Assessment of Rooftop Area in Austin Energy's Service Territory Suitable for PV Development

Submitted by:

Steven M. Wiese, Principal
Aziz Hussaini, Research Assistant
Benjamin Ryan, Research Assistant
Steven Lapointe, Analyst

Final Assessment and Report
July 24, 2009

This assessment and report was created for Austin Energy with funding from the U.S. Department of Energy's Solar America Cities program. For more information, see http://www.solaramericacities.energy.gov/.

Table of Contents

Executive Summary

As part of the Solar America Cities program, Austin Energy proposed to perform an assessment of the rooftop area available for PV development within its service area. Austin Energy contracted with Clean Energy Associates (CEA) to perform the analysis. This report summarizes the project objectives, data sources and methodological approach employed, and results.

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?

CEA utilized data sources from the Travis and William County Appraisal Districts, the City of Austin and Austin Energy to construct a rooftop assessment model. In the process of identifying available data, CEA documented several other data sources and provided this information to Austin Energy.

The model developed incorporated a top-town, stepwise analytical approach to determine the rooftop square footage available on buildings in Austin Energy's service area. It began with an estimate of the gross rooftop area, then applied progressive screens to reduce this value to an estimate of rooftop area suitable for solar PV development. The screens were employed to:

- Exclude structurally unsound roofs;
- Exclude improperly oriented roofs;
- Exclude shaded rooftop area; and,
- Exclude areas not covered by modules due to spacing between modules for ventilation, serviceability, and other rooftop access requirements.

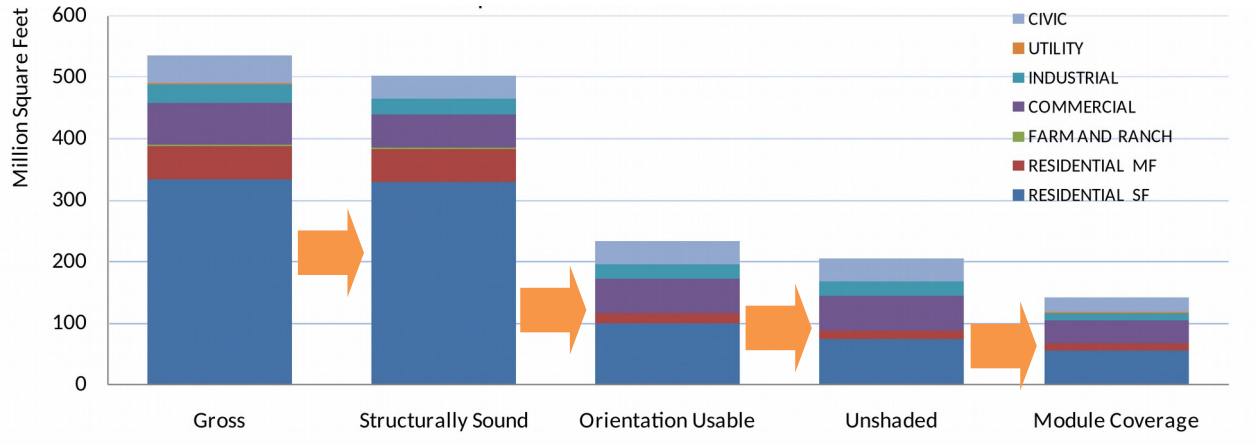
Once an available rooftop square footage figure was obtained, the model applied factors to convert the available square footage into available power (MW) and annual energy (MWh) potential under three different PV development scenarios:

- Scenario 1. Current technology (all crystalline silicon modules deployed). In this scenario, the model assumed all PV would be installed using typical currently commercially-available high-efficiency crystalline silicon solar panels.

- Scenario 2. Combination of CSi and thin film. This scenario assumed residential properties would use crystalline modules (due to their space constraints) while non-residential properties would deploy thin film technologies. Because current thin film products have a lower power density than crystalline products, this results in lower estimates of both total capacity and annual energy.

- Scenario 3. All thin film. This scenario assumed that all available rooftop space was devoted to thin film modules. Due to the lower power density rating of thin film products, this scenario resulted in the lowest estimates of total capacity and annual energy.

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 the screens were applied, this figure was reduced to 142 MSF available for PV development. The figure below illustrates the result of each screening step. The step which considered usable orientation had the largest affect overall, especially among residential property types.



The model then converted the rooftop area suitable for solar PV development into capacity and annual energy estimates pertaining to deployment scenario 1. It shows that 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 (see table below). Slight differences in the percentage allocations by property type are due to differences in estimated production between residential and other property types (Austin Energy's solar production data shows that residential properties have a slightly lower production factor than commercial properties).

	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%

The model then compared the potential rooftop solar capacity and annual energy generation to Austin Energy's current generation capacity and annual generation mix. It showed that if fully developed, the potential rooftop PV capacity would total 2,324 MW, or about 84 percent of current generating capacity. The potential annual energy generation comprises 27.6 percent of current annual energy generation, a smaller share than capacity due to the low capacity factor of PV generation relative to other generating resources.

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%

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%

Finally, the model calculated the potential annual energy generation under the three different PV development scenarios. As expected, it showed that increasing the share of thin film PV in the deployed mix resulted 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.

	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%

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.

