A Solar Rooftop Assessment for Austin

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ABSTRACT

The objective of this project was to create a model for assessing the amount of rooftop area on commercial, industrial, institutional, and governmental buildings in Austin Energy's service area suitable for solar electric energy development and, based on this model, determine the potential installed capacity and annual energy production from solar electric installations on the rooftops of these buildings.

Key questions addressed by this project were:

1. What is the aggregate rooftop area, rooftop area suitable for PV project development, and potential for PV capacity and energy production from rooftop solar photovoltaic systems on key building types in Austin Energy's service area?
2. How do the potential capacity and annual energy production from rooftop solar electric systems compare with Austin Energy's current capacity and annual energy requirements?

1. DATA SOURCES

Clean Energy Associates (CEA) identified and used data from each of the following sources in conducting the rooftop assessment:

- Travis Central Appraisal District (TCAD) database
- Williamson Central Appraisal District (WCAD) database
- City of Austin Geographic Information System (GIS)
- Austin Energy Customer Information System (CIS)
- Austin Energy Solar Program database
- Austin Energy Solar Meter Readings database

In addition, several other sources of potentially relevant data were identified but not ultimately used in the data analysis:

- State of Texas Buildings Database
- Austin Independent School District (AISD) facilities data
- University of Texas facilities data

2. MODELING APPROACH

CEA's model employed a stepwise analytical approach to determine the rooftop square footage available on buildings in Austin Energy's service area. Once a square footage figure was obtained, CEA applied factors to convert the available square footage into available power (MW) and annual energy (MWh) potential. The following sections detail the stepwise approach to modeling.

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1. **Identify gross square footage of available rooftop space in Austin Energy's service territory by property class.** We began by identifying the gross square footage of available rooftop space in Austin Energy's service territory by property class. The key property classes identified were:

    - RESIDENTIAL SINGLE FAMILY
    - RESIDENTIAL MULTI FAMILY
    - FARM AND RANCH
    - COMMERCIAL
    - INDUSTRIAL
    - UTILITY
    - CIVIC

    Because the utility service territory covers a portion of both Travis and Williamson Counties, assessors' data from each county was overlayed with the City of Austin's Geographical Information System (GIS) to obtain property data relevant to the utility service territory. In addition, because the assessors' databases do not include tax-exempt properties, the square footage of tax exempt properties was added to the analysis using Austin's GIS and Customer Information System.

    Neither the Counties' assessors' data nor the City's GIS data is perfectly suited to estimating rooftop space. The assessors' data, for example, contains square footage information only on areas which may be occupied. For residential properties, this does not include garages or covered porches, both of which might be suitable for PV installations. In this sense, the assessors' data can be assumed to under-represent available rooftop space. In contrast, the City's GIS data is derived from building footprint polygons, and may include structures such as small sheds or picnic structures which might not be appropriate for PV installations. The GIS data therefore can be assumed to over-represent available rooftop space. The model derived square footage estimates from each data source but used the average of the two values as the gross square footage.

2. **Exclude structurally unsound roofs.** The model made adjustments to account for roofs that were structurally unsound. Adjustment factors were derived for each property type through industry experience and were reviewed for consistency with previous studies[1]. As an example, adjustments were made to exclude mobile homes from the single family residential square footage total. This reduced the overall residential square footage by approximately 1 percent. For commercial, industrial and other categories, 80 percent of structures were assumed to be structurally sound.

3. **Exclude improperly oriented roofs.** The model made adjustments to exclude roofs that would not be useful for PV development due to their directional orientation. [An adjustment factor of 30% was assumed for residential categories and was consistent with previous published studies and industry experience. The adjustment means that 30% of available rooftop area was assumed to be available. The project team did not conduct a roof-by-roof analysis, but rather assumed a distribution of roof orientations and slopes and excluded north-facing slopes, and extreme east- and west-facing slopes. These analyses yielded factor estimates in the range of 30-45%, and a final value of 30% was considered to be a conservative assumption.

4. **Exclude shaded rooftop area.** The model incorporated Austin Energy's database of residential solar site inspections to quantify the percentage of residential properties in each zip code which were rejected due to shading. Austin Energy produced a map showing the number and percent of non-qualifying residential surveys by zip code (see Figure 1). The study of Austin Energy's residential inspection database yielded an adjustment factor of 75 percent for single-family residential categories. (This adjustment implies that 25% of residential rooftops were unshaded). Separate adjustment factors of 90 percent for multi-family residential categories, and 98 percent for commercial, industrial and other categories were applied (implying a model assumption that 10 percent of multi-family rooftop area, and 2 percent of commercial industrial, and other rooftop areas, were subject to shading).

