Application of GIS to Support Regional Policy for Development of Renewable Energy in Southern California: An Exploratory Case Study Analysis

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WORKSHOP ON GEOGRAPHIC INFORMATION SYSTEMS

December 14, 2014

Auckland School of Business

Location: Case Room 1, 260-00

The authors are appreciative for funding from Grant Award No: 07-69-06995 from U.S. Department of Commerce.

Outline

- Background and context
- Model for integrated policy acceptance
- Research Questions
- Methodology
- Findings
- Outcomes
- Practical implications
- Conclusion
- Questions

Background and Context

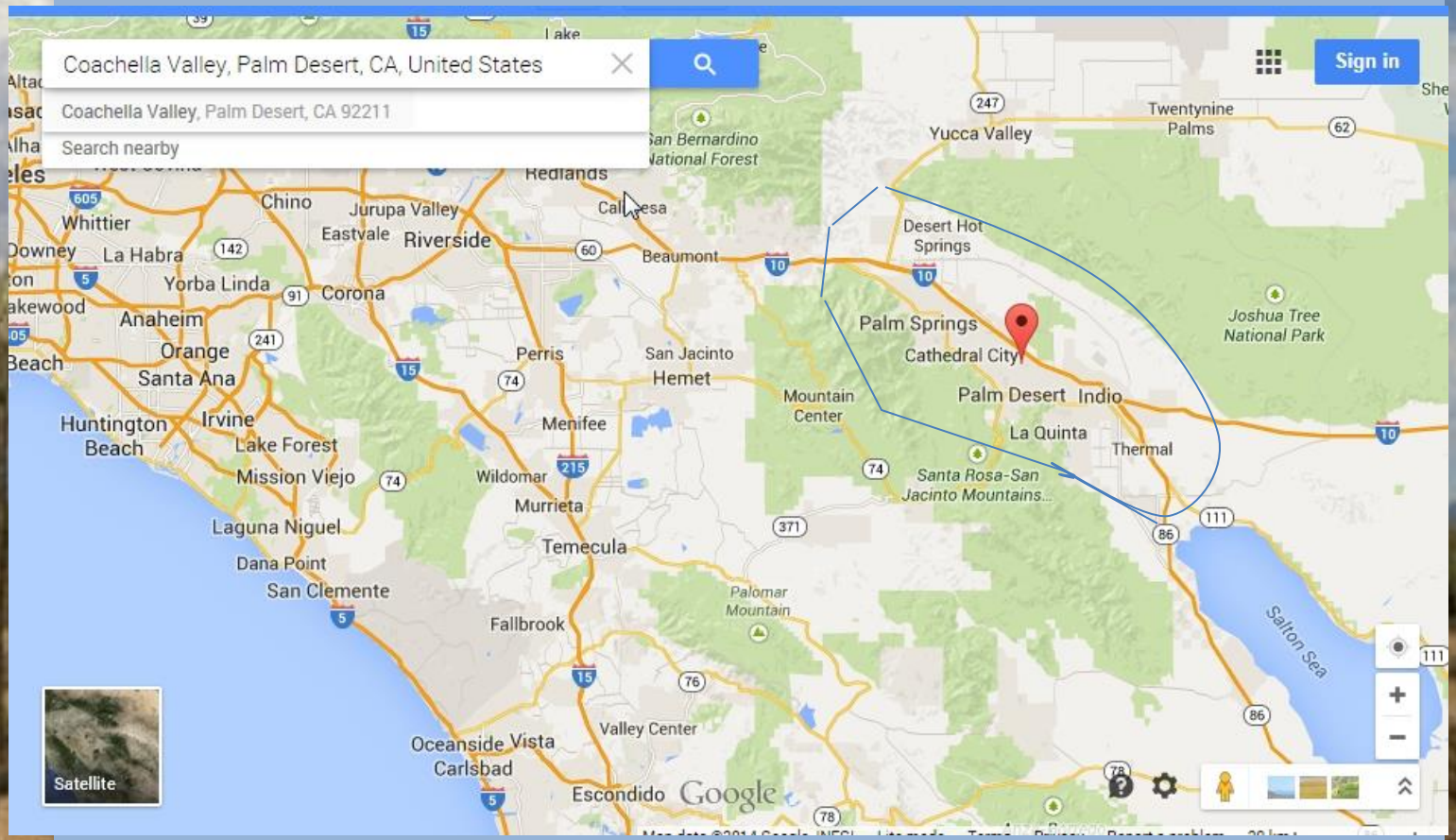
- **A multi-disciplinary research project was funded by U.S. federal government to explore the potential for renewable energy development and manufacturing in Coachella Valley, which is a Valley to the East of Los Angeles, with an urban population of about 500,000 and desert and mountain environment.**
- **It has one of the nation's largest natural environments for renewable energy, in particular solar, wind, and geothermal energy.**

Background and Context

- **What was the Motivation?**
  - **Climate Change & Fossil Fuels**
  - **Coachella Valley Economic Partnership has interest in Renewable Energy – to Expand the Valley Economy beyond Agriculture & Tourism**
- **How to describe the potential?**
  - **End Market/Customers <– Demographics**
  - **Supply Chain Activities <– Manufacturing & Operations for Solar, Wind Energy**
- **What Challenges & Opportunities for Renewable Energy? Sustainability Pillars**

Background and Context

- **Where is the Coachella Valley?**



GIS as an analytic tool

- GIS was utilized extensively in the research as an analytic tool, including the following:
  - Map the natural features of the Valley
    - Map the existing renewable energy operating sites
    - Map the location of renewable energy distribution and manufacturing firms
    - Map transportation corridors
  - Map similar features for national leading renewable manufacturing industry areas in the U.S., in particular Baltimore metropolitan area for solar energy and Houston metropolitan area for wind energy.