In sum, 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; as such it does not consider the economic feasibility of projects, but instead 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 3.2 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.

1. Project Objectives

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?

2. 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

Detailed information about each identified data source is included in Appendix 1.

3. 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 follow sections detail the stepwise approach to modeling.

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 (see Figure 1 below), 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.

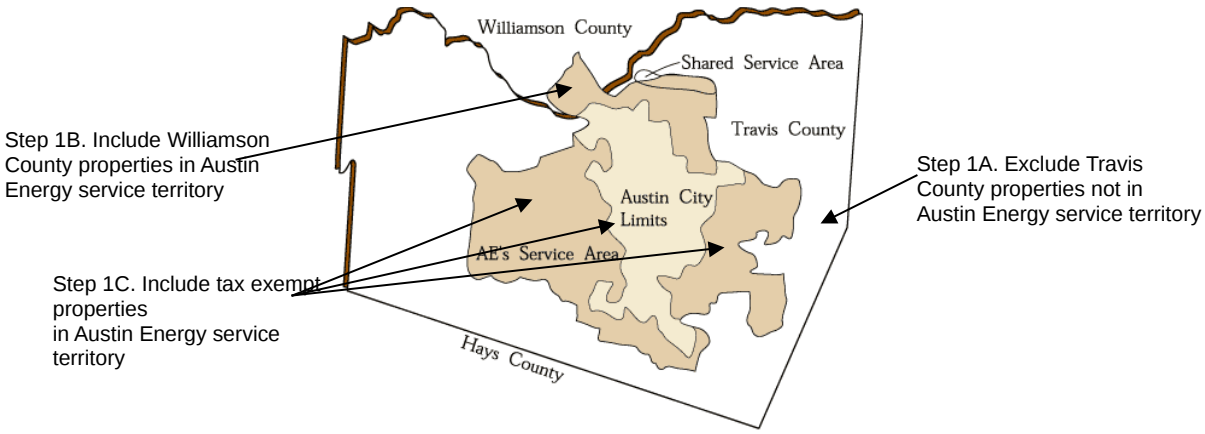


Figure 1. Austin Energy's Service Area, Travis and Williamson Counties

Neither the Counties' assessors' data nor the City's GIS data was 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. 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; this figure was derived from industry experience and is supported by similar studies.[1]

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. The adjustment factor was 30% for residential categories and was based on previous published studies and industry experience.

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 2). The model applied an adjustment factor of 75 percent for single-family residential categories, 90 percent for multi-family residential categories, and 98 percent for commercial, industrial and other categories.

   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).

[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.

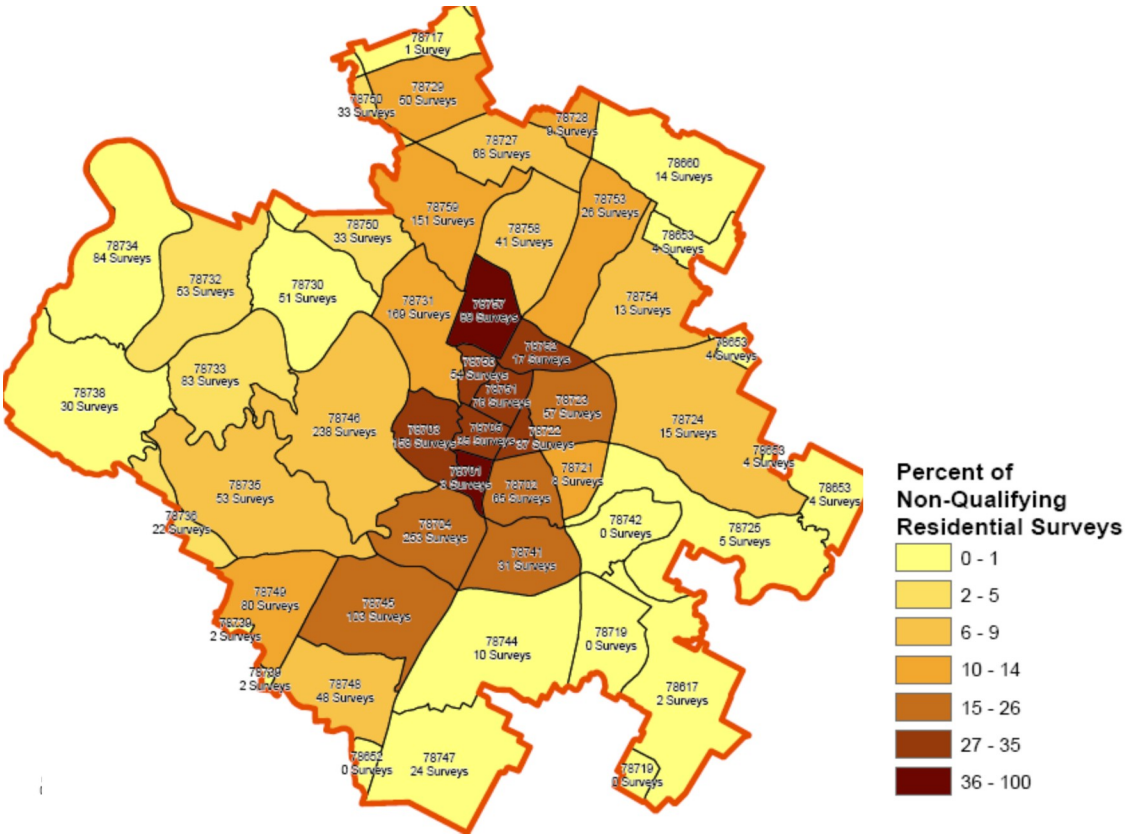


Figure 2. Concentration by Zip Code of Non-Qualifying Residential Surveys

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.