[1] See, for example, Rooftop Photovoltaics Market Penetration Scenarios, Navigant Consulting - February 2008 (Prepared for NREL); and California Rooftop Photovoltaic (PV) Resource Growth Potential by County, Navigant Consulting - September 2007.

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The single family residential adjustment factor was derived from the Austin Energy rejection data, and applied to the residential rooftop square footage in the model on a zip code by zip code basis. The raw rejection rate was doubled before incorporation into the model, because it was assumed there would be some selection bias among the population of sites selected for such inspection (i.e., property owners who requested Austin's program inspection would tend to be those who initially considered their properties to be a suitable candidate for solar development).

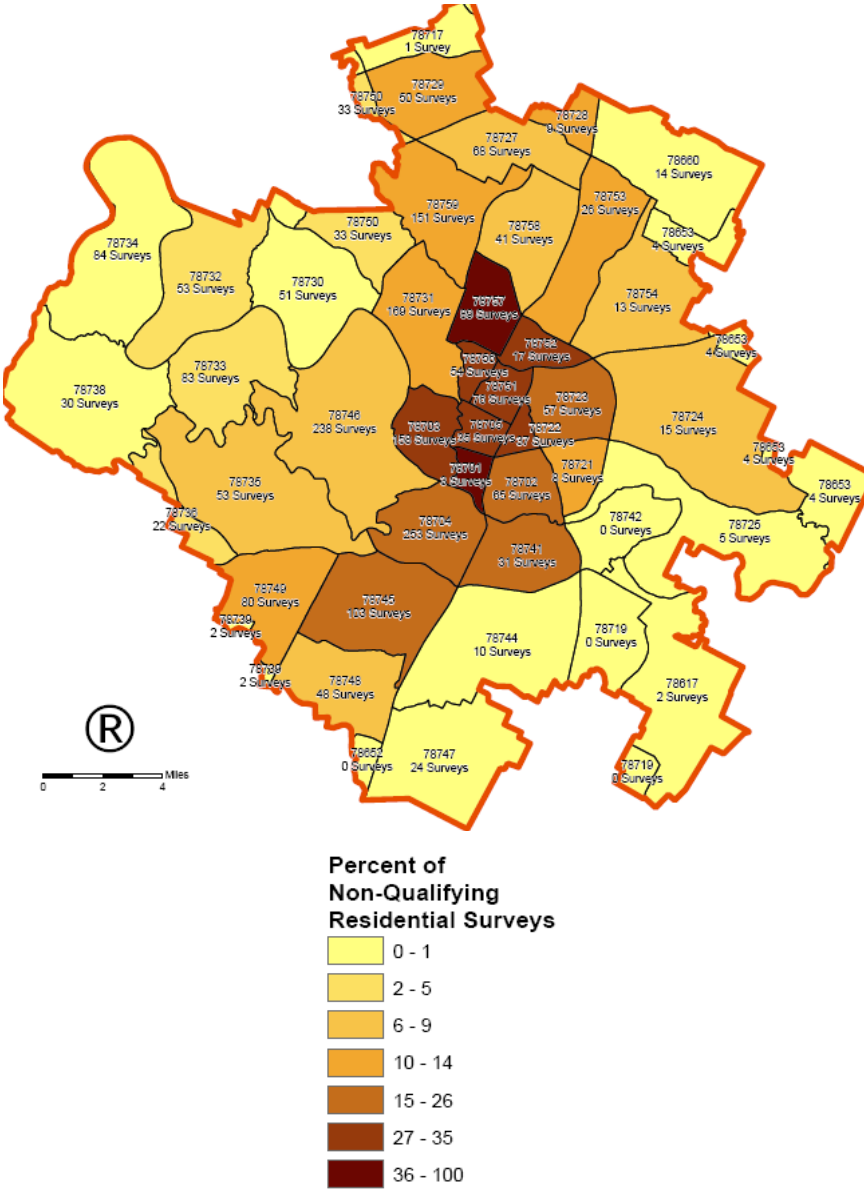

Figure 1. Concentration by Zip Code of Non-Qualifying Residential Surveys

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5. **Exclude areas not covered by modules.** PV arrays are rarely deployed to cover 100 percent of available rooftop space. Instead, some area is left open between modules to prevent inter-array shading, to allow for ventilation, and to allow for conduit runs, mechanical equipment, and installer or other personnel access to the array and other rooftop equipment. Other areas cannot be covered with modules due to physical and/or sunlight obstructions such as roof vents and drains, rooftop air conditioning units, or other rooftop equipment. A module coverage factor of 75 percent was applied to residential properties, 70 percent for commercial and civic properties, and 50 percent for industrial and utility properties.

