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Renewable Energy: Problems and Prospects in Coachella Valley, California

James B. Pick
University of Redlands

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To my wife, Dr. Rosalyn M. Laudati,
for her patience and continual support
and encouragement during the project,
and in loving memory of her mother
Edythe Laudati.

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Contents

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Chapter 1
Introduction

Abstract Coachella Valley is introduced as an area of southern California with extensive renewable energy resources both in the Valley and in the surrounding areas to the north and west. It is chosen as the focus region for the book due to its energy resources and a community that is encouraging innovation in starting up renewable manufacturing and operations. The history of the Coachella Valley includes arrival of the railroad in the late nineteenth century, spurring over a century of population and economic growth; expansion of dry-climate agriculture; and renown for tourism. The Valley's current social, transportation, economic, and business growth is described. The principles of renewable energy are introduced, especially for solar energy, wind energy and geo-heat. The book objectives include to gain understanding of the extent of and potential for renewables in the Valley, to analyze emerging renewables entrepreneurship and innovation, and to synthesize the Valley's problems and prospects for renewable development. The book also includes conceptual models, the detailed urban profile of the Valley, and benchmark comparisons of the Valley with wind energy in Texas and solar energy in Maryland.

1.1 Introduction

This book analyzes the problems and potential of renewable energy in the Coachella Valley of California. In the twenty-first century, renewable energy has become a major factor worldwide because of its affordability, capacity, prevalence, and reduced environmental impact. Other older major pillars of global energy, such as coal, oil, and natural gas continue to dominate. They contribute to the accumulation of CO_2 and other greenhouse gasses, which have grown in cumulative amount to the extent of raising the Earth's temperature, stressing biota, melting glaciers, and threatening low-lying natural and inhabited areas worldwide. Another energy pillar used in some nations is nuclear energy. Although it does not emit CO_2, it runs the risk of disastrous contamination, and has issues related to the disposal of radioactive wastes, and accidental or terrorist breach of the plant. Additionally, nuclear energy requires large volumes of cooling water to absorb the heat generated by the plant. Renewable energy—solar, wind, geothermal, and hydro among others—have less injurious environmental impacts, and are scaling up in capacity, especially solar and wind, due to lowering cost, scientific and engineering advances, favorable market forces, and government support.

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In this book, the Coachella Valley of California is selected as a focal region in which to study renewable energy development. Emphasis is placed on the associated social, economic, political, transportation, manufacturing, and innovation aspects in the Valley. The Valley is among the U.S. regions most richly endowed by nature with renewable resources. This is because the Valley has a dry desert environment in its inhabited parts. It receives large intensity of sunlight for solar energy which is favored by mostly cloud-free weather. Several specific Valley locations are endowed with fairly consistent and high-velocity wind currents that favor large-scale wind energy plants. Also, the Valley is located about 75 miles north of the Salton Sea geothermal deposits which are among the largest in North America. This not only indirectly influences the Valley's electrical energy supply but also increases potential for small-scale domestic uses of the earth's surface heat through ground source heat pumps. The Valley's physical environment and its renewable resources are reviewed in Chap. 2 on the basis of secondary and largely government sources of information.

The study in this book includes evaluation of how the region's socioeconomic, business, and transportation features can influence development of renewables; the scope of markets for solar and wind energy in the Valley; and spatial relationships of renewable energy facilities with location of workforce, markets, suppliers, and transportation. The Valley has a variegated pattern of demographic features, income, education, and skill levels. These profiles point towards the need for coordinated socioeconomic planning by the Valley's nine major cities, unincorporated areas, economic development agencies, and nonprofits.

A conceptual model, the Integrated Policy Assessment Theory of Renewable Energy, is presented and shown to be supported by the development processes and advances that have occurred in renewable energy in the Valley. The model is also useful in identifying gaps and missed opportunities that can be compensated for in building up the Valley's renewable sector and extending its benefits to its citizenry.

Further investigation includes a benchmark comparisons of the Valley's social, economic, and transportation factors for incipient solar and wind energy manufacturing with two other metropolitan regions outside of California. These regions are exemplary in renewables manufacturing, namely for solar energy comparison with the Baltimore-Columbia-Towson metropolitan area, and, for wind energy, comparison with the Houston-The Woodlands-Sugar Land metropolitan area.

The book concludes by examining in broad terms the future potential for wind, solar, and geothermal operations, manufacturing, and innovation in the Coachella Valley. What are the positive and negative long-term factors impacting this potential? How much of the Integrated Policy Assessment Theory of Renewable Energy has been realized and what light can it shed on future advances in renewables in the Valley and surrounding regions? This leads to policy recommendations, grounded in the book's research findings, for the governments, businesses, and nonprofits that are stakeholders in the region.

The stimulus for the research stems from a grant awarded to the Coachella Valley Economic Partnership and sub-awarded to University of Redlands. The funding was provided by the Obama Administration's initiative on "Investing in Manufacturing Communities Partnership," which sought to help a variety of communities cultivate an environment for firms to create productive and skilled manufacturing jobs in a variety of regions and thereby accelerate the nation's resurgence of manufacturing. The government recognized and awarded funding to standout communities to demonstrate the best practices in bringing together local stakeholders and engaging in long-range planning to integrate well-focused investments across each community's industrial ecosystem to create broad-based prosperity (U.S. Department of Commerce 2013).

The Investing in Manufacturing Communities Partnership (IMCP) initial round of funding launched in September 2013. It awarded $7 million in U.S. Department of Commerce pilot grants to 44 communities across the country, one of which was the Coachella Valley Economic Partnership in Palm Springs, California (U.S. Department of Commerce 2013, 2016). This round of funding sought to spearhead a major reform effort to "reward communities for creating globally competitive environments that attract, retain, and expand investment in manufacturing and spur international trade and exports." The outcome pursued was to help communities develop plans to build industry strength through improved transportation and energy infrastructure, workforce training, strengthened supply chains, specialized research, as well as export promotion and improved access to capital (U.S. Department of Commerce 2013). There was emphasis on creating robust, new manufacturing jobs not only in urban areas in the U.S., but also in rural areas. This was bolstered by coordination with the Department of Agriculture and White House Rural Council. The Environmental Protection Agency collaborated on the program by emphasizing renewable energy and reduction of brownfields through new manufacturing. Likewise, the IMCP program was linked with the U.S. Small Business Administration's (SBA) interest in encouraging small manufacturing firms to join into supply chains (Department of Commerce 2013). The IMCP provided $2.6 million in pilot grants.

In May of 2012, a dozen "designated manufacturing communities" received up to $25 million each from Department of Commerce and other federal agencies to implement their manufacturing development plans and stimulate investment and partnerships with the public and private sectors (The White House 2014). Subsequently in July of 2015, a second dozen "designated manufacturing communities" received funding up to the same limit (U.S. Department of Commerce 2015). The Coachella Valley Economic Partnership did not receive this additional funding, which largely was approved for major urban complexes with large existing manufacturing sectors, such as the Connecticut Advanced Manufacturing Region, and Pacific Northwest Partnership Region (U.S. Department of Commerce 2015). Except for the Coachella Valley grant, none of these 24 "designated manufacturing communities" or the preceding pilot projects had focus on renewable energy development. Thus, the Coachella Valley pilot grant was unique in the IMCP Program in its focus on renewable energy.

In particular, the present project was funded in 2014 by U.S. Department of Commerce IMCP award number 07-69-06995 to Coachella Valley Economic Partnership, through a sub-award to University of Redlands. A portion of the sub-award, to conduct case studies and analyze the renewable energy manufacturing industry ecosystem in Coachella Valley, is the catalyst for the present research, which draws in part from the findings of that sub-award. Subsequent funding for the present project was provided by the Research Committee of School of Business at University of Redlands.

This chapter is organized into sections on the background of the Coachella Valley and its economy and society, background on renewable energy, the objectives of the book, methodologies, and a summary of the book's content.

1.2 Background on the Coachella Valley

The Coachella Valley is a 303 square mile desert and mountain region located in the south central part of California, northeast of San Diego and in a basin to the northwest of the Salton Sea (see inset on Fig. 1.1). It is part of the Inland Empire-Salton Trough region which encompasses the most seismically active part of the San Andreas earthquake fault (Wadsworth 2014). The central part of the Valley is a

(Modified from Esri, 2015)

Fig. 1.1 Coachella Valley and its Cities and Unincorporated Areas, with Boundaries (Modified from Esri 2015) desert floor area surrounded on the northeast and southwest by foothills leading up to mountain ranges that reach 11,000 feet in altitude (see Fig. 1.2). On the Valley floor, which can reach 250 feet under sea level, the summer temperatures average 108 °F, while the winter temperatures average 78 °F. Hence the Valley is a popular winter tourist location.

The Coachella Valley was originally inhabited by early Native Americans. In the late 1800s, the Valley rose in population settlement due in part to the arrival of the Southern Pacific Railroad. A further spur to growth was the construction of Route 66 through the Valley in 1926 and of Route 111 in 1930, which winds past present Palm Springs. By the 1950s, the area started to attract larger numbers of winter visitors and its tourism sector grew. Year-round residents became more prevalent in the 1980s with the advent of more widespread and affordable air conditioning.

Culturally, parts of the Valley such as Palm Springs became known as a favored location by Hollywood entertainment celebrities such as Frank Sinatra, Bob Hope, and Kirk Douglas, and it became a vacation location for U.S. Presidents, including Dwight Eisenhower, and Gerald Ford who retired there. It is the location of many advancements in mid-century American architecture, with residences designed by such notables as Richard Neutra, John Lautner, and Albert Frey. The Valley's central area is also enhanced by the surrounding Joshua Tree National Park, San Jacinto National Monument, and the newly-designated Sand to Snow National Monument adjoining the northwest part of the Coachella Valley.

The population in 2013 of the Coachella Valley's nine largest cities plus its largest unincorporated place totaled 371,200. As seen in Table 1.1, the population of the Valley's largest cities consisted of Indio at 81,393, Cathedral City at 52,337, Palm

Fig. 1.2. Coachella Valley Vista Point (Source: Robert Davis)

Table 1.1 Growth in Coachella Valley Cities, 2005–2013

City	Population 2013	Population increase 2005–2013	Growth 2005–2015 (%)
Cathedral City	52,337	1380	2.7
Coachella	42,784	11,820	38.2
Desert Hot Springs	27,828	8321	42.7
Indian Wells	5081	271	5.6
Indio	81,393	14,854	22.3
La Quinta	38,401	2024	5.6
Palm Desert	49,949	354	0.7
Palm Springs	45,712	-288	-0.6
Rancho Mirage	17,639	1,119	6.8

(Source: California Department of Finance E1 Report, January 1 2013)

Desert at 49,949, Palm Springs at 45,712, and Coachella at 42,784. These cities have sharp differences in relative growth rates, with Indio and Coachella growing at a faster average annual rate of 4.56%, compared to yearly average growth for the other three of 1.14%. This bifurcated demographic growth situation implies that over time the southwest of the Valley will become more populous than its middle and northern parts, and indeed this differential growth is reflected in the projected 2035 Valley population, for which 44% resides in Indio and Coachella, compared to 25% in 2013 (SCAG 2013; U.S. Bureau of the Census 2014).

The Valley also has substantial population located in unincorporated areas, which include Whitewater to the north; North Palm Springs, Garnet, Sky Valley, Thousand Palms, Desert Palms, and Indio Hills in the northeast; and Thermal, Vista Santa Rosa, Bermuda Dunes and Mecca to the south (see Fig. 1.1). In 2008, unincorporated population was estimated to total 105,092 (SCAG 2013) out of a total Valley population of 443,000, and in 2013 was estimated at 126,131 (SCAG 2013; Pick et al. 2015) out of a total Valley population of 503,256. The unincorporated areas are supported for services by Riverside County. For example law enforcement is provided by the county sheriff's office. The high proportion of unincorporated places reflects the recency of the substantial development of the Valley's urban areas. In the last 50 years, peripheral areas have not had sufficient time to be incorporated as cities or annexed to existing cities.

The Valley population grew 2008–2013 at 2.00% annually, a rate expected to increase somewhat in the next 20 years (SCAG 2013) due to shifts in its population towards the southern, more rapidly growing area. The cities also have very large differences in age structure, with younger population located in the outlying cities of Coachella, Indio, Cathedral City and Desert Hot Springs; and older age structures located in the more central, prosperous cities of Palm Springs, Palm Desert, Rancho Mirage, and Indian Wells. There is a variegated age structural pattern as well. For instance, at the youth extreme is Coachella with only 5% of residents over age 65, versus 59% over age 65 in Indian Wells. The older cities given above are linked to higher income and lower poverty, as well as to lower household income from retirement plans (see Table 1.2). For instance, in 2013 Cathedral City's median household

Table 1.2. Income and poverty, Coachella Valley Cities, 2013

	Median household income 2013 (in dollars)	Houshold income from retirement plans (%)	Poverty (percent of population)
Cathedral City	32,473	19	20
Coachella	40,965	6	31
Desert Hot Springs	44,406	18	32
Indian Wells	45,198	47	5
Indio	50,068	22	22
La Quinta	51,188	28	10
Palm Desert	67,723	39	10
Palm Springs	77,526	32	18
Rancho Mirage	83,884	46	14
Thousand Palms	43,813	NA	10

NA = not avaialble
Sources: U.S. Census 2014; CVEP 2015)

income was $32.473, versus Rancho Mirage's $83,884, and the corresponding proportions of income from retirement plans are 6% for Coachella, versus 46% for Rancho Mirage (U.S. Bureau of the Census, 2014. These differences underscore an economic divide between old and wealthy Valley cities and those with young and poorer populations. This divide has bearing on renewable energy development in the Valley and will be examined further in Chap. 4.

Higher education attainment within the Valley is centered in the College of the Desert, founded in 1958, and the more recent satellite campuses of University of California Riverside and California State University San Bernardino. Nonetheless, the overall paucity of educational opportunities led many talented young people to leave the region to attend college, which has resulted in the non-return of many talented Valley natives, a form of brain drain.

Ethnically, the Valley's incorporated cities in 2010 were 42.3% White, 40.1% Latino, 2.3% Black, 3.1% Asian, and 12.2% Other (U.S. Census, 2014). As seen Table 1.3, the Latino population is mostly located in the southern area especially in Indio and Coachella. A part of the traditional downtown area of Indio is seen in Fig. 1.3.

These official totals represent the long-term resident population of the Valley. However, because of the emphasis on tourism, in the cooler months, there is substantial presence of short-term vacationers and retirees from outside the area who visit the area for 3–6 months (CVEP, 2015). This seasonal population increases demand for more service workforce and tends to expands the Valley's economic output particularly in tourism and retail services, although less so in the business and industrial sectors.

In short, the Valley's population of about a half million is growing moderately, but faster in the south, which has more Latino population, is younger, and has lower per-capita income. The established, wealthier cities southwest of the 10 Freeway, tend to have higher percent of older people, higher income, and White ethnicity.

Table 1.3. Ethnicities in Coachella Valley Cities

	White—not Latino	Latino	Black	Asian
Cathedral City	30.9	60.0	2.3	5.2
Coachella	1.6	97.2	0.8	0.1
Desert Hot Springs	31.6	54.3	5.9	2.4
India Wells	87.6	3.9	1.1	6.8
Indio	26.0	68.3	2.0	1.9
La Quinta	62.6	31.8	1.6	2.4
Palm Desert	67.7	2.0	1.3	5.1
Palm Springs	62.4	24.6	4.2	4.7
Rancho Mirage	82.7	11.5	2.5	1.8
Thousand Palms*	43.1	52.5	1.4	1.7

*U.S. Census 2010 (Sources: California Economic Forecast 2015; U.S. Census 2010)

Fig. 1.3. Traditional Downtown, Indio, CA

The Valley's economy emphasizes the sectors of tourism, agriculture, and retail, and to a lesser extent, manufacturing. The tourism industry in the Valley in 2013 totaled $5.8 billion (Descant, 2014), spurred by the good winter weather, proximity to the megacity of Los Angeles, and notable winter annual events such as the Coachella Valley Music and Arts Festival, Palm Springs International Film Festival, BNP Paribas Tennis Open, and Palm Springs Art Fair. The tourist sector comprises 24% of employment in the Valley. The retail sector in 2015 had sales of $5.2 billion (CVEP, 2015), employed 18.8 thousand workers, and consisted of 9100 retail stores. The cities dominating in retail activity are Palm Desert, Plan Springs, Indio, and La Quinta, together accounting for 69% of retail sales (CVEP, 2015).

Agriculture, another major economic sector, had agricultural production value in 2010 of $544 million (County of Riverside, 2012). Production consists of fruits and vegetables, including citrus fruits, artichokes, avocados, onions, leeks, beans, cucumbers, figs, hips, lettuce strawberries, tomatoes, sugar cane, and dates. The latter constitutes 95% of dates produced nationally. Water for agriculture is made possible in the 1930s by the diversion of some Colorado River water, near the Mexican border, to the west through the All-American Canal, and continuing through northward-flowing irrigation drainage canals to reach Coachella Valley.

Within the Valley's economy, the business sector is expanding and includes major businesses shown in Table 1.4. They closely reflect the major sectors of tourism, retail, and agriculture, as well as healthcare/medical and manufacturing sectors. Agriculture and manufacturing firms are mostly headquartered the in low-income cities, while tourism, retail, and healthcare/medicine are located in wealthier ones. The businesses mostly serve affluent consumers throughout the southern California region with services and products, with the exception of the national market of the Ernie Ball guitar string firm. The array of firms demonstrates some Valley capabilities for manufacturing and higher skilled services that is encouraging for potential development of a renewable energy sector, a topic returned to in later chapters.

The Coachella Valley has significant transportation links. Interstate 10 cuts through the urbanized zones of the Valley. It runs through the San Gorgonio Pass and connects in the west to the Inland Empire (Riverside-San Bernardino-Ontario Metropolitan Area). It extends to the Los Angeles-Long Beach-Santa Ana Metropolitan Area and in the east to Arizona, including the Phoenix-Mesa-Scottsdale Metropolitan Area, and to state and national locations beyond. Interstate 10 is mapped in Fig. 1.1 and pictured in Fig. 1.4 as it runs past a wind farm in the San

Table 1.4. Major Businesses in Coachella Valley

Name	Location	Type of business
Coca Cola Bottling Plant	Coachella	Bottling subsidiary
Desert Regional Medical Center	Palm Springs	Decentralized medical services
Eisenhower Medical Center	Rancho Mirage	540-bed hospital
Ernie Ball	Coachella	Manufacturer of electric guitar strings
Guthy-Renker	Palm Desert	Mail order informercial producer
J W Marriot-Desert Springs Resort	Palm Desert	Hotel
La Quinta Golf Course	La Quinta	Golf Courses
Shields Data Gardens	Indio	Dates
Siemens Water Technologies	Palm Desert	Manufacturer of water filtration systems
Sun World Internatioal LLC	Coachella	Wholesale fruits and vegetables
Universal Protection Service	Palm Desert	Security guard and patrol service

Fig. 1.4. Interstate 10 with Wind Farms, San Gorgonio Pass, CA (Source: Kevin Dooley)

Gorgonio Pass. The other major highways in the Valley, California Routes 111 and 86, provide extensive traffic connections and tend to be much less congested than comparable highways in greater Los Angeles as seen in Fig. 1.1. A proposal is under consideration for the costly Whitewater River Parkway (also referred to as CV Link), a 50 mile pathway for bikes, small low-speed electric vehicles, and pedestrians to interconnect the Valley's major cities (CVAG 2016). If the proposal overcomes obstacles such as right-of-way, safety, maintenance cost, and if it is approved by the cities, it would stimulate solar powered small-vehicle design and development.

The Valley has a train connection to Riverside and beyond to the west, but service is limited to several trains a day. For air transport, the mid-sized Palm Springs International Airport has jet connections to major cities in the west and mid-America, as well as to Toronto and Vancouver in Canada. This transportation network is important for shipping of renewable energy components to operating sites, distribution areas, and manufacturing facilities.

1.3 Background on Renewable Energy

This section provides an introduction to the major forms of renewable energy that are significant for the Coachella Valley, namely solar, wind, and geothermal energy. For each energy type, the section explains the renewable; describes its current prevalence worldwide, nationally, and in California; indicates its importance for the Coachella Valley; and discusses its environmental benefits and detriments. This brief background will be expanded upon in Chap. 2.

1.3.1 Solar Energy

Solar energy represents the conversion of sun's energy into electricity or heat. The direct conversion to electricity is termed solar photovoltaic energy since the conversion takes place directly in solar photovoltaic panels, which have no moving parts. Solar thermal energy refers to conversion of the energy of the sun to generate heat, most commonly in the form of hot water or other liquids. Solar photovoltaic energy is more prevalent in use than solar thermal, and it is the solar energy type emphasized in this book. Photovoltaic energy is derived directly from the massive energy of the sun reaching the earth, which is estimated at 8000 times the current world usage of fossil fuels plus nuclear energy (Boyle 2012b). The basic component for converting solar energy into electric energy is the small photoelectric cell composed of the same kinds of semiconductor materials as those in micro-electronics. Photovoltaic cells are highly efficient; able to reach over 20% efficiency, i.e. 20% of solar energy received is converted into usable electricity.

Solar photovoltaic systems, which consist of panels containing photovoltaic cells and inverters which convert the direct current from the panels into alternating current (Boyle 2012b) can be utilized in centralized plants, commercial/industrial buildings, in homes, or in remote places. A commercial solar power facility is referred to as a solar power plant or solar farm. A large solar photovoltaic plant can have over 500 MW of solar capacity. It is designed to place thousands of photovoltaic panels over a large land area. The panels directly convert solar energy into electrical energy in the form of direct current, which is in turn converted by inverters into alternating current, which is output to the electrical transmission grid.

A different plant design, concentrating solar power (CSP) reflects solar energy by a large array of mirrors over a large land area, usually moveable mirrors known as heliostats (Everett 2012), which are able to track the position of the sun by continuously changing their skyward orientation. The heliostats focus the solar radiation on a receiver at the top of a tall solar tower at the center of the plant site. The heat from the receiver can be used to create steam to turn a turbine and generate electricity, or alternatively, it can heat a transfer fluid which can be pumped to the ground level, where it in turn heats steam to run a ground-level turbine (Everett 2012). An example of a CSP plant is the Desert Sunlight Solar developed by First

Solar Inc., located 50 miles to the east of the Coachella Valley, which commenced operations in 2014 at 550 MW capacity (First Solar 2016). The plant provides sufficient electricity to the utility firm, Southern California Edison, to serve 160,000 homes. Built over three years, it uses no water and emits reduced CO_2 emissions compared to an equivalent fossil plant.

A residential photovoltaic system is usually installed on the rooftop of a home providing electricity to the power grid through contracts with a utility firm. Similar to power plants, residential solar panels produce direct current energy, which is converted to alternating current for the grid, a form suitable for most electrical devices. The usual home system produces 3–7 kW, which at upper limits might be sufficient to fulfill the electrical consumption needs of the household. Additionally, these systems often provide net surplus energy for purchase by the utility firm.

The energy produced by solar energy undergoes a diurnal cycle, which reaches maximum energy intensity during daylight hours and zero intensity at night. Hence, there is need for energy storage or transfer to avoid nighttime losses. One solution is battery storage; however, batteries run down over time. They are expensive and have limited use in large-scale solar energy production. Another means to preserve electricity is to send it during sunlight hours onto the transmission grid, which acts as balancer, relieving the supply need for fossil or nuclear sources during daylight hours but relying on those energy sources at night. If a home provides net surplus solar energy to the grid, some states such as California require public utilities to provide "feed-in tariffs". These tariffs require payments from the utility to the customer, which are established contracts between the two parties.

Another type of solar energy, remote solar photovoltaic, is appropriate for remote locations such as a distant hiking lodge or geological monitoring station, which depend on energy year-round, but for which access lines to the power grid are too expensive to construct given the low level of remote demand. Such remote systems are utilized extensively in developing nations, which often have limited and unreliable grids and low average household income.

The amount of solar photovoltaic energy in California and the U.S. is expanding rapidly. As seen in Table 1.5, solar photovoltaic energy generation in the U.S. grew nationwide most rapidly 2006–2015 among the major renewable energy types (EIA 2015, 2016). The U.S. in 2015 had 20,009 MW of installed solar photovoltaic capacity, which is projected to grow to 31,645 MW by year 2030 (U.S. Energy Information Administration 2015, 2016). As seen in Fig. 1.5, for California, expansion of large-scale solar photovoltaic power plants in California has grown from almost 0 to 5697 MW between 2001 and 2015, the most rapid expansion of any renewable energy type during that period (California Energy Commission 2015). Additionally, in 2015 there was an estimated 5100 MW of installed small-scale, mostly domestic, solar photovoltaic energy, with 760 MW pending (California Energy Commission 2015). The extraordinary California solar growth is supported by state incentives and programs the California Solar Initiative, the New Solar Homes Partnership, the Emerging Renewables Program, the Self-Generation Incentive Program, and mandated feed-in tariffs for utilities to domestic customers, (California Energy Commission 2015).

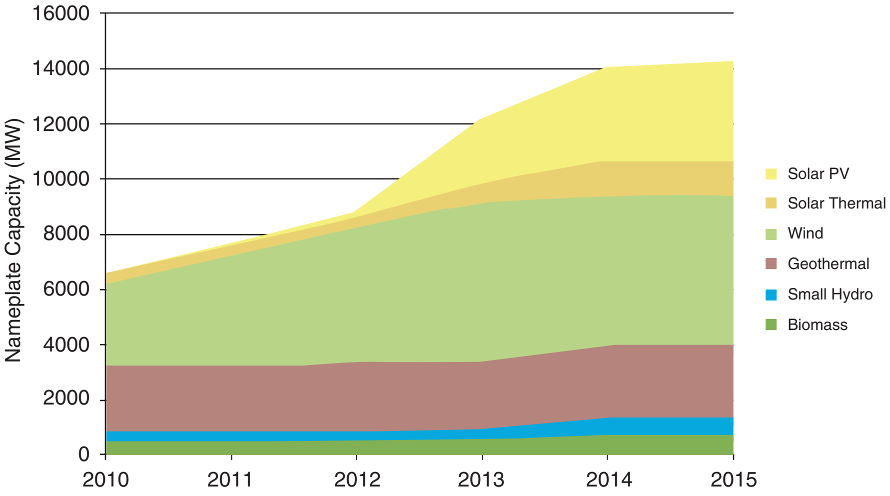

Fig. 1.5. Change in Nameplate Capacity in Megawatts for Large Scale Renewable Energy Sources, California, 2010–2015

Table 1.5. Growth of Net Generation from Renewable Sources, United States, 2006–2015, in thousand megawatt hours

		Utility-scale facilities, by type of renewable energy				Distributed
Year	Conventional hydro	Wind	Geothermal	Solar thermal	Solar photovoltaic	Solar photovoltaic
2006	289,246	26,589	14,568	493	15	NA
2007	247,510	34,450	14,637	596	16	NA
2008	254,831	55,363	14,840	788	76	NA
2009	273,445	73,886	15,009	735	157	NA
2010	260,203	94,652	15,219	789	423	NA
2011	319,355	120,177	15,316	806	1,012	NA
2012	276,240	140,822	15,562	876	3,451	NA
2013	268,565	167,840	15,775	915	8,121	NA
2014	259,367	181,655	15,877	2,441	15,250	9,536
2015	251,168	190,927	16,767	3,241	23,232	12,141

NA = not available. (Source: EIA 2016)

Production from renewable energy sources has detrimental environmental impacts, although the consequences are limited compared to traditional sources of fossil and nuclear energy. For solar, centralized photovoltaic installations contain small amounts of toxic substances that might be released especially if a fire occurred. Other environmental drawbacks to solar are perceived visual unsightliness and consumption of land. Visual issues for domestic use can be mitigated by specially-designed photovoltaic panels that blend in with roof materials, while solar plants are commonly located away from populated areas reducing visual impacts. Solar plants consume substantial amounts of land, the loss of which can be calculated based on the opportunity cost of the displaced land. Land consumption consists of the direct land use i.e. for towers, photovoltaic panels, and supporting infrastructure, as well as total land use of the entire area within the site boundaries of the installation (Ong et al. 2013). Averaging different types of technologies, one estimate indicates a solar plant consumes 3.5 acres per gigawatt-hour per year (Ong et al. 2013). There are sometimes hybrid solar and wind plants, co-located on shared land, which reduces land incursion. For instance an Australian hybrid solar and wind electrical plant co-located 64,000 photovoltaic panels and six large wind turbines on the same land area (Clover 2015). On the other hand, photovoltaic solar has the advantages of lack of any major pollutants, no noise effects, essentially inexhaustible supply, and long equipment lifetimes often over 25 years.

1.3.2 Wind Energy

Wind energy is the second major renewable energy type examined, and a prominent energy source in the Coachella Valley. It has a long history, which for many centuries consisted of stand-alone wind mills. Wind energy grew rapidly in the latter part of the twentieth century so that by 2010 there was 200 GW of wind energy capacity installed worldwide (Boyle 2012a).

Wind energy is based on converting the kinetic energy of wind into the rotational energy of turbines that, in turn, is converted into direct current electrical energy and then by an inverter into alternating current for input to the transmission grid. The electrical energy produced by wind energy is roughly proportional to the square of the wind speed. Since winds are stronger at higher elevations, often facilities are placed on high ground or tall turbines are utilized.

There are many sizes, shapes and orientations of wind turbines, which affect the efficiency of electricity production, and are suitable for particular local wind environments and facility designs (Boyle 2012a, b).

As with other renewables, wind energy has some adverse environmental impacts, albeit much less than for fossil fuels. For land-based wind facilities, certain animal species particularly birds are impacted. One study indicated that wind turbines collide with between 100,000 and 440,000 birds annually (Boyle 2012a). Another species impacted by turbines is bats. In some circumstances, birds and bats will learn to avoid turbines ahead of time. Furthermore, airplane traffic can sometimes be affected due to radar interference caused by wind turbines, but this is mitigated by locating of wind facilities away from airports (Boyle 2012a).

Noise is a common environmental issue from wind farms. A turbine's noise is roughly at the level of vehicles at moderate to low speeds. The noise can be reduced by spacing, since the noise impacts drop off with distance of office buildings or residential dwellings from the plant. Also, modern technological improvements in turbines have helped mitigate the noise levels (Boyle 2012a).

Another issue for a wind facility is its perceived adverse visual impact that lowers enjoyment of surroundings, an issue culturally and politically driven. Some cultures such as the Dutch have accepted the visual appearance of wind mills for centuries. Part of today's challenges is the rapid growth in size and number of solar turbines and the modern industrial design of large turbines, stretching hundreds of meters into the air, designs which are far removed from the feeling of familiar historic windmills (Pasqualetti et al. 2002). Although the pure environmentalist will not be happy with any modern wind facility design, some commentators have argued for a "pluralistic approach," stating that the same energy can be produced with insensitive utilitarian designs or with creative designs that are mindful of the taste and sensitivities of local citizens (Brittan 2002).

Because wind currents are irregular worldwide, wind patterns must be surveyed in targeted land zones, in order to place wind turbines where there are stronger and more consistent winds. Wind surveyors perform sampling at different times of the day and year, and at varied sites, to inform the decision on a wind installation (Tovar 2014). For complex landscapes with irregular wind patterns, computer simulation can be applied to better estimate the prime locations to conduct physical tests for potential wind facilities. Geographic Information Systems (GIS) has become a standard tool in prospecting for sites and modeling optimal locations.

The development of commercial wind energy involves land acquisition, permitting, design and construction of plants; and provision of access to the transmission grid (Tovar 2014). Land is commonly leased and then must receive a governmental permit to operate as a wind site. In applying for a permit the environmental impacts of the proposed plant and mitigation measures must be studied, documented and approved; existing or new transmission lines identified and approved; and contracts established with the utilities for power delivery. Developers perform most or all of these steps or sub-contract parts of them. Also, the development cycle depends on economic studies, which establish costs and benefits and compare alternative scenarios for risk-adjusted returns on investment. Workers are needed at all stages of the cycle including skilled experts in wind pattern analysis, land acquisition managers, environmental impact analysts, economists, business analysts, financial investors, entrepreneurs, power plant developers, and, once the facility is operating, operational and maintenance personnel. Residential wind energy development, considered in Chap. 2, is highly constrained due to its distracting environmental externalities.

Wind energy has grown rapidly in the U.S., from 4147 MW in 2001 to 74,472 MW in 2015 (AWEA 2015). It is widespread, with forty of fifty states having installations in 2015. From 2011 to 2015, capacity expanded by 27,542 MW (Bailey and Davidson 2016), reflecting a strong national thrust towards this largely non-polluting and abundant energy. Wind energy has been stimulated over the past decade or so by federal incentives, an aspect continued with the extension of federal incentives for wind energy for the period 2016–2021, enacted by Congress in late 2015.

Geographically, five states accounted in 2015 for over half of wind energy capacity. Texas leads with capacity of 17,713 MW. Its extraordinary capacity is driven by the state's large population, presence of very strong wind currents especially in central and western Texas, the primary location of the U.S. wind manufacturing industry in greater Houston metropolitan area, and state incentives. The latter include construction of Competitive Renewable Energy Zone (CREZ) transmission lines, which specifically serve the state's wind energy regions (Bailey and Davidson

2016). The CREZ lines have given Texas sufficient infrastructure to double its utilization of wind energy, enabling wind-generated electricity to be transported from remote Texas locations to the state's large population centers (Marston 2014). The state government has been supportive of wind energy initiatives. In 2014 wind energy accounted for 39.7% of Texas's electricity and has attracted substantial industry to the state (Marston 2014).

Behind Texas, Iowa ranks second with 6212 MW of wind capacity, followed by California with 6108 megawatts, Oklahoma with 5184 MW, and Kansas with 3766 MW (Bailey and Davidson 2016). Most of these states have broad stretches of flat prairie conducive to strong year-round wind currents. By contrast, California has natural areas of high-wind climate and topography in certain areas, one of which is the northwest part of Coachella Valley.

1.3.3 Geothermal Energy

Another form of renewable energy, geothermal, is relevant to this book because the Coachella Valley is neighbor on its south to the vast Salton Sea geothermal field and because a smaller form of geothermal energy production, ground source heat pumps, is starting to be installed in urbanized sections of the Valley. Geothermal energy stems from the heat of the earth, issuing from the planet's core, which has a temperature approaching 12,600 °F. That energy flows by slow convection to the earth's surface layers, where it is transferred by conduction to the earth's surface. The conduction layers have a significant heat gradient, i.e. the rate at which temperature rises with depth. The heat tends to have higher flows in areas core to the earth's tectonic plate edges, which includes the Coachella Valley and Imperial County to the south, areas also subject to high seismicity.

Geothermal energy is extracted by drilling boreholes that go down as far at 10,000 feet and which bring hot fluids (brines) to the surface, which can be utilized to run steam turbines to produce electricity or to be directly used for commercial heating. One drilling challenge is to find sufficiently hot fluids that once brought to the surface will be efficient and economically viable in producing electricity. The direct uses of the geothermal water are for space heating aquaculture, and heating of swimming pools and greenhouses.

