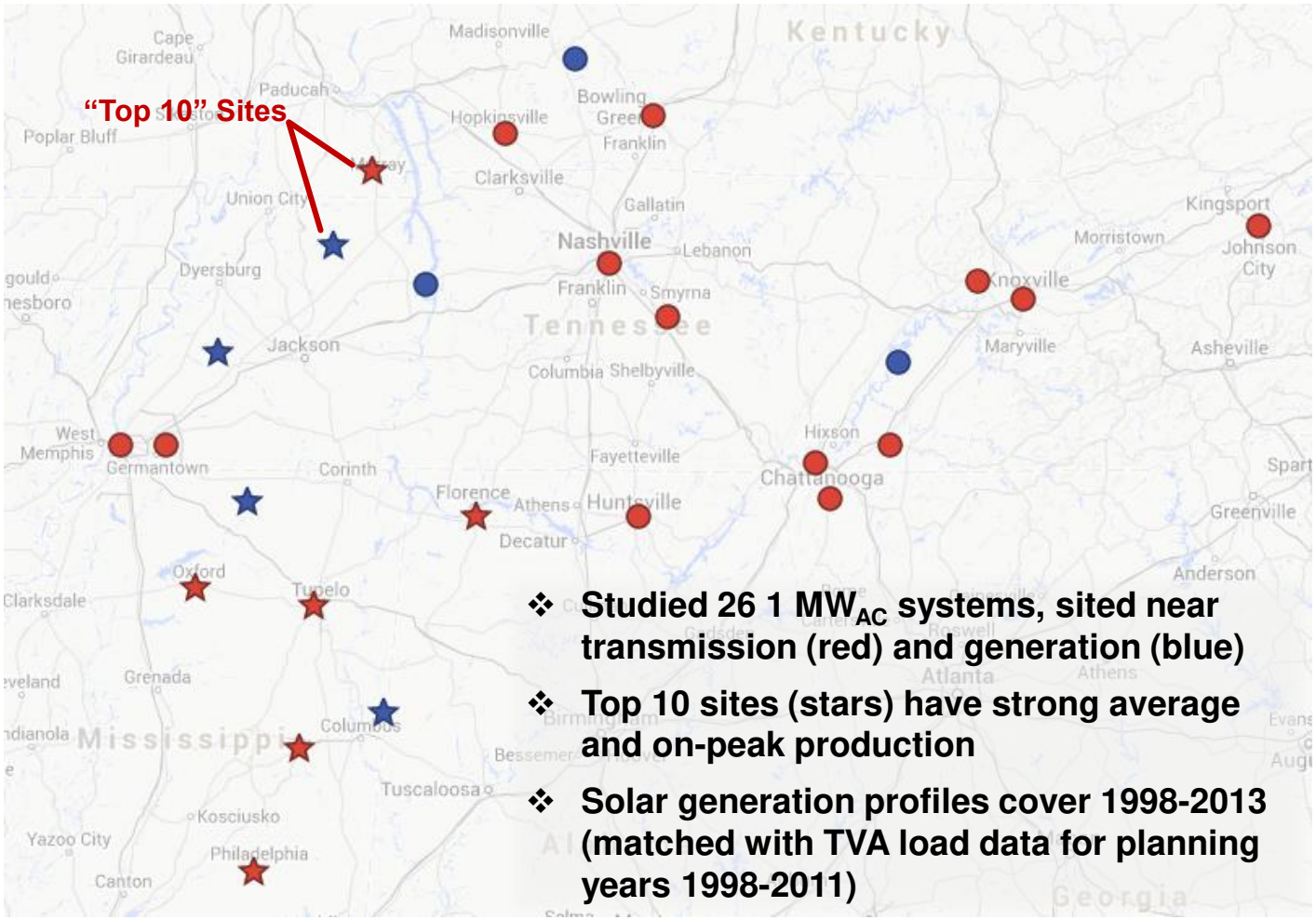


Top Ten Sites (Aggregated)	Fixed Tilt	Tracking
Capacity Factor (AC), Annual	20.5 %	23.2 %
Capacity Factor (AC), On-Peak	45.5 %	58.7 %
Dependable On-Peak Capacity	41.8 %	55.1 %