Importance of supply chain

- Renewable energy operation depends on global supply chains, and on their geographies:
  - The supply chains vary by types of renewable energy, i.e. solar, wind, and geothermal.
  - Geography is critical for some aspects of the supply chains
    - Wind – commercial size turbines are huge and require often oceanic transport and night-time conveyance on major highways.
    - Geothermal – power plant components require transport, as well as geographic proximity for direct use of the brines.
    - Solar – huge commercial plants require siting away from urban population.
    - Solar – geography of residential and business locations influences solar intensities.

Simplified Renewable Energy Supply Chain Activities

Model for Integrated Policy Assessment of Local and Regional Renewable Energy Development

Extra-Local Conditions →	Renewable Site-specific Characteristics	GIS as tool →	Policies for Regional Political Systems
A. Federal, state, & local political structures	A. Geographical environment*		A. Level of government (local, regional)
B. Federal, state, & local laws	1. Proximity to renewable sites		B. Non-governmental organizations
C. Cost of energy from renewables	2. Topography		C. Leadership system
D. Cost of non-renewable energy	B. Physical environment*		D. Decision-making processes
E. Environmental standards	1. Solar radiation		E. Spatial-based policies
	2. Wind velocity		F. Regulations
	3. Sub-surface geology		1. Exploration
	4. Transportation access		2. Land acquisition
	C. Demographic, social, & econ. attributes*		3. Installation of facilities
	1. Population		4. Production
	2. Education		5. Consumer use
	3. Occupation		
	4. Home value		
	5. No. manuf. firms & employees		
	6. Percent of sales in manufacturing		
	7. Median net worth		
	8. Prof./scientific/ tech. employees		
	9. Internet use for bus. Purchase		
	10. Total crime index		

* GIS can applied for analysis

(modified from Butler and Pick, 1982)

Research Questions

1. What is the size and spatial extent of the natural resource of renewables in the Coachella Valley?
2. What are the spatial aspects of social and economic factors that relate to renewable energy in the Coachella Valley?
3. What is the spatial arrangement of Coachella Valley's interstate ground transportation system and how does that relate to renewables' manufacturing and operations in the Valley?

Methodologies

The data were analyzed by “spatial data analysis,” i.e. descriptive and exploratory spatial analysis, as described by O’Sullivan and Unwin (2003).

It does not represent the category of “spatial statistical analysis,” in which the data are represented by a statistical model (O’Sullivan and Unwin, 2003).

- The reason for not doing a spatial statistical analysis is that there are not accurate dependent variables for sub-county units such as zip codes and city boundaries available.

Methodologies (cont.)

- The data sources included U.S. Census (2009, 2010-2014, 2014), State of California (2014), Solar Energy Industries Association (2014a, b), American Wind Energy Association (2014), and Esri Inc. (2014).
- Descriptive data analysis was done using descriptive statistics from the software of SPSS Inc. and Excel, and mapping produced by Esri's ArcGIS 10.2 and its cloud-based GIS service, Business Analyst Online (BAO).
- The latter, although having fewer functions than the former, has the advantages of ease of use and much more extensive accompanying data sets