Although direct uses of hot water have been present for millennia, the first commercial geothermal power plant was built and operated in Larderello, Italy, in 1913. It was followed by early plants in the Geysers in Lake County, California and in the Wairakei geothermal area in New Zealand. In 2015, there were 12.8 GW of operating geothermal electrical capacity, located in 24 countries, with an estimated 27–30 GW of projected electrical capacity to be added by the early 2030s (Geothermal Energy Association 2015). The direct heat energy use is also growing rapidly.

The environmental impacts of geothermal energy include noise pollution in well drilling and testing, disposal of used drilling fluids, air pollution emitted from power plants, induced seismicity, and longer term effects from land subsidence (Butler and

Pick 1982). Air pollutants emitted include CO_2, hydrogen sulfide (H_2S), sulfur dioxide (SO_2), hydrogen, methane (CH_4), and nitrogen, while used drilling brines are polluted with sodium and potassium chlorides, heavy metals, dissolved silicates, and sometimes carbonates (Garnish and Brown 2012). Although the issue of H_2S smell was substantial with early power plants, today it is reduced as a problem due to sophisticated chemical systems to mitigate it.

Although some CO_2 is emitted, a wind plant emits at one third the rate of a comparable fossil fuel plant and one seventh that of a coal plant (Garnish and Brown 2012). Another controversial environmental externality is seismicity induced by the geothermal drilling. Fortunately, this problem can be largely controlled by reinjecting the spent geothermal brines to restore the pressure originally present in the subsurface reservoirs. Reinjection also counters land subsidence, since the subsurface volume and pressure are better maintained. Finally there is a problem, as with solar and wind energy, of land use consumption, which reduces agricultural production and displaces farm workers (Pick et al. 1985). However, that reduction, mostly from a plant's spaced drill sites, is less than for solar plants having extensive photovoltaic panels and mirrors.

Ground source heat pumps are particularly relevant in Coachella Valley, since they can be used for heating in the winter and reversed for cooling in the summer, a system mechanism detailed in Chap. 2. The most noticeable environmental effect is noise, stemming from the mechanical operation of the heat pump, located indoors or outdoors. For a residential ground source heat pump the other externalities of commercial geothermal are largely not present or reduced.

Ground source heat pumps were responsible for 80% of the growth in direct geothermal heat from 1995 to 2010 (Garnish and Brown 2012), leading to an estimated 4 million such pumps installed worldwide by 2015 (author's estimate, based on Garnish and Brown 2012). It is expected that these ground source heat pumps will continue to spread rapidly including in the Coachella Valley.

1.4 Book Objectives

The objectives of this book are as follows.

a. Propose a model for integrated policy assessment of local and regional renewal energy development. The model considers the factor of federal and state conditions, including political structures, pricing of energy sources, and environmental standards. The model includes a second factor of site-specific characteristics consisting of the physical and geographical environments, social, economic, and demographic characteristics, supply and demand of renewable energy, and attitudes of local leaders. These two factors influence the local political systems and its policies and regulations. Some components of this model include location and can be spatially displayed and analyzed. Geographic information systems (GIS) and descriptive statistics are used as methods to reveal the spatial impacts of socio-economic, physical, manufacturing, and transportation characteristics on renewable energy policies.

b. Analyze the current state of renewable energy resources in the Coachella Valley and immediate surrounding areas. This is done based on data from federal, state, and local government agencies and nonprofit organizations, in order to assess the amount of solar, wind, and geothermal resources, their history, how they are situated, and their present operational use.
c. Analyze the demographic, labor force, economic, and social dimensions of the Coachella Valley and the spatial patterns of those dimensions with respect to present consumer adoption of renewable energy and to the small renewables manufacturing sector, and the implications for future expansion of the Valley's renewable energy consumption and production.
d. Examine findings on the business and governmental environment in the Coachella Valley for the development of renewable energy. This goal is addressed by data drawn from local and regional information sources and from findings of interviews conducted with Valley leaders in business and government. What is the market demand for renewables? How are regulations influencing this demand? What is the current extent in the Valley of manufacturing and in particular renewables-related manufacturing?
e. Compare the Valley's readiness for renewable energy manufacturing to two of the leading solar and wind energy manufacturing metropolitan areas in the nation. For solar energy manufacturing, the benchmark comparison is with the greater Baltimore-Columbia-Towson Metropolitan Area, and for wind energy manufacturing with the Houston-The Woodlands-Sugar Land Metropolitan Area. The comparison informs understanding of Coachella Valley's challenges and opportunities at an early stage of renewables manufacturing, in light of two exemplary regions which have progressed to a mature stage.
f. Analyze the emergence of renewable energy entrepreneurship and innovation in the Valley. Based on interview studies of seven small and medium-sized renewables companies and two city governments, and information from a leading regional business development organization, the profile of the Valley's emerging renewables sector is examined, including its supply chain, the role of nonprofits, support and regulation by governmental organizations, and implications of entrepreneurship and innovation for renewables development locally.
g. Synthesize, based on the other objectives, the Coachella Valley's important prospects and opportunities for development of renewable energy, as well as the problems and barriers.

1.5 Summary of Book Content

The book's seven chapters support these objectives. This chapter introduces the book's origin, project sponsors, and overall objectives, and addresses the setting and historical background of the Coachella Valley, as well as its prominent demographic and economic dimensions. The basics of renewable energy are introduced, stressing solar and wind energy, as well as geothermal, which is being slightly tapped in the Valley at the present time. The extent of use of these types of energy worldwide and in California is explained, environmental impacts introduced, and trends examined. Lastly, the book's objectives are presented.

Chapter 2 delves into more detail on the solar, wind, and geothermal resources as they relate to the Coachella Valley. The wind energy farms in the northwest Valley are described along with their potential for expansion along and restraining factors. For example, a new federal master plan of renewables in California's deserts might reduce growth in wind energy in the region. While solar energy is adopted increasingly for residential solar use, some uses are in industrial and government buildings. Nearby very large solar energy plants between the Valley and Arizona border will contribute energy to California's grid and indirectly add to electricity support in the Valley.

Geothermal energy is examined relative to the vast but underutilized Salton Sea geothermal resource centered approximately 50 miles south of Coachella City in the southeast Valley. The prospect of ground source heat pumps for domestic use is seen as a feasible geo-heat product and service for the Valley.

Also in Chap. 2, the displacement of land in dry-climate agriculture by renewable energy land use is discussed. An overview of the spatial arrangement of wind and solar plants in the region is given. The Renewable Generation Requirement (RPS) goals for renewables are examined, as well as the determination of many states and hopefully the nation to reach these goals within 10 to 25 years.

Chapter 3 explains the main conceptual model utilized in the book. The model of Integrated Policy Assessment of Local and Regional Renewable Energy Development (IPALRED) posits that extra-location conditions are exogenous influences on the renewables development process, leading in turn to consideration of site-specific characteristics, including the geography, physical environment, and demographic, social, and economic characteristics. They in turn influence a variety of policies for regional political entities. Overall this model provides the book's conceptual basis in applying the knowledge from extra-local and site-specific conditions to inform regional policymaking.

The chapter also mentions and Central Place Theory (CPT) (Christaller 1933) and its elaboration (Berry and Garrison 1958). CPT is a well-known geographic theory for understanding and comparing the complexity of cities and urban areas, is built on the concepts of centrality, range, and threshold, where the latter is the minimum market necessary at a given range to justify selling a good or service. CPT provides a conceptual background to understand the relationship of Coachella Valley to Los Angeles in being able to support markets for renewables, as well as in understanding relative maturity stages for renewables in the Valley's market versus national mature and leading regional markets.

The book's research methods of population projections, geographic information systems, and interview techniques are explained in this chapter, as well as the diverse sources of data.

Chapter 4 considers the socioeconomic and urban profile of Coachella Valley. The population and its cities are analyzed in detail and the population is projected to year 2030. The spatial patterns are analyzed of socioeconomic attributes including income, education, and wealth, and the section considers in detail the Valley's economic strengths, including its limited manufacturing sector.

The chapter concerns the commercial and residential markets for producing wind, solar, and domestic geothermal (ground-based heat pumps) in the Valley. Spatial analysis reveals the spatial arrangement of commercial wind and solar installations both within the Valley and to the East for solar. In the West, in the area of San Gorgonio Pass, hundreds of wind turbines output considerable electrical energy that is purchased by utilities for the electrical grid of southern California. That location has the advantage of not causing noise disturbance or physical danger to nearby populated areas, while also being close to large electrical demand of the metropolitan areas of San Bernardino and Riverside.

There are small solar plants within the Valley, currently totaling 55 MW (MW). It is clear that the Valley's own energy supply represents a high level of solar energy supply, about 10.3% (estimated) of the Valley's energy supply in 2013. Because of rapid growth in residential solar projected for 2014, we estimate the Valley will have 99.1 MW of installed residential solar capacity at the end of 2014. By contrast, between the western Coachella Valley and Arizona, there is a massive series of solar electrical generating plants in process of development/construction with several already operating. The total capacity in development/construction is 3077 MW, which equates to one and a half nuclear plants. Once built, the environmental externalities will be much less than for equivalent fossil fuel plants.

Chapter 5 compares the Coachella Valley with two benchmark national leaders, namely for solar the Baltimore-Columbia-Towson Metropolitan Area and for wind the Houston-The Woodlands-Sugar Land Metropolitan Area. The purpose is to identify key factors that led these areas to national prominence in renewables and to derive insights into how the Valley could look ahead, put in the right stepping stones and precursors to develop much a stronger renewable energy sector.

In doing this, the history of growth is examined for the benchmarks. Demographic, social, and economic attributes in the book's conceptual framework, the Integrated Policy Assessment of Local and Regional Renewable Energy Development (IPALRED), are analyzed for the benchmarks and compared to the same attributes in the Valley, to identify current strengths and weaknesses relative to readiness to expand renewable energy projects and initiatives.

Spatial comparisons are conducted between the Valley's underlying socioeconomic and transportation patterns and its presently limited renewables' manufacturing. The pattern of locating renewables facilities in those exemplary metros is then applied to the Coachella Valley's situation, and recommendations are made for future siting and zoning of renewable manufacturing in the Valley.

Chapter 6 focuses on the limited amount of innovation on renewables that is presently occurring in the Valley. For solar energy, solar battery assembly and control systems are undergoing small-scale R&D, while *Renova* has innovated in the maintenance of residential solar panels. For geothermal, *Desert GeoExchange* is introducing ground source heat pumps for residential heating, a product drawing partly on the world class expertise of its affiliated firm, *Geothermal Resources Group*.

Solar Power Cells is a small start-up firm with the goal to manufacture storage solutions for solar energy. *EV Enterprises* manufactures electronics components for renewable energy, which included battery chargers, control systems, and power supplies for emerging technologies such as lithium batteries and LED lighting. *Indy Power Systems*, headquartered in Indianapolis, Indiana, produces hybrid battery packs for electric vehicles that blend different types of batteries to provide lower costing, while *Heliotex* in Palm Desert produces automatic solar panel cleaning systems which are marketed regionally and are beginning to be sold nationally.

Although starting at a modest level, the products and services being produced by this handful of innovative firms could become a larger and more prominent cluster of renewables manufacturing and services. The supply chains for solar and wind energy are examined in order to identify where the interviewed companies fit on supply chains. The several firms examined serve as examples of the potential for the Valley to innovate in renewables. The roles of other stakeholders in Coachella Valley's renewables entrepreneurship are examined including nonprofits, innovation centers, universities, and local governments.

Chapter 7 first compares the case of Coachella Valley with the conceptual IPALRED model, to seek to understand what parts of the model were validated and other parts that could not be validated or were missing necessary data. Based on the IPALRED model and its fit with the Coachella Valley, prospects and opportunities for development of renewable energy are identified, as well as problems and barriers. The opportunities include financial benefit from the federal government's investment tax credit and the mandate to achieve the ambitious renewables standard set by the State of California. Another prospect for companies is to leverage strengths into innovation and entrepreneurship, assisted by local nonprofits. There are opportunities related to a significant semi-skilled labor force in the Valley. Moreover, the Coachella Valley's community colleges and university branches have ongoing initiatives in renewables and training. Development of renewable energy versus fossil fuels can reduce water resource usage in a drought period.

On the other hand, problems and barriers include an often stringent State of California regulatory environment, inconsistent county and city regulations, reduced entrepreneurial financing in the Valley, resistance to renewable energy by major utilities, limited resident scientific/engineering workforce for R&D, supply chain competition nationally and internationally, restrictions extending the transmission grid to serve renewable plants, and challenges in net metering and financial credit leading to expanded residential adoption of solar. The last chapter section underscores the critical importance of leadership in local and regional government, nonprofits, and businesses that are motivated to significantly develop the Coachella Valley's renewables sector.

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Chapter 2
Renewable Energy Features of Coachella Valley

Abstract The processes of climate change and greenhouse gas emissions provide a twenty-first century backdrop that accentuates the problems of adding to global warming through use of fossil fuels and coal. The UN agreement of 2015 calls for reduced warming and more renewable energy use. In contributing to reduced climate change, the Coachella Valley has had increasing residential use of solar energy and some geo-heat, while ample wind electrical generation is being provided initially by the large San Gorgonio commercial wind farms in the northern Coachella Valley. Probably the largest renewable energy in neighboring areas is the complex of large, utility-scale solar electricity plants in operation or being built east of the Coachella Valley. The chapter gives background on how the renewables-based electricity production can take place in the Valley and what the challenges are. Case examples are given of the San Gorgonio Wind Farms and cities of Palm Springs and Coachella. The potential shift from dry-climate agriculture to renewable energy land use is examined.

2.1 Introduction

This chapter builds on Chap. 1 by discussing the worldwide need for renewable energy, examining the national and state regulatory and policy setting for renewable energy, as well as considering the local political and regulatory issues in the Coachella Valley. Next, the chapter explores the estimates of residential solar use in the Valley. Current and projected electricity production from solar and wind plants are examined for the Valley and its surrounding region, including their spatial arrangement, and financial and environmental aspects.

The chapter also analyzes several medium-sized to large-scale renewable energy projects that are completed or ongoing, including the San Gorgonio Pass wind farms, Genesis Solar Energy Center, and City of Palm Springs solar initiatives. In the background of these projects are difficult challenges and problems for solar developers and operators. These challenges are exemplified by the troubling case studies of SunEdison and Abengoa, firms that have renewables projects in southern California.

The potential of ground source heat pumps for residential use in the Coachella Valley is considered in terms of national, regional, and local factors, and the

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opportunities of sharing agriculture and renewable energy on the same land is examined. The chapter conclusion brings together the current status, spatial arrangement, restrictions, development, and future opportunities for productive use of the Valley's solar, wind, and geo-heat resources.

2.2 Regulatory and Political Issues and Opportunities for Renewables

Renewable energy development is influenced by global, national, and regional regulatory and political issues. This section reviews several regulatory trends that underpin the prospects for renewables in the Valley and its surroundings. These trends set a background for discussing the local and regional extent of residential use and the production of renewable electricity from centralized solar and wind plants.

In the broadest sense, renewable energy in the twenty-first century is favored by the looming environmental threat to the planet from greenhouse gas emissions and global climate change. For more than two decades, this global crisis has been known. It became prominent with the reports of the Intergovernmental Panel on Climate Change (IPCC), based on a compendium of scientific investigations. The first IPCC report in 1990 has progressed to the fifth report of 2014, based on studies involving over a thousand scientists from 195 nations, a group that received the Nobel Prize in 2007 (IPCC 2015). IPCC reports warn, for this century, of expanding amounts of greenhouse gases in the atmosphere, rising global atmospheric and oceanic temperatures, rising sea levels, and melting ice sheets (IPCC 2015). Thirty percent of the emission of greenhouse gases is estimated for the U.S. to issue from production of electricity, with coal and natural gas accounting for 66% of electricity generated and over 90% of the CO_2 emissions (EPA 2016). These planetary issues have established an underlying need to focus on renewable energy sources as a crucial step to reduce greenhouse emissions.

The need to reduce greenhouse gases was reaffirmed as a global goal by the United Nations Climate Accord of December, 2015, and its accompanying agreements. The UN accord set the goal to limit the worldwide temperature rise for the remainder of the twenty-first century to less than 2 °C, with a preferred goal of 1.5 °C increase. Each of the 186 nations signing the agreement sets its own goal through its own nationally determined contribution (NDC), which is subject to review internationally (Eddy 2015; C2ES 2015). To specifically reduce carbon, the agreement includes a goal by the second half of the century of net greenhouse gas neutrality, which is the situation in which manmade greenhouse emissions will equal the removal of greenhouse emissions by "sinks." A "sink" is the sequestration of atmospheric greenhouse gases in the ocean or earth. Each country's NDC report will be subject to review every 5 years. To reach the end-of-century temperature goal, global financial investment in threat mitigation would need to reach $100 billion per year by 2020 and continue to grow after that (C2ES 2015).

Side agreements accompanying the main agreement focus more on renewables. The Mission Innovation Pledge commits 20 developed and developing nations to double investment in renewable energy every 5 years, while the Breakthrough Energy Coalition, under the leadership by Bill Gates, seeks to invest private capital in clean energy development (C2ES 2015). Additionally, the International Solar Alliance led by France and India has the goal to greatly expand solar energy usage in developing countries (C2ES 2015). The UN accord and accompanying side-agreements establish coordinated long-term goals. The worldwide consensus forms an umbrella under which national, regional and local renewable energy expansion in the U.S. can gain impetus.

In the United States, the Obama Administration set a goal to advance renewable energy use, which was reiterated and strengthened by Presidential measures which were announced in August of 2015 (The White House 2015). The measures included $1 billion in distributed clean energy loan guarantees; added financing for renewable energy in single-family housing, approval of a transmission line to provide electrical grid connection for a 485 MW photovoltaic solar farm in Riverside County; and R&D funding to double photovoltaic panel efficiency (The White House 2015). The measures were in concert with the sharp reductions in coal energy production mandated in the Obama Administration Clean Power Plan of 2015, as well as with the Administration's effort to make up for loss of coal production (Bailey 2016). Also in 2015, the Administration set the objective to lower greenhouse emissions by 2025 to 26–28% below 2005 levels (The White House 2015).

A federal legislative boost that will advance renewable energy production was the approval by the U.S. Congress in December of 2015 of a 5-year extension of the production tax credit (PTC) and alternative energy investment tax credit (ITC), with paced declines from year to year (Bailey 2016). Current renewable energy production projects starting up in 2016 will have the 30% tax credit, which will be phased down by 1/5 increments each year until the full phase-out occurs in 2021. The PTC and ITC, in place since 1992 and 2006, respectively, are notable federal benefits that have advanced solar and wind energy production and consumption, and they will continue in lessening amounts, timed to end just as the Obama Administration Clean Power Plan, possibly to be reduced or eliminated by the Trump Administration, will start up in 2022 (The White House 2015; Bailey 2016).

The federal government also has regulations that restrict renewable energy development by imposing air pollution standards and restricting use of federal lands. One new regulation that partly limits the potential of wind and solar energy development in the Coachella Valley is the plan and rules issued in fall of 2015 by the U.S. Bureau of Land Management (BLM) for locating wind and solar energy facilities on BLM lands in the California desert (Rader 2015). In this immense area of 22.5 million square acres, the plan calls for achieving a balance between environmental preservation and energy production. Although it sets the ambitious goal to permit 20,000 MW of renewable capacity on BLM lands, in another aspect, it is restrictive to future growth. This is because it allocates millions of acres to conservation and specifies only certain areas for renewable development.

An estimated 80% of the most optimal wind energy locations within the BLM lands in the California desert is restricted from wind development (CWEA 2015).

Although BLM conservation areas do not include Coachella Valley land, BLM areas impinge closely enough on the Valley's borders to restrict wind developments through "edge effects." For instance, a protected bird species in a conservation area neighboring the Valley also would have protection inside the Valley through flight patterns (Roth 2015). The plan also assumes large amounts of renewable energy will be developed on neighboring county lands, ignoring that each county is less and less inclined to allow for additional renewable development on its own land (Rader 2015).

Within the United States, the Renewable Portfolio Standards (RPSs) provide regulatory policies for most of the states, while some including California have unique regulations and policies. An RPS is a state policy that establishes a target percentage of energy production in renewable energy by a given date. For California, the 2015 RPS goal, approved by the state legislature and governor, is for renewable energy to account for 33% of retail electricity sales by 2020 and 50% by 2030. California progressed to nearly achieving at the 25% mark in 2015 (California Energy Commission 2015).

By comparison, the highest states in RPS have established targets between 2020 and 2045 as follows: are Maine (40% by 2017), Alaska (50% by 2025), Oregon (50% by 2040), Hawaii (40% by 2030, with 100% by 2045), and New York (50% by 2030) (National Conference of State Legislatures 2016). California's strong state government support for a high RPS goal is a positive factor for solar and wind energy production for the Coachella Valley and neighboring region.

By 2015 California's nameplate renewables capacity grew to 18.7 GW, of which 30.5% was in solar, 32.1% in wind, and 14.4% in geothermal, while renewable electricity generation was 20.0% in photovoltaic, 38.6% in wind, and 20.9% in geothermal, as seen in Table 2.1 (California Energy Commission 2015). Nameplate refers to the maximum capacity that can be offered by the given renewables facilities. The disparity for solar percent between capacity and generation is due to solar panel inactivity at night and in cloudy weather.

Historically, geothermal energy had led solar and wind energy up to 2011, when wind energy surpassed it (see Fig. 2.1). Solar was a minor source of electrical generation up to about 2011, when it commenced an exponential expansion, growing from 2000 GW hours in 2011 to 12,200 GW hours in 2015 (California Energy Commission 2015). The generating capacities of the leading renewable energy types in the U.S. are shown in Fig. 2.2.

Table 2.1 California renewable energy capacity and generation, in-state, by type, 2014

Type	Installed nameplate Capacity (MW)	Percent	Generation (GWh)	Percent
Solar photovoltaic	5700	30.5	12,600	26.1
Solar thermal	1250	6.7	2450	5.1
Wind	6000	32.1	12,200	25.2
Geothermal	2700	14.4	12,000	24.8
Biomass	1300	6.9	6350	13.1
Small hydro	1750	9.4	2750	5.7
Total	18,700	100.0	48,350	100.0

(Source: California Energy Commission, 2015)

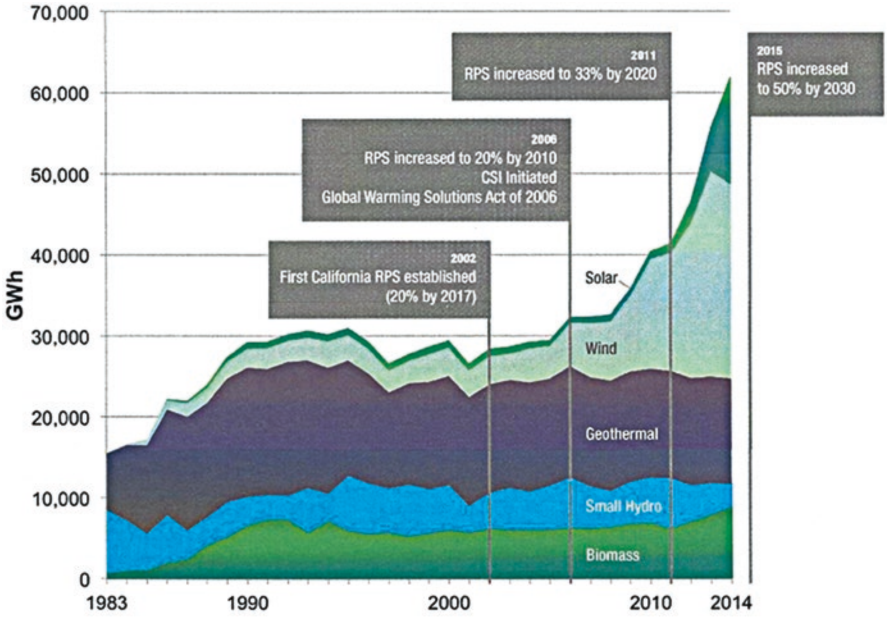

Fig. 2.1 California renewable energy generation by resource type, 1983–2014 (Source: California Energy Commission 2015, Fig. 9, p. 9)

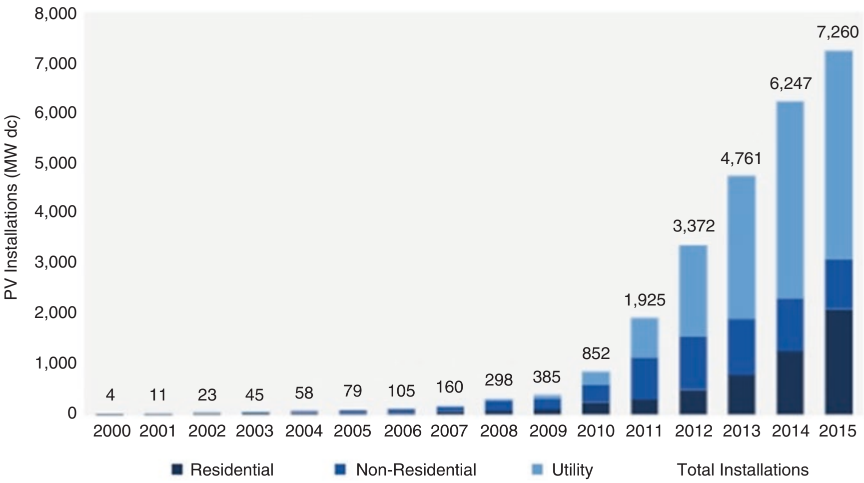

Fig. 2.2 Annual U.S. Solar Photovoltaic Installations, 2000–2015 (Source: GTM Research, Fig. 1.1, p. 5, March 2016)

The large and rapidly growing renewable sector and the ambitious RPS goals in California imply that new and expanded transmission lines need to be constructed, including to remote renewable production sites. In 2015, the state responded with the Renewable Energy Transmission Initiative (RETI 2.0), an executive order

(B-30-15) from California Governor Jerry Brown (California Energy Commission 2015). It required the California Energy Commission, California Public Utilities Commission, and California Independent System Operator (ISO) to identify the expanded and new transmission lines, which are critical to the speedily evolving renewables projects. The issue of California's transmission lines holding back renewable development is considered further in Chap. 5, relative to Texas's transmission grid success for wind energy.

2.3 Residential Solar Use in Coachella Valley

Solar residential utilization has been expanding rapidly since 2010 in the nation, California, and Coachella Valley. The reasons underlying the extraordinary expansion are reduced solar cost for households, improved photovoltaic panel efficiencies, backing of the Obama Administration, and state-approved net metering for solar home owners. In Coachella Valley, an important positive factor is a vigorous residential solar industry sector led by companies such as *Renova* and *Hot Purple Energy*, a topic examined in Chap. 6.

As shown in Fig. 2.2, annual residential solar additions in the U.S. grew in 2015 by 2099 MW, while non-residential solar photovoltaic expanded by 1011 MW, and utility photovoltaic increased by 4150 MW (GTM Research 2016). In 2010, the annual residential photovoltaic addition was only 200 MW while solar capacity additions grew 10-fold from 2010 to 2015.

A beneficial consequence of this considerable expansion is that California's small-scale photovoltaic installed capacity in 2015 totaled 5100 MW (California Energy Commission 2015). Small-scale refers to operating facilities of 20 MW capacity or less (California Energy Commission 2015; GTM Research 2016). Based on the ratio of state residential solar capacity to state population (California Department of Finance 2015), the current Valley population served with residential solar is estimated at 37,187 or about 7.4% of total population, but that proportion can be expected to rise considerably in the next few years. Similarly interpolating from the state, the Valley's installed residential photovoltaic capacity at the end of 2015 is estimated at 45.9 MW, with 10.3 MW added in 2015.

There are constraints on this sharp rise in residential solar use in the Valley which include the low average income in most of its urban periphery, a topic explored in Chap. 4, and resistance to solar by some of the homeowner associations in the Valley. The homeowner associations are known to be deeply concerned about what they consider unsightly appearance of solar panels to residents and visitors. Accordingly, many of the associations have required deposits and fees for solar construction within their territory (Roth 2015). If the restrictions are opposed by homeowners, the association holds the cards, through the leverage of potential association disapproval of future improvements sought by residents. However, favoring the residents to prevail over the association are federal and state laws that protect the homeowner, such as the California Solar Rights Act (CA Civil Code 14), enacted in

1978, which limits a resident's electricity loss from these homeowner-association restrictions to no more than 10%.

The Act also prohibits homeowner association restrictions that impose increases in solar energy cost to the homeowner of over $1000; requires an association that is violating the Act to pay the homeowner a penalty; and restricts the cost of required home aesthetic modifications to under $2000 (EIA 2015).

Geothermal energy plants are not present in the urban area of the Coachella Valley. This is due to possibly serious environmental problems, city code restrictions, and siting challenges. On the other hand, the ground source heat pump constitutes a promising form of residential renewable energy that is at an early stage of adoption in the Valley. In Chap. 6, the strategy of *Desert GeoExchange*, a division of the *Geothermal Resource Group*, to market ground source heat pumps in the Valley is examined.

2.4 Solar and Wind Plants in Coachella Valley and Surroundings: Capacity and Place

A large complex of solar and wind commercial electricity generating plants is located in the region neighboring the Coachella Valley, with a small set of plants within the Valley. Electricity from the complex is mainly sold to utility companies for distribution by means of the electric power grid, in particular over the Western Interconnection Grid. While small solar plants serve the Valley, the large wind and solar plants provide gridded energy throughout southern California and Arizona. Even though most of the energy is not being consumed within Coachella Valley, the Valley's proximity to these electrical renewable energy plants is propitious for development of renewable energy business and employment in the Valley, a potential considered further in Chap. 7.

Before analyzing the region's electricity-generating complex for renewables, the extent and spatial distribution of solar and wind electrical generation are reviewed for the U.S. As seen in Table 2.2, the national solar photovoltaic electrical generating capacity in 2013 was 5.2 GW (EIA 2015), which we interpolate, based on the Energy Department's 2020 projections, to be 7.8 GW in 2015, while the solar thermal electrical energy generating capacity in 2013 was 1.3 GW, which we extrapolate to 1.44 GW in 2015. As is evident in Fig. 2.3, most of this energy capacity is concentrated in California (over 2500 MW, i.e. 2.5 GW), with lesser amounts in Nevada and Arizona (1–2.5 GW each), followed by Florida (0.5–1 GW).

The national geographic distribution of solar plants, which are operating, under construction, or under development, is dominated by the massive complex of solar in California and adjacent areas in Nevada and Arizona, shown in Fig. 2.4. The solar plants include both photovoltaic plants (PV) and concentrating solar power plants (CSP) (SEIA 2016). Outside of the Southwest, solar concentrations are evident in Southern Colorado; West Texas; Baltimore, Maryland, and surrounding urban areas; Charlotte, North Carolina, and surrounding areas; and other parts of North Carolina; and southern Florida.

Table 2.2 Renewable energy net summer capacity in gigawatts, United States, 2013 and projections 2020–2040

	Net summer capacity generation (GW)						
	2013	2020	2025	2030	2035	2040	Annual % growth rate, 2013–2040
Electric power sector[a]							
Solar photovoltaic	5.2	14.4	14.7	15.7	17.9	22.2	5.5
Solar thermal	1.3	1.8	1.8	1.8	1.8	1.8	1.2
Wind	60.3	82.0	83.0	86.3	95.6	108.2	2.2
Geothermal	2.6	3.8	5.3	7.0	8.2	9.1	4.7
Wood and other biomass	3.3	3.5	3.5	3.6	4.2	5.5	1.8
Municipal waste	3.7	3.8	3.8	3.8	3.8	3.8	0.1
Conventional hydro	78.3	79.2	79.6	79.7	79.8	80.1	0.1
Total, electric power sector	154.7	188.6	191.6	198.0	211.2	230.6	1.5
All sectors							
Solar	12.7	27.6	31.9	39.0	48.3	60.6	6.0
Wind	60.5	82.7	83.8	87.3	96.7	109.7	2.2
Geothermal	2.6	3.8	5.3	7.0	8.2	9.1	4.7
Wood and other biomass	8.3	8.9	8.9	9.1	9.6	11.1	1.1
Municipal waste	4.1	4.3	4.3	4.3	4.3	4.3	0.1
Conventional hydro	78.4	79.5	79.9	80.0	80.1	80.4	0.1
Total, all sectors	166.8	206.8	214.1	226.6	247.2	275.2	1.9

(Source: U.S. Energy Information Administration, 2015)
[a]Electricity only and combined power plants with regulatory status

2.4.1 Solar Plants

This subsection describes in more detail the growing presence of utility-scale solar plants in southern California and the Coachella Valley region. In southern California, the largest solar projects (PV and CSP) are located close to Interstate 10 between the Coachella Valley and the Arizona border, shown in Fig. 2.5. The largest of these operating plants, the *Desert Sunlight* plants in Desert Center and *Genesis Solar Energy* in Blythe, total 0.58 GW. As seen in Table 2.3, an additional 1.325 GW from seven large solar plants are under development in the cities of Blythe, Desert Center, and in Riverside County (SEIA 2016). Two other very large solar plants under development somewhat further away from the Coachella Valley are the *Sterling Project* in Lake Havasu City, California, with 1.2 GW capacity, and the *Palen Project* near Desert City with 0.54 GW of planned capacity (SEIA 2016). If all these large plants are completed by 2018, the southern California region would have a total solar plant capacity of 4.30 GW, equivalent to about 40% of the nation's existing solar plant capacity in 2015. Another complex of large operating solar plants and development is located in southern Imperial County near the Mexican border

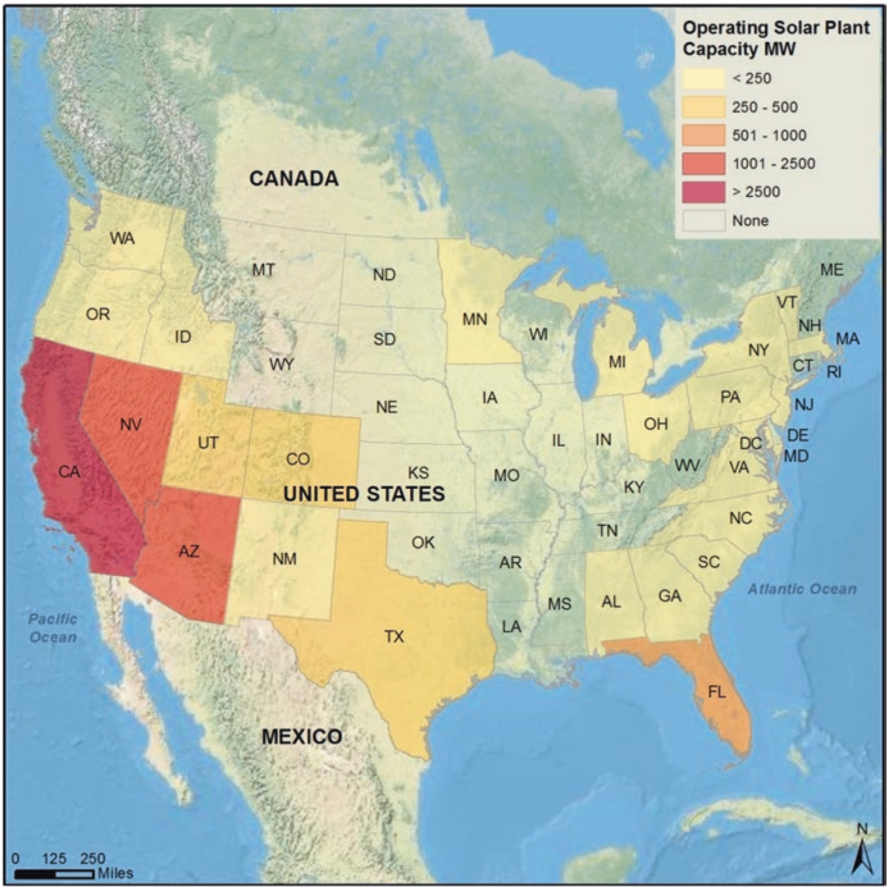

Fig. 2.3 Capacity by state of operating solar plants, U.S., 2015 (Source, SEIA 2016)

and is outside of the scope of this book, shown in Fig. 2.6, since its energy will be mostly gridded to the San Diego metropolitan area.