Once the total area was obtained, the analysis continued within three PV development scenarios. 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 three installation scenarios were:

- **Scenario 1. Current technology (all crystalline silicon modules deployed):** In this scenario, the model assumed all PV would be installed using typical currently commercially-available high-efficiency crystalline silicon solar panels. A power density factor of 17.2 watts per square foot was applied to these modules to estimate the capacity which could be installed. Capacity was converted to annual energy by using factors derived from Austin Energy's metering of installed PV systems in its service territory. A production factor of 1,321 kWh/kWdc installed was used for residential systems; 1,357 kWh/kWdc for commercial and industrial systems. These factors were derived from Austin Energy's metered production data for residential and commercial solar energy systems.

- **Scenario 2. Combination of CSi and thin film.** This scenario assumed residential properties would use crystalline modules (due to their space constraints) while non-residential properties would deploy thin film technologies. The power density factor for the thin film modules was 10.0 watts per square foot; the energy production factors assumed in Scenario 1 were unchanged.

- **Scenario 3. All thin film.** This scenario assumed that all available rooftop space was devoted to thin film modules. Because thin film products have a lower power density than crystalline products, this results in lower estimates of both total capacity and annual energy.

4. Results

4.a. Rooftop Area Suitable for Solar PV Development

The table and graph below (Figure 3) presents a summary of the stepwise screening approach, starting with gross rooftop square footage and excluding unusable areas until arriving at an estimate of 142 million square feet of rooftop space usable for PV development within Austin Energy's service area. It shows that the gross available rooftop area within Austin Energy's service territory is approximately 536 million square feet, and that the area available for coverage with solar panels is approximately 142 million square feet. The screening step which eliminates the most square footage is the one which considers usable orientation: this screening step has the largest effect on residential rooftop area. The figure shows how this available area is divided among property types.

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

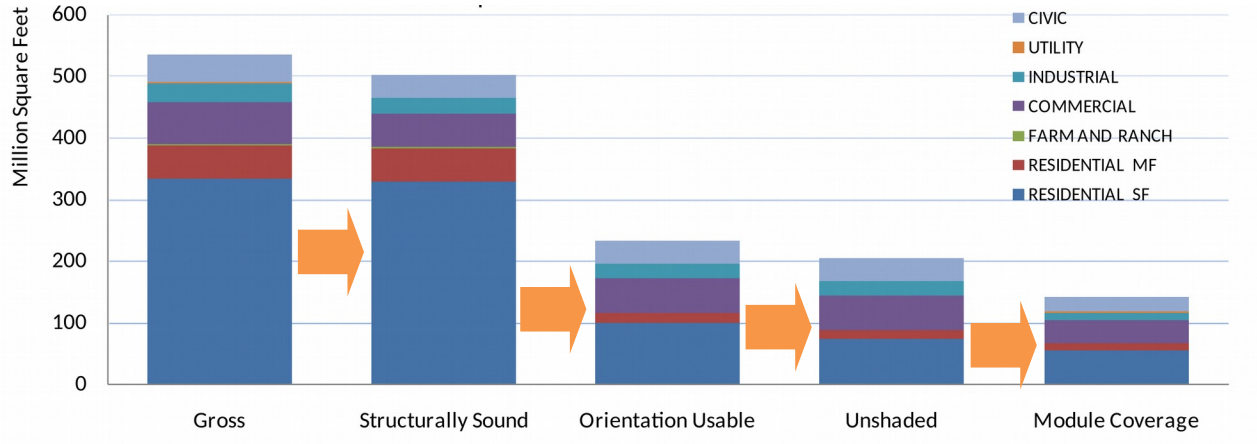


Figure 3. Rooftop Area Screening Details: Area Suitable for PV Installation, by Property Type

4.b. 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. It shows that 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. The largest contributors to total capacity and generation are in the residential, commercial and civic sectors. The pie charts and table show little difference in the relative breakdown of capacity versus energy; this is because the production factor for residential installations (1,321 kWh/kWdc) is only slightly lower than that used for non-residential installations (1,357 kWh/kWdc).