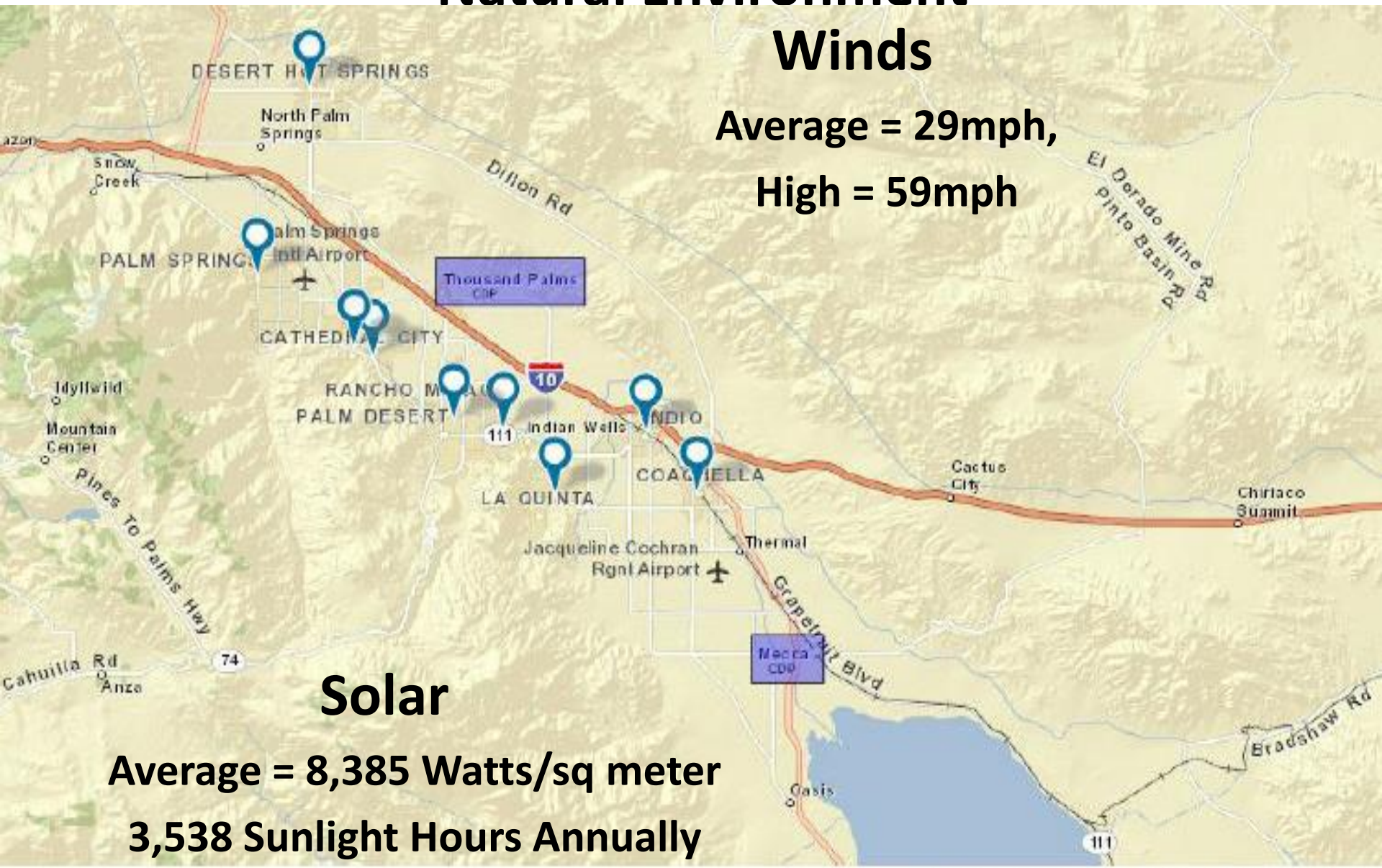
Methodology - Interviews

- Interviews were conducted of seven leaders of renewable energy firms, two government officials, and three renewable energy experts.
- Those findings informed in rich, qualitative detail about the policies and barriers to developing renewables' manufacturing, distribution, and operations in Coachella Valley
- For instance, the Valley's renewables' manufacturing potential was shown to be greatest for solar energy, since it has much more residential market in the Valley than the slight use of home or business wind turbines or domestic heat pumps.
- The interview findings are not covered in this presentation. . (See Perry, Pick, and Rosales, 2014).

Where is Coachella Valley, California?

(Data Source: Esri, BAO, 2014)

Coachella Valley's Major Cities and Natural Environment



Winds

Average = 29mph,

High = 59mph

Solar

Average = 8,385 Watts/sq meter

3,538 Sunlight Hours Annually

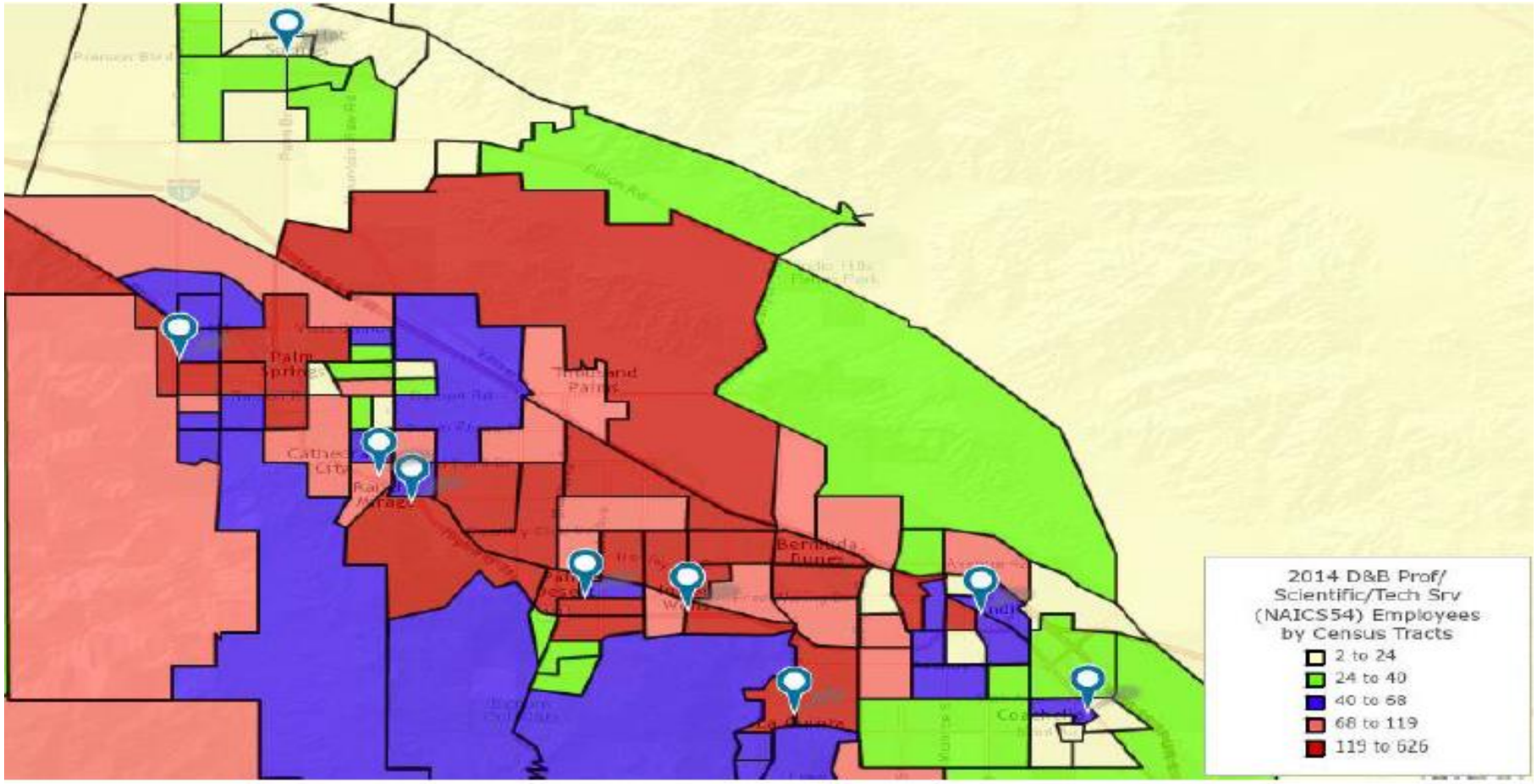
(Data Source: Esri, BAO, 2014)