6. **Estimate rooftop area covered by PV modules.** These progressive screens resulted in an estimate of the total square footage of rooftop area which can be covered by PV modules for each property type within Austin Energy's service area.

Three PV development scenarios were analyzed: all crystalline silicon modules, a combination of crystalline silicon and thing film modules, and all thin film models. In each scenario, the model calculated the total DC and AC capacity of PV systems which can be installed within the available area and the resulting expected annual energy production. The all crystalline silicon modules (scenario 1) resulted in higher estimates of both total capacity and annual energy than either other scenario. Figure 2 below shows the various produciton and power density factors used in the analysis. All production factors were derived from Austin Energy's metered production data for residential and commercial solar energy systems.

	All Cystalline Silicon Modules	Combination of CSi and Thin Film	All Thin Film
Power Density Factor	17.2 W/sf	10 W/sf	10 W/sf
Production Factor: Residential	1,321 kWh/kWdc	1,321 kWh/kWdc	1,321 kWh/kWdc
Production Factor: Commercial & Industrial	1,357 kWh/kWdc	1,357 kWh/kWdc	1,357 kWh/kWdc

Figure 2. Power density and production factors used in PV development scenarios

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3. RESULTS

3.1 ROOFTOP AREA SUITABLE FOR SOLAR PV DEVELOPMENT

The model used data from the Travis and Williamson County Appraisal Districts and from the City of Austin's GIS to estimate the gross available rooftop square footage in Austin Energy's service area at 536 million square feet (MSF). After filtering was applied, this figure was reduced to 142 MSF available for PV development.

Million Square Feet

	Gross	Structurally Sound	Orientation Usable	Unshaded	Module Coverage
RESIDENTIAL SF	333	328	98	74	55
RESIDENTIAL MF	55	55	16	15	11
FARM AND RANCH	2	2	1	0	0
COMMERCIAL	70	56	56	55	38
INDUSTRIAL	30	24	24	24	12
UTILITY	1	1	1	1	1
CIVIC	46	37	37	36	25
	536	502	233	204	142

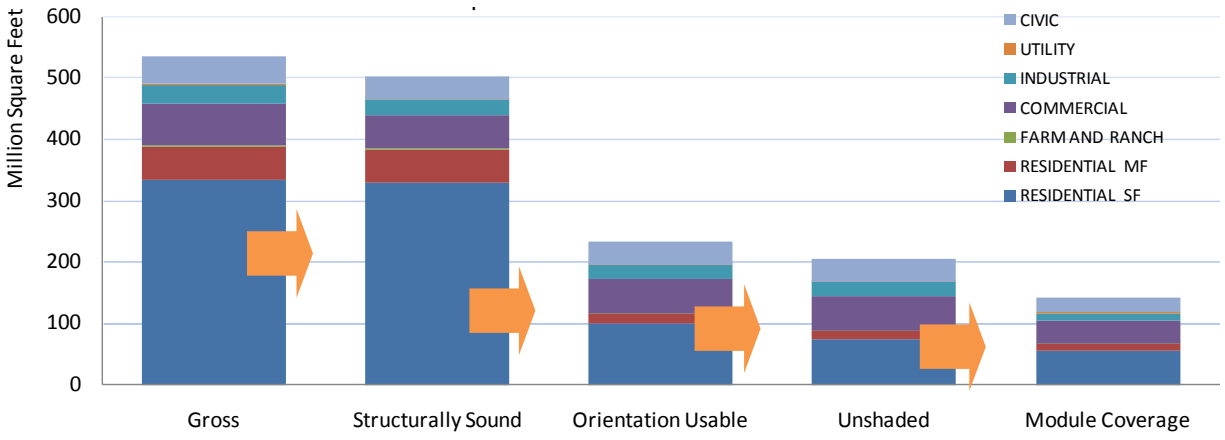

Figure 3. Rooftop Area Screening Details: Area Suitable for PV Installation, by Property Type

3.2 Potential Rooftop PV Generating Capacity and Annual Energy

The table and graph below convert the rooftop area suitable for solar PV development into capacity and annual energy estimates pertaining to deployment scenario 1. The rooftop area suitable for solar PV development in Austin Energy service area could accommodate a total of about 2,446 MW (DCstc) of solar generating capacity, and generate approximately 3.3 million MWh of energy annually.