The solar plants in 2015 operating or under development in the Coachella Valley and neighboring areas (summarized in Table 2.3) comprise operating plants are all photovoltaic, while two other centralized solar power (CSP) plants, *Rice Solar Energy Project* and *Sonoran West* are under development in Riverside County (SEIA 2016).

Within Coachella Valley, there are two operating solar plants of 5–9 MW each, located in Palm Springs; one located in Desert Hot Springs of 9 MW; and four of 1–12 MW capacity located near the City of Twentynine Palms, which is about 30 miles northeast of Desert Hot Springs and separated from it by the Joshua Tree National Park, shown in Fig. 2.7. The latter plants serve Twentynine Palms, a fairly remote city. Overall, the solar plants within the Valley are currently offering minor amounts of electricity, although the City of Palm Springs has plans, considered later in the chapter, to expand its solar capacity.

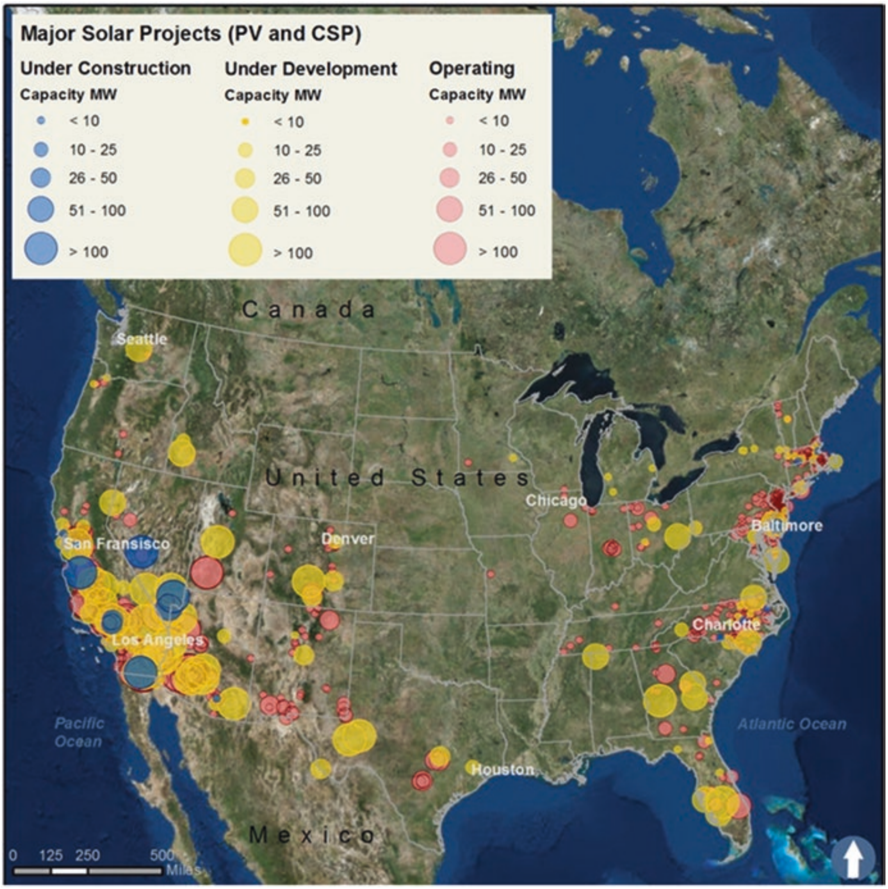

Fig. 2.4 Solar plants in the U.S., by capacity in MW and type, 2016 (Source: SEIA 2016)

2.4.2 Wind Plants

Wind energy, as explained in Chap. 1, is limited to geographical areas that have natural topographic and atmospheric features favoring wind. Coachella Valley is exceptionally endowed with natural wind features along the San Gorgonio Pass. This chapter sub-section first examines the national picture on wind energy, followed by California's situation, and then describes the San Gorgonio wind complex.

The nation's wind energy plants had a capacity of 60.3 GW of wind energy in 2013 (EIA 2015), which we extrapolate, based on Department of Energy forecast for 2020, to be 66.5 GW in 2015, an amount comprising 4% of the nation's total electrical generation. As shown in Fig. 2.8, the nation's wind energy capacity is dominated by Texas, followed by California and Iowa, and then by Washington and

Fig. 2.5 Obama Administration Interior Secretary Sally Jewell at Desert Sunlight Solar Farm, Desert Center, CA (Source: U.S. Department of the Interior)

Table 2.3 Solar plant projects Operating or in Development, Coachella Valley and Surroundings, 2016

Projects operating	City	Operator(s)	Technology	Capacity (MW)	County
Desert Sunlight 300	Desert Center	First Solar	PV	327.1	Riverside
Desert Sunlight 250	Desert Center	First Solar	PV	249.7	Riverside
Genesis Solar Energy Project	Blythe	NextEra Energy Resources	PV	125	Riverside
NRG Solar Borrego I	Borrego Springs	NRG Energy/SunPower	PV	26	Riverside
Subtotal				727.80	
Projects in development		**Operator(s)**	**Status**	**Capacity (MW)**	**County**
Blythe Solar I	Blythe	NA	PV	110	Riverside
Blythe Solar II	Blythe	NA	PV	125	Riverside
Blythe Solar III	Blythe	NA	PV	125	Riverside
Blythe Solar IV	Blythe	NA	PV	125	Riverside
Desert Harvest	Desert Center	EDF Renewables	PV	150	Riverside
Rice Solar Energy Project	Riverside County	NA	CSP	150	Riverside
Sonoran West	Riverside	Bright Source Energy	CSP	540	Riverside
Subtotal				1325.00	
Total				2052.80	

NA = not available (Source: SEIA, 2016)

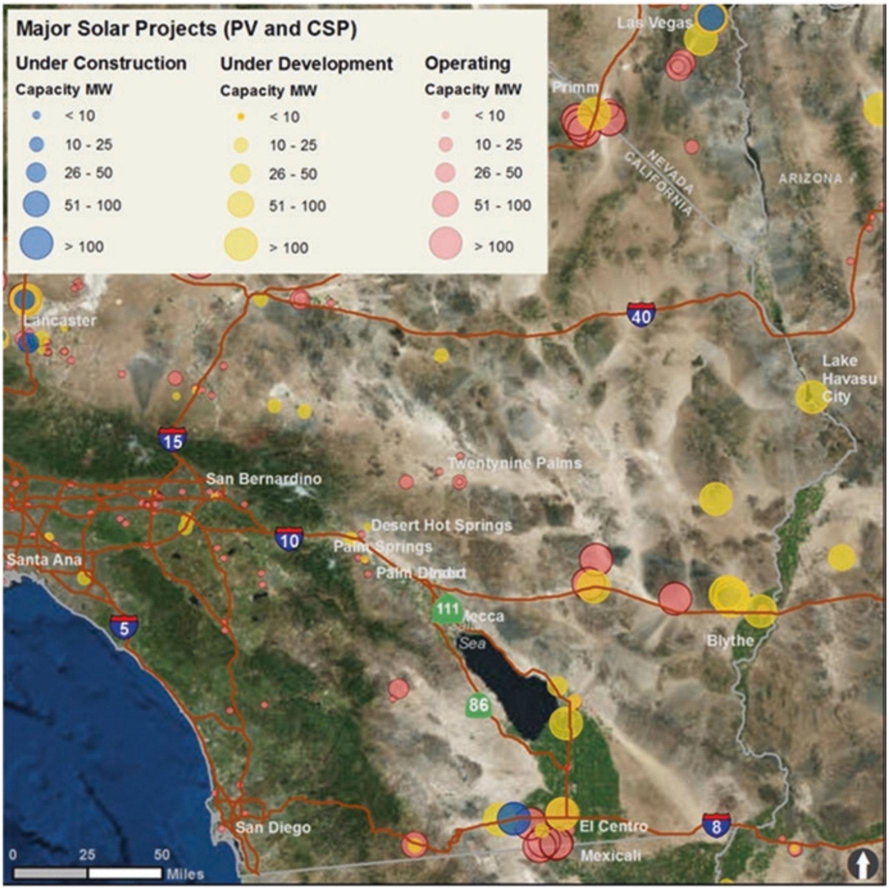

Fig. 2.6 Solar plants in Southern California, by capacity in MW and type, 2016 (Source: SEIA 2016)

Oregon in the Pacific Northwest and the prairie states of Oklahoma, Kansas, Minnesota, and Illinois. The spatial distribution of wind farms of over 100 MW, shown in Fig. 2.9, reflects the huge concentration in western and northern Texas as well as in Oklahoma and Kansas extending up to Iowa and Illinois and further north, while Southern California has several complexes of large plants and there are concentrations in the San Francisco Bay Area and parts of central Washington and Oregon. Because of its dominant state position in wind power capacity of 17.7 GW in 2015, Texas, and in particular the Houston-The Woodlands-Sugar Land Metropolitan Area will serve as a wind-energy-manufacturing benchmark for comparison with the Coachella Valley in Chap. 6 (EIA 2015).

California in 2014 had wind energy capacity of 6.0 GW (California Energy Commission 2016). In southern California, the spatial distribution of wind energy, shown in Fig. 2.10, reveals large geographic concentrations in the Tehachapi Pass

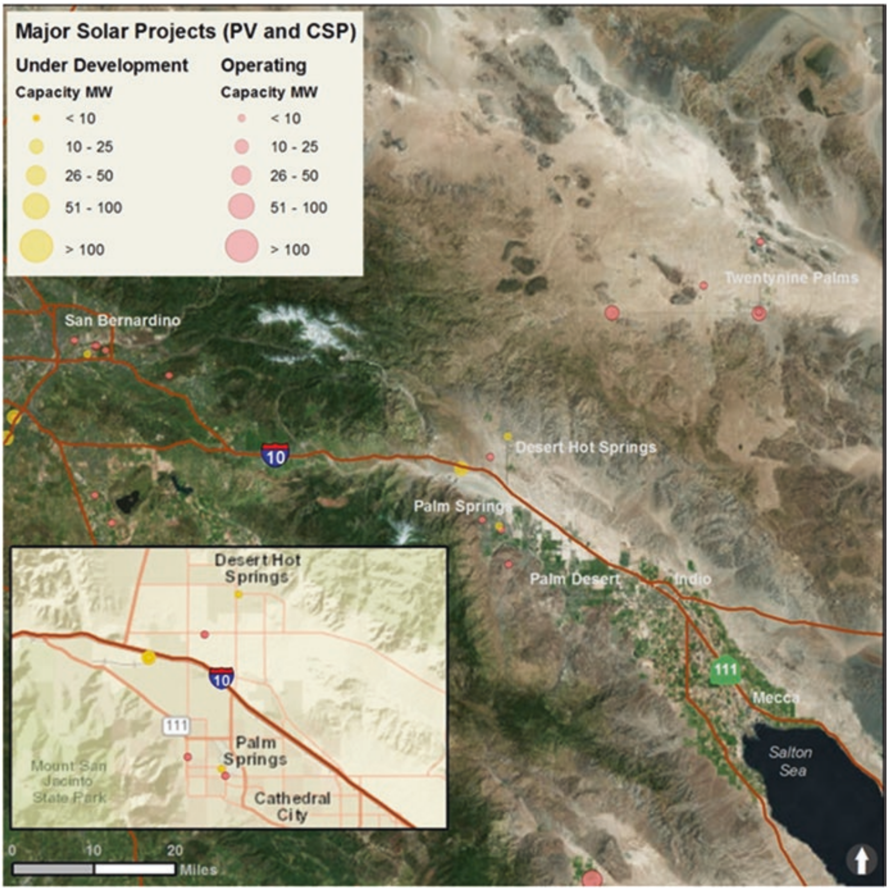

Fig. 2.7 Solar plants, Coachella Valley and surrounding area, by capacity in MW and type, 2016 (Source: SEIA 2016)

Wind Farm, between Los Angeles and the Central Valley at 3.24 GW, in the San Gorgonio Wind Farm at 0.75 GW, and in the Ocotillo Wind Energy Project in southern Imperial County, bordering Mexico at 0.31 GW (AWEA 2015; CWEA 2016). California's concentrated geographic distribution, compared to the wide dispersion of wind plants across the prairie in middle America, shown in Fig. 2.8, is due to the specific conditions of wind topography and climatology necessary to justify wind plants in California's more complex landscape.

The detailed mapping of the San Gorgonio Pass wind farms, shown in Fig. 2.11, includes many massive turbines, particularly in the Whitewater area, of between 1 and 2 MW each of capacity. The entire complex of 21 separately-owned farms stretches for 14 miles on the north and south sides of Interstate 10 (see photo in Fig. 1.4). Comparison of this map with the city boundaries of the Valley shown in Fig. 1.1 shows that the two urban entities directly bordering on the San Gorgonio

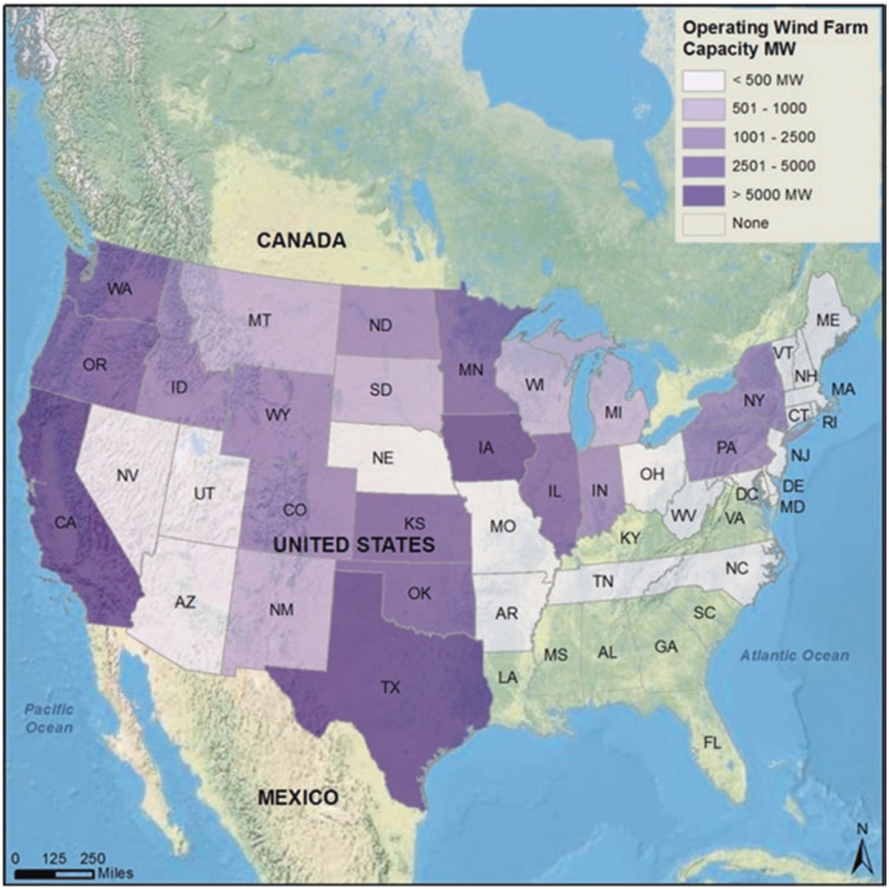

Fig. 2.8 Capacity by state of operating wind plants, U.S., 2016 (Source: AWEA, 2016)

wind energy complex are the City of Palm Springs in its northwest corner and the unincorporated Census Designated Place of Whitewater to the north of Interstate 10 between portions of the wind complex. The population of these areas is only several thousand people and is subject to some adverse environmental impacts from the wind complex, mainly sound. The close proximity of a wind farm in the San Gorgonio Pass to a rock quarry in the City of Whitewater is shown in Fig. 2.12.

The broader influence of this large-scale wind farm project on the City of Palm Springs will be covered in the next section. On the benefit side, these wind farms provide a source of renewable energy for the Valley and beyond, as well as the indirect benefits to the Valley of strengthening demand for suppliers, providing a small number of long term plant operating jobs, and adding to a local pool of knowledge about wind energy and renewables.

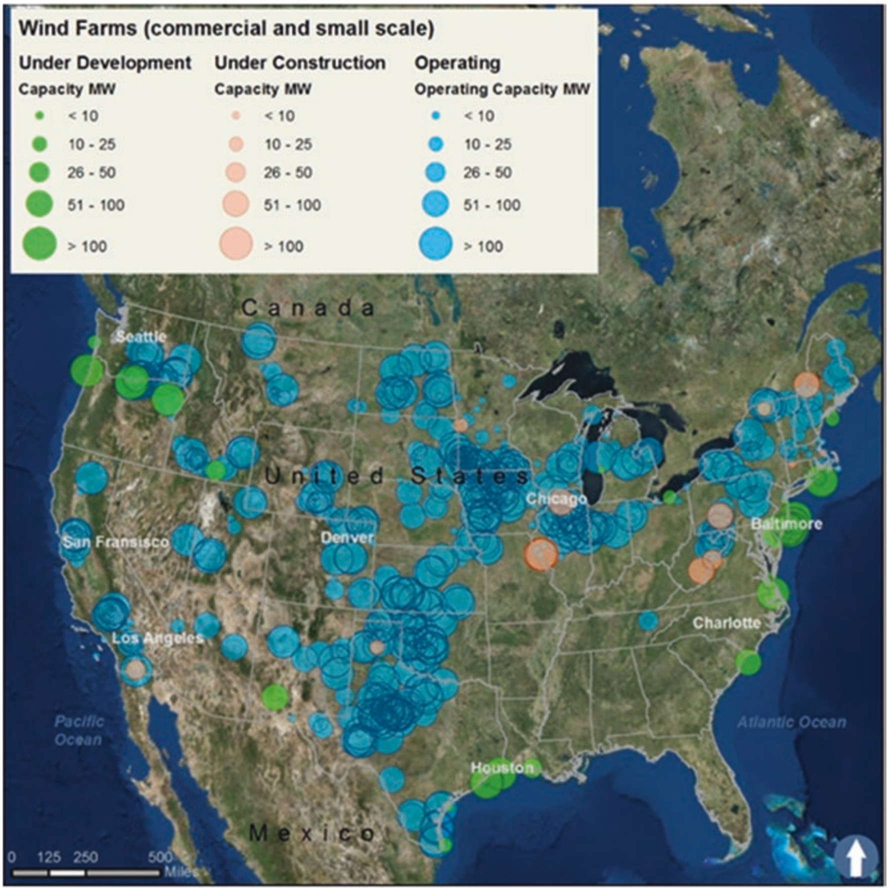

Fig. 2.9 Wind plants in the U.S. by capacity in MW and type, 2016 (Source: AWEA 2015)

2.5 Cases of Renewable Energy Projects in Coachella Valley and Surroundings

Several cases that illustrate the challenges of achieving success and sometimes failure in renewable energy production are the San Gorgonio wind farms, City of Palm Springs solar initiatives, City of Coachella's slow pace in renewables, the Desert Sunlight solar mega-plants, the *Genesis Solar Energy Project*, and the failures of *SunEdison* and *Abengoa*.

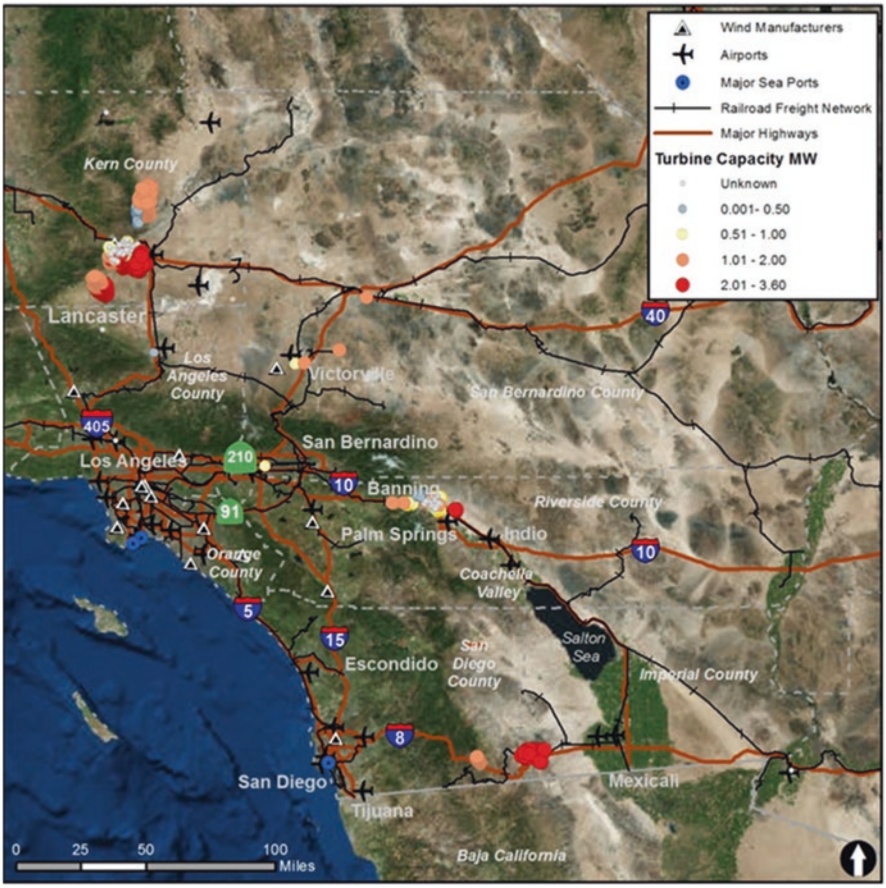

Fig. 2.10 Wind plants in Southern California, by capacity in MW and type, 2016 (Source: AWEA 2016)

2.5.1 Desert Sunlight Plants

The *Desert Sunlight Solar Farm*, located on 3800 acres of Bureau of Land Management (BLM) land near Joshua Tree National Park and six miles north of Desert Center, a town along the Interstate 10 between the Coachella Valley and Arizona border, represents one of the most successful solar plants in the U.S. The farm's twin plants have total capacity of 577 MW. The farm's success depended on a loan guarantee from the Obama Administration of $1.5 billion. Besides *Desert Sunlight*, the loan guarantee program helped 16 other large-scale solar plant projects and served to stimulate large-scale solar production nationally (Roth 2015). A key success factor for Desert Sunlight was to procure the necessary power purchase agreements (PPAs) with several large utility companies. Approval of PPA(s) in advance of construction is considered a necessity for obtaining renewable plant

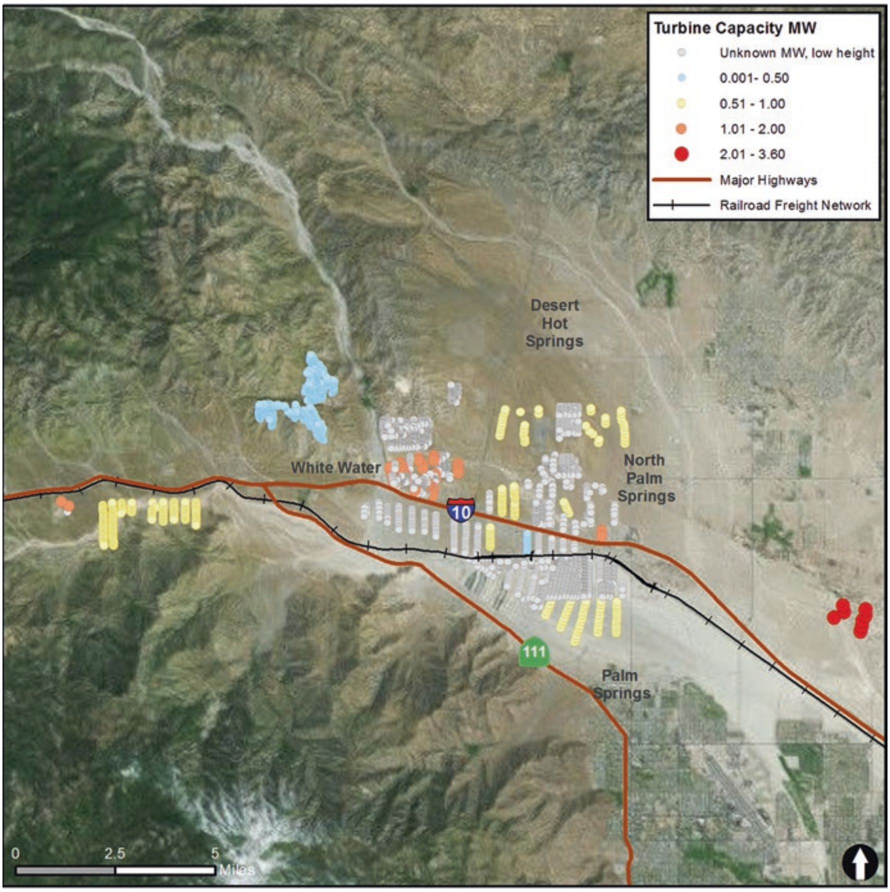

Fig. 2.11 San Gorgonio wind farm showing distributions of turbines by capacity in MW and type, 2016 (Source: AWEA 2016)

construction funding. Further, to gain local support, the developer, *First Solar*, donated a half million dollars for improvements to Desert Center's community center (Roth 2015); provided support to K-12 and community college education; and sponsored local events (First Solar 2016).

The *Desert Sunlight Project* employed 440 construction workers during its building phase (First Solar 2016) and continues to employ 15 full-time employees as long-term operating personnel (Roth 2015). The project also has provided $400 million in tax revenues to Riverside County and direct benefits to county businesses (First Solar 2016). On the downside, environmentalists and Indian groups have criticized the environmental impacts, while others opposed the twin plants as representing what they consider a wasteful federal loan program. Nonetheless, this large-scale solar plant project has been an overall success due to careful planning and attention to the needs of key stakeholders.

Fig. 2.12 A wind farm in the San Gorgonio pass in proximity to a rock quarry in the City of Whitewater, CA

Another successful solar plant project, *Genesis Solar Energy Project* from *NextEra Energy Resources*, was completed in Blythe, California near the Arizona border at a capacity of 125 MW. For *Genesis*, necessary PPAs were hard to obtain, so the plant ended up at 125 MW, half of its original design capacity of 250 MW. Ultimately the realistic plan of downsizing resulted in a loan guarantee and a fairly smooth development process. The plant currently employs 47 operational workers.

In contrast to these successes, other large-scale solar projects near the Valley in the federally-designated Riverside East Solar Energy Zone and the BLM land extending east to Arizona have been slowed down or stalled for several reasons, including slowing of the federal loan guarantee program, uncertainty for several years on whether the federal government's Investment Tax Credit for renewables would be renewed (it was renewed in late 2015, with slow phase out), strident Indian concerns, and environmental opposition. An example of the latter is the statement of criticism in 2015 from the nonprofit organization, Basin and Range Watch, that includes environmentalist and Indian members, regarding the stalled 484-megawtt *Blythe Solar I-IV Solar Power Projects* (AWEA 2015), located just west of Blythe. They stated that "the site [of the Blythe Solar Project] was home to several archeology sites, Pleistocene desert pavements with old, rounded river cobbles, old growth desert ironwood trees and other microphyll habitats. This is all being converted to a large photovoltaic facility" (Basin and Range Watch 2016).

Several other large solar plant projects on hold in the area between Coachella Valley and the Arizona border are *Desert Harvest* (150 MW capacity) from EDF Renewables; *Rice Solar* (150 MW); and *Sonoran West* (540 MW) from Bright

Source Energy (AWEA 2015). These developers have faced similar challenges in obtaining PPAs from the major utility firms, partly because the utilities had already reached their state-mandated RPS targets. Adding to the challenge have been the growing difficulty in garnering federal loan guarantees, gradual phase-out over the coming years of the federal investment tax credit for solar investment, and strong opposition from environmental and Native American constituencies.

Box 1: Solar Failures of Global Firms, with Implications for Coachella Valley and Region The problems and challenges of developing solar plants were epitomized in the 2015 bankruptcies of two very large solar firms, SunEdison and Abengoa, both of which have solar plant projects in southern California, including SunEdison's small planned municipal solar project in Palm Springs. Their experiences serve as a warning sign about the risks inherent in the renewable energy industry.

SunEdison, originally a manufacturer of components of chemicals, which later proved important for photovoltaic panels, was founded in Missouri in 1959. It grew along with the solar industry into a multi-billion dollar developer, with vertical integration extending from panels to solar plants, more than 3000 employees, over 2 GW of solar plant operating worldwide, and claimed, prior to March 2016, to have the largest portfolio worldwide of solar systems (SunEdison 2016). However, in April of 2016, it fell into serious trouble due in part by taking on too much debt, making the disastrous acquisition of Vivant Solar, and creating risky arrangements with utility companies known as yieldcos (Solomon 2016). A yieldco is a separate firm spawned off from a renewable developer which purchases renewable energy plants from the parent company and operates them, while still planning to give regular stockholder dividend payments.

SunEdison's debt at the time of its bankruptcy was $11 billion, which stemmed from an accumulated series of acquisitions as it sought to grow rapidly. When SunEdison was presented with the opportunity to acquire the major residential solar firm, Vivint Solar, at the price of $2.2 billion, in order to make the purchase payment SunEdison was forced to go beyond its limited cash reserves and garner a loan from Goldman Sachs as well as to force one of its yieldcos, TerraForm Power, to contribute to SunEdison's purchase balance of $1 billion, mostly with its own equity (Solomon 2016). Unfortunately, this whole arrangement toppled over when the stock prices of SunEdison and its TerraForm Power subsidiary crashed due to SunEdison's huge debt and increasing global oil prices. When SunEdison tried to exit the Vivint purchase, Vivint sued SunEdison for $1 billion, resulting in the pullout of SunEdison's lenders and inability by SunEdison to pay its financial obligations, forcing it into bankruptcy on April 21, 2016 (Cardwell 2016). In the process, the City of Palm Springs yanked away from SunEdison its seven small solar projects, and proceeded to approach other developers. The moral of the story is that a renewables firm should avoid becoming so absorbed by acquisitions that it develops a complicated and overly large debt structure.

Another unsuccessful example of solar renewable growth is Abengoa from Spain. Once a global giant in solar renewables, Abengoa also mishandled its finances, although differently than SunEdison. Abengoa was founded in Seville in 1941 to manufacture electricity meters, and it later progressed to putting electrical panels in buildings and factories. After implementing its initial CSP solar plant in Spain during 2007, it grew to world leadership in centralized solar production. By 2016 it commanded a quarter of the world market for CSP plants (Minder 2016). This included the Solana and Mohave CSP plants in the U.S., which were planned to benefit from huge U.S. federal grants, tax credits, and federal government loan guarantees.

Abengoa's sudden fall was due both to the combination of cessation of subsidies by the Spanish government and softening of the solar thermal demand in Spain (Minder 2016). Debts mounted and in 2016, Abengoa declared bankruptcy in the U.S. under Chapter 15, which applies to cases where a bankruptcy case outside the U.S. is the dominating case. The Spanish bankruptcy, if it occurs, will be one of Spain's largest ever (Fitzgerald 2016a, b). This was again a case of a global solar firm growing more rapidly than its financial base could support. The trigger here was loss of subsidies and weakening solar markets in the home nation. Both cases represent the downside of a rapidly expanding solar market. To sum up, the cases underscore the need for prudent planning and controls of solar industry growth.

2.5.2 San Gorgonio Wind Farm Complex: History and Development

The San Gorgonio wind farm complex is the nation's oldest; its first wind turbine having appeared in 1980 (Breeding 2013). Developers initially reasoned that since its land was subject to sandstorms and marginal for economic development, there would not be problems and opposition (Pasqualetti 2011). However, the early start-up began to face major push back from a variety of stakeholders. The utility company for the wind farm, Southern California Edison (SCE), was tentative in its early support, worried about how to interconnect the wind energy with existing energy flows. Additionally, planners in Palm Springs and nearby localities were concerned with keeping the project in line with conservative and prudent planning (Throgmorton 1987). More strident pushback came from environmental groups which registered complaints about the wind farm's unsightliness. In response to rising prices at the time, a publicly owned Desert Public Power Association (DPPA) was founded to manage the development of energy resources in the Valley (Throgmorton 1987).

Due to citizen resistance and discontent with the wind farm, Riverside County commissioned a public opinion survey in the mid-1980s. The survey results indicated that the public mostly felt wind energy should be implemented, although a third of respondents were concerned that the land value near the wind farm would be devalued (Pasqualetti and Butler 1987). However, this mostly supportive public opinion was not reflected by the local press, which opposed the development (Righter 1996). In 1982, city and county planners responded by imposing zoning restrictions and limiting turbines to certain land areas, putting a cap on the height of turbines, and other steps (Throgmorton 1987; Pasqualetti 2011). Consequently, the earlier surge in development was stalled.

Nevertheless, by the mid-1990s, opinion and support had gained favor of the San Gorgonio wind farms. The county and city officials concurred that the problems of wind projects interfering with farming were "non-existent" (Righter 1996). The City of Palm Springs realized it could have substantially more tax revenue, while also mandating that unused wind facilities would be dismantled and removed to restore the land to its original condition (Righter 1996). Additionally, ordinances to protect rare birds were passed that required the reporting of birds killed by wind turbines (Pasqualetti 2011). Fortunately for the developers, the issue of noise complaints lessened as wind turbine technology advanced steadily in reducing noise.

This historical sequence has resulted today in one of the nation's largest and most successful complex of wind farms. The obstacles and arguments along the way were resolved allowing renewable development in Coachella Valley. The case shows that a municipality can contend with community opposition, yet end up with acceptance by the community as well as with regulation and controls in place.

