Distributed Solar Energy for Austin

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Executive Summary

Rising fossil fuel prices, increased price volatility, and an increasing potential for conflict over fossil fuel sources pose obstacles for continued economic growth of a fossil fuel economy. Additionally, fossil fuels emit greenhouse gas emissions to the atmosphere that contribute to climate change. The United Nations Climate Change Conference being held in Copenhagen may lead to the development of a new framework for combating climate change and greenhouse gas reductions for each country. With the development of the Smart Grid, solar power can play a role in reducing dependence on fossil fuels and the negative impacts of greenhouse gas emissions.

Current electric grids are outdated and overloaded, which results in inefficiency of transmission systems. The growing gap between electricity demand and transmission capacity will exacerbate the situation. The solution is either to construct new transmission, increase the capacity of existing transmission, or to build new distributed generation sources near demand sources to avoid the need for new transmission lines. Distributed generation can reduce the need to import electricity and reduces transmission losses. Municipal solar generation plants can significantly contribute to energy generation capacity, much more quickly and cheaply than adding individual solar panels to each house. A 2 MW solar plant requires about 10 acres of land and can serve approximately 1,000 homes. Solar generation plants are also less controversial than building a new coal-fired power plant and less costly.

Most of the data used in this study came from the City of Austin GIS Data Sets and the Capital Area Council of Governments (CAPCOG). Other sources include the City of Austin Land Use website and The GeoCommunity. To identify suitable parcels on which to construct a solar generation power plant, I researched positive and negative site selection criteria. Positive criteria included proximity to utility lines, low tree density, and low market value. Negative criteria included floodplains, within 150 feet of roads, and parks, preserves, and golf courses. I also evaluated the cost efficiency of suitable parcels to minimize the economic impact of purchasing land on which to construct the solar generation plant.

The recommended parcel on which to construct a solar generation plant is a 309 acre parcel located in Northeast Austin. The selected parcel could provide 62 megawatts (MW) of solar generation, enough to power 30,900 homes.
Introduction

As oil production within the United States declines, we are relying increasingly on foreign sources of fossil fuels. Continued population growth also places pressure on existing infrastructure in order to meet higher energy demand. The population of Texas is rapidly increasing, and Austin is one of the fastest growing cities within the state. The development of a Smart Grid that would use digital technology to allow small distributed generation sources to feed into the electrical grid is a potential method to increase energy independence, reduce global warming, and increase the electric grid’s resilience. A distributed generation system could also achieve increased electricity generation while avoiding the enormous costs and time associated with permitting a new coal-fired power plant.

Distributed Generation
A distributed generation system is one in which small generation units help balance the overall energy flow of the electric grid by augmenting conventional power sources, often during peak power periods. Distributed generation units include combinations of fuel cells, combined heat and power systems, waste heat recovery generation, wind, small gas-fired generators, and solar units. The diversity of generation sources reduces fuel cost risks by decreasing the reliance on any one source. In addition, it can improve security and decrease susceptibility to sabotage.

Current electric grids are outdated and overloaded, which results in inefficiency and the potential for cascading blackouts from old equipment and the inability to regulate electricity distribution during energy demand spikes during summer or winter.¹ The growing gap between electricity demand and transmission capacity will exacerbate the situation. The solution is either to construct new transmission, increase the capacity of existing transmission, or to build new distributed generation sources near demand sources to avoid the need for new transmission lines. Distributed generation can also reduce the need to import electricity and reduces transmission losses.² A Smart Grid can regulate energy flow over the electric grid from multiple sources to compensate for fluctuations in demand, rather than electricity flowing in one direction from the central power plant to consumers as in conventional grid systems.

Solar Power
Although solar power requires sunlight to generate electricity and is relatively less reliable for peak demand, it is an important energy source to offset pollution by reducing the amount of energy that must be generated by conventional fossil fuel sources. Greenhouse gas emissions are receiving increasing scrutiny, and EPA Administrator Lisa Jackson recently announced “greenhouse gases threaten the public health and welfare of the American people,” which lays the foundation for regulating greenhouse gas emissions.³ Therefore, solar power provides a method for increasing generation capacity while removing harmful emissions from the environment. One of the other benefits of

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² Balick, Ross. 2002.
³ Jackson, Lisa P. 2009.
solar power is that it is much less controversial to construct new small-scale solar power generation plants than a new coal-fired power plant and as a result less costly to construct.