Population of Coachella Valley and its Cities, 2000-2013, with projections

COUNTY/CITY	4/1/2000	1/1/2001	1/1/2008	1/1/2009	1/1/2010	4/1/2010	6/1/2013	Annual growth rate 2003-2013	Annual growth rate 2008-2013	Annual growth rate 2008-2020	Pop projected to 2020 (U. Redlands)	Pop projected to 2035 (SCAG)
Riverside County												
Cathedral City	42,647	43,853	50,401	50,812	51,093	51,200	52,977	1.15	1.00		56,786	64,600
Coachella	22,724	23,146	38,521	39,079	40,508	40,704	43,092	4.89	2.24		50,329	128,700
Desert Hot Springs	16,582	16,664	25,115	25,690	25,888	25,938	27,902	4.91	2.10		32,282	58,100
Indian Wells	3,816	4,123	4,828	4,910	4,947	4,958	5,000	1.78	0.71		5,253	5,800
Indio	49,116	49,681	74,007	74,590	75,263	76,036	80,302	4.24	1.63		89,942	111,800
La Quinta	23,694	25,459	36,744	37,116	37,044	37,467	39,331	3.17	1.36		43,234	46,300
Palm Desert	41,155	41,685	47,453	47,993	48,215	48,445	50,508	1.56	1.25		55,088	56,800
Palm Springs	42,805	43,025	44,028	44,348	44,480	44,552	46,584	0.72	1.13		50,394	56,100
Rancho Mirage	13,249	13,798	16,815	17,037	17,165	17,218	17,799	1.68	1.14		19,265	22,900
Coachella Cities - Total	255,788	261,434	337,908	341,573	344,601	346,518	363,495	2.69	1.46		402,307	551,100
Other Incorporated												24,300
Coachella Valley (UofR)			443,000				489,626		2.02		563,261	
Coachella Valley (SCAG)			443,000				503,256			2.58	604,000	884,000
Coachella Valley, Unincorporated Areas (SCAG)			87,500				126,131					308,600
Riverside County Total	1,545,387	1,589,708	2,102,741	2,140,626	2,179,692	2,189,641	2,292,507	2.81	1.73		2,584,620	

(Data Sources: U.S. Bureau of Census, 2014, SCAG, 2013)