	MW (DCstc)	%	MWh (AC)	%
RESIDENTIAL SF	950	38.8%	1,255,448	38.3%
RESIDENTIAL MF	190	7.8%	250,528	7.6%
FARM AND RANCH	5	0.2%	6,442	0.2%
COMMERCIAL	658	26.9%	893,135	27.2%
INDUSTRIAL	203	8.3%	275,660	8.4%
UTILITY	9	0.4%	12,559	0.4%
CIVIC	431	17.6%	584,836	17.8%
	2,446	100.0%	3,278,609	100.0%

Figure 4. Rooftop PV Technical Potential Generating Capacity and Annual Energy, Deployment Scenario 1

3.3 Potential Rooftop PV Capacity Relative to Existing Generation Mix

The table and graph in Figure 5 below show Austin Energy's current generation capacity mix and display the technical potential rooftop PV capacity in comparison. Austin currently obtains energy from coal, nuclear, natural gas, renewable energy, and purchased power generators which comprise 2,760 MW of generating capacity. If fully developed the potential rooftop PV capacity would total 2,324 MW, about 84 percent of current generating capacity.

EXISTING CAPACITY	MW (AC)	%
COAL	607	22.0%
NUCLEAR	422	15.3%
NATURAL GAS	1,444	52.3%
EXISTING RENEWABLES	13	0.5%
PURCHASED POWER	274	9.9%
EXISTING TOTAL	2,760	100.0%

	MW (AC)	% of Existing Capacity
POTENTIAL PV	2,324	84.2%

Figure 5. Rooftop PV Technical Capacity Potential Relative to Existing Generation Mix (Development Scenario 1)

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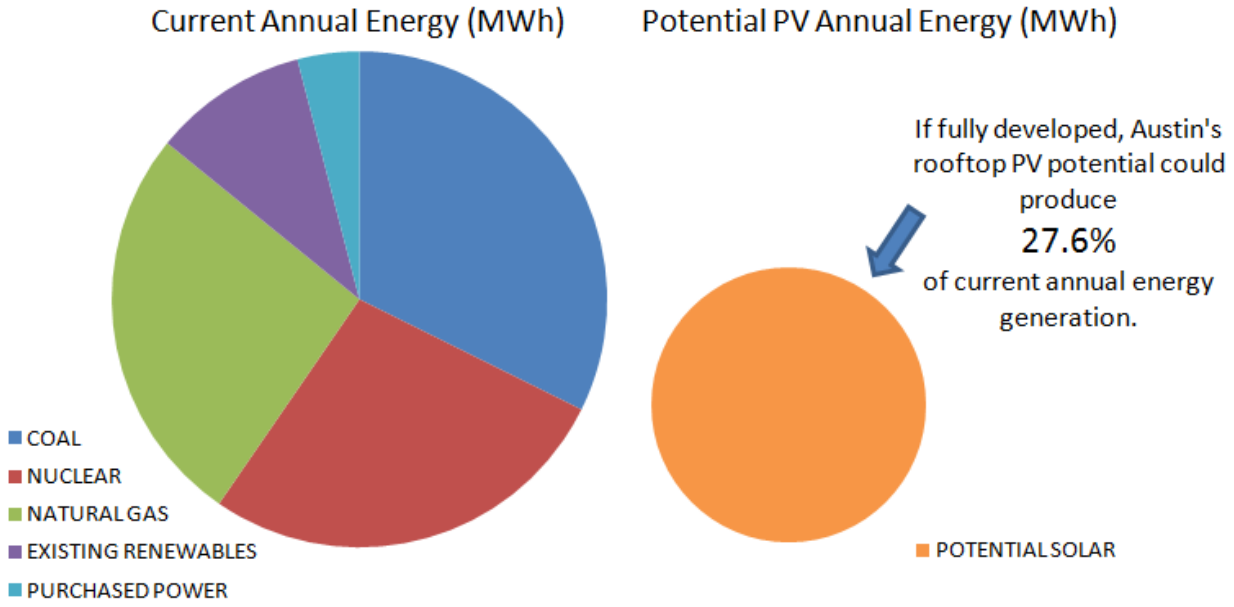
3.4 Potential Rooftop PV Energy Relative to Existing Generation Mix

The table and graph in Figure 6 show Austin Energy's current annual energy consumption by resource and display the technical potential rooftop PV annual energy in comparison. It shows that if fully developed, Austin Energy's technical potential rooftop PV resources could produce 27.6 percent of current annual energy consumption. The potential annual energy generation comprises a much smaller share of current annual energy (27.6%) than it does of current generation capacity (84.2%) due to the low capacity factor of PV generation relative to other generating resources.