2.5.3 City of Palm Springs' Bumpy Success in Renewables in City Properties

This case examines the City of Palm Springs recent initiative to implement solar photovoltaic electricity in many of its city premises. The city's interest stemmed from the pledge from the City of Palm Springs to lower greenhouse gas emissions, by year 2020, to 7% below the levels in 1990 (Roth 2016a, b). The city proceeded to negotiate contracts with SunSolar and SunEdison to install photovoltaic panels at the city facilities in Sunrise Plaza, the Palm Springs convention center, Demuth Park, the Desert Highland Unity Center, a wastewater treatment facility, a downtown parking structure, and a fire station. The cost savings annually to the city was estimated at about $25 million over 25 years (Roth 2016b). Some criticism was received from local solar photovoltaic operators particularly Renova Energy (see Chap. 6) who felt that the City should have chosen local Valley developers.

The city initiative stalled for a while due to the 2016 bankruptcy of SunEdison. Fortunately, the city planners had not attained final city council approval of the SunEdison contract. The city dropped SunEdison and moved to two runners-up in the bidding process, Renova from Palm Desert and SolarCity from San Mateo, to take over the former SunEdison-designated projects (Roth 2016b). This case illustrates the motivation of the City of Palm Springs to set an example by implementing renewables for its own facilities, while it also reveals negative attitudes from local solar firms which felt passed over by the original award to SunEdison.

2.5.4 Planning Policies for Renewables Development in City of Coachella

The City of Coachella's lukewarm stance on renewables contrasts with the Palm Springs case. Following a boom time, the Coachella was hit hard economically by the Great Recession of 2007–2010. The recession brought high unemployment, elevated rates of foreclosure, and abandonment of some real estate subdivision projects. Although the city recognized the need in the long term to address environmental challenges to reduce greenhouse gas emissions, achieve energy efficiency, and assure good water and air quality (City of Coachella 2015), in the post recessionary period it had to confront immediate challenges to lower the high rate of poverty (as high as 25%), re-start its housing and real estate sectors, and improve substandard infrastructure. The latter priorities reduced its attention on renewable energy.

Nonetheless, in its General Plan Update of 2015, Coachella adopted "Sustainability and Natural Environment Goal 2," which is to attain "an energy efficient community that relies primarily on renewable and non-polluting energy sources" (City of Coachella 2015). Eleven of the fourteen polices under Goal 2 encourage renewable energy development particularly "passive solar design, alternative energy (solar, wind, biomass) in public and private developments, renewable energy for open-space areas, prohibition of new developments and renovation that impede solar access, allowance of renewable energy projects in passive open space, and the requirement for passive solar design features in public buildings" (City of Coachella 2015). Although these are planning policies, rather than accomplished projects, adoption of the General Plan Update represented, for the first time, a broad city commitment and higher priority for renewable energy development. This is promising, especially given that the City of Coachella comprises a poorer and less educated part of the Valley.

2.6 Ground Source Heat Pumps for Coachella Valley

Building on Chap. 1, this section discusses the principles of the ground source heat pump (GSHP) in greater depth, its environmental effects, the economics of this technology, and the prospects for marketing it in the Coachella Valley. The GSHP is a building-based or home-based centralized cooling and heating system driven by flows of different temperatures between the building or home and the subterranean earth (Boyle 2012). A GSHP in a home is shown in Fig. 2.13. The GSHP depends on the principle that beneath a certain depth in the ground, i.e. under about 10 feet, the temperature ceases to fluctuate much and approaches the average air temperature throughout the year (Department of Energy 2016a, b). In the hot air temperatures of the summer, when people seek cooling in their homes, heat can be pumped by the GSHP from the interior of the home into the ground, which is cooler.

Analogously, in the winter, with cool air temperatures outside, and the home needing heat, the GSHP can pump heat from the ground into the home, which is warmer than the subterranean ground source. Once in the home, the heat is moved by a refrigerant, which becomes hotter or colder through a compression cycle of conversion between vapor and liquid states by an evaporator, compressor, and condenser. The movement of heat absorbed from the ground into the house is referred to as the ground loop. There usually is also a secondary closed system, in which the evaporator provides the heat to a refrigerant gas which is then compressed, elevating the temperature of the gas. Finally the compressor transfers the heat to the home's or building's central heating, with the cooled water being returned to the earth through the ground loop. In the ground the tubing can be looped deep down vertically to 100–500 feet, or can be arranged horizontally in a shallow trench at depths

Fig. 2.13 Ground source heat pump inside a home (Source: Yorkshire Housing)

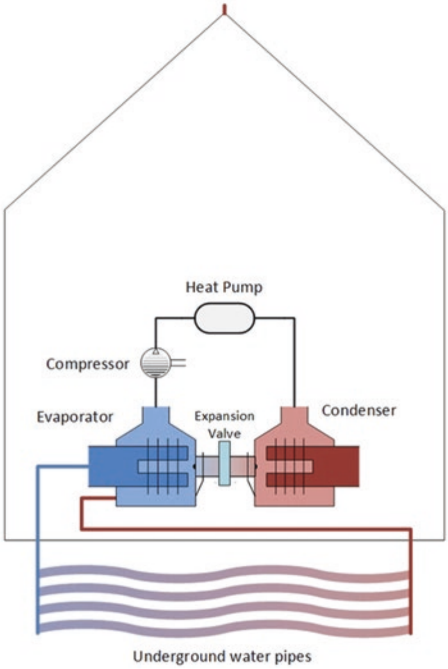

Fig. 2.14 Closed loop system for a Ground Source Heat Pump

of 3–10 feet, see the diagram of a closed loop system in Fig. 2.14. The deep, vertical systems gain heat mostly from the surrounding geologic layers, while the shallow-trench systems gain heat from the sun.

In another design, the open system, water is taken out of a water body, forms a circulation loop, and exchanges heat with the primary loop, and then ends up returning water to the water body or injecting it into the ground. This is used less often in the Coachella Valley, as it depends on having a water body nearby.

The heat pump is located in the home or building and constitutes its central heating/cooling equipment. It has a variety of optional design features, such as providing hot water, water to melt pavement ice, and space heating or cooling. It replaces the conventional furnace and air conditioner, and compared to them is significantly more efficient.

The GSHP is environmentally sound, being high in energy efficiency and non-polluting.

A minor environmental detriment is presence of some noise affecting the home or building occupants and immediate neighbors. Electricity necessary to run the GSHP system constitutes a cost, but among other things solar panels can be installed to offset it. With vertical drilling, there is also the remote environmental risk of accidentally encountering a water pocket might result in overspill at the surface.

Economically, a GSHP involves large capital investment, but subsequent savings for many years compared to competing technologies. In 2015, a GSHP has up-front cost of over $15,000, with a break-even point of 2–10 years through lowered utility bills. Since 2009 there has been a federal 30% tax credit allowable on a qualified

GSHP system (Department of Energy 2016a). In the winter, a GSHP has average efficiency, ratio of heat output to electricity input, of 300–600%, compared to 175–250% for conventional air-source heat pumps (Department of Energy 2016a, b). Presently about 50,000 GSHPs are installed annually in the U.S.

Another aspect of cost is that vertical systems require much less land area than horizontal systems, implying that locations with high land value are suitable for the more expensive vertical systems. Since the siting of the subterranean components depends on knowledge of the soil layers and geology, costly professional advice is needed for this aspect as well as for proposing the appropriate system design.

In the Coachella Valley, GSHPs for homes and buildings are in the early stage of adoption. Several factors that influence GSHP adoption in the Valley are levels of citizens' incomes and the challenge of balancing GSHP heat flows in a desert environment. The market for GSHP favors affluent residential buyers, since a GSHP requires a large up-front capital cost. For a poor family residing on a small land plot, ironically the cost is even higher due to the need for vertical drilling and tubing. Moreover, there is not a financial credit vehicle presently widely available in the Valley for low income citizens to obtain loans for a GSHP. Early market residential penetration will mainly comprise affluent homeowners who have the means to pay or finance the up-front cost, can afford the elevated electrical charges that typify the Valley, and who tend to favor a sustainable environment.

A GSHP needs to be designed to balance the heat flows throughout the year. This means the heat taken out of the ground in the winter should be approximately equal to the heat returned into the ground in the summer. In the Coachella Valley, a design challenge in the desert environment is that much more heat is put into the ground in the summer due to the high outside temperatures than can be extracted in the winter, potentially causing an imbalance, so that ground temperatures tend to increase over time (Osborn 2014). This problem can be alleviated by drilling extra bore holes to relieve the heat build-up in the ground.

One of the pioneering companies, Desert GeoExchange is discussed in Chap. 6. Some of the early projects by Desert GeoExchange have been at federal installations and at Sunnylands, the former Annenberg estate now run by the Annenberg Foundation. These entities are financially solid; able to look at the long-term for payoff in lower energy costs; and are willing to take risk in achieving a sustainable alternative.

In summary, the ground-based heat pump constitutes a promising alternative in the Coachella Valley for the heating and cooling of homes and buildings, and offers long-term energy savings and higher efficiencies, with the caveat that start-up costs are significant and successful systems require careful, professional design.

2.7 Renewable Energy and Agricultural Land Use

Given California's, including the Coachella Valley's, robust agricultural sector, development of centralized renewable power plant benefits from being co-located in agricultural land. Although this co-location is less feasible with centralized solar energy due to land coverage with panels or mirrors, it is more readily done with wind centralized facilities (Ravi et al. 2016; Union of Concerned Scientists 2016). Co-location is also accomplished with geothermal centralized power plants (Butler and Pick 1982), although that aspect is not considered further since there are no geothermal plants in Coachella Valley.

California has considerable agricultural land and the most state agricultural production nationally. In 2012 California's farm acreage of 25,569,001 ranked 14th in the nation (American Farmland Trust 2016), but the sales value of all its agricultural products was the highest nationally, at nearly 11% of the national total (USDA 2014). In 2012, California also led the nation in the number of farms that produce renewable energy at 5845, versus 2nd place Texas at 4824 farms. Since California had 80,500 farms in 2012 (USDA 2014), 7.3% of the state's farms were doubling up by having co-located agricultural and renewable energy production. Based on state farm acreage and Coachella Valley's 65,745 acres of farmland (Marx and James 2015), we estimate that fifteen Coachella Valley farms are doubling up with agriculture and renewable energy in 2012. Farms that would fit into this pattern would most likely be near small solar plants with distributed photovoltaic panels, allowing the co-location of the panels and cropland (Ravi et al. 2016; Union of Concerned Scientists 2016).

Co-location within the area of the San Gorgonio Wind Farm is hampered by land unsuitable for agriculture. Another constraint is the necessity for close proximity of eligible farms to transmission lines, since even at fairly short distances installing a transmission line from the farm to the transmission grid is very expensive. In spite of these obstacles, there is the potential for city governments, especially in more rural parts of the Coachella Valley to provide subsidies or tax credits to stimulate Valley farmers to consider co-location of agriculture with wind turbines or spaced solar panels on suitable farms.

2.8 Conclusion

The global challenges of carbon pollution and climate change constitute a backdrop that raises the importance of developing renewable energy solutions nationally, statewide, and locally. The background and features of renewable energy are considered, and the present levels, spatial arrangement, and expansion of renewable energy in the Coachella Valley and surroundings are analyzed. There are regulatory and political constraints, as well as incentives, that are present at the federal, state, and local levels which favor certain approaches to renewables in the Coachella Valley.

Residentially, the Valley's most developed renewable energy type is solar photovoltaic panels, while residential wind energy has a very low adoption rate. In Coachella Valley, ground source heat pumps are in the early adoption phase. At the level of power plants, the large-scale but challenged rollout of solar and wind plants has been found to be feasible but constrained by market demand for renewable energy once RPS goals are achieved, by some environmental issues, and by regulations.

Cases are described of the successes and failures of particular renewable energy projects in the Valley and surrounding regions, including the San Gorgonio complex of wind farms, large-scale solar plants, and renewable initiatives or lack thereof by cities. A warning signal about unchecked growth and greed are the bankruptcies of the solar giants SunEdison and Abengoa, both of which have operated solar plants in southern California. Lastly, the benefit of co-locating renewable energy production and agriculture on farm land is examined, and although its present impact the Coachella Valley is small, co-location may increase as farmers seek more diversification and as agricultural land becomes scarcer. Overall, this chapter explains and reaffirms that there are ample renewable resources in the Valley and its surroundings, indicates the pathways so far that have been taken to develop the resources, gives caution about risks and constraints that may impede the utility and benefit of the resources.

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Chapter 3
Conceptual Models and Methods

Abstract This chapter introduces and explains the conceptual models for the book, the Integrated Policy Assessment for Local/Regional Renewal Energy Development (IPALRED) and Central Place Theory (CPT). IPALRED considers the influences of the factors, (a) federal and state conditions and (b) renewable site-specific characteristics, on (c) renewable policies for local and regional political systems. The detailed components of these factors are described and several renewable site-specific characteristics for which GIS is applied are identified, such as the geographic environment, and demographic, social, and economic characteristics. GIS could not be applied to some model components because relevant spatial data were not available. The IPALRED model forms the conceptual backbone of the overall study, and is examined based on qualitative and quantitative data. The book's exploratory research methods are described, which include descriptive statistics, GIS, and interview techniques; and the sources of data are described. The second conceptual model, Central Place Theory (Christaller, 1933; Berry and Garrison, 1958) provides the background to understand the relationship of Coachella Valley to Los Angeles in being able to support markets for renewables, as well as in understanding relative maturity stages for renewables in the Valley's market compared to leading metropolitan markets. CPT is not tested formally in this book, with only the single Coachella Valley case, but is recommended for testing in broader, more data-intensive future studies.

3.1 Introduction

The book's renewable energy research project was designed with the goals of understanding current renewable energy prevalence, location, consumption, manufacturing, and the supply chain in Coachella Valley. In addition, the project evaluated the Valley's potential for future development of the renewable energy sector. The chapter begins by presenting and explaining the research goals of the study. Next, the chapter presents the conceptual theories that the study is based on. The primary theory is the Model of Integrated Policy Assessment of Local and Regional Renewable Energy Development developed by the author. This theory conceptualizes how an integrated policy assessment of renewable energy development leads to

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local and regional decision-making and renewable energy policies. A secondary theory, Central Place Theory (Christaller, 1933; Berry and Garrison, 1958) is also discussed within this chapter. It is useful in making comparisons between a range of metropolitan and urban regions.

The chapter explains the research methods utilized in this study, which consist of descriptive statistics, geographic information systems (GIS), and interview methodology. The chapter ends with a short section that explains the sources of data for the study.

3.2 Research Goals

The research study has eight goals.

1. Examine the present extent of renewable energy development in the Valley and its neighboring regions,
2. Analyze the human and societal factors associated with exploiting the renewable energy resources,
3. Analyze the spatial configuration of the electrical production from renewable energy and its electrical transmission in the Coachella Valley and surrounding areas.
4. Analyze the demographic, labor force, and economic dimensions of the Coachella Valley and the spatial patterns of those dimensions, with respect to the locations of renewable energy manufacturing facilities, and the implications for future expansion of renewables consumption and production.
5. Compare leading national regions in wind and solar energy manufacturing with Coachella Valley, in order to identify the readiness of the Coachella Valley to develop and enlarge its renewables manufacturing sector. In particular, the research examines and compares the development of wind energy production and manufacturing in the Houston-The Woodlands-Sugar Land metropolitan area in Texas and development of solar energy production and manufacturing in the Baltimore-Columbia-Towson metropolitan area in Maryland, with the situation of the Coachella Valley in California.
6. Gain understanding of the supply chains of renewable energy businesses operating in the Coachella Valley. Through interviews, gain insight into the key links in renewables supply chains in order to understand and assess renewable energy supply, assembly, and manufacturing and assess its future potential.
7. Explore the beginning and future potential of renewable energy innovation in the Valley.
8. Consider the opportunities and challenges for the leaders and stakeholders in the Coachella Valley to advance business and consumer uses of renewable energy.

   The chapter now turns to present a broad conceptual framework for the book for analyzing the complex dimensions and interrelationships in these research questions.

3.3 Conceptual Framework: Integrated Policy Assessment for Local/Regional Renewable Energy Development

The conceptual framework for the research study is the model of integrated policy assessment for local/regional renewable energy development (IPALRED), shown in Fig. 3.1. This framework has three major factors: Federal and State Conditions, Renewable Site-specific Characteristics, and Policies for Local and Regional Political Systems. Each of the first two factors influences the "Policies for Local and Regional Political Systems" factor. In its broad form, the framework posits that Federal and State Conditions influence local/regional policies and that site-specific characteristics near locations of renewable energy domestic users, commercial facilities up and down the supply chain have influences on local/regional policies. This section will now explain each of the three framework factors in greater depth.

In the framework, federal, state, and local political structures, laws, and regulations constrain as well as stimulate renewables development. At the national level, the Bureau of Land Management might restrict renewable power plant development on a portion of its land or levels of federal tax credits can be established for renewable

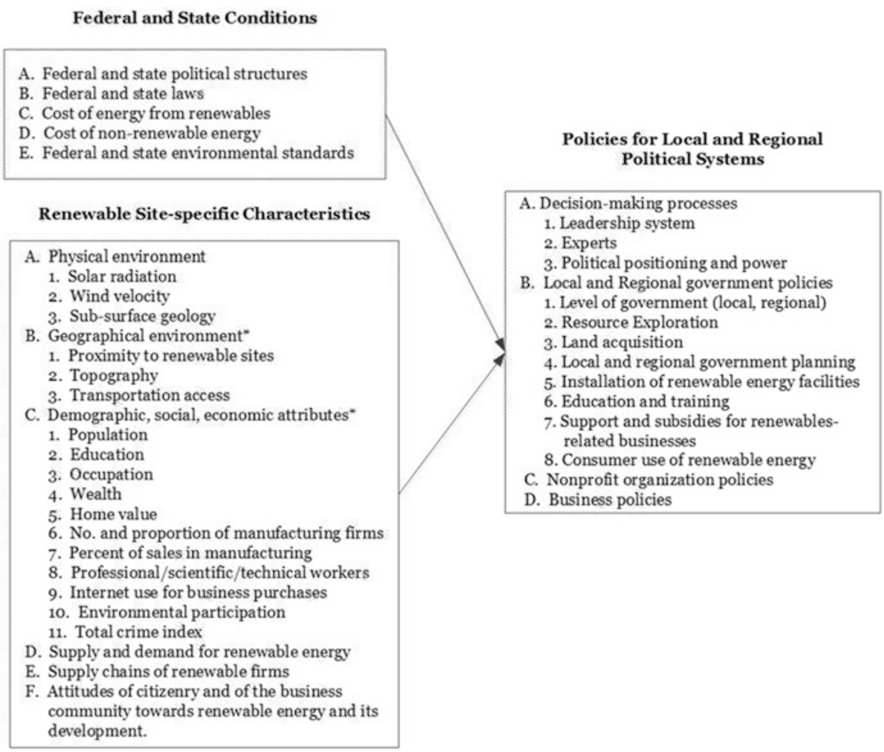

Fig. 3.1 Model of integrated policy assessment of local and regional renewable energy development

energy. At the state level, agencies can approve electrical transmission line corridors, or a subsidy can be given to solar companies for residential installations for low-income households to stimulate residential solar installations. At the local level, local zoning restrictions can disallow wind energy farms to be located near urban settlements due to noise or safety considerations, or a local municipality can establish incentives to attract solar manufacturers.

Cost factors to the consumer for renewable energy depend on national and global markets for competitive energy types—both renewable and non-renewable. The solar and wind energy costs for electricity to the consumer are set by utilities under state regulation. For most consumers with photovoltaic home systems, cost of electricity would be lowered through net metering, if it is available. For ground source geo-heat, the consumer with such a system would need to do a cost-benefit analysis to determine how the heating and cooling costs would compare with the costs of conventional home heating and air conditioning. The cost factors for renewable energy producers are complex and vary by factors that include energy form, location, competitive markets, weather patterns, and access to the transmission grid.

Environmental standards are set by the federal and state governments and can limit renewables development. For instance, state air pollution laws can restrict geothermal energy development, and federal water quality standards may require re-injection of geothermal brines.

Renewable site-specific characteristics can be influential on the feasibility of providing renewable energy, which in the framework can inform policy making at the local or regional level, as shown in Fig. 3.1. Renewable resources are present in particular physical environments, most of which have a geographic aspect. For example, a single-wind turbine installation is located based on climatic and meteorological conditions that assure there will be sufficient wind currents over time to cost-justify it. Geographic features of the earth and its atmosphere are important. Is the turbine located at sufficient distance from other turbines so the locational pattern of wind flow is not interrupted? Is the proposed location of a solar plant sufficiently distant from a foothill that it will not have shadows at any time during the year?

Another geographical aspect applies to locating renewables manufacturing, assembly, and operating facilities in proximity to ground, air, or ocean transportation routes that can handle the transport of components and finished products. For instance, a factory producing nacelles (i.e. the housing for the generating components of a commercial wind plant) needs to have access to heavy-duty streets and highways, or to ocean shipping, since nacelles can weigh many dozens of tons.

Local demographic, social, and economic attributes have varied influences on renewables including consumption and production. The model includes 11 individual and household attributes that were chosen to reflect consumer market size, socio-demographic profiles of consumers, spending strength, prevalence of manufacturing, wealth, internet use (which reflects access to knowledge of renewables), environmental participation (usually a favorable factor for adoption of renewables) and crime (which is posited as a disincentive especially for commercial facilities). For example, family wealth can influence the decision whether or not to pay the often front-loaded costs of residential solar energy. The market structure of supply and demand is crucial to pricing and amount of sales of solar and ground source geo-heat residential installations. Consumers with more education and with an elevated level of environmental participation would be more inclined to install renewable energy in their homes.

Although some renewable energy markets are very broad, even statewide or national, there may also be local markets based on supply and demand that influence the local consumer. For instance, if there is a vibrant competitive supply of solar installation firms in a local area and limited demand, the pricing is likely to be lower. At a different level, a more complicated market would be the demand by utility firms for renewable energy plants to be developed. As long as the state were short of its RPS goal, there would be more demand which would be favorable to utility-scale plant projects. By contrast, if the state's RPS goal were exceeded, the utilities would no longer be bound to encourage the development of new renewable plants.

Supply chains are often complex for renewable energy, as will be examined in Chap. 6. The specific supply chain for solar energy in a location will help determine the feasibility of businesses operating at varied supply chain steps and location across the range of raw material suppliers, component suppliers, assemblers, and finished product manufacturers.

Finally, attitudes of the local citizenry and the business sector towards renewable energy can influence policies. An example is the early citizen opposition to the wind farms in the San Gorgonio Pass in Coachella Valley. The attitude lowered the level of government policy support, only to be replaced later by positive attitudes of citizens toward the wind farms.

As Fig. 3.1 shows, the model posits that "federal and state conditions" and "the renewable site-specific characteristics" together influence "policies for the local and regional political system." The "policies" outcome factor includes decision-making processes, local and government policies, nonprofit organization policies, and business policies. Decision-making is crucial for effective local policies, and that depends on local and regional leaders, experts, and political positioning and power. Local areas and regions that are unable to make decisions about renewable energy development should have improved policies.

The content of the local and regional government policies is broad and influential, yet limited in some respects. Eight features often included with local/regional policies shown on the right in Fig. 3.1 (B1–B8), but many more features can be included. For example, one feature that has been consistently important to the success of wind energy policies in Texas is education and training, as will be emphasized in Chap. 5. The state and its cities had policies supporting renewable energy education, research, and training, often with joint programs, which over many years yielded workforce, expertise, and leadership.

In the framework, many parts of model can be spatially- informed, such as studying the physical environment using GIS tools, considering socio-demographic features of urban areas by mapping of small areas. In the present study, several of the model components were analyzed by GIS. These are marked with asterisks in Fig. 3.1. Most of the other model components could not be spatially analyzed for the Coachella Valley study, due to lack of availability of data that were spatially referenced. This limitation can be overcome in future studies, if new data-sets, with spatial referencing, become available for those other components.

In summary, the IPALRED conceptual model is very broad and presents an ideal framework, not all of which was attainable in the Coachella Valley project. However, IPALRED does contain the necessary components to address the research questions utilized in this study.

In this research project, the single case example of the Coachella Valley was compared to the conceptual model. However, for some model components, research analysis was based on secondary sources, since incomplete data are available for the Coachella Valley region. In the future, the model can be applied fully if complete and high quality data become available for all components. More research questions implied in the IPALRED framework could also be addressed. Furthermore, if a large number of regional cases were utilized, instead of just the one for the Coachella Valley, the conceptual model could be examined and tested quantitatively including for directionality and strength of effects.

3.4 Central Place Theory

In Central Place Theory, the central place is a urban unit – town, city, or metropolis – that has economic relationships with the rest of the world. The activities of the renewable energy sector in Coachella Valley do not all take place within the Valley, but involve parts of renewables R&D, manufacturing, distribution, retail interactions that may occur far away from the central place, which is the Coachella Valley. For instance, solar residential sales are made by a small Coachella Valley firm, located in Palm Springs, to consumers located outside the Valley, say in the City of Riverside. The Coachella Valley constitutes the central place which has the most importance (termed centrality in this theory). The periphery is the area outside the Valley, where some of the demand is located. By contrast, in another example, wind turbine manufacture is done by a large manufacturer located in the central place of the Houston-The Woodlands-Sugar Land Metropolitan Area and the periphery where the demand lies consists of customers in the states of Texas and Oklahoma.

For renewables operating and centrally located in the Coachella Valley, Central Place Theory (CPT) is useful as a reference theory in determining the power of the centrality, and the geographic arrangement of smaller urban entities that have demand for some good or service from the central place. For renewables manufacturers located in the Valley, CPT might apply less, since the manufactured item, for example a solar battery, could be shipped worldwide at relatively low cost, so demand is not localized, nor is it highly dependent on transportation distances.

Another perspective is to consider manufacturing taking place in a central place other than the Coachella Valley, in this instance viewing the Valley as part of the periphery which contributes to the demand for the good or service. For example, the central place globally for solar panel manufacturing is mainland China, and, on the periphery, a solar manufacturer in the Coachella Valley, has demand for the product.

Central Place Theory, in addition to the principal concept of centrality, has two other main concepts, *range* and *threshold*. *Range* is the distance a consumer will travel to purchase a good or service, while *threshold* is the minimum market needed at a given range, in order to justify selling the good or service. The theory considers two types of goods: *low order goods* and *high order goods*. *Low order goods* are ones sold frequently and are replenished often by the firm in the central place or by firm-designated distributors. *High order goods* are purchased less frequently, at higher cost, and depend on a much larger population of consumers than for low order goods, in order for a small percentage of those consumers to be able to afford the cost of the higher-order good and reckon with the greater distance from the central place (Berry and Garrison 1958; Berry and Parr 1988).

Central Place Theory, as originally formulated by Walter Christaller (1933), formalized the geographic area into a matrix of hexagons arranged in a hierarchy, which could be centered on a Central Place (a city), with Satellite Cities, and Small Cities-Towns of the Distributors or Consumers. Christaller made many assumptions about the theory, such as there is perfect competition, sellers are always seeking maximum profit, and a customer will always visit the nearest location, in measured distance, that can satisfy his demand. There is not space in this report to detail and explain all the functions of the original theory formulated by Christaller (1933; Losch 1938; Berry and Garrison 1958; Berry and Parr 1988; Greene and Pick 2012).

The theory has been criticized, in several respects. (1) It might not apply well in rural regions, where the isolated farm consumer would have to travel to a destination, regardless of transportation distance and cost. (2) The theory is weakened or outmoded for digital goods, where location is much less essential. (3) The theory is too static for situations where the ranges and thresholds are constantly in flux and where competition is irregular and varying in intensity over time. (4) Christaller's hexagonal grid and strict assumptions that accompany it are not realistic to the practical world (Greene and Pick 2012). Several of the criticisms are less applicable to Coachella Valley, for instance, there are not digital goods being produced, making (2) irrelevant. Also, modern formulations of the theory put aside most of Christaller's original highly formalized constructs, and in fact the updated theory integrates well with modern spatial interaction modeling (Openshaw and Veneris 2003). Although there are some rural areas involved in considering Coachella Valley, the areas being examined are mixed urban-rural. Where rural areas dominate, criticism (1) must be taken into account. The criticism regarding the need to incorporate fluctuations in ranges and thresholds can be addressed for longitudinal use of the model by performing such updates at regular time points.

What is the application of Central Place Theory to analyzing the present status of renewable energy and its future prospects in the Coachella Valley? The answer is that a number of key issues can be better understood by taking into account the CPT concepts of centrality, range, threshold, hierarchy of city sizes, and economic complexity of goods and services. The intent here is not to rigorously apply CPT, but rather to suggest key issues in the growth of renewables in the Valley that CPT can shed light on and add a broader regional, and even worldwide perspective.

CPT can potentially illuminate the following issues.

1. Identifying which renewables interactions are contained within the Valley. If the renewables good or service's central place is within the Valley, then there is a hierarchy of production, distribution, and operations with it. Operating residential

solar and ground-based heat pumps is such a phenomenon. Small solar operating firms interviewed in this study are centrally located in either Palm Springs or Palm Desert and serve almost entirely customers within the Valley. The range is a 20–30 mile radius around the central place, with purchasing power thresholds that are exceeded by their customer bases within the range, allowing them to remain profitable firms. The same applies for a ground source heat pump operator headquartered in Palm Desert, which is starting up its marketing within the Valley limits. The higher end customers who are targeted will exceed the threshold. The ground-source-heat-pump firm is avoiding for now lower level customers who, in total, would not exceed the threshold.

For these local firms, the full force of CPT can be applied, with the caveat that range and thresholds must be revisited periodically. The firms might set up distribution centers in Valley cities distant from the central place.

2. Understanding the relationship of southern California Coastal solar and wind manufacturing to start-ups or future new entrants of renewables manufacturers in the Coachella Valley. For instance, there is a cluster of dozens solar manufacturing firms in Los Angeles and to a lesser extent in San Diego that constitutes a much larger solar manufacturing sector than in Coachella Valley. This represents many different steps in the solar manufacturing supply chain.

The Los Angeles (LA) companies are not worldwide leaders selling to a global market, but rather their customer base is predominantly in California and Arizona. If Los Angeles is considered a central place for mid-level solar manufacturing, then a Coachella Valley renewables manufacturer could be considered a distributer or customer of the Los Angeles solar manufacturing cluster. This would imply that the range of the LA solar manufacturing cluster, the central place, would be many hundreds of miles or more, and that the threshold would be exceeded for sufficient demand to exist to keep the greater LA cluster functioning profitably. Coachella Valley firms would contribute to exceeding the threshold.

Central Place Theory also informs understanding of the benefit of comparing the Coachella Valley with the Houston-The Woodlands-Sugar Land and Baltimore-Columbia-Towson metropolitan areas. At present, the comparison should be thought of as the relationship between sophisticated, large renewables manufacturing central places (Houston and Baltimore metro areas) with a peripheral place (Coachella Valley). Coachella Valley can be regarded as much earlier stage of renewables manufacturing, but a place that has the potential to become less peripheral over time, although it is unlikely to eventually become a full-fledged central place such as Houston in renewables manufacturing (or even a full-fledged LA). Yet, the comparison with Houston may be useful in setting policies to transform the Valley more quickly to a considerably more central role than it has now.

3. Large scale utility-scale manufacturing does not conform to Central Place Theory, since transportation is not a major cost and often a one-time delivery of construction components to an operating site being readied for operation. This would imply that renewables manufacturing of complex goods for utility-scale

renewables facilities can take place in distant locations having large to very large and complex manufacturing economies. The example of Houston, Texas, as a national manufacturing central place for wind manufacturing, demonstrates a vast range that is not transportation-dependent, and with a threshold that applies to national and even international customers.

In summary, Central Place Theory has been introduced as a useful theoretical perspective that can be applied to better understand renewable operations to the Coachella Valley, and for solar manufacturing to southern California. While the book's primary conceptual theory is IPALRED, Central Place theory is as useful secondary reference theory, in particular to understand how the Valley relates to the much larger, sophisticated, and diverse Los Angeles metropolitan area, southern California as a whole, and the world, as well as in comparison to the benchmark metropolitan areas emphasized in Chap. 5: the large, sophisticated benchmark for wind energy manufacturing of the Houston-The Woodlands-Sugar Land MSA and, for solar manufacturing, the large and complex Baltimore-Columbia-Towson MSA.

Central Place Theory is not tested in this book with the Coachella Valley case, but it is recommended as a theory for a future, broader, data-intensive study involving the supply-chain relationships between renewables, suppliers, producers, and consumers in varied-sized and geographically-spread-out complex of large metropolitan areas, cities and towns.

3.5 Research Methods

3.5.1 Descriptive Statistics

For the analysis of features of model components, simple descriptive tables, spreadsheets, and charts are utilized. Analyses are conducted by use of descriptive statistics. Multivariate statistical analysis are not utilized due to a deficit of small area data samples on renewable consumption and lack of data samples on the flows and destinations of gridded electricity from utility-scale renewables plants. A future analysis would be enhanced if small area data on renewable consumer use and grid flows were provided by major utility companies, but those data were not available presently.

3.5.2 Geographic Information Systems

GIS is utilized as a tool is for several of the IPALRED model components, as already noted for Fig. 3.1. GIS supports visual mapping information for the geographical environment of the Valley and surrounding area, including maps of the proximity of manufacturers to transportation and social characteristics and the proximity of the

Coachella Valley to the electric transmission grid and to utility-scale solar and wind plants. Another application of GIS is to compare spatial patterns of characteristics in the benchmark metropolitan areas of the Houston-The Woodlands-Sugar Land and Baltimore-Columbia-Towson, for the same set of characteristics mapped for the Coachella Valley.

GIS has been previously utilized to analyze the physical, economic, and social aspects of renewables (Birkin et al. 2002; Butler and Pick 1982; Kwan 2012; Hernandez et al. 2015). Often GIS is an appropriate methodology because renewable electricity production is located at or near the site of the renewable resources, accessible, and in a location that has potential for profit. In addition, the spatial arrangement of energy transmission grid networks and of transportation networks of renewables supply chains can be analyzed with a GIS. Likewise, GIS also can be useful in understanding where market adoption of residential solar installations can occur depending on social, economic, and attitudinal factors.

In the present research, the GIS analysis was conducted with data obtained from the U.S. Census, U.S. Economic Census, California Energy Commission, and two nonprofit organizations: the American Wind Energy Association and the Solar Energy Industry Association), and a GIS company (Esri Inc.). (U.S. Bureau of the Census 2014, 2015; California Energy Commission 2015b; AWEA 2014, 2015; SEIA 2014; Esri Inc. 2016) The software utilized were Esri's Business Analyst Online and ArcGIS 10.3.1. Preliminary mapping was performed with Business Analyst Online, and finished mapping and spatial analysis conducted with ArcGIS 10.3.1. For readers interested in gaining understanding of GIS and locational analytics, several references are recommended (Mitchell 1999; Goodchild and Janelle 2004; Mitchell 2005; Longley et al. 2015).