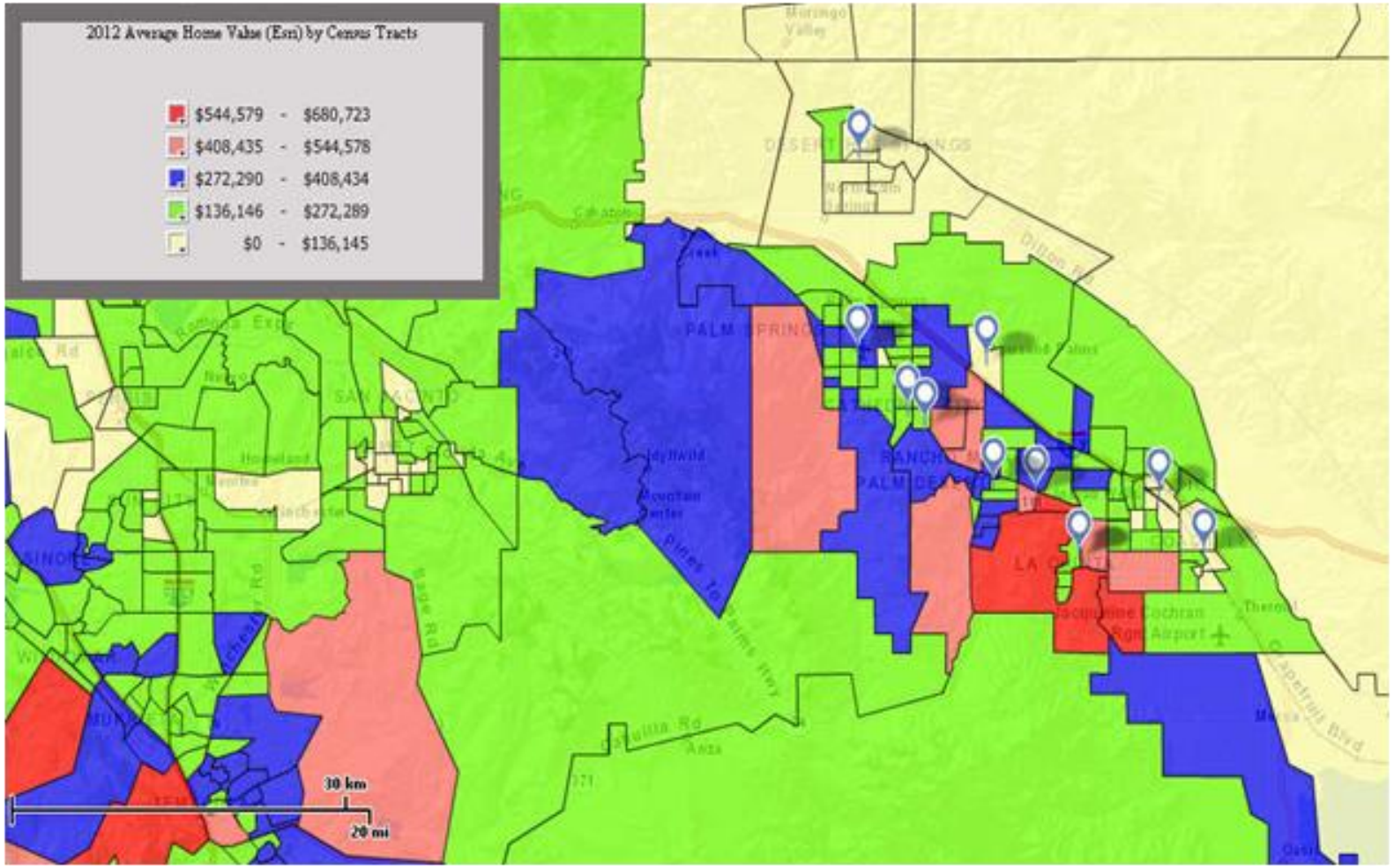
Coachella Valley Population (Customers)



Population 490,000 Total ➡ 550,000 in 2020

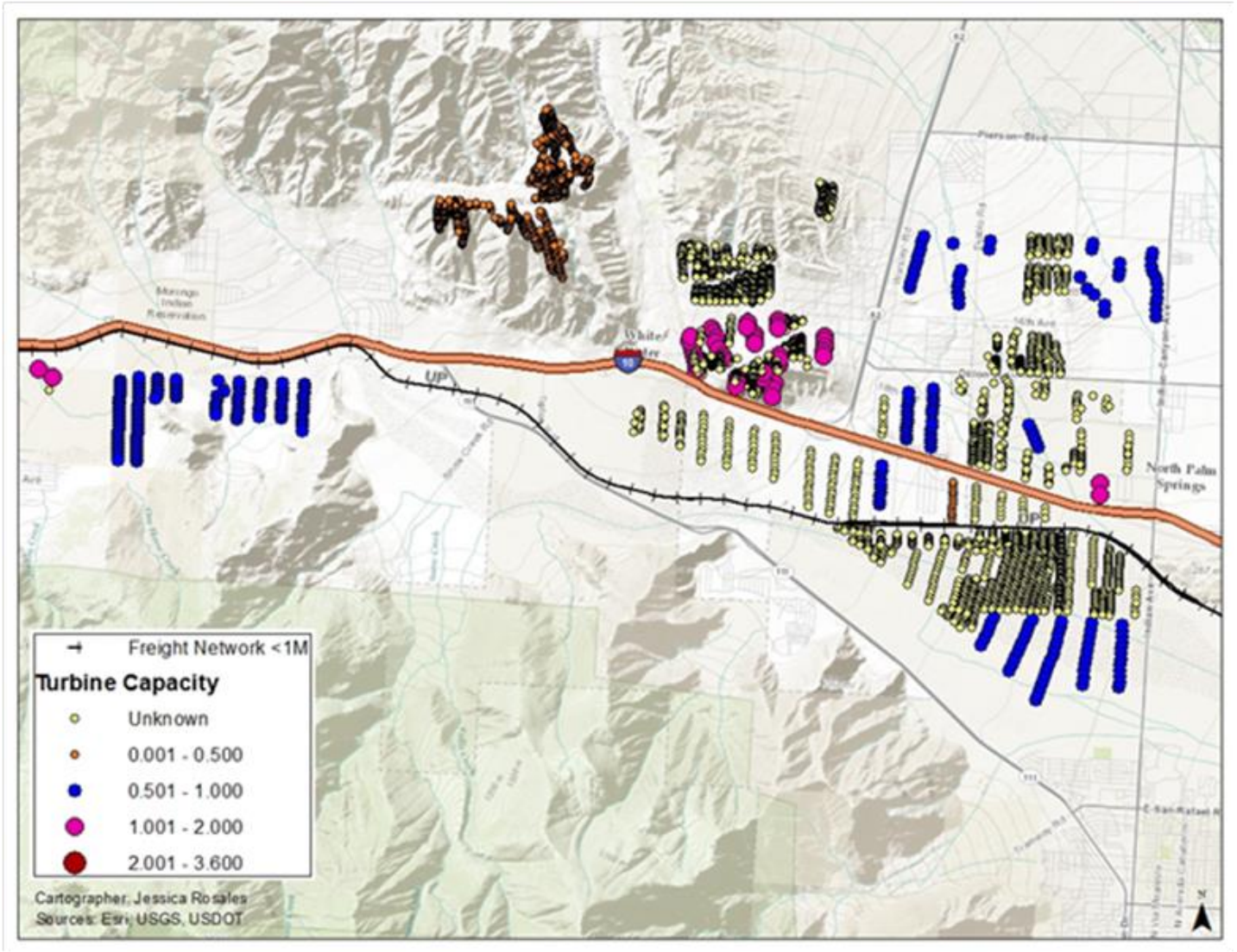
Other Census Data Analyzed: Participation in Environmental Group, Education, Age, Median Net Worth, Employment: Manufacturing, & Scientific/Professional/Technical, Internet Use, Crime