	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%

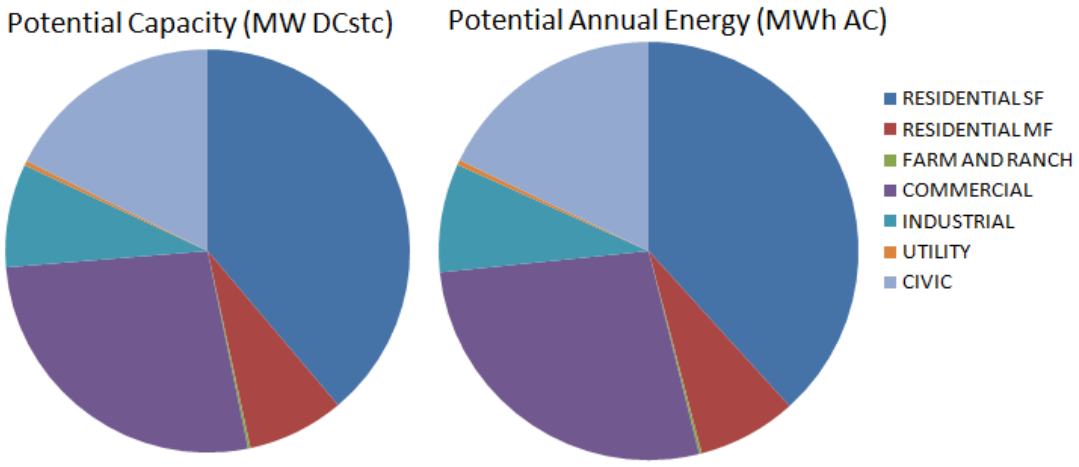


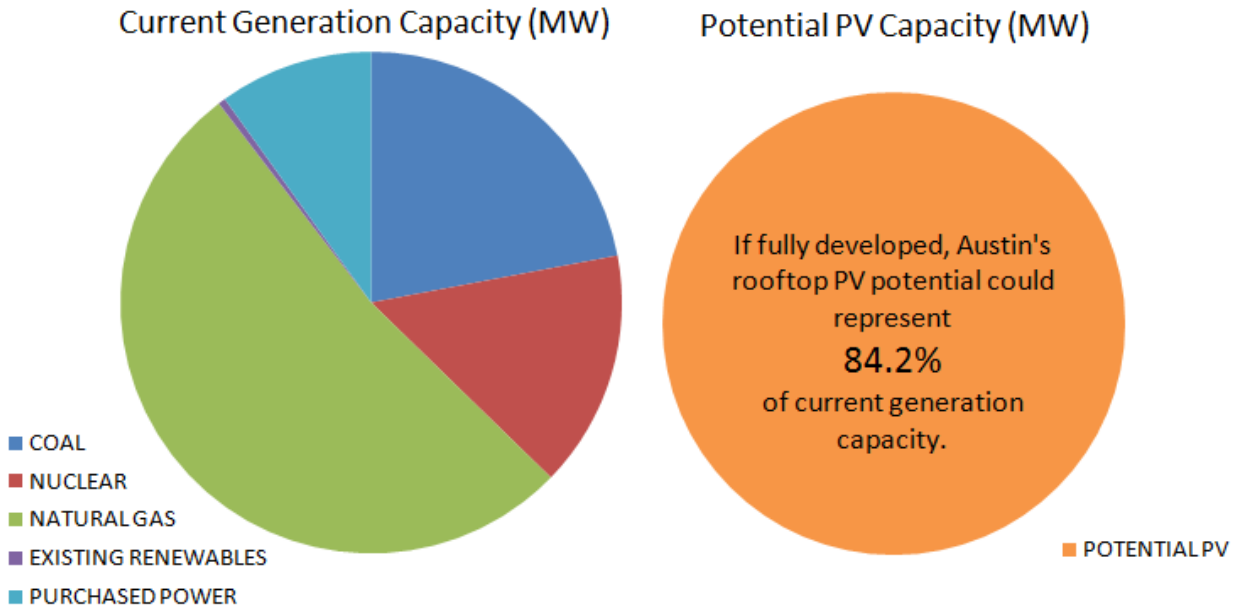
Figure 4. Rooftop PV Technical Potential Generating Capacity and Annual Energy, Deployment Scenario 1

4.c. 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%



Note: Existing resource capacity figures are derived from the Austin Smart Energy Guide (Figure 12).

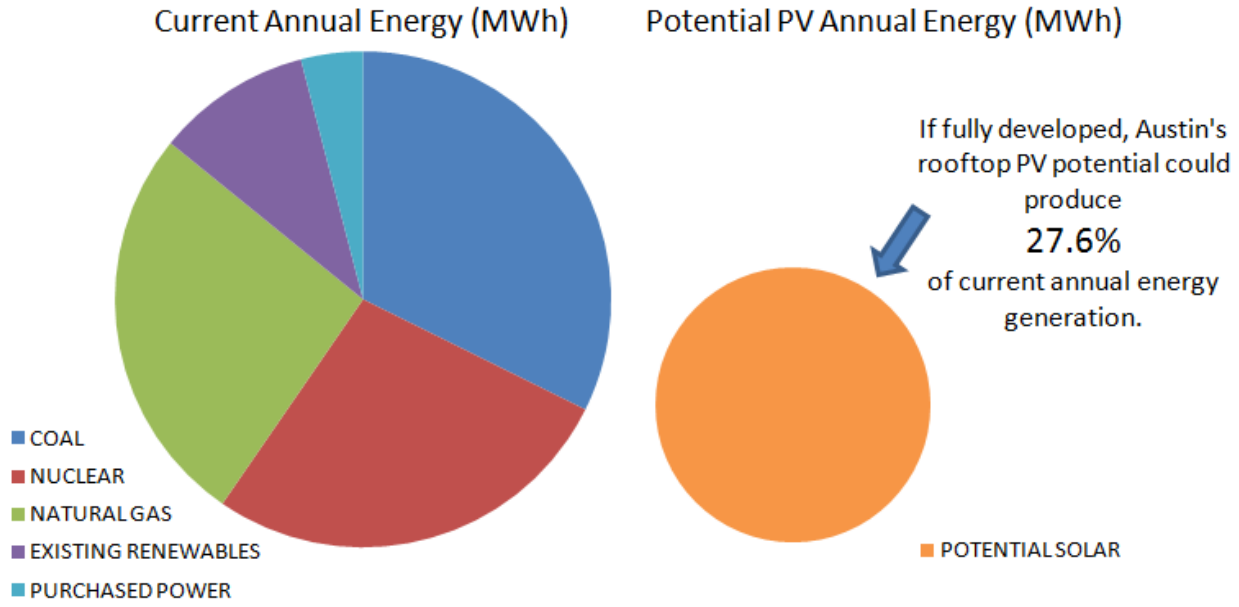
Figure 5. Rooftop PV Technical Capacity Potential Relative to Existing Generation Mix (Development Scenario 1)