**Austin Energy’s Strategic Plan and Solar Energy**

In response to energy’s affect on climate change, Austin Energy set a goal to achieve carbon neutrality on all new generation.\(^4\) Austin Energy promotes the development of clean energy to augment existing capacity. Austin Energy encourages research and development of solar technology through the Pecan Street Project, the Public Involvement Process, the Clean Energy Incubator, and the Austin Climate Protection Initiative. Austin Energy’s goal is to use renewable energy sources as a means to avoid needing to construct a new 700-800 MW conventional power plant before 2020. To meet this goal, Austin Energy set its own renewable energy portfolio standard, which requires 30% of energy generation to come from renewables by 2020. In addition, it set a goal to install 100 megawatts (MW) of solar generation capacity by 2020. Austin Energy recently proposed to increase this goal to 200 MW by 2020. As of 2009 there is only about 3 MW of installed solar energy in Austin, most of that amount coming from home-based solar panels.\(^5\) Most new solar installation comes after 2014, which will allow for further technological advancement in solar technology.

<table>
<thead>
<tr>
<th>Table 1. Austin Energy Renewable Targets and Progress</th>
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<tbody>
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<td>Renewable Energy</td>
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<td>Energy Efficiency</td>
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<tr>
<td>Solar Generation Capacity</td>
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<td>Energy Savings</td>
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* Austin Energy has proposed to increase solar generation capacity to 200 MW by 2020. Source: Austin Energy 2008 Strategic Plan Update.

<table>
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<tr>
<th>Table 2. Austin Energy Generation Sources in Megawatts</th>
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<td>2019</td>
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<td>2020</td>
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| Total | 1,029 | 1,744 | 162 | 1001 | 201               |

*Wind contracts expire.

Source: Austin Energy Resource and Climate Protection Plan.

\(^4\) Clymer, Jennifer. 2009.
\(^5\) Ibid.
Austin Energy is laying the groundwork to successfully manage the Smart Grid as it develops. To date, Austin Energy has completed upgrading the transmission network from automatic meter reading one-way technology to advanced metering infrastructure two-way and installed smart meters. Austin Energy began installing the meter data management system in October 2009. Advanced metering systems enable the digital hardware and software to combine interval data measurement with continuously remote communications, which is necessary for a Smart Grid to regulate electricity flow. The monitoring system collects detailed, time-based information that it transfers to the utility and instructions from the utility to control nodes on the electric grid.

Austin Energy is planning for the development of full on-site solar energy in Austin. On-site solar generation could take the form of roof mounted solar panels or solar generation plants on vacant parcels within the city. Home-based solar panels help increase energy capacity, but the most significant contribution of solar energy will likely come from utility-scale power plants. Municipal solar power plants generally range from 2 to 10 MW in size. The solar panels are mounted on rails to allow natural vegetation to continue to grow between the rows of panels. The sites are commonly located at the edge of cities where land is more readily available. A 2 MW solar plant requires about 10 acres of land and can serve approximately 1,000 homes.

Municipal solar power plants avoid the long-haul, high-voltage transmission lines common with conventional systems, which are expensive to build and expand. Instead, the solar power plants can integrate into the existing local electricity grid by supplying power directly to the distribution grid can feed into the main local utility lines, avoiding the need to build a substation to down-transform the transmission voltage to municipal voltage. Additionally, ground-mounted solar panels avoid the complications that come with mounting them on roofs, such as complying with building codes. They can also be rapidly deployed. A municipal power plant can be constructed in about 12 months. In comparison, a new coal power plant can take 10 to 15 years to complete.
**Problem Statement**

With the increasing concern about the impact of greenhouse gas emissions on the climate and increasing demand for renewable energy, solar energy is an important part of an energy mix. Solar energy is particularly suitable for Austin because of the amount of sun the Central Texas region receives each year. This project will focus on determining suitable vacant parcels within the City of Austin where solar generation units could be sited to provide additional power to the existing electric grid.