Average Home Value by Census Tract, for Coachella Valley, 2012



(Data Source: U.S. Bureau of the Census, 2014)

San Gorgonio Wind Installations in Western Coachella Valley

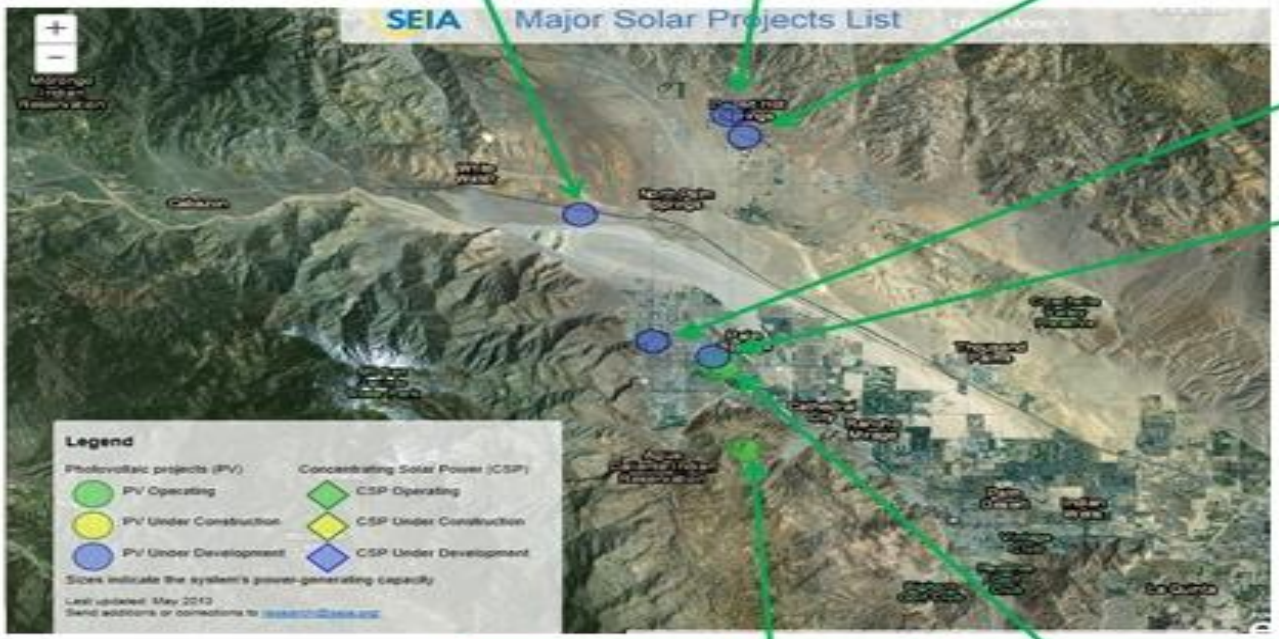


Coachella Valley Solar Generation Activities

13 MW
AES Solar
PV/ Chrystalline Silicon

20 MW
GDT Tek, Wholesale
PV/ Chrystalline Silicon

2.6 MW
Unknown
PV/ Chrystalline Silicon



5 MW
Hanwha SolarEnergy, SCE
PV/ Chrystalline Silicon

4.8 MW
Amonix, SCE
PV/ CPV

PV = Photovoltaic

CVP = Concentrated Photovoltaic

1 MW
SunPower, Alcatel-Lucent
PV/ Chrystalline Silicon
Note: plant is operating

8 MW
Solar Power Inc.
PV/ Chrystalline Silicon
Note: plant is operating

Additional Analysis

Comparison to Solar Energy Supply Chain Baltimore MSA, Maryland

In-Depth Personal Interviews with Solar Energy Executives

Solar Electrical Generating Plants in Operation or Planned between the Western Coachella Valley and Border with Arizona