Solar assessment data from SolarAnywhere FleetView

Clean Power Research

Sites Studied Across the Valley



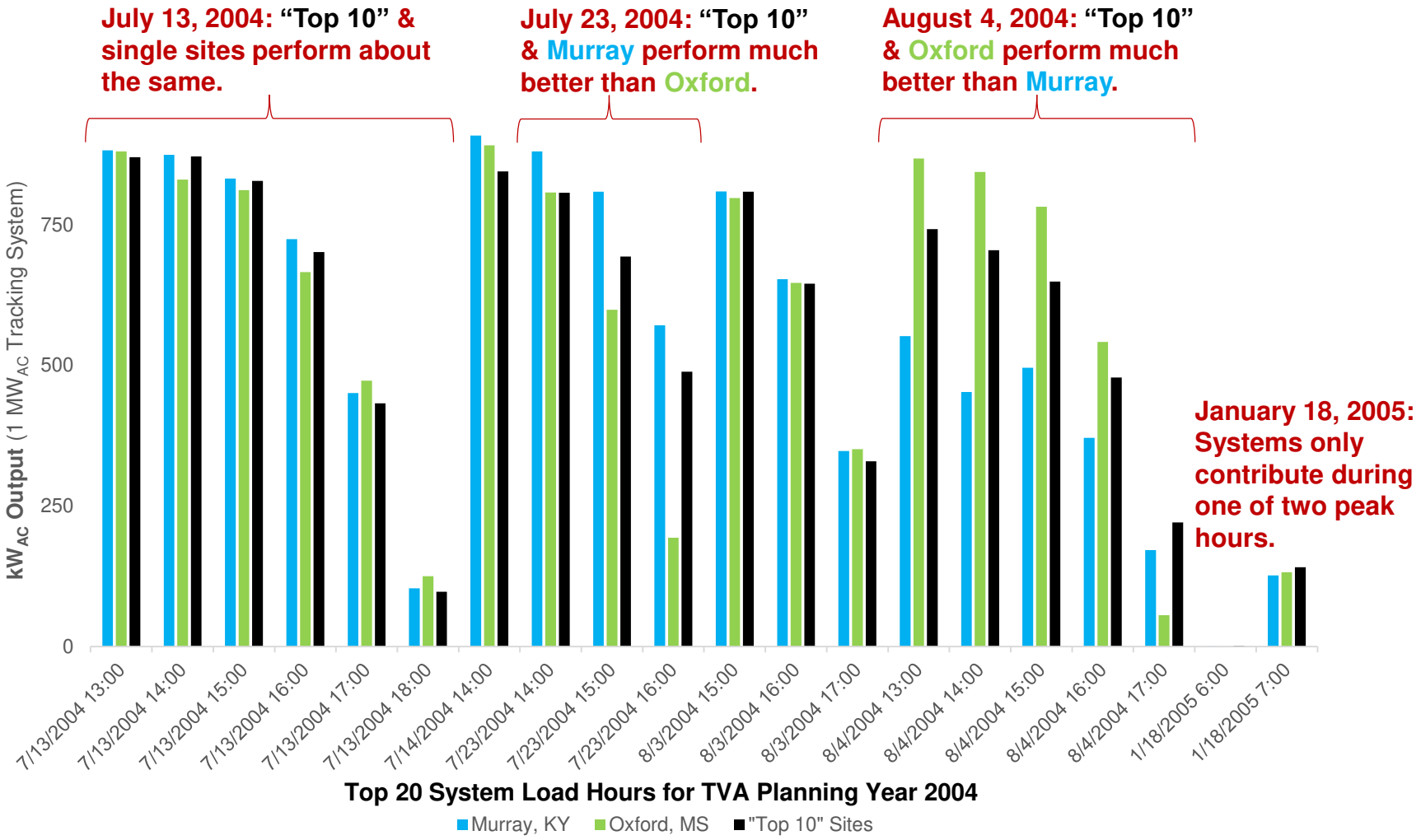
- Studied 26 1 MW_{AC} systems, sited near transmission (red) and generation (blue)
- Top 10 sites (stars) have strong average and on-peak production
- Solar generation profiles cover 1998-2013 (matched with TVA load data for planning years 1998-2011)

Observations

- ✓ **Solar systems perform best on the western side of TVA system, especially in terms of on-peak production.**
- ✓ **The sun is almost always shining during peak hours. Solar systems produce during 19 out of 20 on-peak hours.**
- ✓ **Tracking systems perform better than fixed axis systems.**
  - Generation is somewhat higher
  - On-peak capacity and reliability is substantially increased
- ✓ **Overall results support submission following up on TV-RIX "deep dive" discussions.**
  - Capacity factors are slightly higher
  - On-peak capacity is somewhat lower

CPR – SACE Analysis ***vs TV-RIX Inputs***	**Fixed Axis**	**Tracking**
Capacity Factor (AC)	20.5%	23.2%
- TV-RIX Recommendation	*18%*	*22%*
On-Peak Average Capacity Factor (AC)	45.5%	58.7%
- TV-RIX Recommendation	*n/a*	*n/a*
Dependable On-Peak Capacity Factor (AC)	41.8%	55.1%
- TV-RIX Recommendation	*50%*	*70%*