**Research Question**
- What are suitable locations for new solar generation units within the City of Austin?

**Methodology**

To determine which of the vacant parcels within the City of Austin would be most suitable for solar generation, I first researched both the positive and negative characteristics used to site solar generation plants. This process involved researching literature on solar power generation from the government and Austin Energy. I also spoke with Mark Kapner, Austin Energy’s senior strategy engineer. I was unable to obtain Austin Energy’s site selection criteria because of security and proprietary concerns. However, I was able to determine the relative importance of certain criteria from my discussion with Mark Kapner and reviewing site selection factors from other sources. I determined the following criteria are important factors to consider when determining where to locate a solar generation plant.

A solar generation plant must:
1. Be located near transmission lines.
2. Be located on flat land.
3. Be located on parcels of at least two acres.
4. Be located on a parcel with a low market value.
5. Be oriented to capture the greatest amount of sunlight.
6. Avoid areas, such as golf courses, from which projectiles might hit the solar panels.
7. Avoid cutting down large numbers of trees and protected tree species.
8. Not have dense tree cover that would shade solar panels.
9. Not be located within a floodplain.
10. Not be located near dirt roads that could cause dust to build up on the solar panels.
11. Not be located in parks or preserves.

Due to time constraints, I was unable to include all the selection criteria in my suitability analysis. The factors not included in this study are numbers 2 and 5. I was only able to

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9 Kapner, Mark. 2009.
partially assess factor number 7, as the tree canopy data available did not make a distinction among tree species. For factor number 1, I used primary utility lines. For factor number 10, I was unable to find information on dirt roads within Travis County, so placed a buffer around all roads within the county.

Data Acquisition and Preparation
Most of the data I used came from the City of Austin GIS Data Sets and the Capital Area Council of Governments (CAPCOG). For my analysis I obtained the following files: City of Austin parcels, City of Austin parks, land use, water bodies, and tree canopy. I obtained the following files from CAPCOG: city limits, counties, floodplain, roads, and aerial images of the Manor and Pflugerville areas. I also downloaded primary utility line data for Travis Country from The GeoCommunity website. All files were projected into the NAD 1983 State Plane Texas Central FIPS 4203 Feet.

Suitability Analysis
There are three main steps to the analysis: excluding negative factors, suitability analysis, and determining the cost efficiency of suitable parcels.

Figure 1. Analysis Diagram

Analysis Process
1. Add all shapefiles to the map document.
2. Create a shapefile of parcels classified as vacant in 2008.
3. Create shapefiles of recreational areas, including parks, preserves, and golf courses.
4. Clip shapefiles to the extent of the City of Austin.
5. Dissolve the feature classes to represent only the fields relevant to the suitability analysis for floodplain, parks, preserves, and golf courses layers.
6. Create a buffer of 150 feet around all roads and dissolve the buffer into one continuous buffer.
7. Combine all undesirable factors into one shapefile and dissolve it create one polygon.
8. Clip the undesirable parcels shapefile from vacant parcels shapefile to leave only the parcels that are potentially suitable for a solar generation plant.
9. Determine the percent of each parcel covered by trees by clipping the tree canopy layer to the suitable parcels. Dissolve the tree canopy to create one polygon, used
Field Calculator to determine the area covered by the tree canopy, and divide the
tree canopy area by the total area of the parcel.
10. Exclude all parcels with an area less than 10 acres.
11. Calculate the straight line distance to power lines.
12. Use Spatial Analyst to give a higher weight to parcels based on their proximity to
power lines (the closer the better), and reclassify the raster and classify the data
using equal interval and five classes.
13. Convert the tree canopy shapefile to a raster.
14. Convert the tree canopy shapefile from features to raster and reclassify the raster
to give preference to parcels with a low percentage of tree canopy, use equal
interval and five classes.
15. Convert the suitable parcels shapefile to a raster and reclassify it to give
preference to parcels with lower market values, use equal interval and five
classes.
16. Assign weights to each of the datasets
   • Distance to power lines 40%
   • Parcels with lower market value 40%
   • Parcels with few trees 20%
17. Use Raster Calculator to calculate a combined number based on the attributes of
each parcel to create a new weight shapefile. Reclassify is using equal interval
and five classes.
18. Convert the weight shapefile from a raster to features and intersect it with the
suitable parcels with an area over 10 acres.
19. Rank the suitable parcels from 1 to 5.
20. Use Select by Attributes to select all parcels ranked as 5 and export the data as a
new shapefile.
21. Normalize the data by dividing market value by areas to determine which parcels
are the most cost efficient, and classify it using natural breaks and five classes.
22. Selected the recommended parcel from the most cost-efficient class of parcels.
Findings