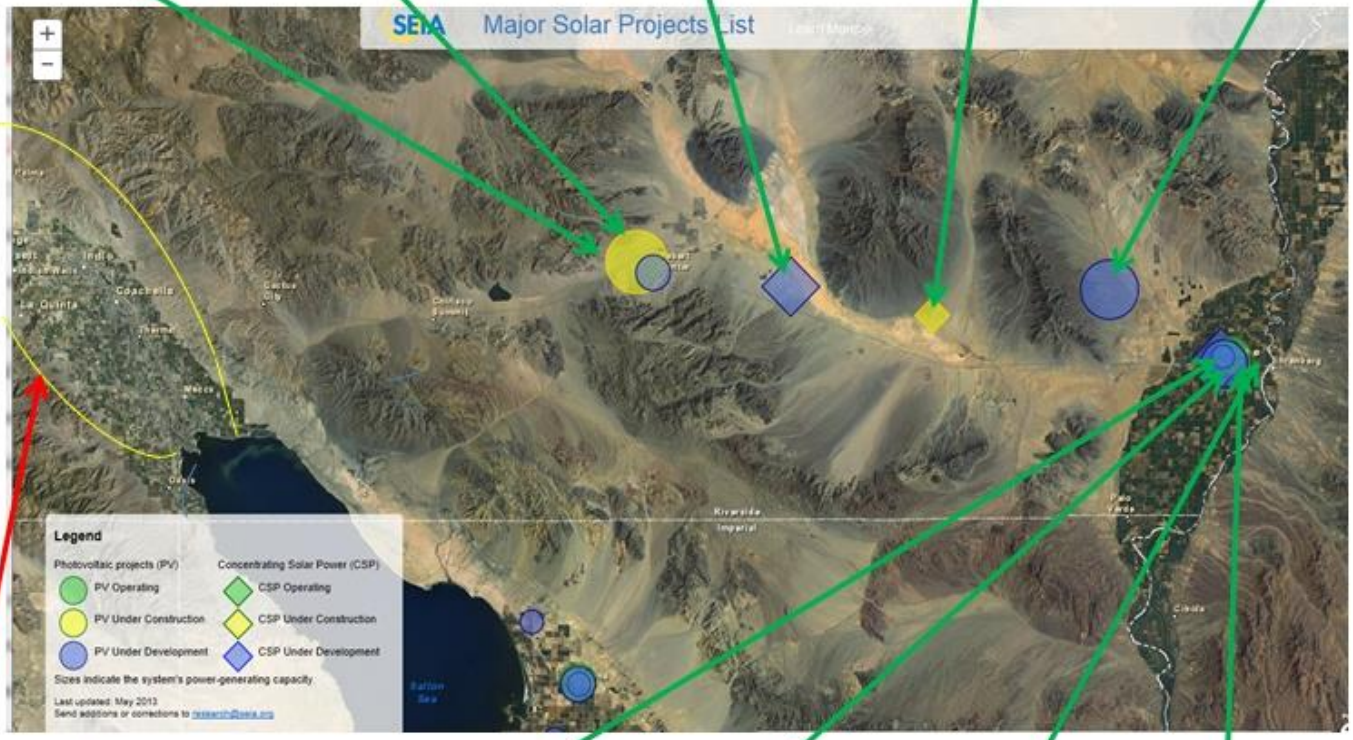
500 MW
First Solar, SCE
PV Thin Film

150 MW
EDF, Riv. County
PV Chryst. Silicon

500 MW
BrightSource, SCE
CSP Power Tower

125 MW
NextEra, PG&E
CSP Parabolic Trough

750 MW
NextEra, Riv. County
PV/Chrystalline Silicon



Coachella Valley

540 MW
BrightSource, SCE
CSP/Power Tower

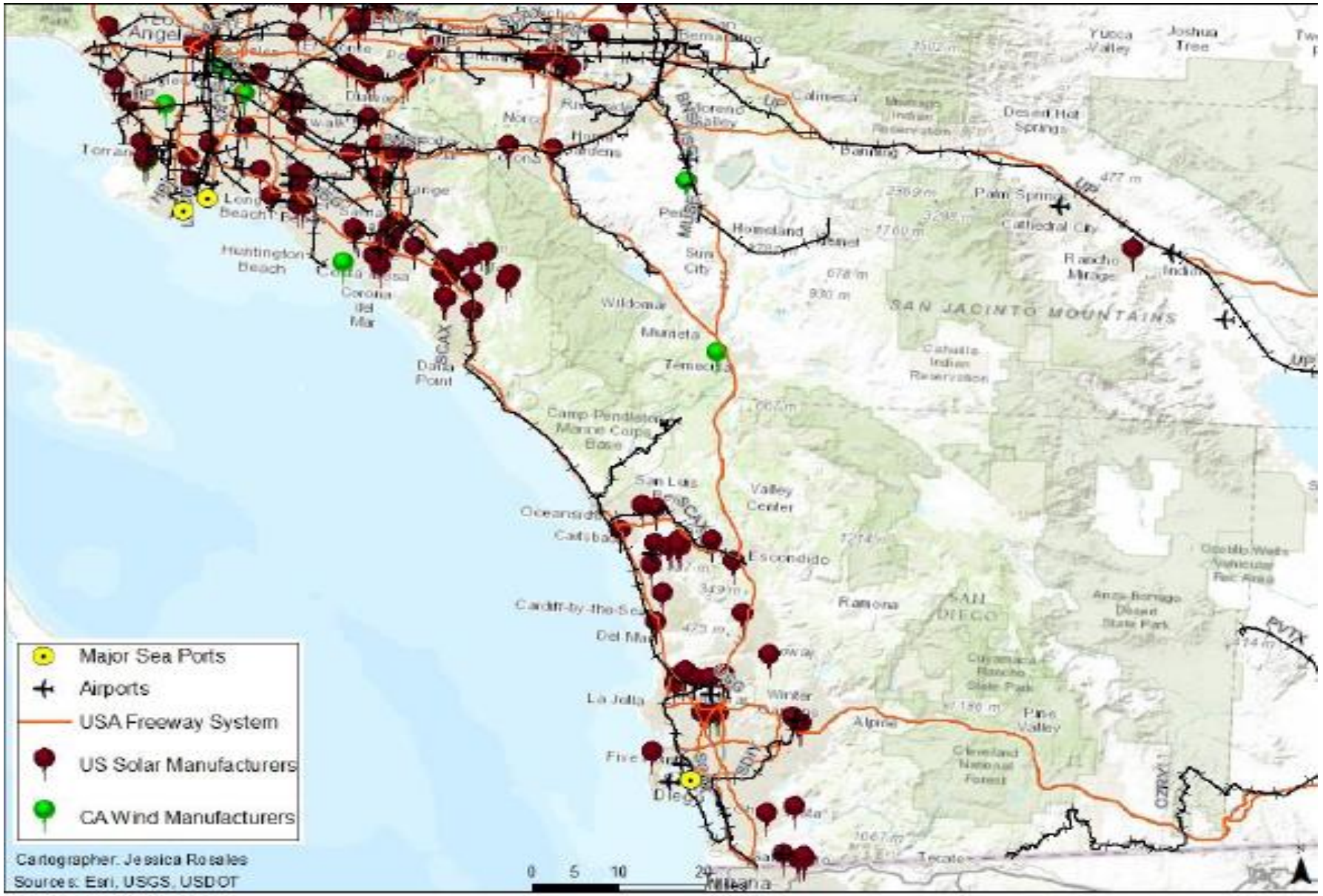
4.7 MW
Amonix, SCE
PV/CVP

486 MW
NextEra, SCE
Chryst. Silicon

21 MW
First Solar, SCE
PV Thin Film
Note: plant is operating

PV = Photovoltaic
CVP = Concentrated Photovoltaic

Southern California: Solar & Wind Manufacturing



(Data source: AWEA, 2013 & SEIA 2014)

Southern California Wind Energy Supply Chain

(Data Source: Esri, BAO, 2014)

Additional Geospatial Analysis

Comparison to Wind Energy Supply Chain Houston MSA, Texas

Limitations

- A limitations of this exploratory research study is the absence of statistical testing. However, the research was intended as exploratory and involves only a single case study, such testing was not possible, but in the future could offer confirmatory testing of findings. Another weakness is that the General Model for Integrated Policy Assessment is not fully examined.
- However, the scope of the model is large, so it is only feasible to test all portions of it in a single exploratory paper.
- Finally, renewable energy and utility companies, although willing to be interviewed, were reluctant for competitive reasons to provide detailed information, including spatial referencing, about their planning, installations, environmental impacts, supply chains, and customers.
- This limits the scope of understanding the commercial and business aspect and particularly the spatial patterns and processes of renewables' development.

Conclusion – Answers to Research Questions

1. *What is the size and spatial extent of the natural resource of renewables in the Coachella Valley?*

   The wind energy resource is shown to be very large in the northwest part of CV, which has commercial wind farms proximate to a major expressway but away from urban population. Solar energy commercial development is seen to be relatively modest proximate to the cities of CV, but very large in the corridor to the East of CV up to the Arizona border. Geothermal energy is minimal in the CV, with no commercial plants, and a bare start on domestic heat pumps.

Conclusion – Answers to Research Questions (cont.)

2. *What are the spatial aspects of social and economic factors that relate to renewable energy in the Coachella Valley?*