3.5.3 Interview Methodology

The primary research carried out in this study involved designing and conducting personal interviews with a total of 12 participants. Participants were renewable energy experts, providers of renewable energy products, or officials and managers from the public sector (Coachella Valley cities). In addition, extensive secondary research, related to the interviews, was conducted with published sources. A variety of relevant secondary data were collected from government, renewable energy trade associations and commercial sites (see Sect. 3.6). The process resulted in a project capable of providing an analysis of the following:

1. The Renewables Sector in Coachella Valley
   (a) Business challenges and opportunities for renewable energy
   (b) Significant factors used in deciding where to locate headquarters and/or operations
   (c) Existing renewable energy businesses in the Coachella Valley

2. Select exemplars of geographic regions in the U.S. successful in attracting and maintaining supply chain activities as a basis for comparison to Coachella Valley, and as a partial basis for recommendations for Coachella Valley.
3. Renewable Energy Supply Chains
4. Key characteristics of cities in the Coachella Valley
   (a) Socio-Economic, Demographic, Natural Environment– analysis of physical, human, and financial resources available to renewable energy companies
   (b) Business activity, including manufacturers, and renewable energy companies

Preliminary exploratory and subsequent formal interviews were conducted to provide in-depth information addressing a variety of issues relating to renewable energy as well as supply chain information. Three participants were identified for preliminary exploratory interviews. The first participant, Paolo Tovar, is a former executive in the wind energy industry with a medium sized firm located in Virginia. The second and third participants are experts from nonprofit institutions intimately involved in the field of renewable energy. John Randall is the Associate Science Director, California South Coast at The Nature Conservancy in San Diego, California. The Nature Conservancy plays a significant role in renewable energy for California by providing information and analysis of the environmental impact of the state's renewable energy projects in California. Dr. Randall leads teams that develop scientific analysis of renewable energy projects in southern California. The third participant, Professor Mike Pasqualetti, is the Co-director of the Energy Policy Information Council (EPIC), and a professor from Arizona State University in the School of Geographical Sciences and Urban Planning (Tempe, AZ). Dr. Pasqualetti has extensive expertise in sustainable energy, particularly including wind, solar, and geothermal, including formal advising to the U.S. Department of Energy, National Academy of Sciences, and the state of Arizona.

The three preliminary exploratory interviews were conducted with this unique set of participants, as they possessed experience in various aspects of renewable energy from business development of wind energy projects to nonprofits that contribute environmental and scientific analysis, advocacy, and recommendations for a range of renewable energy activities in solar, wind and geothermal industries. The preliminary interviews provided a wealth of information to help establish a partial basis for development of a relevant set of questions for subsequent formal interviews with renewable energy business executives and city managers in Coachella Valley. Other questions were developed from literature studies and the author's experience in a prior interview studies of renewable energy.

3.5.4 Interviews of Government and Business Leaders

Nine formal interviews were conducted. Seven interviews were carried out with renewable energy executives and two interviews were conducted with managers in cities in the Coachella Valley. The primary objective of the interviews was to develop a better understanding of the companies' and cities' perspectives on the renewable energy sector and industries in Coachella Valley. The interviews with representatives from the two cities focused on the role of the renewable energy industry in the plans and activities of their respective cities. In particular, the interviews were designed to identify perceived benefits of having renewable energy companies in their cities, steps taken by cities to encourage or discourage renewable energy companies, the challenges or barriers faced in doing so, and potential environmental concerns with respect to renewable energy. A comprehensive list of interview topics is shown in Table 3.1. Ninety-minute interviews were conducted with the City Manager for the City of Coachella, David Garcia and Cathy Van Horn, Economic Development Administrator for Palm Springs' Community and Economic Development Department.

The primary focus of the interviews of renewables firms was to gain understanding of the Valley's renewables sector, and firm initiatives, accomplishments, opportunities, and challenges. Seven formal, semi-structured personal interviews were conducted with these senior executives who have operations or a definable connection to Coachella Valley and surrounding areas. Table 3.2 lists the titles of participants and companies represented (Pick et al. 2015).

Table 3.1 Interview topics for city managers*—Coachella, Palm Springs

Interview topic
1. Major goals in the next 3–5 years for the City of Coachella, including renewable energy
2. Marketing the City to potential renewable energy companies and level interest from them
3. City benefits of renewable energy, including available state or federal subsidies
4. Existing incentives provided to attract manufacturers, including renewable energy manufacturers. Future plans for incentives
5. Barriers or constraints in attracting renewable energy companies or activities
6. Skilled workforce characteristics and requirements, including training, to support manufacturing and renewable energy
7. Major environmental concerns for renewable energy in the city and surrounding valley, including particular concerns for solar, wind and or geothermal

*Participants: David Garcia, City Manager, City of Coachella; Cathy Van Horn, Economic Development Administrator, City Palm Springs
(Pick et al. 2015)

Table 3.2 Renewable energy project executive participants

President and CEO	Indy Power Systems	Indianapolis, IN
President	Solaris Power Cells	Palm Springs, CA
President	EV Enterprises	Palm Springs, CA
President	Hot Purple Energy	Palm Springs, CA
Vice President of Business Development	Simbol Inc.	Pleasanton, CA
CEO and President	Renova Solar	Palm Desert. CA
Vice President Operations	Geothermal Resource Group and Desert GeoExchange	Palm Desert. CA

(Pick et al. 2015)

Five participant companies were in the solar energy industry: Indy Power Systems, Solaris Power Cells, Hot Purple Energy and Renova Solar. One participant company, Desert GeoExchange, was in the geothermal industry. Simbol Inc. was in sustainable materials. Participant companies ranged from four start-up companies to three reasonably well-established companies.

Five of the participants were interviewed by the research team in person at the company's location in the Coachella Valley, and two participants were interviewed by phone. The ninety-minute interviews were recorded and transcribed to ensure accuracy in collecting and subsequently analyzing participants' responses. A complete list of interview questions is shown in Table 3.3. All participants granted permission to use their company names and interview information in reports and publications.

Joe Wallace, presently CEO of Coachella Valley Economic Partnership (CVEP), provided contacts for potential interview participants, which yielded a convenience sample of seven companies in the renewable energy sectors in the Valley and two public officials from the cities of Coachella and Palm Springs. While random samples are often preferred for drawing conclusions from quantitative studies, the convenience sample was appropriate given the exploratory and qualitative nature of our study.

The company participants interviewed were senior executives in their companies, thus were knowledgeable regarding strategic, financial and operational processes and decisions for their respective companies. The participants represented companies that ranged in terms of length in operation. Four companies in the start-up phase included EV Enterprises, Indy Power Systems, Solaris Power Cells, and Desert GeoExchange. Three were well-established companies, including Renova Solar, Hot Purple Energy and Simbol. While the participants were a convenience sample, the companies represent a reasonable range of companies in the supply chain relating to renewable energy. Figure 3.2 is a simplified supply-value chain diagram that can be applied to renewable energy.

While broad commonalities in the respective supply chains for the three renewable energy industries exist, the nature of each industry, products, and organizations involved create particularities for each specific renewable industry. For example, significant differences in physical principles and technologies exist in each of the different renewable energy industries (Boyle 2012). As such, the qualitative approach utilized in-depth personal interviews with open-ended questions to provide sufficient opportunities to identify specific information on supply chain structures, issues, requirements and activities for solar, wind and geothermal industries. Key benefits of personal interviewing with open-ended questions are the opportunity for interviewers to probe participants for clarification and additional depth.

Supply chains represent relatively complex ecosystems of interdependent organizations. The interdependent organizations provide various goods, information and services necessary to serve ultimate customers (Mentzer et al. 2001). The process of serving the ultimate customer consists of many prior stages where organizations engage in a variety of activities to transform and distribute raw materials, manufacture, assemble and distribute components, as well as provide financing and information. Supply chain concepts and findings are covered in more detail in Chap. 6.

Table 3.3 Interview questions renewable energy company executives

Topic	Questions
Basic company information	1. What is your company's primary focus?
	2. Where is your company headquartered? Please briefly describe your company's history.
	3. What is your role in the company?
	4. What is the renewable energy focus of your company? How is your company involved in renewable energy?
	5. How do you plan to develop the renewal energy aspects of your company in the future?
Aspects of Coachella Valley	6. What presence does your company have in the Coachella Valley?
	If your company is present: How do you plan to develop the Coachella operations, activities, initiatives?
	If your company is not present: Do you plan to enter the Coachella Valley? Do you plan to partner with other companies in the Coachella Valley?
	7. What governmental support or incentives in the Coachella Valley does your company have or will seek?
	8. What job skills requirements do or would you have for workers in the Coachella Valley?
	9. What aspects of the Coachella Valley business and economic environment are or would be useful to your company?
	10. What aspects of the Coachella Valley business and economic environment are or would be a barrier or challenge to your company?
Supply chain connections	*Customers*
	11. How would you describe your major customers?
	12. What are the major criteria, such as geographic proximity, your customers use in choosing suppliers?
	13. What are the major criteria in your choice of customers?
	14. How would you describe your customers' customers?
	Suppliers
	15. Who are your primary suppliers?
	16. What role, if any, does geographic proximity play in your choice of suppliers?
	17. What are your suppliers' strengths and weaknesses?
	18 Are there significant opportunities for new firms?
	19. Are there opportunities for supplier consolidation?
	20. Who are your secondary suppliers, if any?
	21. How would you describe firms that serve your suppliers?

(continued)

Table 3.3 (continued)

Topic	Questions	
Opportunities and challenges	22. With respect to the renewable energy aspects of your business, how necessary is proximity to each of the following to your operations? Your suppliers?	
	(a)	Major roadways, such as interstates
	(b)	Airports
	(c)	Railroads
	(d)	Ports
	23. What are your company's growth goals for the next 3–5 years?	
	(e)	What are the most important factors within your company's control likely to affect achieving those goals?
	(f)	What are the most important factors outside your company's control likely to affect achievement of those goals?
	(g)	What government policies support your goals? Impede your goals?
	(h)	What nonprofits, if any, support your goals? Impede your goals?

(Pick et al. 2015)

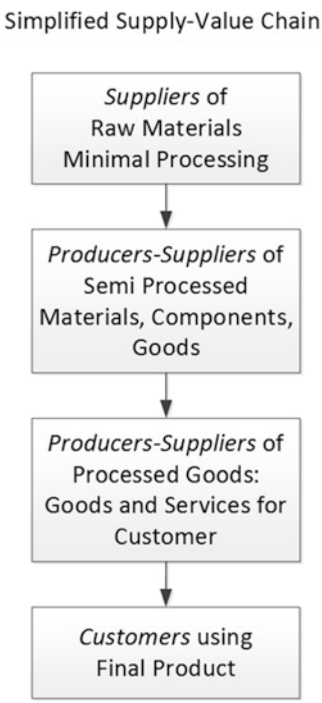

Fig. 3.2 Simplified supply-value chain diagram

Since project goal 6 is to gain understanding of the supply chains of Valley solar and wind companies, the two companies from the geothermal energy industry represent different positions and activities in the renewable energy supply chain. Desert GeoExchange focuses on installations for residential and organizations wanting to generate their own geothermal energy for their own use. Thus Desert GeoExchange provides insights from the perspective of a company creating small-scale systems for customers at the tail end of the energy supply chain. Desert GeoExchange is a subsidiary of a more established company in the geothermal energy industry, Geothermal Resource Group. The Geothermal Resource Group emphasizes provision of consulting, engineering and drilling services for major installations early in the supply chain, at the geothermal energy generation stage.

The second company involved with geothermal energy is Simbol Inc. It possesses a relatively unique position in the geothermal energy industry as it focuses on extracting minerals and materials from geothermal brines. One of the major minerals is lithium, which is used in the production of batteries for renewable energy storage. As a result, Simbol aspired to play a role in the production of storage products in the renewable energy supply chain. The full story of Simbol appears as a case in Chap. 6.

Three of the companies in the solar industry also participated in the storage stage of the solar energy supply chain. Solaris Power Cells manufactures solar energy storage products for business customers to use to power short-range vehicles, such as golf carts, power lighting, and power agricultural applications. The second company, EV Enterprises serves the solar storage sub industry through manufacturing of electronics and components. Similarly, Indy Systems addresses storage by producing an offering that both manages and stores solar energy, with Indy's focus being on business customers. Indy Systems storage offerings can also be utilized for wind energy.

Renova Solar and Hot Purple Energy, the two remaining solar industry companies, provide solar installations (services) for residential and business customers. Renova provides operating and maintenance services for solar installations, and training services for installers. Their supply chain position is downstream, close to the customer.

In summary, while broad commonalities in the respective supply chains for the three renewable energy industries exist, the nature of each industry, products, and organizations involved create particularities for each specific renewable industry. For example, significant differences in physical principles and technologies exist in each of the different renewable energy industries (Boyle 2012). As such, the qualitative approach utilized in-depth personal interviews with open-ended questions to provide sufficient opportunities to identify specific information on supply chain structures, issues, requirements and activities for solar, wind and geothermal industries.

3.6 Data Sources

To accomplish the research analysis, in addition to the interview findings, qualitative and quantitative information was utilized from multiple secondary sources, including publications, websites, and reports. Effort was spent identifying relevant and accurate sources related to each of the three renewable energy sectors, solar, wind and ground source geo-heat, as well as data on cities in the Coachella Valley. Secondary data sources were accessed from federal, state and local government agencies, trade associations, as well as from articles, reports and books authored by academic experts and government authorities and agencies in renewable energy, and from government, business, and nonprofit websites.

Government data sources included U.S. Census and other agencies of the federal government; California, Texas, Maryland, and other state agencies; and nonprofits concerned with renewable energy. U.S. census data are used to describe and map relevant characteristics of the population and businesses of nine cities and two census designated places (CDPs) within Coachella Valley (U.S. Bureau of the Census 2014, 2016). The nine cities are Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage, and the two CDPs are Thousand Palms and Mecca. U.S. Census social and economic data include population, educational attainment, income, net worth, occupation, age, home ownership, internet use, and crime. Data on businesses included business types (by NAICS code), size, workforce, and location. Given the project focus on Coachella, additional detailed data on manufacturers were also identified, mapped and analyzed.

For population estimates of Coachella Valley, projections from Southern California Association of Governments (SCAG) and California Department of Finance were utilized (SCAG 2013; California Department of Finance 2015), including a series with our own modified assumptions. The projections are described in more detail in Chap. 4.

Geographic regions in Maryland and Texas were identified as renewable energy exemplars; hence similar population data for those regions were collected, mapped and analyzed. For data on renewable energy, federal agencies, such as the US Department of Energy, U.S. Geological Survey, and U.S. Energy Information Administration, as well as state agencies in California, Texas, and Maryland were also relevant information sources. These sources were used primarily to collect information and data on renewable energy resources, manufacturing, supply chain, policies, incentives, initiatives, and environmental issues.

In addition, trade and nonprofit associations provided a considerable wealth of specific data on various aspects of renewable energy in the Coachella Valley as well as in the United States. Data on the locations of major solar and wind installations (existing and in development) were collected from the solar trade organization, Solar Energy Industries Association (SEIA) and from the American Wind Energy Association (AWEA), mapped and analyzed (SEIA 2014; AWEA 2014, 2015). Individuals within select trade associations were contacted to investigate the availability of additional relevant data for the study.

Data on manufacturers for major wind, solar and geothermal-related products and services were collected from the U.S. Economic Census for California for California, Texas and Maryland (U.S. Bureau of the Census 2015). Market characteristics including status and forecasts for major installations and jobs in renewable energy came from nonprofits, especially SEIA and AWEA.

Additional data and information were provided by from the following government agencies, trade associations and nonprofit organizations: California Energy Commission (2015a), National Renewable Energy Laboratory (NREL), The Solar Foundation, Coachella Valley Association of Governments (CVAG, 2016), and National Conference on State Legislatures (2016). Transmission corridor data were obtained from Bureau of Land Management (BLM 2009) and the California Energy Commission (2015b).

An extensive analysis of cities in Coachella Valley, including maps, was developed from census data. Cities in the Coachella Valley analyzed included Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, Rancho Mirage, and the Thousand Palms CDP. Some of the census data was provided in geo-referenced format by the company Esri Inc. as part of its Business Analyst Online product (Esri Inc. 2016).

3.7 Conclusion

The book's research goals are presented and described. They build on the book's objectives from Chap. 1 and inform this chapter as well as Chaps. 4–6, which contain the book's research findings. The book's primary conceptual framework, the Integrated Policy Assessment for Local/Regional Renewable Energy Development (IPALRED) is introduced and explained. It is a new model that does not draw directly on past conceptual frameworks. It is a broad model in which two factors, Federal and State Conditions and Renewable Site-Specific Characteristics, which together influence Policies for Local and Regional Political Systems. The model is explained in detail. Renewables development in the Coachella Valley is one case example that utilizes the IPALRED model, but is does not include all the constructs in the full model. The constructs not included in the Coachella Valley case represent a limitation of the book's empirical analysis, and point to further research on the Coachella Valley or other regions that would utilize the complete model.

Central Place Theory (Christaller 1933; Berry and Garrison 1958; Berry and Parr 1988) is presented as a secondary theory, which is not tested in the present research, but provides background understanding of the geographic aspects of the economic relationships and flows of renewable component and products between different sized metropolitan and urban areas in the book.

The empirical methods utilized in the book's research analyses are described, namely descriptive statistics, GIS, and interview methodology. For the latter, structured interviews were conducted of seven renewable energy companies and two city governments. The respondent organizations are briefly introduced, and the importance for the interviewee companies of the renewables' supply chains is emphasized. The supply chain aspect and findings are covered in Chap. 6. Also, the study's data sources from government, nonprofits, and the private sector are described and documented.

In the subsequent Chaps. 4–6, the findings from the study analyses are given, with the goal to seek to answer the research questions. The book conclusions are given in Chap. 7.

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Chapter 4
Socioeconomic and Urban Profile of Coachella Valley

Abstract The Coachella Valley exhibits a range of levels of income, wealth, education, and age structure. Its economic strengths lie in tourism, retirement, specialized agriculture, retail, and associated services. The chapter first reviews literature of prior studies of regional renewable development. Since the Valley as a whole is not a U.S. Census designated area, population projection is done by aggregating components, indicating the Valley's population of about a half million in 2016 is predominantly located in nine small cities with largest being Indio at 80,000 people. GIS analysis is applied to understand, at the census tract level, the spatial patterns of leading socioeconomic variables including income, wealth, education, occupation, manufacturing, professional and technical workers, internet use for business, environmental participation, and crime. Additionally, the Valley's solar and wind energy workforces are estimated. Labor force deficits are apparent, which could be overcome by stemming out-migration or encouraging in-migration of skilled renewable workers. To reinforce this point, a case study is examined of community college renewable energy occupational training.

4.1 Introduction

This chapter provides understanding of the socioeconomic profile of Coachella Valley and discusses the implications of that profile for development of renewable energy. The Valley as a group of cities has great diversity in its socioeconomic and demographic silhouette, as was introduced in the first chapter. For instance some cities are populous, affluent, and older, while others have limited prosperity and are younger and growing more rapidly. The infrastructure and socioeconomic factors are important for the supply chain of renewable energy development, production, and consumption.

For the supply chain, there may be socioeconomic advantages from the manufacturing skills of a small but growing manufacturing workforce, which partly depends on the accumulated experience in an educated but partly retired workforce, and in affluent investors in the Valley who may be predisposed towards start-ups and small

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businesses. It is likely that growth in consumption likely would be positively influenced by proximity to the greater Los Angeles metropolitan area of solar manufacturing and wholesalers, well-established small and energetic retailers of solar technology services, and Valley areas of considerable affluence providing the market potential and opportunities for considerable buying power.

Socioeconomic drawbacks include depressed areas of low education and low income and scarcity of skilled scientific, engineering workforce. By considering the array of Coachella Valley cities in more depth, the study seeks to discover how the socioeconomically and geographically stratified set of cities could work collaboratively in ways supportive to development of renewables. Furthermore, the goal is to understand how the geographic location of these particular cities will influence the prospect of renewables development.

Population projections, mentioned in Chap. 1, indicate the projected relative sizes of the Valley's cities and unincorporated areas, which may inform future demand for residential renewable installations in the Valley. This chapter discusses population projections, including the historical population trajectory, and the assumptions made in future projections.

The spatial patterns of social and economic characteristics are indicators revealing a Valley-wide urban area that is bifurcated along many dimensions, with the extremes of rich, educated, older communities contrasted with poorer, younger ones. Although these contrasts have limited impact on the small renewables manufacturing sector and moderate renewable energy consumption at present, their patterns will be more important in the future in a more populous Valley with the socioeconomic capacity to consume more renewable energy and the anticipated expansion in renewables manufacturing. Besides population, the socioeconomic dimensions of income, education, age structure, wealth, and crime are analyzed, in the context of renewable energy development.

Manufacturing of renewables, presently quite limited, is dependent on the configuration of the local manufacturing sector, since it is partly supplied by components and services from this sector. Hence, the present manufacturing sector is investigated in detail. The chapter concludes by summarizing the Valley's key socioeconomic features in the context of future renewables development.

4.1.1 Literature Review

Prior literature considered socioeconomic aspects of energy development at scales ranging from U.S. Census block groups to Zip codes, and found a variety of linkages between social, economic, and political conditions with energy requirements and consumption for individuals, households, small areas, counties, and nations. Several studies, which bear on the present research, are examined here. They have a focus on major socioeconomic determinants, including income, urban status, education, ethnicity, and public perception/opposition, as well as considering studies of direct and indirect energy requirements/consumption and how determinants alter depending on type of energy use. The section includes varied measures and types of energy, not putting particular focus on renewable energy, as the specific literature on the social and economic aspects of renewable energy is slight.

An early study of the socioeconomic aspects concerned geothermal energy development in the Imperial Valley of California (Butler and Pick 1982). Initial production was underway of the large geothermal deposits. Imperial County, energy and utility corporations, and other stakeholders sought information about the demographic, social, and economic profile of the county and its major cities, in order to answer such questions as supply of energy workforce, population exposure to environmental impacts, spatial array of population with respect to location of geothermal facilities, and projections of future county population and settlement patterns.

Spatial analysis of the county's socioeconomic characteristics including dependency ratio of Spanish-speaking population, percent of labor force by gender, household mobility, and migration was related to scenarios regarding geothermal development. Externalities investigated included the land area and consequent labor force displaced from a geothermal production field by a geothermal power plant, and its drill sites. For instance, for a 100MW power plant, the projected number of displaced farmworkers varied between 9 and 50 by year 2020 (Pick et al. 1985). A public opinion survey concerned citizens' understanding of geothermal energy, extent of information about it, regulation, perceived environmental problems, and issues of land ownership. Generally, the county population favored geothermal development, but with strict regulation (Butler and Pick 1982). This study informs some of the research in the present book, for example the topics of labor force, pattern of Hispanic/Latino settlement, projected population, and displacement of agricultural land use by renewable facilities, which in the present study consist of commercial solar panels and wind turbines.

Income is a correlate of energy production and consumption, since it represents the economic potential to make necessary capital and operating investments and to afford energy consumer products and services. Moreover, for renewable energy, wealthier economic units are posited to be more accepting of the need for energy development that entails fewer environmental impacts. A broad study of household energy requirements in five nations found that household expenditure is by far the most important correlate of energy requirements/consumption (Lenzen et al. 2006). Detailed governmental data were utilized for Australia, Brazil, Denmark, India, and Japan. Although energy consumption, except for Japan, increased as expenditure grew, the functional shape of its increase varied, after controlling for other socioeconomic and demographic variables. The authors argue that the different functional relationships with expenditures depend on present energy, economic, and political factors, as well as historical happenings such as energy shortages and prior government policies, the extent of energy resources, present market conditions, human behavior, culture, politics, and environmental and energy policies (Lenzen et al. 2006).

Another dimension of differential change is that the average energy requirement of a household varies by nation, after controlling for socio-demographic factors (Lenzen et al. 2006). For example, American household consumers generally use more energy than consumers in middle-income nations. This is ascribed to cultural and lifestyle choices. The varied relationships with income between nations was contrary to the commonly accepted Environmental Kuznets Curve (EKC), which posits that a nation with low income has low energy consumption, which increases with greater income, but eventually as high income is reached energy consumption has an inflection peak and then turns downward.

Kwan (2012) studied influences of socioeconomic factors on the geographic adoption of solar photovoltaic arrays throughout the United States, finding that the most important influences were solar insolation i.e. a measure of the amount of solar energy reaching a destination), the amount of financial incentives, reduced electricity cost, and income, which corroborates the Lenzen findings. In a study of Australian households (Wiedenhofer et al. 2013), per-capita income was a strong predictor for direct energy requirements and an even stronger predictor of indirect energy requirements (i.e. the costs of externalities associated with producing the energy such as environmental impacts).

In the aforementioned study of energy consumption in five nations (Lenzen et al. 2006), other important factors present besides income varied from country to country and included amount of energy resources, major historical energy events, social and cultural norms, consumer behavior, current energy market conditions, and energy and environmental policy measures. Since the nation was the unit of analysis, more information is available on markets, history, and energy/environmental policy. In the case of this book, the unit is a small region of a nation, so our framework discussed in Chap. 4 does not include markets or history, but does take into account energy and environmental policies for the state and nation.

The above study of the U.S., Kwan (2012) found other effects besides income, which included housing costs, median home value, electricity costs, government incentives, insolation, education, and Hispanic/Latino population, while inverse factors included working age population, percentage Black, percent Asian, suburban location, and registered Democrats. Most of these factors are included in this chapter's socioeconomic analysis including home value, Hispanic population, age structure, cities, and unincorporated areas. Since the Coachella Valley does not have suburbs, the unincorporated areas provide urban differentiation. This study (Kwan 2012) emphasized that knowing the influential factors would aid policymakers in formulating and deciding policy adoption measures for socioeconomically deprived areas.

The findings on positive effects of percent Hispanic/Latino population were also present in a survey study of minority group attitudes towards environmental change (Whittaker et al. 2005). This study examined 6 measures of attitudinal positions on environmental change. A major finding is that Hispanics/Latinos trended upwards in showing more sensitivity to issues of the environment than Whites. The trend for 2/3 of environmental positions surveyed is that Whites are reducing their sensitivity and support. On only the issue of cost of environmental spending did Whites move up while minority respondents moved down (Whittaker et al. 2005). Other socioeconomic factors favoring environmental positions were youth, female gender, and Democratic Party affiliation. The consensus of these studies is that Hispanics/Latinos are increasingly supportive of positions of better environment.

Coachella Valley urban forms vary between heavily populated urban cores, suburban areas, and a hinterland of rural unincorporated areas, and prior studies have shown that those differences influence the type of suitable renewable energy development (Kwan 2012; Wiedenhofer et al. 2013). The contrast between these areas is evident in Fig. 1.2, with a hilly rural zone in the foreground and the urban Valley floor in the distance. One such study examined the effects urban forms for Australian households on direct and indirect energy uses (Wiedenhofer et al. 2013). The investigators defined urban, suburban, and rural areas based on population density and the Australian Census definition of central business district. Direct energy effects are based on the present-day energy requirements and usage, while indirect energy effects derive from the cumulative environmental impacts over time of the energy used in producing goods and services (Wiedenhofer et al. 2013). The study considered that rural and suburban residents depend much more on private transport than those in the city center, who opt for public transport.

The study also found that direct energy use per capita is lowest for the urban center and more for suburban and urban forms, while indirect use was highly dependent on income level, so suburban residents had indirect energy requirements about 10% higher than urban residents (Wiedenhofer et al. 2013). The study also identified predictors of energy requirements, which for indirect energy were linked strongly to income but tied inversely to car transport to work. Since community distances are relatively short in the Coachella Valley, this implies that indirect energy effects would be lessened. For direct energy requirements, the determinants were positive for income but inverse for population density and annual days of warm weather. However, in the hot summers of the Coachella Valley, it's likely the direct energy determinants would be positive due to the extensive use of air conditioning. Determinants also varied by type of energy use, such as private transport, public transport, residential, and food-related.

For Coachella Valley, this study is helpful in inducing the differential effects of factors in the denser, older Valley cities versus the lightly populated periphery of unincorporated areas, as well as evaluating the energy requirements and determinants stemming from the Valley's limited public transport. Although this book concentrates primarily on direct energy use, the Wiedenhofer et al. study is a reminder of the impact of indirect energy requirements. For instance, the energy production needed to manufacture a wind turbine for use in a San Gorgonio wind farm has environmental and other externalities, albeit in distant places, that need to be recognized. Up until now, there appears to have been little public opinion concern in the Coachella Valley of these indirect effects.

4.1.2 Cities

There are nine cities in the Coachella Valley, introduced in Table 1.1, which in 2013 totaled 363,495 in population and accounted for three quarters of the estimated Valley population. The cities vary greatly in their socioeconomic features as is seen in Table 4.1.

Before discussing their characteristics, the nine cities need to be described. These cities are interlinked with each other in a jigsaw-like pattern (see Fig. 1.1). Palm

Table 4.1 Demographic and economic profile of Coachella Valley Cities, 2010

Attribute	Cathedral City	Coachella	Desert Hot Springs	Indian Wells	Indio	La Quinta	Palm Desert	Palm Springs	Rancho Mirage	California
Population, 2010	51,200	40,704	25,938	4958	76,036	37,467	48,445	44,552	17,218	37,253,956
Persons 65 years and over, percent, 2010	14.40%	4.50%	9.60%	55.10%	12.40%	20.90%	32.90%	26.50%	44.00%	11.40%
Language other than English spoken at home, pct age 5+, 2008–2012	55.60%	89.60%	48.00%	12.90%	55.20%	26.30%	21.60%	28.70%	17.00%	43.50%
High school graduate or higher, percent of persons age 25+, 2008–2012	73.30%	46.80%	67.30%	96.80%	72.20%	89.80%	91.20%	87.40%	94.70%	81.00%
Bachelor's degree or higher, percent of persons age 25+, 2008–2012	15.40%	4.20%	12.00%	54.00%	17.30%	33.60%	34.40%	33.50%	39.50%	30.50%
Median value of owner-occupied housing units, 2010–2014	$194,000	$150,900	$139,700	$649,600	$211,900	$366,800	$325,900	$285,700	$544,100	$383,900
Median household income, 2010–2014	$44,763	$41,611	$32,883	$100,742	$50,528	$72,099	$53,456	$45,404	$77,304	$61,400
Total number of firms, 2007	3928	2261	1970	801	5889	4219	7434	6146	2662	3,425,510

Attribute	Cathedral City	Coachella	Desert Hot Springs	Indian Wells	Indio	La Quinta	Palm Desert	Palm Springs	Rancho Mirage	California
Manufacturers shipments, 2007 ($1000)	0	108,278	0	0	124,481	0	0	D	0	491,372,092
Retail sales, 2007 ($1000)	962,679	197,723	120,868	28,223	789,255	784,724	1,538,131	643,662	437,771	455,032,270
Land area in square miles, 2010	21.5	28.95	23.62	14.32	29.18	35.12	26.81	94.12	24.45	155,779.22
Persons per square mile, 2010	2381.50	1406.00	1098.40	346.2	2605.70	1066.90	1807.00	473.4	704.3	239.1

(Source: U.S. Bureau of the Census 2016a, b, c)

Springs has the most land area of 94.12 square miles, which comprises about a third of the 9-city land area. Palm Springs was the earliest city, and consequently was able to occupy extensive land mostly to the south of the Highway 111. Because of its extensive area, its land density is among the lowest for the cities. A view of a retail area along Highway 111 in Palm Desert is seen in Fig. 4.1. Adjoining Palm Springs to the north is Desert Hot Springs; to the east is Cathedral City; and to the southeast is Rancho Mirage. Desert Hot Springs is poorer and Rancho Mirage more affluent than Palm Springs. Desert Hot Springs has the lowest household income and housing value of the nine cities, low education, and a weak economy in retail and manufacturing.

To the southeast of Rancho Mirage are three cities tightly interlinked with each other: Palm Desert, Indian Wells, and La Quinta. Indian Wells, although the smallest city in land area, is the Valley's wealthiest, most educated, and most elderly city, with 55% of its residents of age 65 or older. These northwest cities have over half of the Valley's retail sales, but very slight manufacturing. They emphasize tourism, seasonal visitors, and retirees. To their southeast, in contrast to them, is the pair of cities, Indio and Coachella, with relatively low incomes and home prices, as well as lower levels of education. Both are strong in manufacturing, while Indio also has a substantial retail sector. Indio is the largest Valley city in population at over 80 thousand and together they experienced a high growth rate during the years 2005–2015. Desert Hot Springs, a poor city with low educational level but no manufacturing, also grew very fast during the period (see Table 1.1).

(Source: Wikimedia Commons)

Fig. 4.1 View of retail area of downtown Palm Desert, CA (Source: Wikimedia Commons)

Broadly speaking, the Valley may be described in terms of Census County Divisions (CCDs), which was established by the US Census Bureau, state, and local agencies to define geographic parts of a county including cities and unincorporated areas. Figure 4.2 indicates the population levels of the Coachella Valley cities and unincorporated areas. The Valley's three CCDs are named for their most populous cities– Desert Hot Springs in the northeast, Cathedral City-Palm Desert to the west of Interstate 10, and "Coachella Valley" CCD to the southeast (Table 4.2). The latter mostly consists of Indio and Coachella, but stretches up to the unincorporated area of Thousand Palms to the north.

The contrast in the three CCDs mirrors the highly contrasting Valley portions, and comparative indicators in Table 4.2 highlight the differences. For instance, Desert Hot Springs and Indio-Coachella CCDs are over 10 years younger; while their poverty levels are nearly double that of the Cathedral City-Palm Desert CCD. Furthermore, the latter has nearly double the proportion of graduate/professional

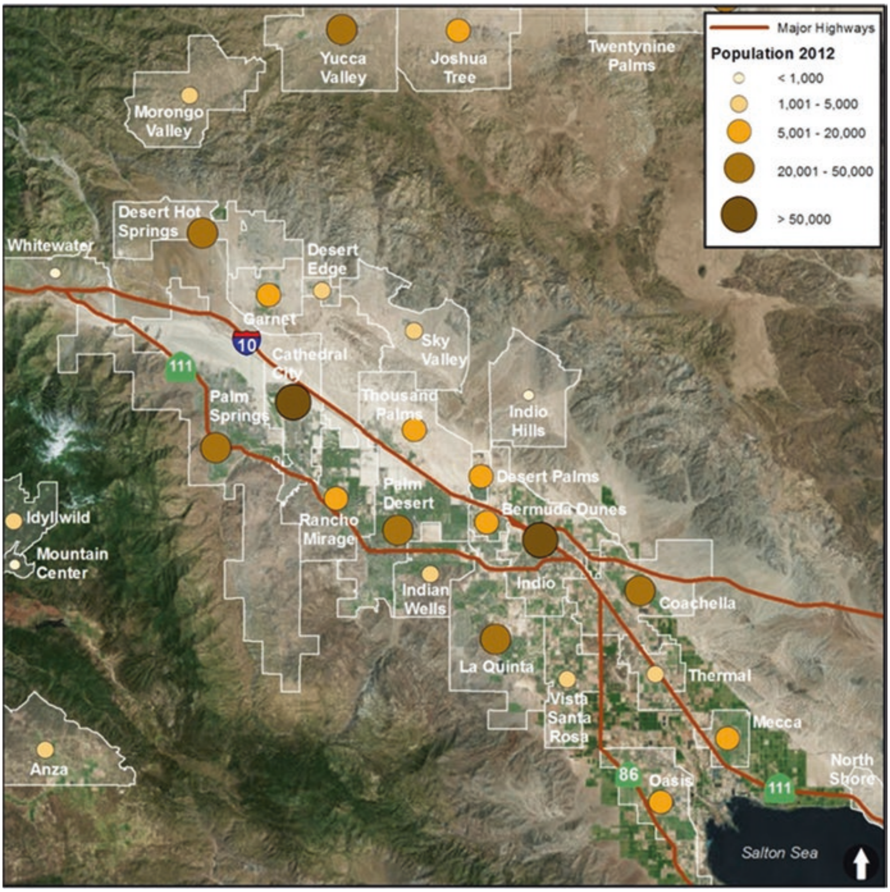

Fig. 4.2 Population of Coachella Valley Cites, 2012 (Modified from Esri 2015)

Table 4.2 Comparison of socioeconomic characteristics of census county divisions of Coachella Valley

	Desert Hot Springs CCD	Cathedral City-Palm Desert CCD	"Coachella Valley" CCD
Population	53,369	148,546	185,688
Median age	36.4	46.6	32.5
Percent Hispanic or Latino Origin	54.5	37.9	71.6
Speak language other than English at home	46.1	35.5	62.4
Less than high school graduate (percent of pop. 25+)	27.2	14.0	32.0
Graduate or professional degree (percent of pop. 25+)	5.5	11.4	6.5
Median individual income	21,116	26,937	21,045
Percent below poverty level	26.9	14.7	25.2
Land area (square miles)	223	148	372

(Source: U.S. Bureau of the Census 2016a, b, c)

degree holders, and considerably higher proportion of English spoken at home. For this book, these three census divisions highlight and support the presence of a socio-economic divide in the Valley.