Reference
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Negative Factors
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Determining Prime Locations
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Map 13. Selected Parcel
Map 1.

Distributed Solar Power for Austin

Austin City Limit and Major Roads

Author: Marc Olivier, December 10, 2009

Sources: Water: City of Austin; city limits, county boundary, and roads: CAPCOG.
Map 2.

**Distributed Solar Power for Austin**

*Vacant Parcels*

![Map showing vacant parcels in Austin, Texas](image)

**Legend**
- IH-35
- Major Road
- Water Body
- Vacant Parcel
- City Limit

**Sources**:
- Parcels and water: City of Austin; city limits, county boundary, floodplain, and roads: CAPCOG.

**Author**: Marc Olivier, December 10, 2009

**Projected Coordinate System**: NAD 1983 State Plane Texas Central FIPS 4203 Feet.
Map 4.

Distributed Solar Power for Austin

Recreational Areas

Author: Marc Olivier, December 10, 2009

Sources: Parks and water: City of Austin; city limits, county boundary, and roads: CAPCOG.
Map 5.

Distributed Solar Power for Austin

Road Buffer

Author: Marc Olivier, December 10, 2009

Sources: Water: City of Austin; city limits, county boundary, and roads: CAPCOG.
Map 6.

Distributed Solar Power for Austin

Constrained Locations and Suitable Vacant Parcels

Author: Marc Olivier, December 10, 2009

Sources: Parcels, parks, and water: City of Austin; city limits, county boundary, floodplain, and roads; CAPCOG.
Map 7.

Distributed Solar Power for Austin

Tree Canopy

Author: Marc Olivier, December 10, 2009
Sources: Water and tree canopy: City of Austin; city limits, county boundary, and roads: CAPCOG.
Map 8.

Distributed Solar Power for Austin

Primary Utility Lines

Author: Marc Olivier, December 10, 2009

Sources: Water: City of Austin; city limits, county boundary, and roads: CAPCOG; utility lines: GeoComm.
Map 9.

Distributed Solar Power for Austin
Vacant Parcel Market Value

Vacant Parcel Market Value ($)
- 0 - 1,144,540
- 1,144,541 - 3,012,260
- 3,012,261 - 6,748,370
- 6,748,371 - 15,291,470
- 15,291,471 - 21,977,930

IH-35
Major Road
City Limit
Water Body

Author: Marc Olivier, December 10, 2009
Projected Coordinate System: NAD 1983 State Plane Texas
Central FIPS 4203 Feet.

Sources: Parcels, parks, water, and tree canopy: City of Austin;
city limits, county boundary, floodplain, and roads: CAPCOG;
utility lines: GeoComm.

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Map 10.

Distributed Solar Power for Austin
Ranked Parcels

Suitability Rank
1 (low) 2 3 4 5 (high)

Author: Marc Olivier, December 10, 2009

Sources: Parcels, parks, water, and tree canopy: City of Austin; city limits, county boundary, floodplain, and roads: CAPCOG; utility lines: GeoComm.
Map 11.

Distributed Solar Power for Austin

Suitability Rank and Selection Factors

Author: Marc Olivier, December 10, 2009

Sources: Parcels, parks, water, and tree canopy: City of Austin; city limits, county boundary, floodplain, and roads: CAPCOG; utility lines: GeoComm.
Map 12.