4.d. 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)

4.e. Annual Energy Potential in 3 PV Development Scenarios

The table and graph in Figure 7 below summarize 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.

It should 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%

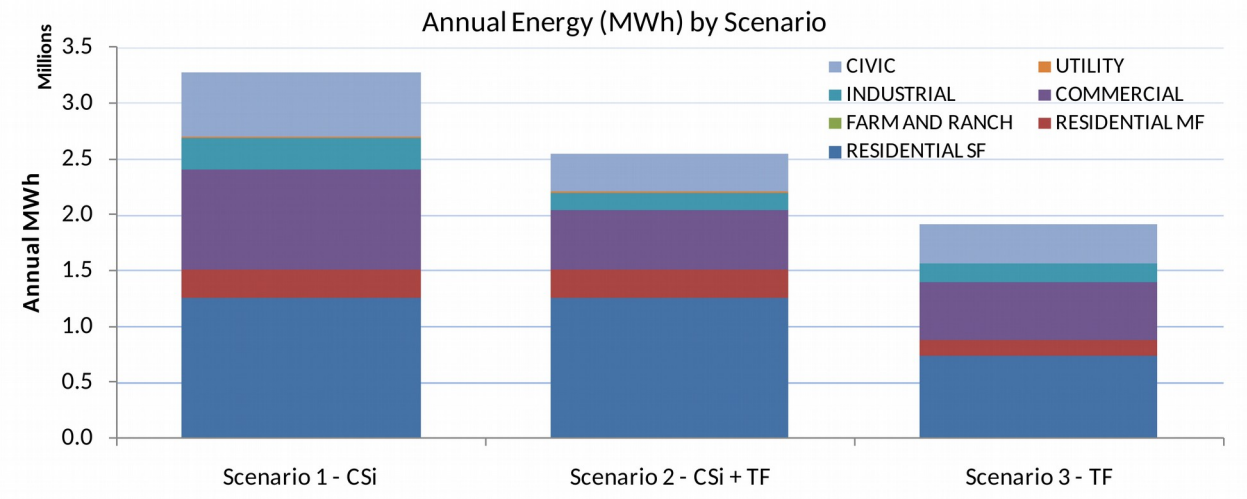


Figure 7. Rooftop PV Technical Potential Annual Energy Generation in 3 Deployment Scenarios

4.f. Distribution of Commercial and Industrial Rooftop Area

Figure 8 illustrates the distribution of gross commercial and industrial rooftop area in the Travis County Assessor's District (TCAD) data set. It shows that 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. These figures indicate an opportunity to capture a large share of commercial and industrial rooftop space by targeting the largest buildings.

	COMMERCIAL (F1)		INDUSTRIAL (F2)	
Total buildings	**14,409**		**132**	
Rooftop square footage	**134,348,725**		**8,047,750**	
Top 10 bldgs sq ftg	3,157,538	2%	3,981,099	49%
Top 100 bldgs sq ftg	17,407,435	13%	7,746,772	96%
Top 200 bldgs sq ftg	27,192,087	20%		
Top 300 bldgs sq ftg	34,683,988	26%		
Top 400 bldgs sq ftg	40,884,041	30%		
Top 500 bldgs sq ftg	46,180,878	34%		
Top 600 bldgs sq ftg	50,891,305	38%		
Top 700 bldgs sq ftg	54,894,552	41%		
Top 800 bldgs sq ftg	58,558,099	44%		
Top 900 bldgs sq ftg	61,823,741	46%		
Top 1000 bldgs sq ftg	64,768,293	48%		
Top 1500 bldgs sq ftg	76,517,334	57%		
Top 2000 bldgs sq ftg	85,317,006	64%		