More specific city characteristics (Table 4.1) compare the nine major cities with each other and with the state of California. Generally, versus the state, most of the Valley cities have a much higher percentage of older (65+) age people, with Indian Wells and Rancho Mirage having about half elderly. The educational level among the cities mostly resembles the state for high school graduation, although Coachella trails considerably. For bachelor or higher college education, Coachella, Desert Hot Springs, Cathedral City, and Indio are seem to be much reduced while Indian Wells stands out as much higher at 54% of population with a college degree. Indian Wells and Rancho Mirage stand out as the most affluent cities, well above the state average in income and housing value. At the low end of education and wealth/income are Desert Hot Springs at the northern edge and the unincorporated areas at the southwestern edges of the urban complex.

The economic configuration of the cities is examined relative to its potential for renewable energy manufacturing, which benefits by presence of a manufacturing sector and by professional, engineering, and technical services support. Recent data from the 2012 Economic Census (U.S. Bureau of the Census 2016b) point to the strengths and weaknesses of the Valley's nine major cities. The largest manufacturing cities, based on value added, are Coachella and Palm Springs, with respective manufacturing value added of $370 million and $167 million (Table 4.3). Manufacturing value added is defined as the net output of the manufacturing sector, after subtractingintermediate inputs. Hence, in the Coachella Valley, these two cities contribute by far the most value beyond the value of their inputs, and thus should be recognized as the manufacturing leaders among the cities. Later in the book, these manufacturing cities are seen to demonstrate opposite support and encouragement

Table 4.3 Manufacturing levels by City, Coachella Valley, 2012

City or place	Manufacturing total establishments	Manufacturing No. of Estabs. 20+ employees	1–4	5–9	10–19	20–49	50–99	100–249	250–499	500+	No of Employees	Annual payroll ($1000)	Value added ($1000)
Cathedral City	13	0	13								29	1264	5454
Coachella	11	6	4	0	1	3	1	1	1		773	37,460	370,253
Desert Hot Springs	2	0	2								NA	NA	NA
Indian Wells	1	0	1								NA	NA	NA
Indio	25	5	13	4	3	3	2				329	13,122	30,734
La Quinta	4	0									6	277	601
Palm Desert	40	5	26	8	5	1					196	6116	12,877
Palm Springs	27	4	19	0	4	2	1	0	1		624	23,281	167,172
Rancho Mirage	5	0	4	1							12	371	793
Thousand Palms	12	3	3	1	5	3					165	4646	19,280
Coachella Cities Total	140	23	85	14	18	12	4	1	2	0	2134	86,537	607,164
California	38,765	9906	18,104	5559	5196	5268	2313	1643	443	239	1,163,341	69,316,766	236,764,751

(Source: U.S. Bureau of the Census 2016b) for renewables manufacturing, the City of Palm Springs favoring it and Coachella manifesting little interest or support. The cities have comparable number of employees and distribution of firms by size, with the largest firm sizes in the range of $250–499 million. The cities of Cathedral City, Desert Hot Springs, La Quinta, Indian Wells, and Rancho Mirage have reduced manufacturing, which may be tied to lower wealth/income levels for the former two and the larger retirement profiles for the latter two.

The potential to expand renewables manufacturing partly depends on professional, technical, and engineering services. A small renewables firm cannot afford many types of professional expertise in-house. Availability for consulting or boutique services is essential and they will only exist locally if there are other industry sectors that need their services, which for the Valley include the medical/healthcare and the tourism sectors. The services are divided quite unequally between the cities, in a different pattern from manufacturing (Table 4.4). The leading cities are Palm Desert and Palm Springs, annually with $140 million and $111 million respectively of spending annually in professional, scientific, and technical services, provided by over 1500 employees.

It is not surprising that the leading nonprofit association for renewables development, Coachella Valley Economic Partnership (CVEP), and most of its start-up clients are located in Palm Springs. At the low end, with very little professional and technical services are the relatively poor cities of Cathedral City, Coachella, and Desert Hot Springs. Coachella has the most manufacturing output among the cities, but has less need for professional services since its manufacturers produce low to medium-end, non-technical products. Manufacturing jobs comprise 9.1% of the city's labor force and fall into the areas of food, apparel, metal, petroleum and coal, machinery, computer/electronic products, and transportation (SCAG 2015).

An example of a non-technical manufacturer in Coachella Valley is Ernie Ball, which produces guitar strings, cables, picks, straps, and other guitar products. The firm's headquarters are in San Luis Obispo but most of its manufacturing is located in the City of Coachella. It has about $40 million in annual revenue, and 150 employees, split between the City of Coachella and their headquarters. It was founded by Roland S. "Ernie" Ball in 1958, and even though he died in 2004, it has remained under family control. Ernie Ball had a colorful career as a professional musician, and developer of "Slinky" guitar strings, products used internationally by music greats such as Paul McCartney, the Rolling Stones, and the Eagles (Ernie Ball 2016). The company exemplifies the concept of a firm that is utilizing Coachella's low cost structure for manufacturing, while maintaining executive management, administration, professional services, and R&D external to the Valley. Even though the Ernie Ball firm has been quite successful, Coachella city remains an unlikely base for high-end innovation in renewables.

Siemens Water Technologies, another Valley manufacturer, located in Palm Desert, produces industrial water filtration systems. It exemplifies more technology-driven manufacturing, drawing on a world-class parent company that could provide engineering expertise for renewables start-ups.

Table 4.4 Profile of professional, scientific, and engineering/technical services in Coachella Valley Cities, 2012

Attribute		Cathedral City	Coachella	Desert Hot Springs	Indian Wells	Indio	La Quinta	Palm Desert	Palm Springs	Rancho Mirage
Prof., Sci. Tech. services	No. of establishments	40	7	8	37	74	89	260	191	78
	Revenues ($1000)	10,994	2220	4380	22,505	33,048	65,434	140,169	110,593	57,490
	No. of employees	99	30	215	99	308	339	862	664	305
Engineering services	No. of establishments	2	0	0	0	3	4	19	6	1
	Revenues ($1000)	0	0	0	0	NA	NA	9830	1725	NA
	No. of employees	0	0	0	0	NA	NA	69	9	NA
Management, Scientific, Technical, and Consulting Services	No. of establishments	3	0	1	0	14	28	53	18	21
	Revenues ($1000)	798	0	NA	0	5236	32,454	17,134	7798	8661
	No. of employees	4	0	NA	0	31	99	113	110	47

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

4.2 Population Including Unincorporated Areas

In addition to the nine major cities, Coachella Valley has an estimated 126,000 people residing in unincorporated places and on Riverside County land. This includes some Native American population living on the outskirts of the Valley. About two fifths of this population resides in unincorporated Census Designated Places (CDPs) that neighbor or are close to the complex of nine cities. As seen in Table 4.5, people residing in the nine CDPs, with the exception of Bermuda Dunes and Desert Palms CDPs, tend to be marginal socioeconomically, with low education, depressed household incomes, and low housing values, indicators lower than ever for the rather impoverished Coachella city. The CDPs, except for Whitewater, Bermuda Dunes, Sky Valley, and Desert Palms, also tend to have very high percentages of residents of Hispanic/Latino origin, ranging from 62 to 99%, as well as residents who speak a non-English language at home, largely presumably Spanish, in the range of 46–96% (U.S. Bureau of the Census 2016a, b, c). These places have younger population than for Valley's cities.

The hamlet of Whitewater, with only 469 residents varies by having a low population of Hispanic or Latino origin (16.4%) and low non-English speaking at home (6.7%), yet it is very poor (43.7%) and has low college education (8.9%). It is located inside and adjoining the San Gorgonio Wind Farm. By contrast, the Bermuda Dunes and Desert Palms CDPs have profiles that resemble the mid-socioeconomic range of the Valley's cities. For instance their respective household incomes at $60,494 and $56,108, which are about $28,000 more than the seven marginal CDPs, and which are comparable to cities such as Palm Desert and Palm Springs. Unsurprisingly, both CDPs are south of Interstate 10 and a part of the "jigsaw puzzle" of the city complex. It is likely that they would fairly soon become incorporated as cities or annexed by existing cities.

These findings further add to the picture of the Valley as socioeconomically divided, with the seven marginal unincorporated places forming part of an even larger semi-circle of peripheral areas in the north, northeast of Interstate 10, and south of the City of Coachella. The implication for the rest of the chapter is that the surrounding marginal areas are likely to grow more rapidly than the cities complex. Moreover, they have limited present economy or workforce to contribute to renewable manufacturing and consumption. Nonetheless, the areas may augment their income, education, and socioeconomic status over time, contributing more to renewable prospects in the future.

4.2.1 Projection

The population projection of the Coachella Valley and its nine cities and unincorporated areas is based on a special projection to 2008, performed by the Southern California Association of Government (Boegle 2013). Further, the projection draws

Table 4.5 Demographic and economic profile of Coachella Valley unincorporated areas

Attribute	Bermuda Dunes CDP	Desert Palms CDP	Garnet CDP	Indio Hills CDP	Mecca CDP	Sky Valley CDP	Thermal CDP	Thousand Palms CDP	White-water CDP	California
Population, 2012	7719	6776	6380	910	8912	2493	3570	7946	469	38,066,920
Persons 65 years and over, percent, 2012	10.70%	88.70%	8.60%	4.90%	4.20%	24.40%	6.10%	21.80%	14.50%	12.10%
Language other than English spoken at home, pct age 5+, 2008–2012	23.20%	7.20%	75.80%	74.00%	95.90%	35.20%	94.00%	46.00%	6.70%	43.80%
High school graduate or higher, percent of persons, age 25+, 2010–2014	91.20%	97.20%	67.20%	63.40%	29.80%	79.60%	47.70%	76.40%	78.10%	81.50%
Bachelor's degree or higher, percent of persons, age 25+, 2010–2014	34.70%	43.70%	12.30%	10.90%	1.40%	15.90%	0.10%	16.70%	8.90%	31.00%
Median value of owner-occupied housing units, 2012	$338,900	$357,000	$96,100	$191,400	$104,600	$98,800	$22,400	$138,300	$86,800	$371,400
Median household income, 2008–2012	$60,494	$56,108	$30,579	$37,386	$26,473	$34,107	$26,344	$43,813	$15,500	$61,489

(continued)

Table 4.5 (continued)

Attribute	Bermuda Dunes CDP	Desert Palms CDP	Garnet CDP	Indio Hills CDP	Mecca CDP	Sky Valley CDP	Thermal CDP	Thousand Palms CDP	White-water CDP	California
Individuals below poverty level	10.0%	8.6%	19.6%	17.3%	44.3%	26.7%	46.2%	10.1%	43.7%	16.4%
Hispanic or Latino origin	38.3%	2.4%	73.1%	80.5%	98.6%	42.9%	99.6%	62.2%	16.4%	38.2%
Land area in square miles, 2010	2.95	2.67	11.29	NA	6.96	NA	12.70	23.64	NA	155,779.22
Persons per square mile, 2010	2471.8	2605.6	668.1	NA	1232.5	NA	523.2	326.4	NA	244.4

(Source: U.S. Bureau of the Census 2016a, 2016b, 2016c) on the U.S. Census 2013 data for the Valley cities. The annual growth rates of the cities were interpolated from 2008 to 2013, to obtain the projection's annual growth rates for cities.

The projected population of the Coachella Valley in 2020 is 604,000 according to the Southern California Association of Governments (SCAG) (2013), while our own projection, based on the interpolated rates, is 563,261 population in 2020 (see Table 4.6). SCAG assumed a continuing rate of growth for Coachella Valley of 2.58% yearly, which is about the same rate as its cities grew in the 2000s. One of the reasons for continuing the high rate is that in 2013, SCAG estimated the Coachella Valley to have a population of 126,131 in its unincorporated areas, which are located mostly to the east and far south of Interstate 10, and it assumes these areas have high growth rates. In our own projection of the unincorporated areas, shown in Table 4.6 as Coachella Valley (UofR), we assume a continuing rate of growth half way in between SCAG's long-term 2008–2020 growth rate of 2.58% and our own estimated growth rate 2008–2013 of 2.02%.

Long-range SCAG (2013) projections indicate the Coachella Valley population in 2035 will be 884,000, of which 308,600 will be in unincorporated areas (see Table 4.6). However, some of the unincorporated areas may become incorporated or annexed to an existing city. The projection of 2035 population of major cities indicates Coachella at 128,700 and Indio at 111,800, showing the Valley's population center moving to the southeast.

The projections point towards a region in 21 years that will be significantly larger, approaching a million people, as well as having a larger, more differentiated, and more specialized economy, which could support complex manufacturing, a topic returned to later.

4.3 Spatial Patterns of Income, Wealth, Education, and Age

Since the Coachella Valley varies considerably in socio-economic levels among its cities and unincorporated areas, it is useful to spatially examine the variation by census tract for selected demographic, educational, occupational, economic, and social attributes. This section first considers the demographic, educational and occupations patterns, and later on looks at economic and social patterns. The unit of analysis of the map displays in this section is the census tract and the source of data for these maps is for year 2015 except for the crime index, which is for 2014 (Esri Inc. 2015). In its updated demographics, Esri offers annual updates that its internal demographic research unit estimates from data that were originally collected by the U.S. Census American Community Survey or U.S. Census of Population (Esri Inc. 2016).

The *total population* in 2015, shown on Fig. 4.3, reveals a fairly even distribution of census tracts in the urban areas. Generally in the range of 2500–5000 persons per tract in the older areas of Palm Springs, Cathedral City and Palm Desert, but higher levels of 5001–7500 persons per tract in the newer tracts of La Quinta, Indio,

Table 4.6 Population projections to 2020 and 2035 for Coachella Valley, its cities and unincorporated areas

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	25,886	25,938	27,902	4.91	2.10		32,282	58,100
Indian Wells	3816	4123	4826	4910	4947	4958	5000	1.78	0.71		5253	5800
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	44,026	44,346	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	

(Source of SCAG projections, reported by Boegle 2013)

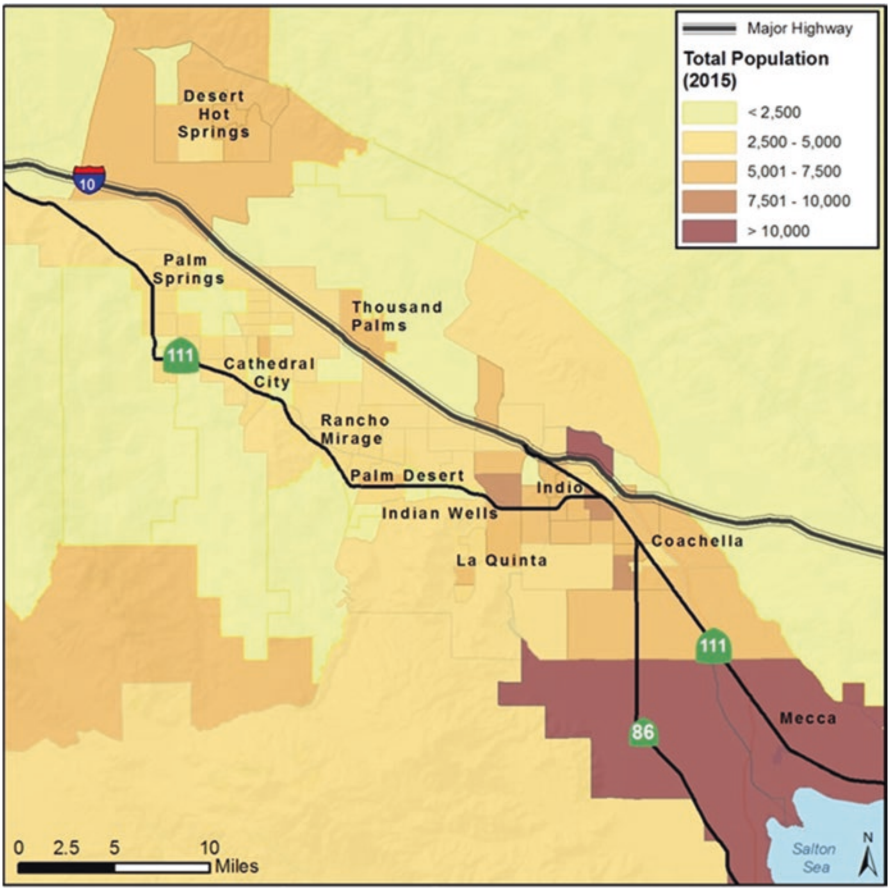

Fig. 4.3 Population of the Coachella Valley, by census tract, 2015 (Modified from Esri 2015)

Coachella, Thousand Palms CDP, and Desert Hot Springs. Mecca, with a population of 8912 in 2015 appears very high, but that is an anomaly due to its being located in a census tract larger than its CDP boundary. This map reveals a sprawl pattern of the urban complex, with historically small census tracts in the older areas, and large, populous tracts in newer areas to the north and south.

College graduates, shown as percent of population 25+ in Fig. 4.4, reflect dramatic differences in educational level. Looking first at areas north of Interstate 10, they are mostly in the range of 5–10%, with the exception of Desert Palms CDP, not labeled on the map, and one tract in Indio. By contrast, the urban areas south of Interstate 10 are predominantly in the range of 16% to over 25% college educated. At the low end of less than 5% with college education is a portion of the city of Desert Hot Springs, and the Mecca CDP, areas that have been more agricultural in the Valley's history.

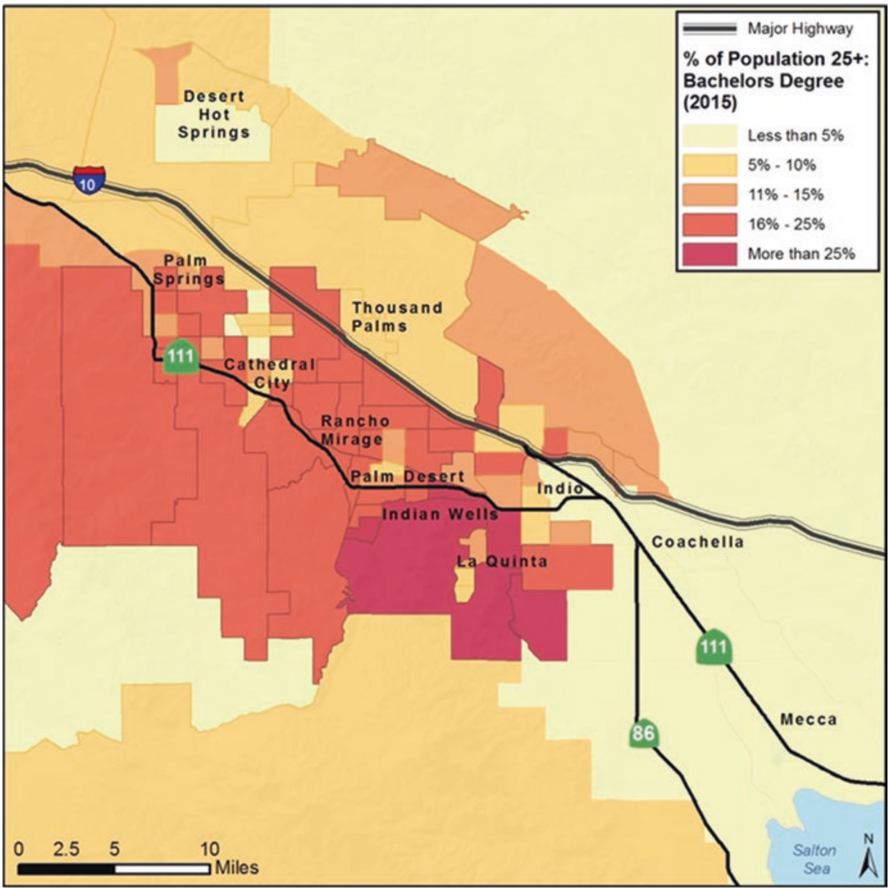

Fig. 4.4 College graduates, percent at this level, population 25 years or older, Coachella Valley, 2015 (Modified from Esri 2015)

The most educated- tracts are in Indian Wells and parts of La Quinta, with over 25% college-educated. Unsurprisingly, *high school graduates*, people with terminal degree of high school as percent of population age 25+, are much more prevalent in the periphery of the urban complex of cities, and lowest in the more educated cities as shown in Fig. 4.5. In several tracts: Desert Hot Springs, Indio, Coachella, and Mecca, the percent of high school graduates is low and the population with terminal grade school education is high. There are many ways to analyze dimensions of education, but these two measures reiterate the concept of a bifurcated Valley, with more educated cities in the southwestern city complex and less educated people north of Interstate 10 and in parts of Coachella and in the Mecca CDP to the south.

The geographic pattern of *professional/scientific/technical services employees* emphasizes stronger presence mostly in the wealthier, more educated cities of Palm Springs and in its older northern section of Palm Desert, Rancho Mirage, Indian

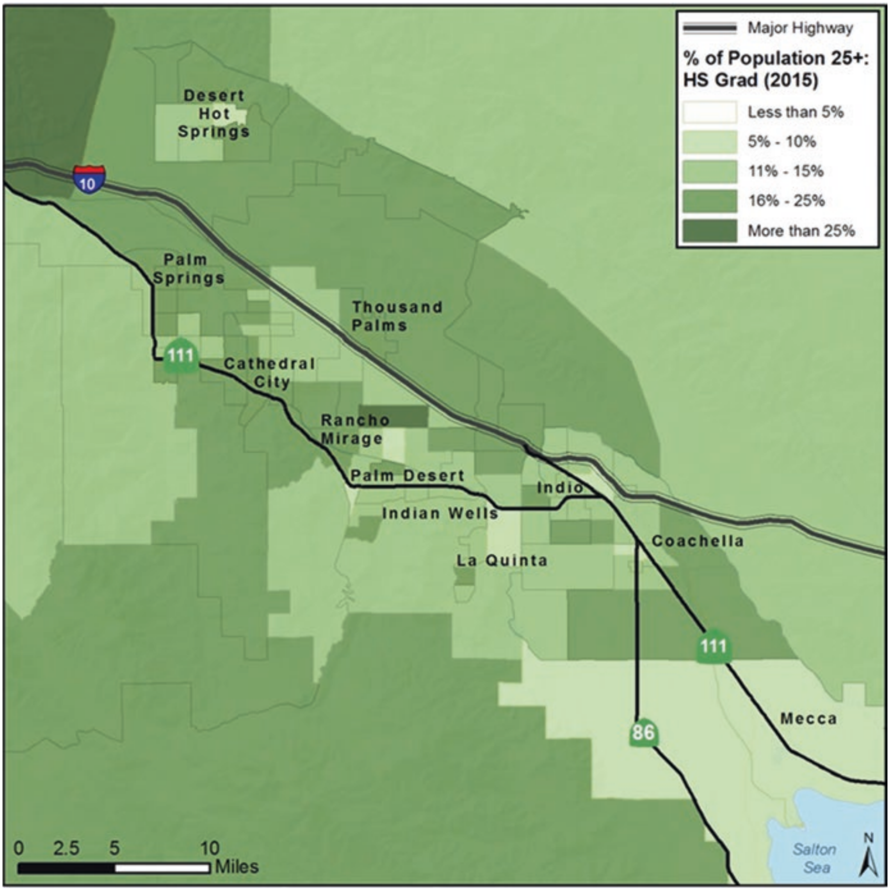

Fig. 4.5 High school graduation, percent at this level, population 25 years or older, Coachella Valley, 2015 (Modified from Esri 2015)

Wells, La Quinta, and parts of Indio and Indio Hills. As seen in Fig. 4.6, the areas with very little such employees are to the north and southeast, again corresponding to the Valley's socioeconomic divide and including Desert Hot Springs, Thousand Palms CDP, Coachella, and Mecca which is contained in one large tract. These services contrast with the concentration of *production employees*, many involved in agriculture, seen in Fig. 4.7, which are concentrated in the economically poorer areas of Desert Hot Springs, Thousand Palms, Indio, and Coachella, with scattered presence in Palm Springs and Cathedral City. A production employee is a broader concept than manufacturing employee and includes workers at any point in the supply chain and in plant-related services, who are up to line-supervisor level (U.S. Bureau of the Census 2016c).

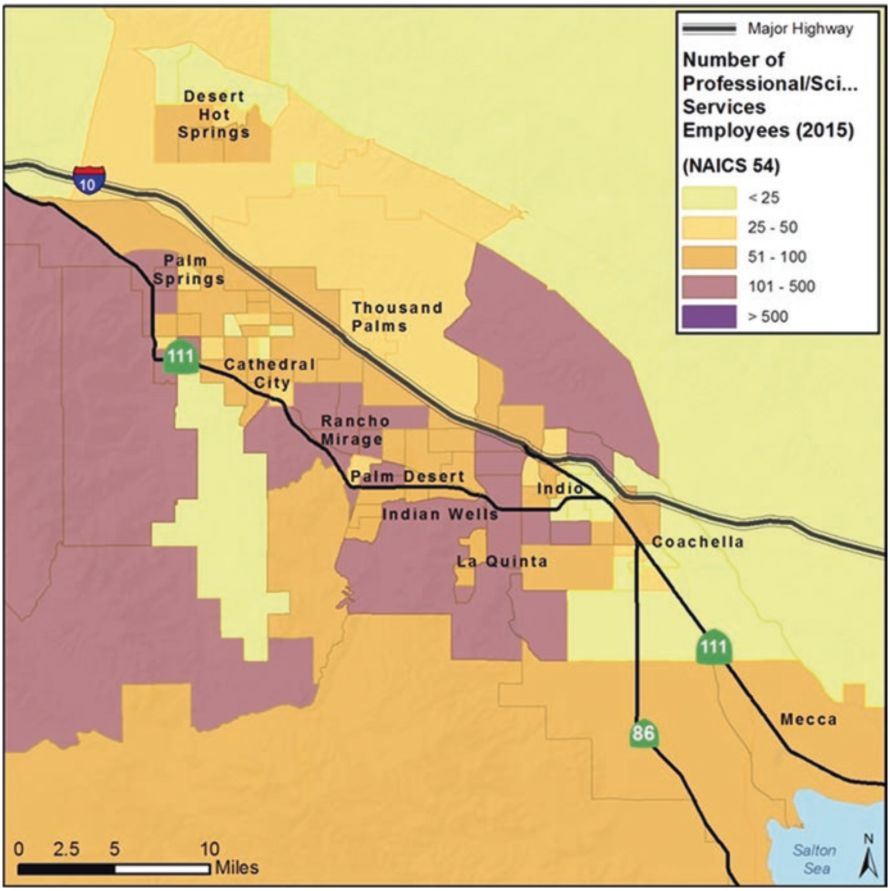

Fig. 4.6 Number of profession/scientific/technical services employees, Coachella Valley, 2015 (Modified from Esri 2015)

The *median net worth* in the Coachella Valley has considerable range, which corresponds to the large variations in household income and the value of housing across the cities and unincorporated areas. As seen in Fig. 4.8, the highest median net worth category of greater than $250,000 is located in La Quinta, Indian Wells, parts of Palm Desert, and Rancho Mirage, while Desert Hot Springs, scattered sections of Palm Springs and Cathedral City, most of Indio, most of Coachella, and Mecca are characterized by household net worth of under $75,000. This wealth differential can influence both consumer capacity to invest in domestic renewable energy, as well as the location of the potential pool of investors in renewables.

The manufacturing sector in the Coachella Valley produces mostly low-tech products and generates about $ 0.25 billion annually. Product examples include guitar strings from Ernie Ball, dates from Shields Date Gardens, and bottle assembly

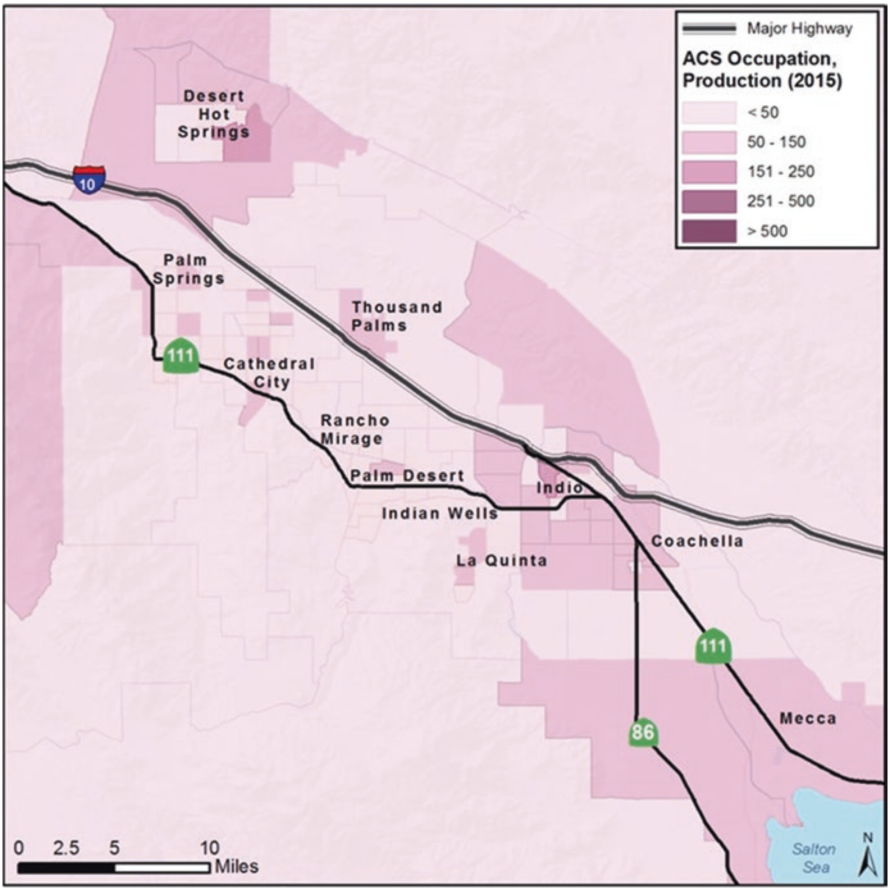

Fig. 4.7 Number of production employees, Coachella Valley, 2015 (Modified from Esri 2015)

from Coca Cola Bottling, shown in Table 1.4. As seen in Fig. 4.9, the *manufacturing employees* predominantly work in poorer, less educated parts of the Valley, in the areas north west of Interstate 10, and in the far south in Coachella and parts of Indio, while some workforce resides in a small, less affluent part of Palm Springs north of Highway 111 and a small portion in Palm Desert (U.S. Bureau of the Census 2016a, b, c). *Sales in manufacturing,* shown *in* Fig. 4.10, corresponds very closely to manufacturing worker locations, while the *number of manufacturing firms* (Fig. 4.11) is highest in parts of Palm Springs, Cathedral City, Palm Desert, Thousand Palms CDP, and Indio. The key manufacturing locations give a clear geographical picture of the most likely potential locations for manufacturing related to renewables.

Three general socioeconomic and business variables are helpful in defining the environment for both consumption and production aspects of renewables. With the expectation that renewables have greater purchasing support from consumers who are environmentally aware and motivated, interest in the environment is included

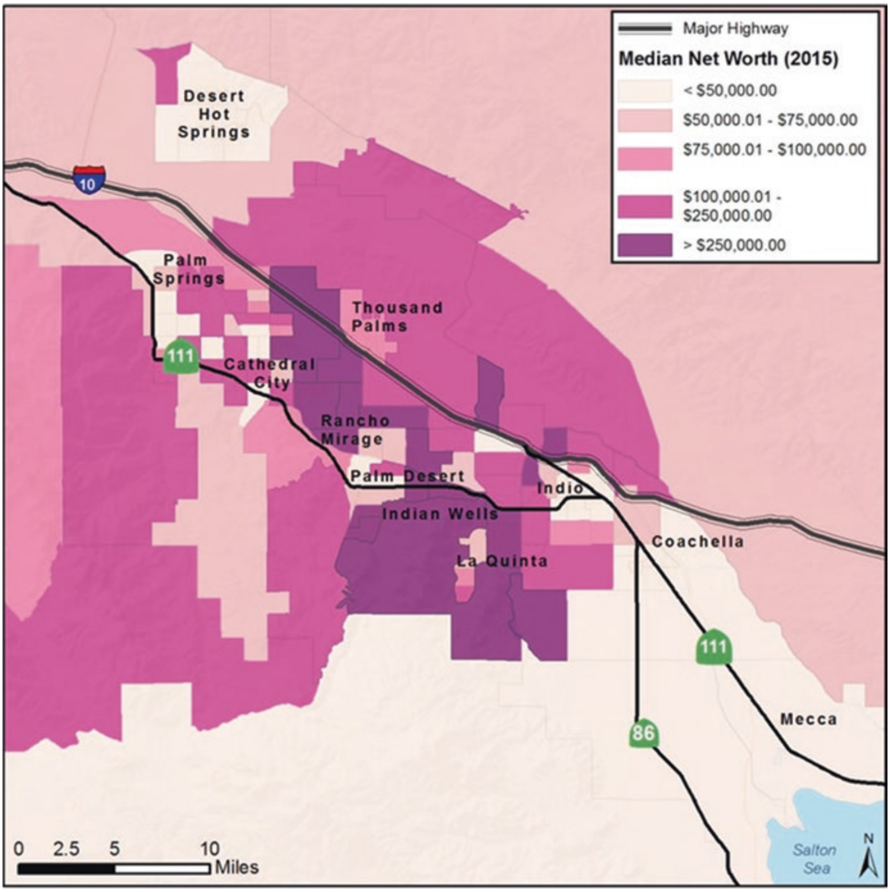

Fig. 4.8 Median household net worth, Coachella Valley, 2015 (Modified from Esri 2015)

and is measured by the number *of people who participated in an environmental group cause* during the prior year, (see Fig. 4.12). This participation variable is highest in more residential parts of the wealthy communities of Rancho Mirage, Indian Wells, Desert Palms, and La Quinta, and lowest in the more mountainous parts of south Palm Springs and Palm Desert, in Coachella, Desert Hot Springs (although the surrounding unincorporated county land has high participation), and northeastern peripheral and unincorporated areas, including Desert Edge CDP, Sky Valley CDP, and Indio Hills CDP (see Fig. 1.1). Hence, from a consumer standpoint, the population that can better afford domestic solar energy or heat pumps is also more environmentally motivated. From the local investor standpoint, the locations with most wealth and capability to invest also tend to have more interest in the environment.