Distributed Solar Power for Austin
Suitable Parcels by Cost per Acre

Market Value ($ per acre)
- 0 - 22,600 (most cost-efficient)
- 22,610 - 40,930
- 40,940 - 69,450
- 69,460 - 151,400
- 151,500 - 412,200 (least cost-efficient)

Sources: Parcels, parks, water, and tree canopy: City of Austin; city limits, county boundary, floodplain, and roads: CAPCOG; utility lines: GeoComm.
Map 13.

Distributed Solar Power for Austin

Selected Parcel

Selected Parcel Information:
- Acreage: 309 acres
- Area open: 301.6 acres
- Area tree canopy: 7.4 acres
- Distance to utility line: on parcel
- Market value: $6,748,368

Author: Marc Olivier, December 10, 2009

Sources: Parcels, parks, water, and tree canopy: City of Austin; aerial image, city limits, county boundary, floodplain, and roads: CAPCOG; utility lines: GeoComm.
Analysis

Based on the site selection criteria used, there are numerous vacant parcels within the City of Austin on which Austin Energy could construct municipal solar generation plants. The suitable parcels are primarily located around the edges of Austin near the city limits, particularly on the east side of Austin, where more undeveloped land is readily available. Tree canopy cover is sparser to the east. The market value of land near the city limits is also less expensive, making a solar generation project more cost effective.

The ability to connect to existing utility lines is a significant limiting factor. Transmission lines are extremely expensive to construct, so utility companies seek to minimize the distance between the utility line and the generation site. The prevalence of transmission lines within the City of Austin means that no parcel is located more than two miles from a primary utility line. This means that Austin is particularly suitable for distributed solar generation projects because that it minimizes the amount of transmission line and expense needed to connect a site to the existing grid.

Since this study omitted certain site selection factors and used proxies for other factors, the suitability analysis is limited. Limitations of this study include:

- **Site selection criteria**: I was not able to obtain the specific site selection criteria that Austin Energy would use to decide where to locate a solar generation plant given the sensitivity of electric utility data and security. Consequently, I used my judgment based on other sources of information available from government sources, private companies, and knowledge of environmental information. As a result, there may be other suitable parcels to consider in a more detailed study when making a final decision about where to site a solar generation plant.

- **Limited utility line data**: Security and propriety concerns prevented me from obtaining a current detailed data set of utility lines within the City of Austin. I was able to obtain data of primary utility lines from 1999, but the transmission system is likely more developed now than what the data set would suggest. Therefore, there may be other suitable parcels to evaluate with more recent and complete data.

- **Vacant land information**: The data I used were available from 2008, which means some suitable parcels may now be developed. Although this study did not identify any suitable vacant parcels in the downtown area of Austin, there may still be suitable surfaces on which to mount solar panels. Austin could evaluate the potential to mount solar panels on building roof tops, parking garages, or other surfaces that currently are going unused.

- **Tree information**: The City of Austin has an ordinance which prevents cutting down environmentally valuable trees, such as oak trees. To avoid selecting a parcel that might contain a high number of environmentally valuable trees, I used tree canopy data as a proxy tree density. However, the tree canopy data did not
identify particular species of trees. Therefore, some sites that may have a high
density of cedar trees, which are not protected, may have been eliminated.
Similarly, some of the suitable parcels may contain environmentally valuable
trees that could limit full development of portions of the parcel.

- **Topography and sunlight**: Land slope and the ability to capture sunlight greatly
  influence the generation potential of solar generation plants. This study did not
  include topography as a site selection factor. However, the topography as one
  moves west across Austin generally becomes more varied and rocky. Most of the
  suitable sites identified in this study are located east of Austin where the land is
  relatively flat and more prairie-like than that found on the Edwards Plateau.
  Consequently, some of the identified suitable parcels will need to be verified to
  ensure that they comply with design standards for solar generation plants.