Aggregating "Top 10" Sites Improves On-Peak Capacity



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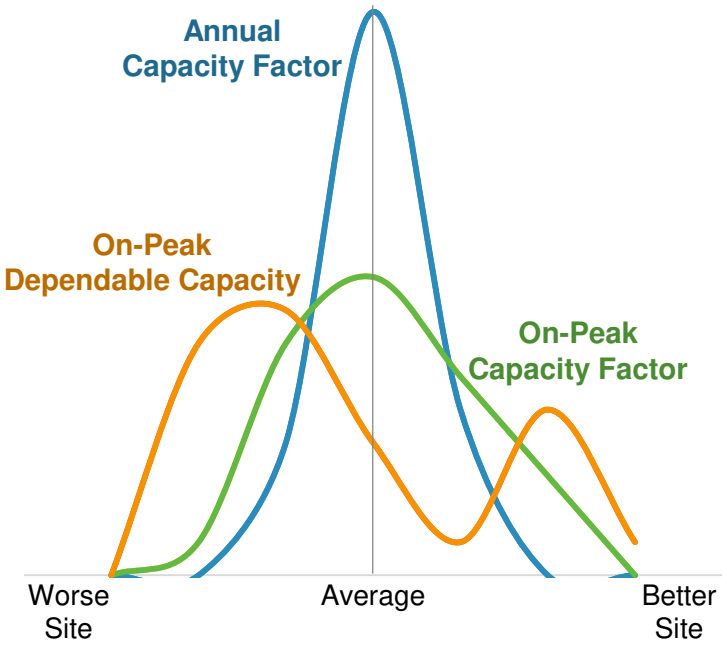
Siting Matters Most for On-Peak Capacity

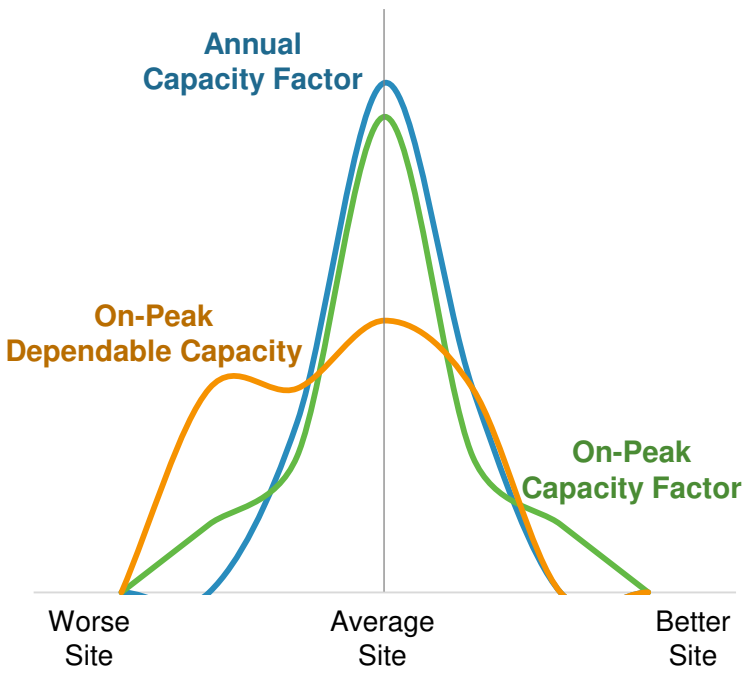
Siting affects on-peak capacity for fixed axis systems more

… than for tracking systems.

Fixed Axis Systems



Tracking Systems



Capacity factor is calculated as average kW_{AC} output for a 1 MW_{AC} system.

The "Best" Systems Studied

"Top Ten" Sites	State	Fixed Tilt			Tracking		
		Annual CF	On-Peak CF	Dependable Capacity	Annual CF	On-Peak CF	Dependable Capacity
Caledonia CC Plant	MS	20.73 %	45.36 %	39.97 %	23.47 %	58.46 %	52.97 %
Gleason CT Plant	TN	20.10 %	47.03 %	43.44 %	22.73 %	60.92 %	55.01 %
Lagoon Creek CT-CC Plant	TN	20.40 %	47.11 %	41.06 %	23.13 %	60.71 %	52.20 %
Magnolia Plant CC	MS	20.31 %	45.14 %	40.25 %	23.03 %	58.01 %	52.75 %
Murray	KY	19.97 %	46.80 %	42.55 %	22.57 %	60.53 %	55.06 %
Muscle Shoals	AL	20.25 %	44.28 %	42.27 %	22.85 %	57.43 %	55.55 %
Oxford	MS	20.62 %	46.48 %	42.66 %	23.40 %	59.94 %	55.61 %
Philadelphia	MS	20.83 %	41.61 %	37.04 %	23.60 %	53.60 %	47.39 %
Starkville	MS	20.76 %	44.68 %	37.04 %	23.55 %	57.23 %	52.04 %
Tupelo	MS	20.62 %	46.21 %	43.65 %	23.36 %	59.94 %	55.53 %
"Top 10" Sites Studied		**20.46 %**	**45.47 %**	**41.82 %**	**23.17 %**	**58.68 %**	**55.12 %**

Capacity factor is calculated as average kW_{AC} output for a 1 MW_{AC} system.