   Of the sixteen site-specific characteristics that appear in the Model, six were examined spatially in the exploratory case study. All six, in particular topography, transportation, population home value, percent of sales in manufacturing, and crime had spatial aspects related to renewable energy development.

Conclusion – Answers to Research Questions

3 *What is the spatial arrangement of Coachella Valley's interstate ground transportation system and how does that relate to renewables' manufacturing and operations in the Valley?*

- The ground transportation system was analyzed with GSI and shown to have limited expressway access i.e. only Interstate 10, for the first 70 miles of routing from the Coachella Valley, and then opening up to a large and complex highway network giving access to two major oceanic ports and dozens of renewables manufacturing sites in greater Los Angeles.
- Overall distances are significant for cost of transport, and time-consuming especially for very large equipment items. Roads to some operational commercial sites would need to be large and durable.

Conclusion – Policy Recommendations

- *What are the policies recommended based on the Model, and what role does GIS play in developing the policies?*
- Examples of policies include recognition of a sharp socio-economic divide in the CV for attracting renewables workforce and facilities. This divide is unfortunate and could lead to future tensions and conflict. GIS mapping can delineate detailed patterns of this divide as well as progress that can be made on narrowing it.
- Recommendations on policies to attract manufacturers can be based on the dominant current location of CV manufacturing in the City of Coachella and southern adjacent unincorporated areas. Additionally, the CV crime patterns are shown by spatial mapping to be in selected affluent census tracts, which can inform policymaking in those cities.

Conclusion

- Renewable energy is growing rapidly in the United States and worldwide, due to concern about pollution and other unwanted externalities of non-renewable energy.
- Renewable energy development can be analyzed at different scales of the world, nation, states, and regions/local areas.
- This research studied the development of renewable energy in the Coachella Valley region of southern California, based on a Model of Integrated Policy Assessment. T
- he exploratory study utilized GIS and descriptive statistics to provide a single case example of portions of the Model.
- This study has explored the use of GIS for analyzing policy-related conditions and characteristics and proven useful in formulation of government policies. Future enlargement of the study can strive to populate the entire Model with spatially informed findings yielding powerful support to regional policymaking.