- **Zoning and permitting**: Zoning and permitting will restrict what can be
  constructed on a certain parcel. Given the time constraints of this study, I did not
  evaluate how parcels are zoned and the permitting conditions could affect a
  design of a solar generation plant.

- **Planning information**: In the site selection process, the City of Austin would need
  to consider how a solar generation plant would affect the surrounding community.
  While a solar generation plant would have many benefits for electricity
  generation, once constructed, the site would not be available for alternative uses.
  The needs of the given community need to be balanced with the site selection
  criteria.

**Recommendation**

I recommend that Austin Energy construct a municipal solar generation plant on the
parcel located near the intersection of Harris Branch Parkway and East Parmer Lane in
northeast Austin. I recommend the selected parcel because:

- The parcel is large: 309 acres.
- The utility line traverses the parcel avoiding the need to construct a long
  transmission line to connect the site.
- It is not located in or near a floodplain.
- The parcel has relatively little tree cover.
- The site is located about 200 feet from the nearest road, which will allow
  particulate matter and road spray from the surrounding roads to drop out of the air
  before reaching the solar panels.
- The site has good access for maintenance vehicles from East Parmer Lane and
  State Highway 130.
- There are no existing structures on the parcel.
• The parcel is one of the most cost-effective options (approximately $21,800 per acre; total of $6,748,368 for the entire parcel).

Assuming that a 2 MW solar plant requires about 10 acres of land to serve approximately 1,000 homes, Austin Energy could expect the selected parcel to generate about 62 MW of power and serve 30,900 homes. The selected parcel would exceed Austin Energy’s goal to have 61 MW of installed solar power generation by the end of 2014.

The constraints and site selection criteria used in this study are not exhaustive. Austin Energy should conduct further analysis to ensure the selected parcel meets all design requirements. In addition, an environmental assessment of the selected parcel is necessary to determine the solar generation plant’s impact on the surrounding ecosystem and animal habitat.
References


Baldick, Ross. Presentation to the President’s Council of Advisors for Science and Technology. August 15, 2002


Cover photo: © Marc Olivier, December 4, 2009
Appendix
Data Sources

City of Austin Data Sets
Website: ftp://ftp.ci.austin.tx.us/GIS-Data/Regional/coa_gis.html
Data Files: coa_parcel, hydro_p.zip, coa_parks.zip, tree_canopy_2006.shp

City of Austin Land Use
Website: http://www.ci.austin.tx.us/landuse/gis.htm
Data File: 2003LU.shp

Capital Area Council of Governments (CAPCOG)
Website: http://www.capcog.org/information-clearinghouse/geospatial-data
Data Files: city_limits.shp, counties.shp, floodplain.shp, roads.shp, Manor_NW.sid,
Pflugerville_East_SW.sid

The GeoCommunity
Website: http://www.geocomm.com
Data File: utline.e00

Expanded Methodology

Verify and project all layers into NAD 1983 State Plane Texas Central FIPS 4203 Feet.

Adding Data:

1. Add parcels (parcels.shp).
2. Add county boundaries (counties.shp).
3. Add city limits (city_limits.shp).
4. Add floodplains (floodplain.shp).
5. Add street centerlines (roads.shp).
6. Add City of Austin parks (coa_parks.shp).
7. Add water bodies (hydro_p.shp).
10. Add power lines (utline.e00).

Creating a Vacant Parcels Shapefile:

1. Create a new shapefile from parcels.shp with vacant parcels only.
   a. Use Select by Attributes to select only parcels identified as “VLI_2008”
      (vacant land inventory 2008).
   b. Export the selected parcels to a new shapefile and name it
      “vacant_parcels.”
   c. Remove the parcels layer.
2. Add counties.shp containing the ten counties in the Central Texas region.

**Create Shapefiles for Preserves and Golf Courses:**

1. Create a preserve shapefile.
   a. Use Select by Attributes to select only parcels identified with land use code “750” (preserves).
   b. Export the selected parcels to a new shapefile and name it “Preserves.”

2. Create a golf courses shapefile.
   a. Use Select by Attributes to select only parcels identified with land use code “720” (golf courses).
   b. Export the selected parcels to a new shapefile and name it “Golf_Courses.”