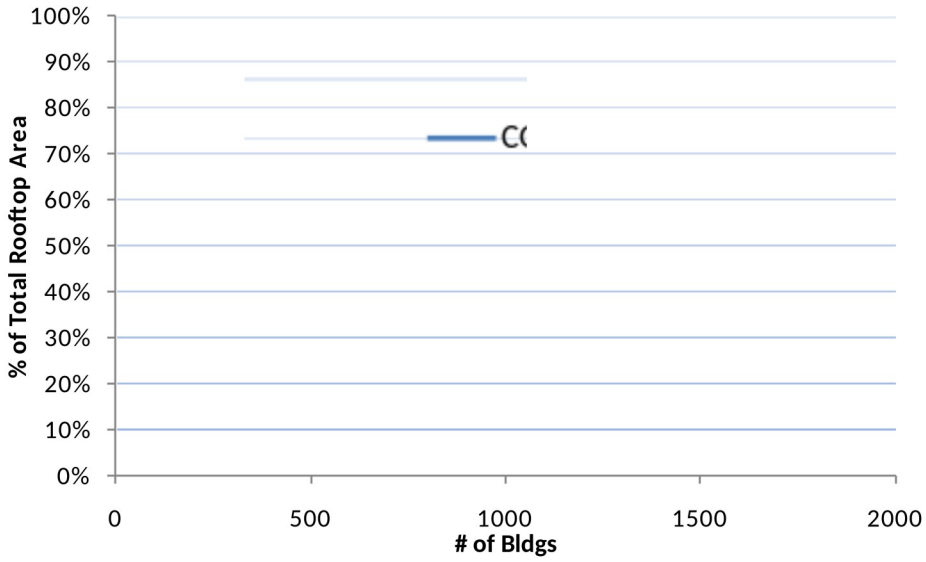


Figure 8. Commercial and Industrial Buildings Distribution

4.g. Rooftop Area by Use Category and Zip Code

On request from Austin Energy staff, Clean Energy Associates produced an estimate of the rooftop availability for each use category by zip code, starting with City of Austin GIS data rather than the combined GIS and Travis and Williamson County Assessor's District sets used in the rest of the analysis. Because of this difference, the input gross rooftop area and the output estimate of rooftop area suitable for solar development were higher than in the rest of the model.

The GIS data was run through the model in the same way as the combined data set, but with finer granularity at the zip code level. All reduction factors were applied exactly as they were in the original model, except for the shading factor.

In the original model, the residential shading factors were derived on a zip code by zip code basis, and then aggregated with weighting factors according to the total square footage in each zip code. Thus, a single residential shading factor was derived and applied to all residential square footage. In this analysis, we simply applied the shading factor data directly to residential installations in each zip code rather than applying a weighted average. Note, not all zip codes in the Austin Energy service area contained data in the shading factor study, in which case it was assumed that those areas would exhibit similar shading factors as neighboring zip codes. Because the GIS data set had broken commercial and industrial data sets into smaller (<150,000 square feet) and larger (>150,000 square feet) buildings, we also assumed a lower shading factor for larger buildings (0.98, meaning only 2 percent of area was screened out for shading). This was assumed because with such a large footprint, trees and surrounding buildings are less likely to shade these buildings' roofs.

As mentioned before, the results of this analysis were different due to the exclusive reliance on GIS data. The rooftop model started with 536 million gross square feet of rooftop area and ended with an estimate of 142 million square feet suitable for rooftop PV development. This analysis started with 704 million gross square feet of rooftop area and ended with an estimate of 188 million square feet suitable for rooftop PV development. Aside from the differences due to the input data set, no appreciable difference resulted from the minor methodological differences employed to account for shading. The ratios of rooftop area suitable for PV development to gross rooftop area were nearly identical: 26.7% in the model and 26.8% in this analysis.

The top-down analytical approach employed by the CEA model is intended to produce an overall estimate rooftop area available for solar deployment. The model is intended to provide a reasonably accurate estimation in the aggregate, though 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.

Detailed rooftop area by use category and zip code derived from the GIS is presented in Figure 9.