The "Rest" of Systems Studied

Other 16 Sites	State	Fixed Tilt			Tracking		
		Annual CF	On-Peak CF	Dependable Capacity	Annual CF	On-Peak CF	Dependable Capacity
Bowling Green	KY	19.63 %	42.40 %	36.83 %	22.11 %	55.17 %	49.66 %
Chattanooga	TN	19.98 %	43.81 %	39.47 %	22.46 %	57.91 %	52.84 %
Chickamauga	GA	20.24 %	43.40 %	38.15 %	22.81 %	57.46 %	50.88 %
Cleveland	TN	20.21 %	42.10 %	37.53 %	22.73 %	55.49 %	50.89 %
Cordova	TN	20.36 %	44.50 %	38.15 %	23.06 %	56.91 %	49.43 %
Hopkinsville	KY	19.77 %	44.36 %	39.40 %	22.32 %	57.67 %	50.95 %
Huntsville	AL	20.02 %	41.93 %	36.12 %	22.58 %	54.69 %	49.70 %
Johnson City	TN	19.76 %	38.44 %	29.85 %	21.99 %	50.91 %	44.10 %
Johnsonville Fossil Plant	TN	19.99 %	44.86 %	42.24 %	22.55 %	58.29 %	53.05 %
Knoxville	TN	20.18 %	42.08 %	36.80 %	22.61 %	56.14 %	50.71 %
Memphis	TN	20.47 %	45.49 %	37.62 %	23.21 %	58.25 %	46.39 %
Murfreesboro	TN	19.71 %	42.16 %	36.20 %	22.18 %	54.54 %	51.52 %
Nashville	TN	19.72 %	43.51 %	37.46 %	22.21 %	56.72 %	52.71 %
Oak Ridge	TN	19.94 %	42.32 %	37.19 %	22.35 %	56.72 %	51.94 %
Paradise Fossil Plant	KY	19.62 %	43.36 %	37.98 %	22.11 %	56.25 %	51.66 %
Watts Bar Plant	TN	20.01 %	43.68 %	38.22 %	22.41 %	57.75 %	54.43 %
All 26 Sites Studied		**20.16 %**	**43.97 %**	**39.53 %**	**22.75 %**	**57.22 %**	**52.88 %**

Capacity factor is calculated as average kW_{AC} output for a 1 MW_{AC} system.

Methods and Sources

- Clean Power Research was contracted to simulate hourly production for two PV fleets – a fixed fleet and a tracking fleet each of 26 systems.
- The simulation used CPR's SolarAnywhere FleetView modeling services, standard resolution (10 km x 10 km x 1 hour resolution).
- Fixed tilt fleet: 1 MW_{AC}, south-facing, 20-degree tilt angle
- Tracking fleet: 1 MW_{AC}, N/S tracking axis, 0-degree tilt angle, tracking rotational limit of +/- 45°
- All systems configured with 4,800 modules in 12 rows with a relative row spacing of 2.5 and combined DC_{PTC} rating of 1,200.5 kW. A general derate factor of 85% was used along with an inverter with a CEC weighted average efficiency of 98% and an albedo of 0.15.
- SACE obtained TVA hourly load data from Ventyx Velocity Suite for 2003-2012 and from FERC's website for 1998-2002.
- Annual capacity factors (AC) were calculated directly from the entire SolarAnywhere 16 year dataset.
- On-peak capacity factors (AC) were calculated based on the average capacity factor over the 20 highest load hours in each TVA planning year (1998-2011 includes June 1998 through May 2012).
- Dependable on-peak capacity (AC) was estimated as the 4th lowest average on-peak capacity factor from the 13 planning years 1998-2011. For the "Top 10" aggregate resource, the 4th lowest year is 2004. The dependable on-peak capacity method follows the method outlined in TVA's presentation at the TV-RIX wind resource "deep dive" meeting. (The method used by TVA in the corresponding solar presentation.)
- A more accurate method for assessing solar capacity value is the effective load carrying capacity method (ELCC), which requires system modeling. Regardless of the method chosen, these energy pattern data should provide an adequate basis for determining dependable summer and winter capacity. Energy pattern data could also be used to develop a "typical meteorological year" normalized solar output pattern, although some additional data might need to be obtained to complete the dataset.
- The "top ten" sites were selected to optimize the overall results across all three evaluation measures.