**Clipping Data to the Austin City Limits Shapefile:**

1. Separate Travis County from other Central Texas counties.
   a. Use Select Features tool to select Travis County.
   b. Create a new layer from the selected feature and name it “Travis County.”
   c. Remove the counties layer.

2. Clip the city_limits layer to the extent of Travis County.
   a. Select Analysis Tools ➔ Extract and select the Clip tool.
   b. Select city_limits as the input feature.
   c. Select Travis_County as the clip feature.
   d. Name the output feature as “city_limits_travis.”
   e. Remove city_limits layer.

3. Exclude cities other than Austin in Travis County.
   a. Open Attribute Table and select the record for Austin.
   b. Export data as a new shapefile and name it “city_limits_travis_austin.”
   c. Remove city_limits_travis layer.

4. Clip each layer to the extent of the City of Austin limits within Travis County.
   For each of the 7 layers (roads, floodplain, vacant_parcel, Preserves, Golf_Courses, coa_parks, tree_canopy_2006):
   a. Select each layer in turn as the input feature.
   b. Select city_limits_travis_austin layer as the clip feature.
   c. Add “_Clip” to the end of each shapefile name.
   d. Remove the corresponding original unclipped layer.
   e. Repeat for each layer.

**Dissolving Feature Classes**

1. Simplify the feature classes so that they only represent the fields relevant to the suitability analysis. For each of the 4 clipped layers (floodplain, Preserves, Golf_Courses, coa_parks):
   a. Add field named “Zone.”
   b. Use Field Calculator to assign a value of “0” to each record.
   c. In Data Management Tools ➔ Generalization, select the Dissolve tool.
d. Select each layer in turn as the input feature.
e. Check the box next to “Zone” to select it as the dissolve field.
f. Remove the corresponding original clipped layer.

**Buffer and Dissolving Roads**

1. Select Analysis Tools ➔ Proximity and select the Buffer tool.
2. Select roads as the input feature.
3. Enter 150 feet in the “Linear Unit” distance window.
4. Dissolve the separate buffers into one continuous buffer by selecting “ALL” as the dissolve type.

**Combining Undesirable Factors**

1. Union layers of areas to avoid (roads_Clip_Buffer, city_of_austin_parks_Clip_Dissolve, Golf_Courses_Clip_Dissolve, Preserves_Clip_Dissolve, and floodplain_Clip_Dissolve). Name new shapefile as “Undesirable_Areas_Union.”
2. In Data Management Tools ➔ Generalization, select the Dissolve tool.
3. Check the box next to “Zone” to select it as the dissolve field.
4. Remove the Undesirable_Areas_Union layer.

**Remove Undesirable Parcels from Vacant Parcels**

1. In Analysis Tools ➔ Overlay select the Erase tool.
2. Select vacant_parcels_Clip as the input feature.
3. Select Undesirable_Areas_Union_Dissolve as the clip feature.
4. Name new shapefile as “suitable_areas.”
5. Remove Undesirable_Areas_Union_Dissolve.

**Percent of Parcel Covered by Trees**

1. Clip tree_canopy_2006_Clip layer to extent of the suitable_parcels layer.
   a. Select Analysis Tools ➔ Extract and select the Clip tool.
   b. Select tree_canopy_2006_Clip as the input feature.
   c. Select suitable_parcels as the clip feature.
   d. Name the output feature as “tree_canopy_2006_Clip_Suitable.”
   e. Remove tree_canopy_2006_Clip layer.
2. Dissolve tree_canopy_2006_Clip_Suitable into one polygon by selecting “GRIDCODE” as the dissolve field.
3. Name new shapefile as “tree_canopy_2006_Clip_Suitable_Dissolve.”
4. Clip tree_canopy_2006_Clip_Suitable_Dissolve to suitable_parcels and name new shapefile as “suitable_parcels_tree_canopy.”
5. Determine area of each suitable parcel covered by tree canopy.
   a. Open Attribute table and Add Field to suitable_parcels and name it “Area_Vac.”
b. Set Type as Double.
c. Go to Field Calculator and select Calculate Geometry.
d. Set Units to Acres.
e. Open Attribute table and Add Field to suitable_parcels_tree_canopy and name it “Area_Can.”
f. Set Type as Double.
g. Go to Field Calculator and select Calculate Geometry.
h. Set Units to Acres.