EXISTING ENERGY	MWH	%
COAL	3,840,000	32.3%
NUCLEAR	3,240,000	27.3%
NATURAL GAS	3,120,000	26.3%
EXISTING RENEWABLES	1,200,000	10.1%
PURCHASED POWER	480,000	4.0%
TOTAL	11,880,000	100.0%

	MWH	% of Current Annual Energy
POTENTIAL SOLAR	3,278,609	27.6%



Note: Existing resource annual energy figures were provided by Austin Energy.

Figure 6. Rooftop PV Technical Annual Energy Potential Relative to Existing Generation Mix (Development Scenario 1)

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3.5 Annual Energy Potential in 3 PV Development Scenarios

Table 6 below summarizes the model results under the three different PV development scenarios. They show that increasing the share of thin film PV in the deployed mix results in lower annual energy generation than if crystalline technologies are deployed. Where Scenario 1 (crystalline deployment only) resulted in approximately 3.3 million MWh of annual solar energy production, Scenario 2 (crystalline deployment on residential rooftops; thin film deployment on commercial and industrial rooftops) resulted in about 2.5 million MWh per year, and Scenario 3 (thin film only) resulted in 1.9 million MWh per year. Note that the deployment assumptions in Scenario 2 do not assume a mixing of crystalline and thin film technologies within any sector, resulting in equivalent estimates of production in the residential sectors between Scenarios 1 and 2, and equivalent estimates of production in other sectors in Scenarios 2 and 3.

It should also be noted that the model used power density factors derived from currently commercially-available high-efficiency crystalline and thin film modules; technological changes would potentially alter these results.

	Annual MWh		
	Scenario 1 CSi	Scenario 2 CSi + TF	Scenario 3 TF
RESIDENTIAL SF	1,255,448	1,255,448	731,187
RESIDENTIAL MF	250,528	250,528	145,911
FARM AND RANCH	6,442	6,442	3,752
COMMERCIAL	893,135	520,172	520,172
INDUSTRIAL	275,660	160,547	160,547
UTILITY	12,559	7,315	7,315
CIVIC	584,836	340,615	340,615
	3,278,609	2,541,067	1,909,498
	% of 2008 Annual Energy Generation		
	27.6%	21.4%	16.1%

Table 7. Rooftop PV Technical Potential Annual Energy Generation in 3 Deployment Scenarios

4. ADDITIONAL INFORMATION

As additional tasks, CEA provided Austin Energy with:

- Detailed information about the largest commercial and industrial rooftops. In the commercial sector there are over 14,000 buildings with about 134 million gross square feet, and the largest 1,000 buildings in this sector encompass nearly 50% of the gross area. In the industrial sector there are 132 buildings, and the largest 10 buildings encompass about 50% of the gross area.
- Estimates of the rooftop availability for each use category by zip code, starting with City of Austin GIS data. A table summarizing the results of this analysis is included in section 4.g. of the report. While the model is intended to provide a reasonably accurate estimation in the aggregate, the level of accuracy is necessarily reduced at finer levels of granularity, such when broken down by zip codes or at the level of individual buildings. Still, we believe the zip code break down can provide a useful screening of PV development opportunities throughout the City.

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5. CONCLUSION

This study presents an assessment of the rooftop area available for PV development within Austin Energy's service area. It is a technical potential assessment only, and does not consider the economic feasibility of projects. Instead it presents a summary of the overall potential for rooftop PV development within the utility service area. The model employed found that if fully developed, rooftops within Austin Energy's service area could accommodate approximately 2,446 MW (DC stc) of PV capacity, capable of producing approximately 3.3 million MWh annually. This annual generation is equivalent to about 27.6 percent of Austin Energy's 2008 annual energy generation requirement. Substituting all potential PV capacity with thin film deployment reduces the annual energy production to about 1.9 million MWh annually, equivalent to about 16.1 percent of Austin Energy's 2008 annual energy generation requirement.

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