Zip code	Agricultural	Civic	Commercial>150k	Commercial<150k	Industrial>150k	Industrial<150k	Multi Famliy	Residential	Total SF
78610	2,982	1,553				17,361		13,564	**35,459**
78613	925			298,990				811	**300,726**
78617	17,301	692,734		411,888		52,270	39,501	533,793	**1,747,487**
78652	2,140			29,767		17,449		15,010	**64,367**
78653	9,576	6,338		43,836		34,718		153,876	**248,345**
78660	10,293	424,621		514,734	221,511	299,551	15,061	2,589,471	**4,075,243**
78681		131						107,292	**107,423**
78701		810,087	106,146	3,523,695		104,046	122,907	-	**4,666,881**
78702	481	1,139,901		1,003,244	63,936	1,063,823	190,774	1,234,569	**4,696,728**
78703		658,669		1,061,652		65,009	488,359	1,241,121	**3,514,810**
78704		1,650,422		3,249,161	77,251	408,669	1,262,391	2,355,837	**9,003,731**
78705		1,268,305	107,660	1,119,765			853,188	250,893	**3,599,811**
78712		1,079,134					193	-	**1,079,327**
78717	2,782	177,029		460,500	64,332	30,476	163,505	703,010	**1,601,634**
78719	3,428	213		130,014		14,892		24,452	**173,001**
78721	123	476,441		292,691		557,666	88,174	828,729	**2,243,824**
78722		239,933		309,548		102,887	56,837	350,481	**1,059,686**
78723		660,035	149,994	1,399,921		154,943	475,513	1,898,364	**4,738,769**
78724	20,224	295,842		164,810	88,781	485,973	61,530	948,722	**2,065,883**
78725	24,584	494,001		86,883	365,628	480,496		572,114	**2,023,706**
78726				81,134	99,109	84,759	61,738	1,862	**328,603**
78727	3,511	336,405		1,581,438	493,629	429,725	652,514	3,049,662	**6,546,885**
78728		132,266		645,811	249,817	655,276	317,517	793,265	**2,793,951**
78729		416,576	500,759	1,341,507		218,074	526,953	2,360,567	**5,364,435**
78730	2,285	17,660		558,256		9,023	161,448	1,572,940	**2,321,611**
78731		1,101,741		1,316,234			879,802	3,799,928	**7,097,705**
78732	1,140	57,245		124,628		6,339	61,920	1,021,820	**1,273,092**
78733	10,586	161,372		96,184		41,259	12,455	1,581,934	**1,903,791**
78734	5,072	227,313		539,885		142,799	49,807	2,086,651	**3,051,527**
78735	9,363	343,685		1,012,950		58,475	417,935	1,729,763	**3,572,171**
78736	6,998	17,480		167,683		9,878	27,351	663,258	**892,647**
78738	6,715	355,353		464,653		80,645	95,509	1,402,389	**2,405,264**
78739								78,550	**78,550**
78741	60	431,327	552,560	1,865,707		263,355	1,876,214	1,188,580	**6,177,803**
78742	1,369	35,449		191,198		159,339	1,451	62,686	**451,492**
78744	36,216	644,842		2,425,411	602,747	2,045,916	313,840	2,823,253	**8,892,226**
78745	7,278	1,001,529	182,245	3,157,839		742,383	827,881	4,165,395	**10,084,550**
78746	2,881	942,852	324,487	3,035,788		2,325	545,842	5,315,252	**10,169,427**
78747	31,565	61,545		61,724		20,891	192,080	1,131,880	**1,499,684**
78748	15,091	560,291		648,509		110,844	212,697	3,092,241	**4,639,673**
78749	9,944	733,281		973,706		2,622	600,978	3,744,121	**6,064,651**
78750	819	222,195		801,610		53,364	250,624	1,157,620	**2,486,232**
78751		797,465	167,076	1,243,702		37,160	348,191	544,660	**3,138,254**
78752		726,391	165,230	2,458,332		180,278	476,743	394,201	**4,401,174**
78753	623	600,099	394,988	2,860,821	411,742	1,038,585	1,036,909	2,763,927	**9,107,695**
78754	6,591	442,404		1,395,323	349,857	1,294,685	190,964	391,107	**4,070,932**
78756		872,382		970,596		24,556	213,633	393,541	**2,474,708**
78757		663,611	302,258	3,333,970		402,659	413,489	-	**5,115,987**
78758	525	1,313,200	426,435	3,497,942	340,587	3,007,813	1,342,764	3,092,440	**13,021,705**
78759		525,486	85,733	4,429,923	657,182	152,310	1,384,475	3,928,089	**11,163,198**
Total	**253,472**	**23,816,832**	**3,465,573**	**55,383,563**	**4,086,110**	**15,165,568**	**17,311,658**	**68,153,689**	**187,636,466**

Figure 9. Rooftop Area by Use Category and Zip Code, Derived from City of Austin GIS.

Appendix 1. Data Sources – Detailed Information

The information provided below represents a summary of available data sets; additional details have been circulated among the project team.

A. Travis Central Appraisal District (TCAD) database

Source	Travis Central Appraisal District
Cost	$80 for data on CD-ROM
Contact	Travis Central Appraisal District 8314 Cross Park Drive, Austin, TX 78754 (512) 835-5371 Billie Jean Stone (512) 834-9317 ext. 349 bstone@tcadcentral.org
General Description	TCAD offers a CD-ROM of its current database in MS Access format. The database contains lot and improvement data on all taxable properties in Travis county.
Potentially Useful Data	Database contains legal and mailing addresses of each lot, zip codes, property type (residential, commercial, etc.), lot size, bldg square footage, first floor bldg square footage, roof type, solar tax exempt status. First floor building square footage may serve as a useful proxy for estimating available roof area.
Known Limitations	Because the TCAD data contains information on taxable properties only, there is no information on churches, municipal and county lots, state buildings, universities, schools, and other non-taxable entities. Improvement data does not contain some areas which may be covered with rooftop suitable for solar data, such as garages or covered porches. Database is current (as of summer 2008), though information on each individual property may not be. Using first floor square footage as a proxy for available rooftop area may be misleading for condominium data.
Additional Information	24 building types are represented, though 99.7% of all first floor square footage
Current Status	CD-ROM obtained by CEA, contents posted to CEA Box.net account, access provided to Austin Energy.

B. Williamson Central Appraisal District (WCAD) database

Source	Williamson Central Appraisal District
Cost	$100 for data on CD-ROM
Contact	Williamson Central Appraisal District 625 FM 1460 Georgetown, Texas 78626-8050 (512) 930-3787
General Description	WCAD offers a CD-ROM of its current database in MS Access format. The database contains lot and improvement data on all taxable properties in Williamson county.
Potentially Useful Data	Presumably this database contains similar or equivalent fields as the TCAD database.
Known Limitations	Presumably this database contains similar or equivalent limitations as the TCAD database.
Additional Information	Austin Energy estimates it serves 4,000-5,000 customers in Williamson County.
Current Status	CEA evaluating utility of obtaining this database.