6. Create a table of suitable_parcels_tree_canopy.
   a. Export table as a database file and name it as “Export_Output.dbf.”
   b. Add Export_Output.dbf to the Table of Contents.

   a. Select “geo_id” as the common field.
   b. Select “Keep All Records.”

8. Select all suitable parcels greater than ten acres.
   a. Use Select by Attributes and enter Area_Vac ≥ 0.5.
   b. Export selected features as a new shapefile and name it “suitable_parcels_extenacre.”

9. Open Attribute table for suitable_parcels_extenacre and Add Field. Name it “Per_tree.”
   a. Use Field Calculator to calculate the area of tree canopy to total area of the vacant parcel using the equation: [Area_Can] / [Area_Vac] * 100.

Prepare Shapefiles for Raster Analysis

1. Distance to Power Lines
   a. Set analysis extent to the city_limits_travis_austin layer.
   b. Go to Spatial Analyst ➔ Distance and select Straight Line to create a raster based surface of distances based on a straight line.
   c. Name output as “pwrlin.”
   d. Reclassify the raster by going to Spatial Analyst ➔ Reclassify and select Equal Interval and set Classes to 5.
   e. Invert the New Values to reflect preference for vicinity to power lines.
   f. Remove last row that includes no data.
   g. Save new raster file as “pwrlin_re.”

2. Trees
   a. Convert suitable_parcels_tree_canopy from features to raster and set Field to “Per_Tree.”
   b. Name new raster “supart.”
   c. Reclassify the raster by going to Spatial Analyst ➔ Reclassify and select Equal Interval and set Classes to 5.
   d. Invert the New Values to reflect preference for parcels with a low percentage covered by tree canopy.
   e. Remove last row that includes no data.
   f. Save new raster file as “supart_re.”
3. Land Value
   a. Convert suitable_parcel from features to raster and set Field to
      “MarketValu.”
   b. Name new raster “mrkval.”
   c. Reclassify the raster by going to Spatial Analyst → Reclassify and select
      Equal Interval and set Classes to 5.
   d. Invert the New Values to reflect preference to parcels with lower market
      values.
   e. Remove last row that includes no data.
   f. Save new raster file as “mrkval_re.”

Weighting and Combining Datasets

**Assigned Weights:**
- Distance to power lines 40%
- Parcels with lower market value 40%
- Parcels with few trees 20%

1. In Spatial Analyst go to Raster Calculator.
2. Enter equation: [pwrlin_re] * 0.4 + [mrkval_re] * 0.4 + [supart_re] * 0.2.
3. Make raster permanent by going to Data → Make Permanent.
4. Name new raster “weights.”

Reclassify Weights

1. In Spatial Analyst go to Reclassify.
2. Select weights as the input.
3. Click on Classify and select Equal Interval and set Classes to 5.
4. Remove the last row that includes no data.
5. Name the new raster “weights_re.”
6. Remove weights from Table of Contents.

Combining the Raster and Vector Layers

1. In Spatial Analyst select Convert Raster to Features.
   a. Set weights_re as the input raster, value as the field, polygon as the output
      geometry type, and check generalize lines.
   b. Name new shapefile “rank.”
   c. Remove weights_re.
2. Intersect rank with suitable_parcel_extenacre.
   a. In Analysis Tools → Overlay select Intersect.
   b. Input rank and suitable_parcel_extenacre as features.
   c. Name the new shapefile rank_Intersect.
Select Possible Sites for Solar Units

1. Use Select by Attributes to select all suitable parcels ranked 5 from rank_Intersect.
2. Export data as a new shapefile and name it “best_parcels.”
3. Normalize the data by setting MarketValu as the value and Acreage as the normalization.
4. Use Natural Breaks and set classes to 5.