The *total crime index* (Esri Inc. 2016) measures crime frequency averaged over a variety of crimes, as seen in Fig. 4.13. The index ranges from 1, the lowest mea-

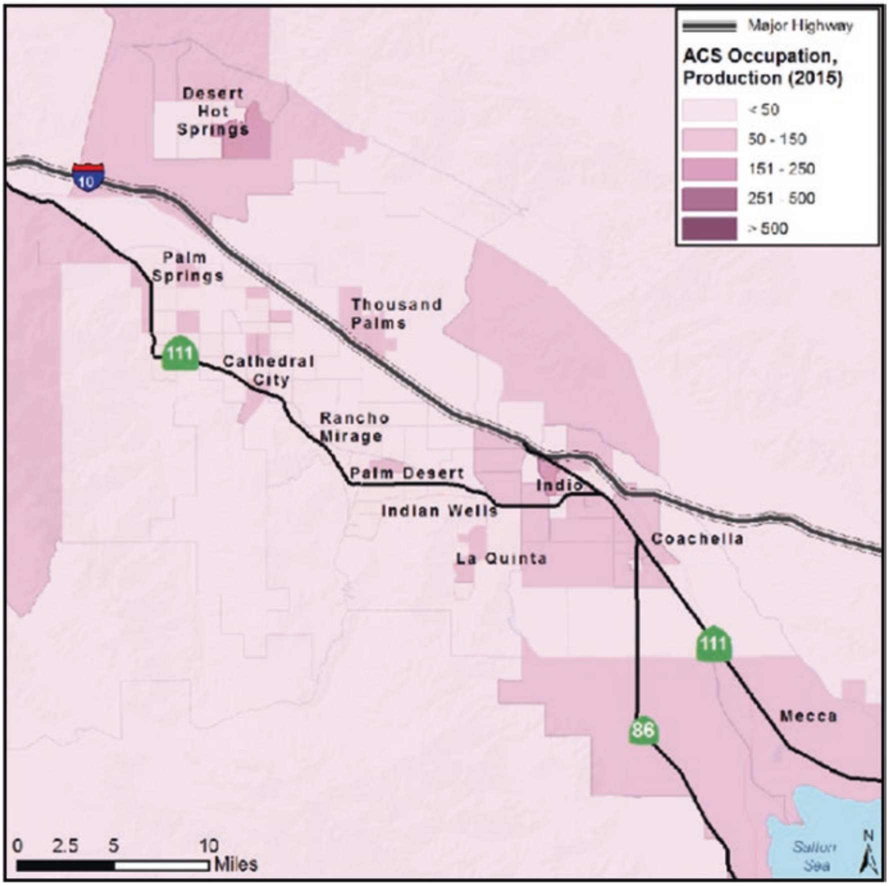

Fig. 4.9 Number of manufacturing employees, Coachella Valley, 2015 (Modified from Esri 2015)

sure of crime, to 100, the highest measure of crime. It is clear that crime somewhat follows the socioeconomic differentials in the Valley, but it also reflects the strength from city to city in combatting crime, and cities' exposures as targets for crime. The high levels for parts of Palm Springs, Palm Desert, and La Quinta may be because some census tracts are inadequately protected. Not surprisingly, there is a high crime index level in the socioeconomically marginal Desert Hot Springs, Indio Hills, Coachella, Thermal, and Vista Rosa CDPs. The relatively high crime rate in most of the urbanized Coachella Valley represents disincentive for attracting skilled labor force for renewable energy development and operations.

Internet use to make a business purchase (percent in last 30 days) indicates the technological readiness for the Valley's population. The divide, here a digital divide, is again apparent, with the wealthy, educated cities having high internet use for business, particularly those cities or portions south of the Highway 111 (see Fig. 4.14). A digital divide is the differences in access and use of technology between segments

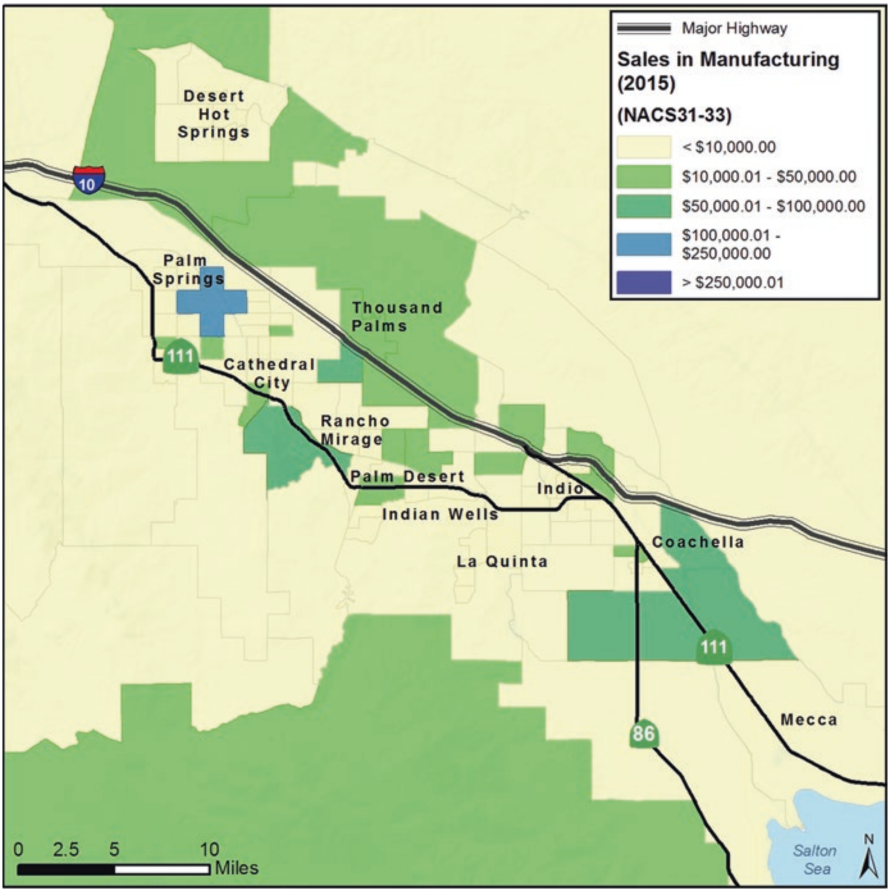

Fig. 4.10 Sales in manufacturing, Coachella Valley, 2015 (Modified from Esri 2015)

of the population or different places. The area north of Interstate 10 stretching from Desert Hot Springs to Coachella and down to Mecca has the lowest usage of less than 10%, with the exception of Indio Hills, Bermuda Dunes and unincorporated county land between the two. Hence, the former area of high Internet use would be more attractive for renewable energy innovators or managers to reside in, and locate their businesses.

4.4 Solar and Wind Workforce in Coachella Valley

The Coachella Valley's renewable energy workforce is an essential aspect of its potential to develop these energy resources. Since a significant portion of renewable workers nationwide are skilled, the renewables sector offers more opportunities to

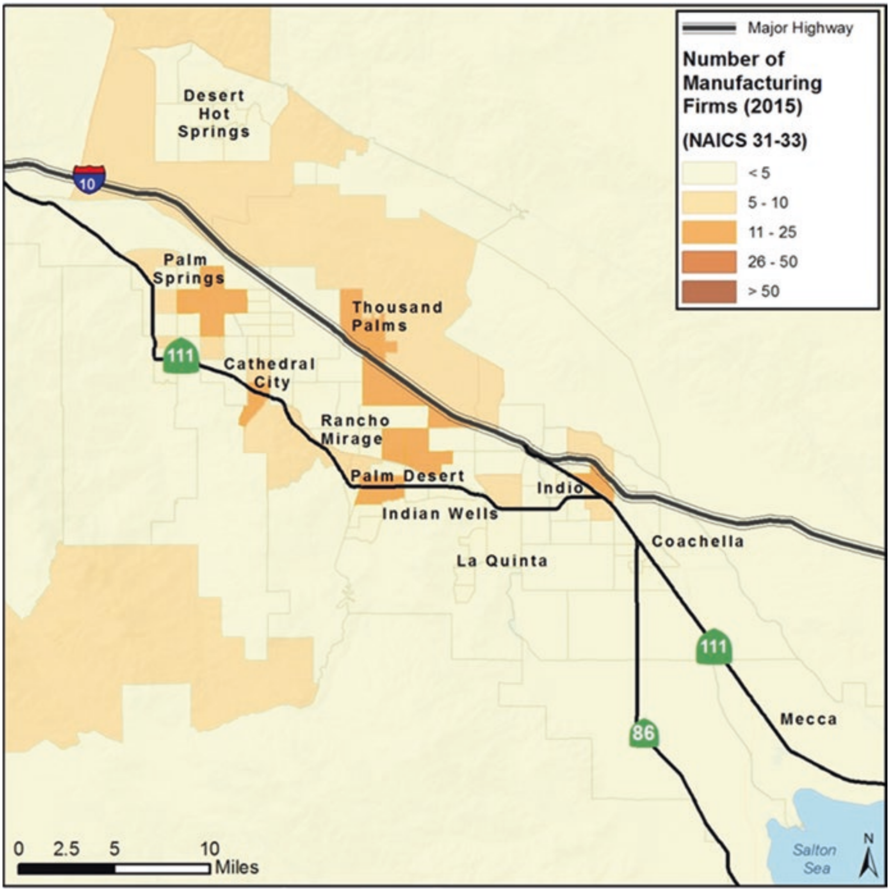

Fig. 4.11 Number of manufacturing firms, Coachella Valley, 2015 (Modified from Esri 2015)

retain existing skilled workers and attract skilled workforce from outside. Moreover, potential expansion in renewables manufacturing will depend on a growing pool of workers with renewables skill and expertise. This chapter section examines the growth of solar and wind workforce from the national, state, and Valley standpoints, and it estimates the current number of solar and wind employees whom reside locally. It finishes by considering the challenge of training new workers, with a case illustrating solar and wind training programs at the College of the Desert and the example of Renova Solar's remarkable emphasis on training.

In 2015, the United States solar labor force was estimated at 209,000 and is presently growing at a 20% rate (Solar Foundation 2016b). The national growth is linked to factors already covered in Chap. 1 including favorable national and state policies, environmental concerns with fossil energy, lowering cost of renewables, and federal subsidies. The solar workforce is unequally distributed by state, with California by far the leader with 36.2% of U.S. renewables workers, followed by Massachusetts

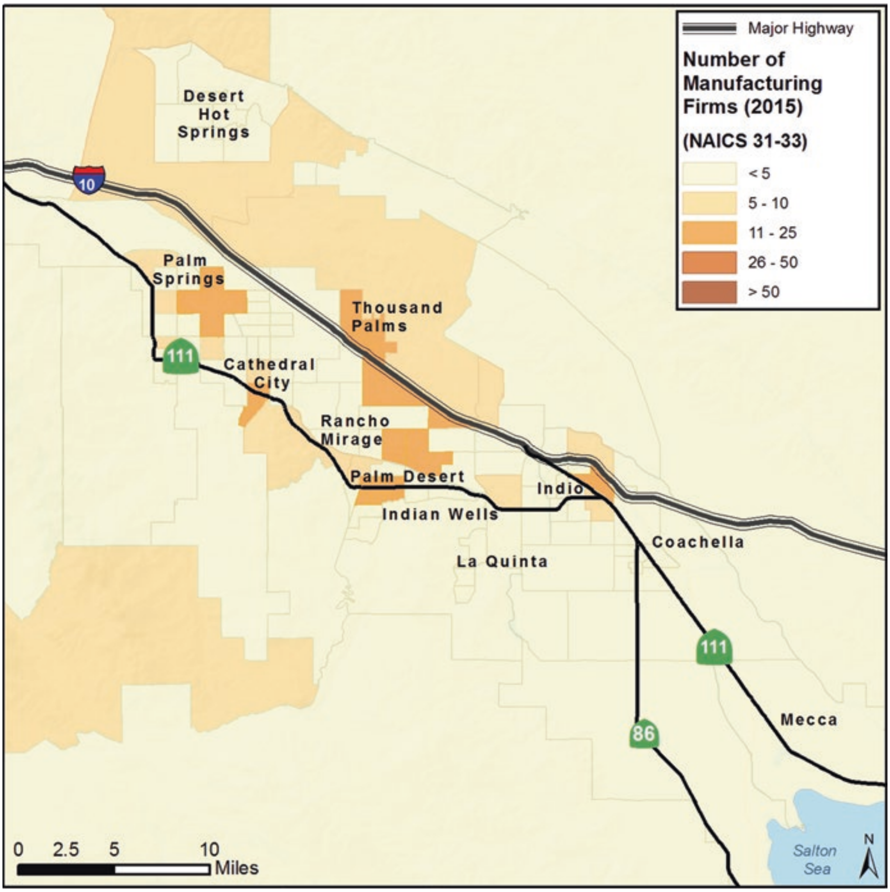

Fig. 4.12 Number of persons participating in and environmental group cause, Coachella Valley, 2012 (Modified from Esri 2015)

with 7.2%. Other leading states in order are Nevada, New York, New Jersey, and Texas. They are mainly large industrial states that have major residential markets, yet about half of these states are in the northeast, a region with much lower solar radiation than the Sunbelt. Their surprisingly large renewables workforce reflects that there is much more to explaining solar demand than levels of radiation, such as leadership and strong popular support for renewables. The example of Germany as a European leader in solar energy, located substantially more to the north than New York, reinforces this point (Kunzig and Locatelli 2015).

California benefits by having high radiant energy in its southern portion, favorable state and local policies, large customer demand for residential solar, energy prices higher than the national average making renewables more competitive, and low installation costs due to the competitive market of solar installer firms. The local and state policies include tax credits, rebates, and ambitious state Renewable

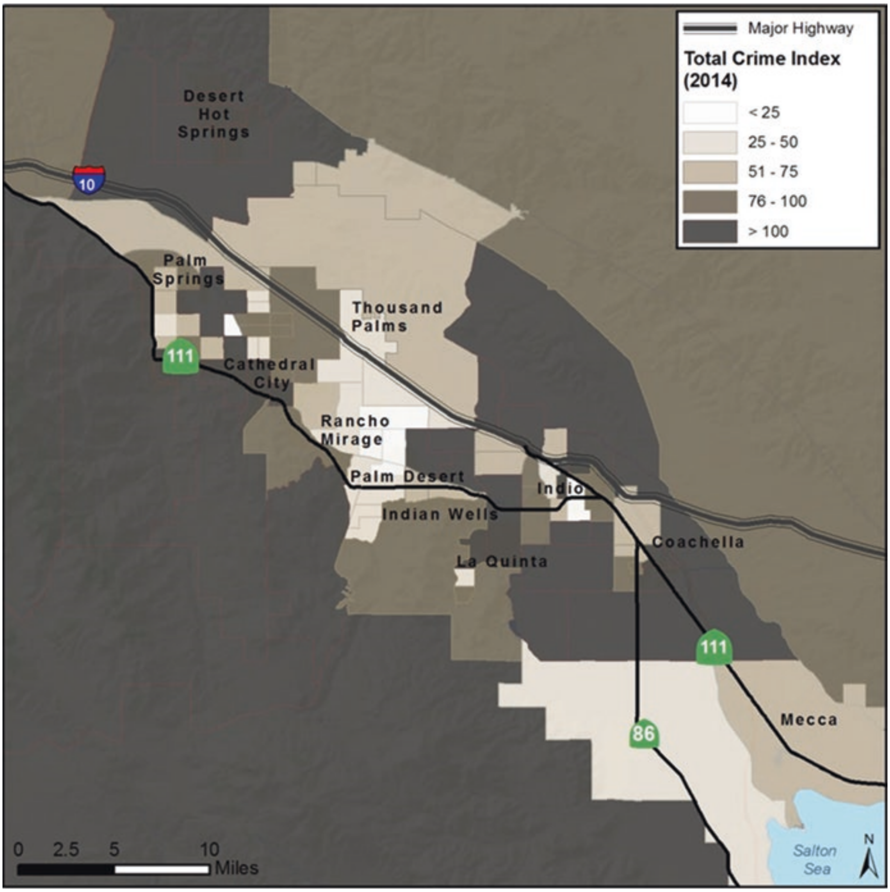

Fig. 4.13 Total crime index, Coachella Valley, 2014 (Modified from Esri 2015)

Portfolio Standards (RPSs). Net metering has been required for public utilities in California, allowing homeowners to sell excess energy to the utility.

California's solar workforce consists mostly of installation jobs (53.7%) and manufacturing jobs (14.8%), in line with the national distribution (Solar Foundation 2016a). Its solar workforce is close to national proportions in minority workers (31.0%, vs. 25.0% for the U.S.), workers age 55+ (17.5% vs. 18.6% for the U.S.) (Solar Foundation 2016a). Hence, the workforce is typical nationally in its profile but much larger than other states.

The number of solar workers in Coachella Valley is estimated by applying the proportion of the state population in the Valley to the state total solar workforce (Solar Foundation 2016a). Based on the cited projection by SCAG of 503,256 residents in 2013 and the official 2015 population count of the state of 39,250,000 people, we calculate that proportionally there would be 1008 solar workers resident in the Valley in 2015 (Boegle 2013; California Department of Finance 2016).

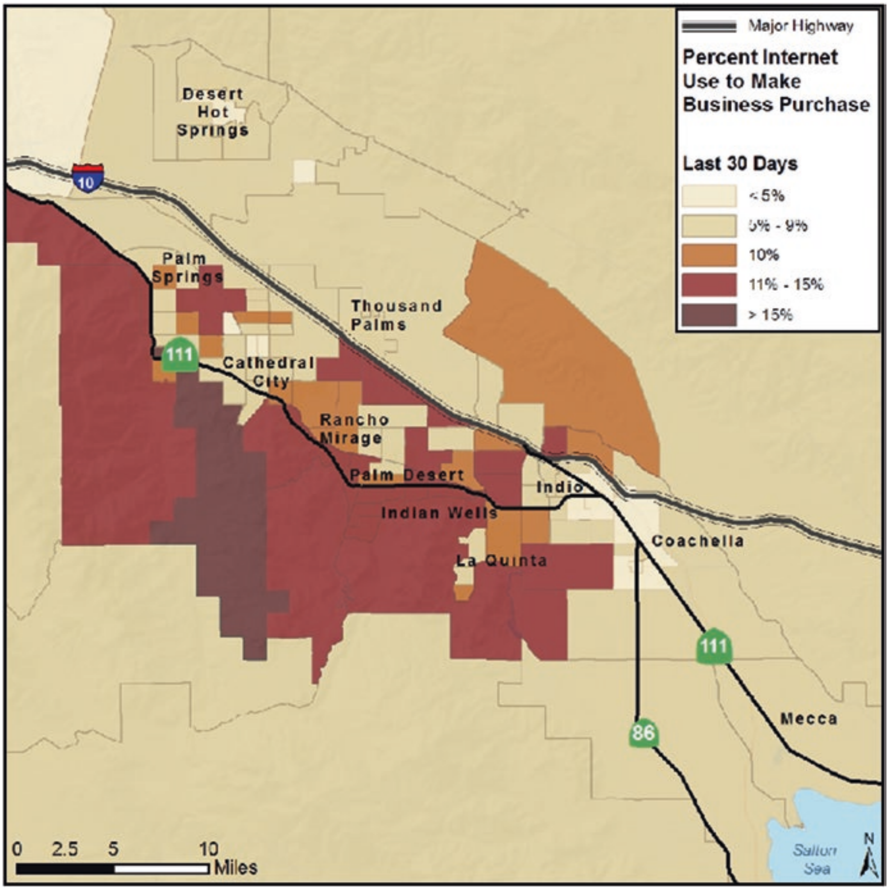

Fig. 4.14 Population with internet use to make a business purchase, percent of population in last 30 days, 2015 (Modified from Esri 2015)

However, since it is in an area of the state with intense radiant sunlight and close to major solar plants towards Arizona, we speculate that the actual proportion is 20–40% higher, yielding a solar workforce of 1210–1411 solar employees.

Even though wind energy surpasses solar in its proportion of U.S. energy supply, with operating capacity of 73,992 MW and 48,500 turbines, its accompanying workforce is less than half that of solar (AWEA 2016). Among the reasons are that wind energy has very little consumer adoption, compared to millions of homes with solar, which are accompanied by workforce in supply chain, sales, marketing, administration, installation and maintenance. Nationally, wind energy has many more commercial power plants than for solar, requiring more workers, but the residential solar numbers are much larger.

In 2015, the wind energy sector had 88,000 full-time employees employed in a wide varied of positions ranging from manufacturing and R&D to project planning, site selection of property, facility development, and construction, as well as domestic sales, marketing, installation and maintenance (AWEA 2016). Wind workforce had a huge growth spurt of 37,500 jobs from 2013–2015, a 74% increase. Nationally in 2015 most wind positions were in operations (47,000 workers), followed by construction/transportation (10,000), manufacturing/supply chain (9000) and other (21,000). Over time, the proportion in manufacturing/supply chain has decreased due to overseas production, robotic factories, and shift towards operating and maintaining the growing base.

Statewise, Texas is the workforce leader with 24,000 wind workers, followed by Oklahoma, Iowa, Colorado, Kansas, Illinois, and California in 7th place. On the other hand, some states including most of the southeast, have no wind operating workers, although manufacturing is present. Texas has the nation's leading wind manufacturing complex around Houston, favored by a natural endowment of strong and largely unobstructed winds in the west and northwest of the state, by a supportive state regulatory environment, and by a large specially-designed grid network in west Texas termed the Clean Renewable Energy Zone (CREZ) transmission lines, which has greatly sparked wind development. Oklahoma in second place at 7000 workers ha many of the advantages of Texas with growing wind capacity.

The wind energy workforce in Coachella Valley is estimated by a similar ratio calculation to that for its solar workforce. Using the AWEA estimate of approximately 3500 wind workers in California in 2015 (AWEA 2016), the number of them in the Coachella Valley is estimated first by multiplying the state total of 3500 by the ratio of 2015 population of Coachella Valley (SCAG 2013 forecast in Table 4.6 projected to 2015 at its 2008–2013 growth rate) to the 2015 California state population (California Department of Finance 2016). This results in an estimate of 47.1 wind workers. We predict that the actual Valley proportion is 20–40% higher, due to the presence in the northwest Coachella Valley of one of the state's largest commercial wind farms, yielding a solar workforce of 57–66 wind employees.

Box 1: Case Study of College of the Desert's Renewable Energy Training The College of the Desert, located in Palm Desert, is a community college with about 10,000 students. It offers 2-year programs leading to an Associate of Arts degree, and enabling some students to transfer to 4-year institutions to complete a 4-year Bachelor Degree. For others, the college provides vocational training in fields useful locally, such as nursing, digital design, public safety, and culinary arts (College of the Desert 2016).

The college has a well-developed set of offerings in renewable energy that provide training to enhance and expand the Valley's skilled workforce in renewables. The programs are centered in the Advanced Transportation Technology and Energy Initiative (ATTE), which has the goals of "keeping California competitive as a national leader in advanced transportation and energy technologies and to transform the workforce in the rapidly developing, technology-driven transportation and energy industries" (College of the Desert 2016). The courses offered include utility-scale solar energy, wind energy, bio fuels, fuel cells, and energy efficiency. For instance, an 8-week course in "Solar Photovoltaic Principles and Applications" trains students in theory, principles, and applications of solar photovoltaics, enabling them to qualify for entry-level solar installation service jobs.

Accompanying ATTE at the College is the Desert Energy Enterprise Center that emphasizes education/energy industry partnerships in demonstrating technology and offering co-training with industry (College of the Desert 2016). This case is a prominent example of how the Coachella Valley community can prepare for future enhancements in renewable sector service employment. By moving in this direction, Coachella Valley community college graduates and trainees may be motivated to seek more advanced education, a cascade that propels local students and may see some of them return to the Valley in R&D jobs.

This case is not unique, as other programs exist in the Valley in K-12 school districts, two university satellite campuses, and Riverside County Office of Education (CVEP 2015). About 1 hour from the Valley is University of California Riverside, which offers world-class education in engineering and science and could be a source of workforce and scientific collaboration on renewables. Moreover, one of the prominent solar companies Renova, which is discussed in detail in Chap. 6, is unusual for a small business of 100+ employees in offering a 60-hour training class to prepare enrollees to take the North American Board of Certified Energy Practitioners (NABCEP) or other solar certification tests (Murphy 2015).

4.5 Conclusion

The Coachella Valley has unique socioeconomic, labor force, and urban features that influence the development and future of its renewable energy sector for better or worse. The Valley's nine major cities are arranged in a jigsaw-like pattern, which is surrounded to the north, west, and south by unincorporated Census Designated Places. The overall geographic distribution reveals a remarkable contrast between the wealthy, educated city complex west of Interstate 10, and mostly poor, less educated, and often politically-weak settlements on their periphery. The total population of the Valley is estimated at about 500,000 in 2013, with growth to 884,000 projected by 2035. In this growth, the younger, higher-fertility periphery of the Valley will expand more rapidly than the older urban core.

Manufacturing is present especially in Palm Springs, Indio, and Coachella, but mostly involves non-technology products not requiring high skills of workers. There is a small but important professional and technical services component of the workforce and economy that is focused on Valley needs for health care and limited manufacturing R&D, yet with some enterprises such as Siemens and the Eisenhower Medical Center that portend a more sophisticated potential for innovation.

The spatial analysis of social and economic factors in the Coachella Valley reinforces in many dimensions the differentiation of a wealthy, educated, older southwestern section of the Valley, in contrast to a more socioeconomically marginal periphery. This difference stems partly from the historical early development of the Valley for agriculture and then later as a seasonal tourism and retirement destination alongside a basic services and agricultural economy, with some recent growth in professional services.

The renewable energy labor force in the Coachella Valley is estimated based on the demographic projections of the Valley, and state/national data on solar and wind workforce. The case study of College of the Desert highlights that a certain "limited" number or organizations and individuals in the Coachella Valley have the initiative and energy to train and educate skilled workers for solar, wind, and other renewable occupations. It represents a small and growing effort by schools, universities, and at least one solar firm to support renewables training and workforce development.

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Chapter 5
Benchmark Comparisons of Leading Wind and Solar Areas with the Coachella Valley: Implications

Abstract Renewable energy development and entrepreneurship in the Coachella Valley, which are at fairly early stages, are compared to benchmark mature metropolitan areas for renewable energy in Texas and Maryland. The purpose is to achieve broader perspective from states outside the U.S. Southwest, and to gain insights into possible opportunities and challenges for the Valley in the future. A literature review examines the history of policy formulation for wind energy in Texas and of barriers to residential adoption of solar. The main chapter focus is on the metropolitanarea benchmarks of Houston-The Woodlands-Sugar Land for wind energy; and Baltimore-Columbia-Towson for solar energy. For each metropolitan area and its state, the history and background of renewable energy are examined, as well as the geographic distributions of renewable manufacturing facilities relative to socio-economic features. Case examples are presented of wind and solar innovation. The findings on the benchmark areas are compared to those from Chap. 4 for the Coachella Valley, and the implications are discussed.

5.1 Introduction

Since renewable energy development, manufacturing, and consumption from renewable energy systems in the Coachella Valley are at fairly early stages, it is useful to compare the status of the Valley's renewable efforts with similar situations in "exemplary" metropolitan areas nationally. This may also serve as benchmarks in evaluating the promise of renewable development in the Coachella Valley. When identifying comparison metropolitan areas and their states, it may be useful to gain broader perspective including states from outside the U.S. Southwest.

This chapter first reviews several relevant academic studies and then shifts to focus on metropolitan areas in two benchmark states: Texas for wind energy and Maryland for solar energy. Texas, a leading hydrocarbon producer across major areal portions of the state, such as the West Texas Permian Basin, is also the standout national leader in wind energy. Maryland is exemplary on the East Coast for its recent rapid growth in usage of solar energy and has one of the nation's most encouraging regulatory environment for solar energy.

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Aspects compared in this chapter include the environment of power grid advantages, state energy development agencies, international forces, transportation, state government support, and regulations. The chapter proceeds to compare the Texas's Competitive Renewable Energy Zone (CREZ) power grid for renewables, which is a critical factor in Texas's wind energy success, and the California's Renewable Energy Transmission Initiative (RETI) 2.0 grid expansion.

For wind energy manufacturing, the Houston-The Woodlands-Sugar Land Metropolitan Statistical Area (MSA) is exemplary and leading Houston firms will serve as examples. Three varied wind energy firms are considered: Broadwind, Royal Dutch Shell, Panhandle Wind, and a fourth case considers how Procter and Gamble is cooperating on a corporate wind farm. These mini-cases provide some lessons about succeeding in wind energy, some of which may be useful in public policy formation for growth in renewable enterprises in the Coachella Valley.

Next, this chapter utilizes mapping to understand the location of wind manufacturers in the Houston-Woodlands-Sugar Land MSA, henceforth abbreviated as Houston-The Woodlands-Sugar Land MSA, relative to the spatial arrangements of social and economic indicators such as income, education, professional and scientific services employees, and manufacturing. By comparison, the proximities may suggest opportune locations of incipient renewables firms in the Valley or the economic subcomponents that currently may be missing or weak and may contribute to future development success.

The Houston-The Woodlands-Sugar Land MSA is a central place that is considerably more complex economically than the medium-sized urban complex of the Coachella Valley. The purpose of the comparison is to try to determine how a presently more peripheral place, in terms of Central Place Theory, might in the future, undergo development of its renewable energy sector to contribute to building a larger and more important urban complex. For instance, how can the Coachella Valley be transformed in the direction of becoming a central place?

In a similar way, the chapter considers Maryland as a leading benchmark state for solar energy development and compares Maryland to the Coachella Valley. Although not as prominent nationally as Texas for wind energy, Maryland is the leading state in the eastern part of the nation in percent growth of solar use over the past 5 years. Moreover, it has among the most encouraging state renewable standards and public policy support in the nation. This chapter will analyze Maryland's solar energy context, history, and exemplary firms from its solar industry.

For example, one Baltimore organization gives solar training for disadvantaged young people. The solar manufacturers Prudent Energy and Konterra, and the solar powering of GM's Chevy Volt factory are also discussed. These varied enterprises have been innovative and may provide proactive insight into prospective solar in the Coachella Valley.

Similar to the study of the Houston-The Woodlands-Sugar Land MSA for wind, the socio-economic setting of the location of solar manufacturers in the Baltimore-Columbia-Towson MSA is examined through mapping in order to glean locational insights into policy and planning formulation for renewable energy in the Coachella Valley. The conclusion section points to major chapter implications for renewables in the Coachella Valley.

5.2 Literature Review

Several prior studies inform the comparative arguments in this chapter. **A** study of policy formulation and application for wind energy in Texas demonstrates how proactive policies can strengthen outcomes (Zarnikau 2011). This study found that the perception of Texas is predominantly as an oil state, rather than a wind state. However, among renewables, wind had the most policy prominence, since Texas lacked hydro and solar and geothermal, which were little developed in 2011. Solar energy has potential for future exploitation in Texas (EIA 2016a).

In looking at the Texas history of wind energy supply and demand from 1970, we see that for the first quarter century supply was two times the demand but evened out and even tilted towards demand in the late 1990s (Zarnikau 2011). A stimulus to the wind sector was the passage in 1999 of Texas Senate Bill 7 (SB 7), which gave developers and consumers' choice of utilities and put in support features for renewables. Subsequently, the nonprofit manager of the Texas grid, the Electric Reliability Council of Texas (ERCOT), adapted flexibly to reduce regulation and allow more competition; this factor further spurred the evolution of wind energy (Zarnikau 2011). Other favorable policies enacted by the state over the past two decades include setting of ambitious Renewable Portfolio Standards (RPS) targets, federal tax credits, the introduction of a system of renewable energy credits in Texas that are tradable, and the legislative passage and implementation Competitive Renewable Energy Zones (CREZ) to spur grid expansion (Zarnikau 2011). The Zarnikau study identified the strength of coordinated and long-term policies in Texas as a backbone of wind energy's success.

An important complement to strong policies is a citizenry that is supportive of adopting wind energy. A study of public attitudes of renewables regarding the Wolf Ridge Wind Farm in north Texas (Swofford and Slattery 2010) surveyed the environmental attitudes of people living in the proximity of this wind farm. Remarkably, most respondents were generally positive about wind turbines as a sign of progress. Support varied by distance from the wind farm, those farther away being more positive about wind energy. Yet the people nearby, while less positive, can have greater effect on local government decisions (Swofford and Slattery 2010).

The well-known environmental attitude of Not-In-My-Backyard (NIMBY) was not supported. On the whole, respondents recognized the environmental and climate change contributions of this wind farm. The authors recommended that those within close proximity to the wind energy facilities should be encouraged to participate in the local discussions and feel part of the decision-making (Swofford and Slattery 2010). Although the policy atmosphere and economic/social levels might differ in other settings, this report of citizen attitudes, albeit in a small slice of the trajectory of wind development, is encouraging.

Another early study of wind energy posited the factors, which affect the location choices for wind facilities (Rodman and Meentemeyer 2006). Utilization of the factors built a GIS model to conduct an analysis to determine the best location of new wind energy farms. The factors include physical requirements such as wind speed, obstacles, ridge terrain, and environmental constraints such: as land use, vegetation, and protected ecology. Human factors such as rural/urban location and nearness to public parkland were also included. Although the factors applied were admittedly limited, they predicted wind farm locations and suitable siting. The model allowed better understanding of why existing facilities are where they are and how proximity influenced opposition. Montezuma Hills, then fourth largest wind farm in the state, was the example provided because it had invoked little public opposition, which the authors ascrib to its agricultural setting away from cities and highways and to meeting nearly all of the suitability factors (Rodman and Meentemeyer 2006). This directly relates to Coachella Valley's bumpy but ultimately successful development of the San Gorgonio Pass wind farms. Those farms met most of the study's criteria, with the exception of not being in a rural location.

A study that informs the rapid rise of solar energy in Maryland was an historical survey of early owners of residential solar energy, in order to project market patterns (Sawyer 1982). The study indicated that the high, up-front cost barrier of adopting solar in the home could be lessened if the adopter were of high educational attainment, elevated income, and professional/managerial occupation (Sawyer 1982). Although costs have come down considerably since 1982, some cost barriers remain, such as the cost of skilled residential project designers, and the study also uncovered associated socioeconomic characteristics linked to solar adoption, some of which relate to the book's findings solar and wind energy manufacturing.