C. City of Austin Geographic Information System (GIS)

Source	City of Austin
Cost	N/A
Contact	Timothy Harvey – Conservation Program Specialist 811 Barton Springs Road, Austin TX 78704-1145 (512) 482-5386
General Description	Austin's GIS contains multiple geographic layers, each of which is created and maintained by different entities within the City of Austin.
Potentially Useful Data	An address layer contains address/lot information; a buildings layer contains building footprint shapes; zip code, Austin Energy's service area, and land use data layers are also available. Each potentially useful layer is further described in the Appendix.
Known Limitations	Building footprint data is known to have derived from satellite data taken in 2003, and so may not represent current information, particularly in areas with high rates of development. Data accuracy of many layers is unknown.
Additional Information	N/A
Current Status	Austin Energy staff will access and query the GIS for the project team.

D. Austin Energy Customer Information System (CIS)

Source	Austin Energy
Cost	N/A
Contact	Timothy Harvey – Conservation Program Specialist 811 Barton Springs Road, Austin TX 78704-1145 (512) 482-5386
General Description	Austin Energy's CIS (Customer Information System) is a database in MS Access format that is maintained by Austin Energy (AE). The database contains customer contact info, addresses, electrical usage, rate and meter information for all AE users.
Potentially Useful Data	Rate Schedule and addresses to identify type and number of users in different areas.
Known Limitations	Customers may not have the proper rate schedule. Some very large residential homes may have a commercial account. Some small commercial buildings may have a residential account. There may be more than one account per building.
Additional Information	N/A
Current Status	Austin Energy staff will access and query the CIS for the project team.

E. Austin Energy Solar Program Database

Source	Austin Energy
Cost	N/A
Contact	Timothy Harvey – Conservation Program Specialist 811 Barton Springs Road, Austin TX 78704-1145 (512) 482-5386
General Description	The Solar Program Database provides information about approximately 2,750 residential and 500 commercial buildings that have applied for solar rebates. These sites have been evaluated to determine their solar access and have been judged suitable for unsuitable for PV installations. Approximately 40 sites have also been evaluated to determine the maximum solar PV module installation potential.
Potentially Useful Data	Legal and mailing addresses of buildings, zip codes for buildings that were judged to be suitable and unsuitable, PV module installation potential versus actual installed module capacity.
Known Limitations	Accuracy of information submitted to rebate program.
Additional Information	N/A
Current Status	Austin Energy staff will access and query the CIS for the project team.

F. Austin Energy Solar Meter Readings Database

Source	Austin Energy
Cost	N/A
Contact	Timothy Harvey – Conservation Program Specialist 811 Barton Springs Road, Austin TX 78704-1145 (512) 482-5386
General Description	Austin Energy obtains periodic meter readings from all net metered solar customers, recording in-flows and out-flows from the customer premise as well as total PV production.
Potentially Useful Data	Annual kWh production from individual project sites or in the aggregate could be helpful in determining power/energy factors used in modeling potential.
Known Limitations	Unknown.
Additional Information	N/A
Current Status	Austin Energy staff will access and query the CIS for the project team.

G. State of Texas Buildings Database

Source	Texas Facilities Commission
Cost	N/A
Contact	Bill Bonham Deputy Executive Director for Facilities, Design, & Construction Texas Facilities Commission (TFC) (512) 463-3446
General Description	Excel worksheet with list of state buildings, including their addresses.
Potentially Useful Data	Legal and mailing addresses of state-owned buildings.
Known Limitations	The list would not identify building on which PV modules could not be installed due to aesthetic or historical preservation issues.
Additional Information	N/A
Current Status	CEA has contacted Mr. Bonham but has not received any data.

H. Austin Independent School District (AISD) Facilities Data

Source	Austin Independent School District
Cost	N/A
Contact	Joe Silva – Assistant Director of Planning Austin Independent School District (512) 414-2667
General Description	List of AISD-owned buildings including their addresses. AISD could possibly provide design drawings for the roofs of many buildings.
Potentially Useful Data	Legal and mailing addresses of buildings, drawing files could be used to obtain roof areas.
Known Limitations	The list would not identify building on which PV modules could not be installed due to aesthetic or historical preservation issues.
Additional Information	N/A
Current Status	CEA has contacted Mr. Silva but has not received any data.

I. University of Texas Facilities Data

Source	University of Texas at Austin
Cost	N/A
Contact	University of Texas at Austin Project Management and Construction Services (512) 471-3042
General Description	The University of Texas at Austin could provide a list of their buildings including their addresses, and possibly design drawings for the roofs of their buildings.
Potentially Useful Data	Legal and mailing addresses of buildings, drawing files could be used to obtain roof areas.
Known Limitations	From previous work experience with the University, it is known that PV modules are not allowed to be installed on burnt orange roof tiles. Drawing files could be used to determine which building have these roofs and eliminate them from consideration.
Additional Information	N/A
Current Status	CEA has contacted the University but has not received any data.