5.3 Background on Texas Wind Energy

Texas stands out as a national leader overall in energy production and utilization. It leads all U.S. states in the production of total energy, crude oil, natural gas, and electricity, and has the second highest CO_2 emissions (EIA 2016a). In March of 2016, the state's net electricity generation was 32.8 million megawatt hours, of which 55% was powered by natural gas fuel and 18% from non-hydro renewables, mostly wind energy. Texas is by far the largest producer of wind energy. Texas has a 2015 installed wind energy capacity of 17.7 GW, which is equivalent to electricity for 4.1 million American homes (AWEA 2017). As mentioned earlier, Texas also has ample potential for solar energy although it is so far only slightly exploited (EIA 2016a).

As pointed out in the study by Zarnikau (2011), implementation of propitious policy in Texas led to unprecedented wind energy expansion. One of the major factors along the way was the consistent support from the Texas state legislature. In 2005, the state legislature amended its 1999 target to require a renewable energy capacity of 5880 MW or about 5% of state electricity, to be online by 2015 and established a target of 10,000 MW of renewable energy by 2025 (Governor's Office 2014). Remarkably, the latter goal was reached by 2010, with wind energy accounting for 86% of it, and by 2015 wind energy alone accounted for 17,700 MW, 80% above the 2025 target (AWEA 2016).

A recent government report (AWEA 2015; DOE 2016) predicts continued wind energy growth, from 9% of state electricity production in 2016 to 37.8% in 2030. The continued growth would provide landowners of wind-farm land with $145.4 million in lease payments, save energy consumption of over 40.6 billion gallons of water yearly, and greatly reduce ongoing carbon pollution (DOE 2016). Accompanying this vast expansion has been development of the nation's largest wind energy workforce, estimated in 2016 at over 24,000 wind energy jobs (AWEA 2017).

Furthermore, Texas industry has over 45 manufacturing plants for wind energy equipment that serves various points in the supply chain, from components to finished blades, nacelles, and turbines (Governor's Office 2014). A nacelle is the box on top of a wind tower that connects together the gears, turbine blades, and other components. Although the complex wind manufacturing supply chain, further analyzed in Chap. 6, may supply wind energy components, assembled parts, and/or complete products nationwide and worldwide, local production is favored due to the high costs of transporting the large, heavy components and assemblies, which are crucial to wind plants. An example is seen in Fig. 5.1, a photo of a large assembled wind turbine being transported by highway. Although wind turbines transportation is less expensive by ship or train, as shown in Fig. 5.2, the ultimate location would still involve often difficult and expensive highway transport along a major or minor highway (see Fig. 5.3).

Fig. 5.1 Large wind turbine blade being transported on a highway (Source: Alexi Kostibas)

Fig. 5.2 Very large wind turbine being transported by train (Source: Michael E. Grass)

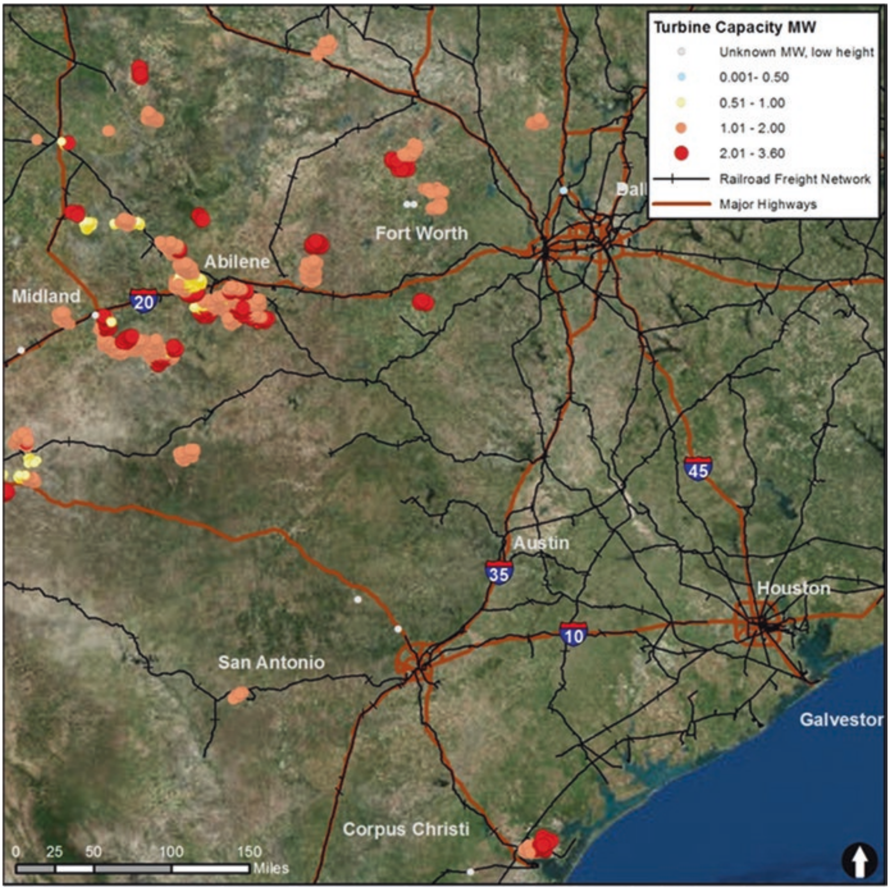

Fig. 5.3 Wind turbine locations in North Central Texas, with railroad freight network and major highway, 2016 (Source: AWEA 2016)

Among the top Texas manufacturing firms are Broadwind Energy (wind turbines and turbine services), Shell Windenergy, a subsidiary of Royal Dutch Shell (development and operation of wind farms, green electricity), Alstrom Wind (nacelle assembly), Trinity Structural Towers, as subsidiary of Trinity Industries of Dallas (wind towers) and lastly, the Ohio-based Molded Fiber Glass Companies, which serve Texas with blade manufacturing. The first two are described more in a later chapter section.

Geographically, wind energy projects are located mostly in the upper central and northern Panhandle areas of Texas and with some along the southern Gulf coast, shown in Fig. 5.4. While a quarter of wind manufacturers, including most of the large ones, are located hundreds of miles away in the Houston-The Woodlands-Sugar Land MSA, shown in Fig. 5.5. The wind farms are clustered in flatter or coastal parts of the state that have excellent high winds, while most of the major wind manufacturers are in the Houston coastal metropolis that contains a large numbers of population,

Fig. 5.4 Texas wind projects and highways, 2016 (Source: AWEA 2016)

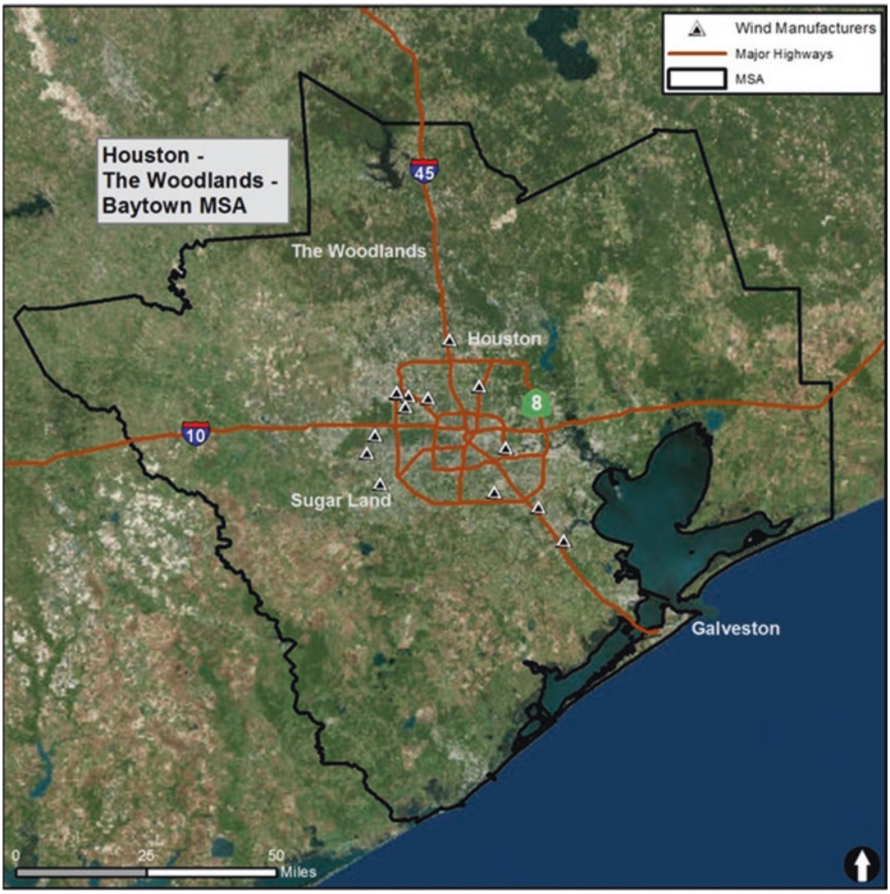

Fig. 5.5 Wind manufacturers in the Houston-The Woodlands-Sugar Land MSA, 2013 (Source: AWEA 2016)

educated people, skilled workforce professionals and scientists, and high intensity of manufacturing, as well as national and global transportation connections via rail, highways, world-class airport and large seaports. Since wind factories produce and purchase components ranging from precision gears and electronics to huge blades, a large and flexible transportation network is essential. The advantages and disadvantages of the Houston-The Woodlands-Sugar Land MSA for high-end wind manufacturing is a topic returned to in a later section.

An important further aspect stimulating this growth has been R&D on wind energy at university and governmental institutions in Texas. Texas A&M University has supported a University Alternative Energy Institute at a branch campus in the city of Canyon and the Texas A&M Wind Energy Center at the main campus in College Station, while Texas Tech in Lubbock formed the interdisciplinary National Wind Institute (Governor's Office 2014). Research consortia include a public-private partnership that innovates and advocates, the National Institute for Renewable Energy in Lubbock; and Lubbock's cutting-edge wind turbine experimental facility, which is a collaboration of the U.S. Department of Energy, Sandia Labs, Denmark's Vestas company, and Group NIRE. In addition, the state government under Governor Rick Perry, provided funds for the National Wind Resource Center, a nonprofit for wind power research and education (Governor's Office 2014).

This R&D hub for wind energy constitutes a world-class center for innovation and training, which has collaborated with and helped synergize the state's manufacturing industry sector. It forms a success model among U.S. states. For Coachella Valley, it suggests that the seeds of community college renewables training the Valley should be supported and bolstered in order to expand the professional workforce, attract new professional workers, educate the general public, and growth innovation. By comparison, it suggests that California would need to have statewide coordinated effort to see the Coachella Valley economy prosper and assume a major renewables role. It also suggests that implementing larger-scale wind manufacturing in southern California would need to build most of the heavy manufacturing in Los Angeles, which is a Central Place with important manufacturing and associated infrastructure, high tech military industrial complexes, and aerospace manufacturing, while building up associated peripheral manufacturing in the Valley.

5.3.1 Importance of ERCOT and CREZ

Another stepping stone to Texas's leadership in wind energy was the strategic initiative by the legislature and Electric Reliability Council of Texas (ERCOT) to implement the Competitive Renewable Energy Zones (CREZ) transmission lines, which stimulated Texas's wind energy sector (The Texas Tribune 2016). The origin of the Texas grid originated with the establishment of the North American Regional Reliability Councils, which divided the North American continent into "interconnection" zones. These broad zones each have their own independent grid management, shown as Fig. 5.6. The Texas Interconnection is unusual because it is a single-state zone. It originated as a way to protect the states electrical production from federal legislation (Galbraith 2011; The Texas Tribune 2011). This zone includes most of the state, but excludes El Paso, the upper Panhandle, and an eastern border slice of Texas. The isolation of the Texas Interconnection has the advantages of better ability to plan and follow consistent long-term policies, but the disadvantages of reduced capability to share energy across its border with a multi-state region. However, grid isolation led to its exemption from federal regulation giving it more flexibility to serve Texas's power needs.

ERCOT, the nonprofit manager of the Texas power grid, has been another proactive force for wind energy. After the Texas legislature authorized the Competitive Renewable Energy Zones (CREZ) in 2005, CREZ was managed by ERCOT. Over the period 2005–2015, ERCOT did a fine job in developing this $6.9 billion project

Fig. 5.6 North American power grid (Modified from North American Reliability Corporation, Available on Wikimedia, 2016)

to construct transmission lines to enable connections of wind farms, often located in remote areas, to the state's grid (EIA 2016a; White and Jimison 2015), such as the large agricultural area of Texas filled with windmills seen in Fig. 5.7. The justification was to bring renewable energy from remote central and northwestern regions of Texas to serve the large market demand for electricity from major cities in the east and south of the state.

ERCOT's strong management of CREZ eventually achieved the goal of connecting over 15 GW of wind farm projects that otherwise would have been curtailed (Del Franco 2014). Recently, some criticism has been aimed at ERCOT for not favoring electricity from natural gas, arguing that natural gas's reduced price gave it precedence, but that was countered by arguments about wind energy's environmental benefits (Del Franco 2014).

Fig. 5.7 Wind mills in agricultural land in Texas (Source: Jerry Beare)

Box 1: Renewable Energy and California's Grid Given the critical importance of Competitive Renewable Energy Zones (CREZ) for wind energy success in Texas, this box compares CREZ with recent initiatives to expand California's transmission grid for renewables. The California grid had a modification favoring renewables in 2008 when the state's Public Utilities Commission (PUC) approved a new transmission line for renewable-generated electricity from the largely agricultural Imperial County to the metropolitan county of San Diego (Wang 2008). Although the Sunrise-SDG&E proposal based its justification on the then California RPS goal of 33% solar and wind by 2020, there were controversies about wind energy's environmental and economic detriments. Nonetheless, the Sunrise project was finished in 2012 and currently is providing over 1000 MW of renewable energy to San Diego.

A recently initiative Renewable Energy Transmission Initiative (RETI) 2.0 is driven by Governor Brown's Executive Order B-30-15, which sets the goal to lower greenhouse gas emissions by 80% below 1990 levels by 2050. RETI 2.0 is in the planning process under the auspices of the state's California Energy Commission for approval. The planning is near completion and has led to the recommendation that transmission lines for renewable energy be extended to four in-state focus areas: East Riverside County, Imperial Valley, Victorville/Barstow and Tehachapi/Lancaster (Campopiano et al. 2016). They are largely desert areas that can build off the "Desert Renewable Energy Conservation Plan" which a consortium of California and federal agencies proposed in late 2015 to best utilize vast southwestern desert areas (RETI 2.0 Management Team, 2016). Several out-of-state pathways for import and export of energy between California and other neighboring states were also considered.

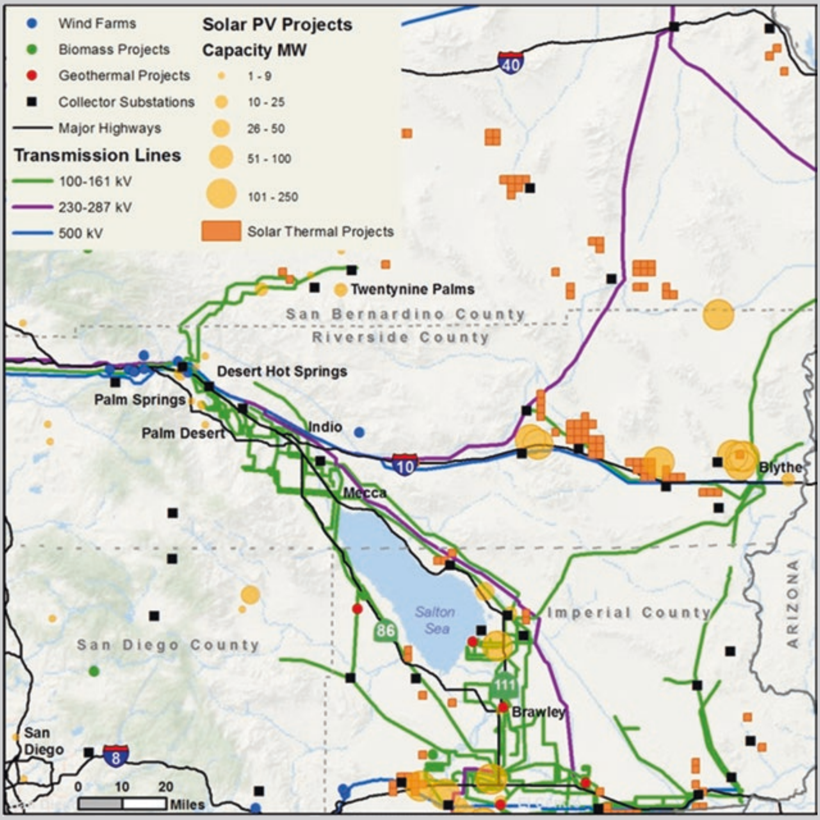

Fig. 5.8 California power grid surrounding Coachella Valley, 2015 (Sources: Bureau of Land Management 2009; California Energy Commission 2015)

Coachella Valley's present transmission lines in the region, shown in Fig. 5.8, reveal that although the San Gorgonio Wind Farm and solar plants near Interstate 10 between the Indio and Blythe are well served by existing power lines, other solar photovoltaic projects are in need of grid extensions to connect with the Western Interconnection Grid (Bureau of Land Management 2009, updated with data from California Energy Commission 2015). Although the comprehensive planning of the California grid prior to RETI 2.0 did not include renewables, the proposed Riverside County focus area does include broad renewables planning. In particular, to serve wind farms being developed at some distance north of Interstate-10 and the Imperial County proposed focus area of prospective solar plants at the south end of the Salton Sea, as well as several geothermal plants.

There are several takeaways from California's approach to transmission grid expansion for renewables. First, renewable energy has not been fully recognized in grid planning, a factor that discouraged or ended quite a few large-scale renewable projects. This may be due to California's having multiple agencies responsible for different parts of the statewide transmission grid approval process, including the California Public Utilities Commission, the California Energy Commission, State Resources Agency, California ISA, Desert Renewable Energy Conservation Plan led by the U.S. Bureau of Land Management, and corridor planning by county agencies, such as Riverside County. What is missing is a strong lead agency such as ERCOT in Texas. The Sunrise Line was an exception that did move forward, but it constitutes a relatively small renewable transmission line. The current RETI 2.0 process takes a broader, long-term, strategic view, but has not yet had a legislative test, which may again limit the inclusion of renewables, given the politics surrounding several local projects. On the other hand, California's high RPS goal is favorable for legislative approval of renewables-based grid expansion.

5.3.2 Wind Energy Industry in Texas

Texas has over 45 wind-energy manufacturing facilities, the most in the U.S. This section gives profiles of four wind energy companies of different sizes and ownership types. They produce products and services that pertain across the wind-energy manufacturing supply chain and serve as models of enterprises in a mature wind-energy manufacturing sector. Accordingly, they can provide ideas for developing the incipient wind-energy manufacturing sector in the Coachella Valley. Even though the Valley's wind-energy manufacturing sector would be unlikely to approach the scale of the sector in the Houston-The Woodlands-Sugar Land MSA, it would likely be an important distributed part of an enlarged southern California wind-manufacturing complex.

The first profile is *Broadwind Energy*, a publicly traded company headquartered in Illinois with over 900 employees. The Abilene-based firm focuses on manufacturing wind towers and providing turbine services. The Abilene facility constructs 150 wind towers yearly and has been growing rapidly. It has unique supply chain advantages including owning a turbine-gear subsidiary with tight-tolerances and producing sturdy towers for multi-megawatt turbines (AWEA 2015). It also maintains and refurbishes turbines, blades, gearboxes and other windmill parts (Governor's Office 2014). Its north central Texas location places it close to the center of the state's largest concentration of wind farms, so transportation is reduced for its in-state market.

Shell WindEnergy in Houston develops and manages large wind farms in Texas, California, West Virginia, and several western states (Shell United States 2016). It is a subsidiary of Royal Dutch Shell, a global energy firm with 2015 revenues of $272 billion. The parent company is known as an oil and gas giant, but with the price reductions in petroleum, it is trying to catch up in renewables. In 2016, it launched a "New Energies" division with focus on wind, biofuels, electrical storage, and hydrogen fuel (Macalister 2016). It is also seeking to innovate in Europe by collaboratively financing and implementing several large offshore wind plants.

The longer standing Houston Shell WindEnergy facility supports eight joint-venture wind projects in the U.S., involving 700 wind turbines (Shell United States 2016). Two of the projects are in Texas: White Dear and Brazos. White Dear, an 80-MW wind farm located near Amarillo, is a joint venture with the large, diversified energy firm Entergy, while Brazos in Fluvanna is a 160-MW wind farm in joint venture with the giant Japanese conglomerate Mitsui (Shell United States 2016). Another two wind plants are managed/supported by Shell WindEnergy in the San Gorgonio Pass wind farm complex and are in collaboration with Goldman Sachs, namely Whitewater Hill (61.5 MW) and Cabazon (48 MW). These farms exemplify extra-local influence on current renewables facilities in the Coachella Valley, since distant parties including Royal Dutch Shell in the Netherlands, Shell WindEnergy in Abilene, and Goldman Sachs in New York are the operators, along with dozens of landowners, many extra-local.

Royal Dutch Shell exemplifies involvement of a multi-national firm in wind energy. It has the benefits of deep financial resources, access to an extensive network of suppliers, experienced management, and world-class R&D. In fact, Shell's largest corporate R&D center, also located in Houston, offers scientific support for wind energy (Shell United States 2016). As wind energy grows in global market share, Shell and other multi-national energy firms are likely to expand wind operations (Donovan 2016, Macalister 2016). In the final chapter, issues of local versus extra-local control and ownership of renewables companies and projects are examined.

Pattern Energy owns and operates the Panhandle I and Panhandle 2 Wind Farm projects in the Texas Panhandle, located about 30 miles northeast of Amarillo in Carson County. Pattern Energy, headquartered in San Francisco designs, develops, manages, and finances wind farm projects in the U.S. Canada, and Chile that have capacity of over 3000 MW of wind power. The decade-old firm has a strong executive team possessing extensive experience in energy infrastructure and government background. It contracts energy sales predominately on a long-term fixed-price basis, giving it financial stability (Pattern Energy 2016).

Panhandle I at 218-MW capacity and Panhandle II at 182 MW produce electricity that is sold to energy affiliates of Citibank and Morgan Stanley respectively, which re-sell it at largely fixed rates. In addition, there are long-term lease agreements with 92 landowners. Pattern encourages good local community relations by contributing to the Community Benefits Program of the Amarillo Area Foundation which provides $150,000 yearly for education and civic activities in Carson County (Amarillo Area Foundation 2016), funding that is meaningful in a county with a tiny population of 5969 people (U.S. Bureau of the Census 2016).

In summary, Pattern wind farms have many of the beneficial characteristics (Rodman and Meentemeyer 2006) of strong wind resource, remoteness from population, rural location, distance from parks, and lack of environmental detriments, as well as good transmission access through CREZ. These characteristics resemble those of the San Gorgonio wind farms, except the latter are closer to urban areas.

EDF Renewable Energy and Procter and Gamble are participating with a growing type of wind farm arrangement in which renewable-generated electricity is purchased by a company in an amount equivalent to the energy use in a non-renewables facility. Although for solar energy this could be done directly by outfitting a manufacturing site with its own solar photovoltaic array of panels, for wind energy, the manufacturing plant is not likely to be co-located with the wind farm because of their usual rural or remote locations. Rather the wind farm is located far away from the manufacturing facility and the purchase acts as an equivalent credit to apply to the energy consumed by the plant.

EDF Renewable Energy, the U.S. a subsidiary of the French firm, EDF Energies Nouvelles, is a San Diego-based large independent producer, project developer, and operator of wind and solar projects in North America, with an installed wind plant capacity of 3809 MW, 644 MW under construction, and contracts to operate and maintain wind plants of 9780 MW (EDF Renewable Energy 2016). Procter and Gamble (P&G), the global consumer products firm, agreed to purchase renewable energy exceeding the 300,000 megawatt-hours per year consumed by its North American Fabric and Home Care factories located in Kansas, Louisiana, Missouri, and Ohio (Abrams 2015). This saving is equivalent to saving of 200,000 metric tons of CO_2 emissions yearly. Besides the wind savings, the other half of energy in the plants, for their process heating of the plants, utilizes natural gas, which has lesser environmental detriments than other fossil fuels. P&G's stands to gain from improved brand image among customers. In support of this point, a P&G Fabric Care executive estimates that about two thirds of its consumers are environmentally conscious (Abrams 2015).

EDF and P&G are also seeking the support of the local community. They expended $53 million and created directly and indirectly 497 jobs locally in construction, as well as providing $1.3 million in local tax payments post-construction (DOE 2016). These sums are significant for Cooke County, which had a 2015 population of only 39,229 (U.S. Bureau of the Census 2016).

In summary, the four cases illustrate multiple advantages of wind development and manufacturing in Texas. These advantages include a growing business sector with expanding workforce, extra-local financing and expertise, reduction in environmental pollution and industrial water consumption, and corporate contributions to the local communities, while disadvantages include disruption of rural ways of life and environmental impacts, such as visual pollution of pristine desert landscapes and limited noise pollution. However, poorly managed firms might result in corporate failures and exploitation of local institutions.

The implications of these success stories for the Coachella Valley are seeds that might be planted in planning growth of wind-energy manufacturing and services, such as seeking unobtrusive locations, establishing cooperative training programs, and engaging external manufacturing firms in environmental trading of electricity from renewable energy, and attracting large multinational firms to invest in the Valley's renewable energy manufacturing supply chain. The prospective renewables development process in the Valley cannot only benefit from the historical lessons, but the national reach of corporate players within the important Texas wind sector can also influence it. An examination of these points in greater depth will follow in Chap. 7.

5.4 Locational Aspects of Wind Manufacturers and Houston-The Woodlands-Sugar Land MSA Socio-Demographics

This section returns to the exploration of the spatial locations of wind manufacturers in the Houston-The Woodlands-Sugar Land MSA compared to the social and economic dimensions of the MSA, similar to the locational analysis in Chap. 4. The questions to be asked are, what socio-economic features are in proximity to wind manufacturers? Are those proximities likely to affect the manufacturer?

As mentioned in Chap. 3, this and a similar exploratory analysis in a later section for solar manufacturing in the Baltimore-Columbia-Towson MSA are useful as benchmarks in determining how suitable the Coachella Valley is from a socio-economic standpoint to develop increased amount of renewable manufacturing. The comparison of the "benchmarks" of the large Houston-The Woodlands-Sugar Land and Baltimore-Columbia-Townson MSAs with the smaller Coachella Valley is intended to underscore how a more peripheral place, in terms of Central Place Theory, might in the future, undergo development into a larger and more important peripheral place, and even be transformed in the direction of becoming a central place. The comparison is not to signify present-day equivalence between the two MSAs and the Coachella Valley, but to suggest steps that can more the Coachella Valley's renewable sector towards greater maturity and centrality.

Even though long-standing manufacturing agglomeration of the major central places of Los Angeles or San Diego may lead many southern California solar and wind energy manufacturers to locate in those centers, nevertheless the Coachella Valley in the next two decades may be able to attract the arrival of manufacturing firms for selected parts of the solar or wind supply chains, a topic addressed in the next chapter. In meantime, incremental growth can occur partly depending partly on favorable social, economic, and demographic features.

5.4.1 Wind Manufacturing and Population, Education, and Wealth

Wind manufacturing firms are located along major transportation routes and in areas of high *population* in the Houston-The Woodlands-Sugar Land MSA (see Fig. 5.9). The location near major Interstates which is attributable partly to the need to deliver oversized, heavy components of wind facility manufacturing, such as turbine blades, which can extend a hundred feet or more in length and require specialized transport. Likewise, nacelles that house all the generating components and can weigh over 55 tons. Supply chain manufacturers of steel wind-energy components also sometimes require transport on major highways. For Coachella Valley, this transportation issue implies that prospective wind manufacturing firms should locate along the I-10 Freeway (see Figs. 2.10 and 5.8).

The wind manufacturers in Houston locate mostly in or nearby areas of high proportion of *college educated population*, although 2 of the 13 firms are located in areas of very low college education to the north and east of the downtown, seen in Fig. 5.10. However, those particular firms might be less interested in the nearby education profiles and more interested in lower land prices and rentals. In Coachella Valley, this suggests that most wind firms would locate on the more educated southwest side of I-10, unless they were seeking low land costs (see Fig. 4.5).

Wind manufacturers are located in transitional areas that straddle areas of high *net worth* of over $250,000 but also adjoining areas of low net worth of less than $75,000. This might be attractive for moderating land costs and being conveniently close the varied wealth levels of the socioeconomic range of workforce from executives, professionals and scientists to factory workers. Since the Coachella Valley is generally medium to high net worth due in large part to the high land values, the straddling seen in the Houston-The Woodlands-Sugar Land MSA would only be possible in the southwest of the Valley, perhaps in Indio or unincorporated areas to Indio's north. Unsurprisingly for *average home value*, a similar straddling of locations takes place in the Houston-The Woodlands-Sugar Land MSA, and the implications for the Coachella Valley are similar

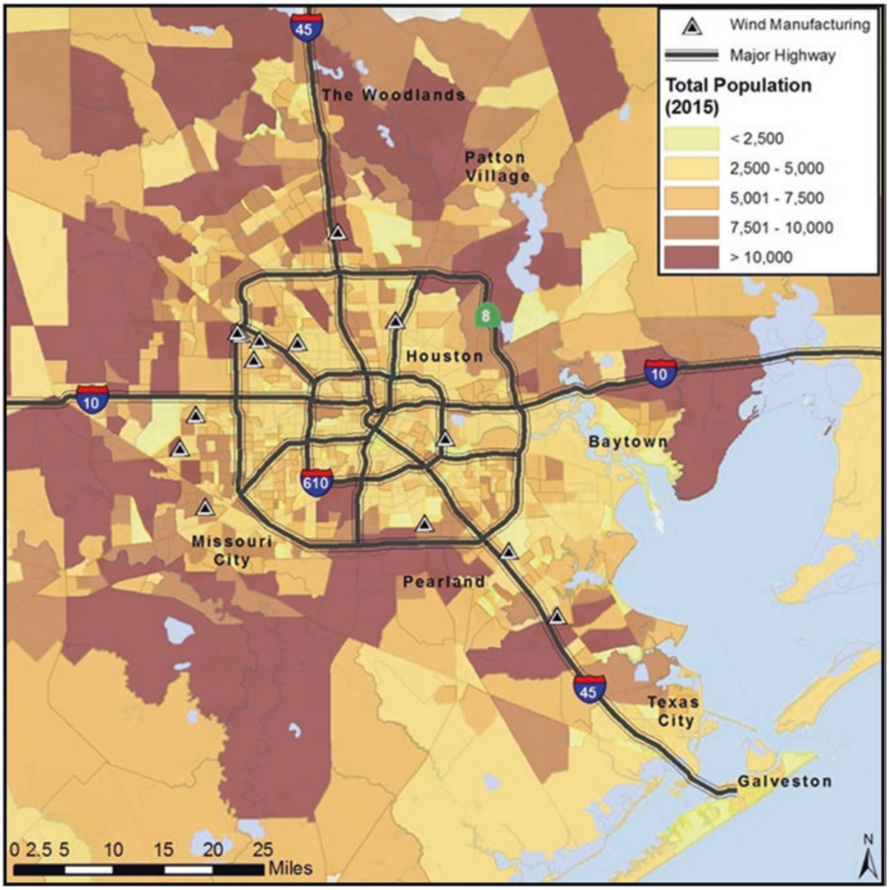

Fig. 5.9 Population in the Houston-The Woodlands-Sugar Land MSA, 2015 (Source: AWEA 2016; modified from Esri 2015)

5.4.2 *Wind Manufacturing and Occupation*

Given the complexity of wind manufacturing, access to *professional/scientific/technical employees* is often a critical factor. In Houston, the volume of these workers is considerable, with greater concentration on the north, west, and southwest sides of the Houston-The Woodlands-Sugar Land MSA where 85% of the wind energy firms are located, shown in Fig. 5.11. By comparison, the Coachella Valley is sparse in these workers—the few present are mostly concentrated within the adjacent area of Indio Hills, Indian Wells, and La Quinta (see Fig. 4.7).

A reason may be that jobs for these workers in engineering, science, and technology are reduced, although there is a moderate medical and healthcare professional

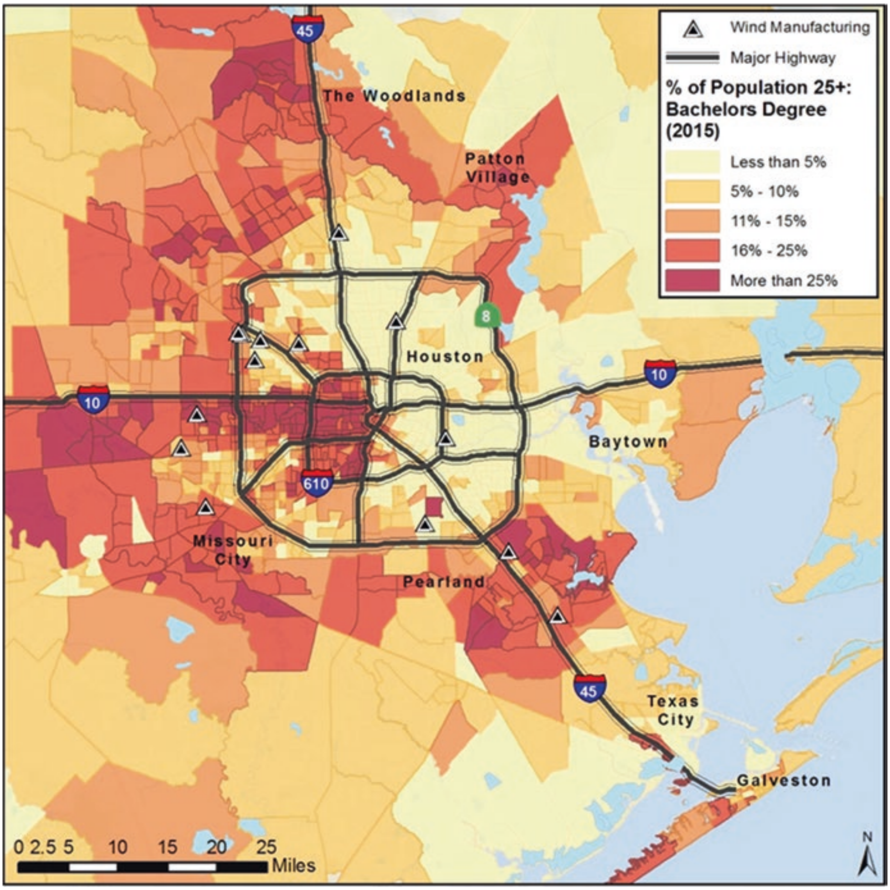

Fig. 5.10 Percent college-educated population, 25 years and older, Houston-The Woodlands-Sugar Land MSA, 2015 (Source: AWEA 2016; modified from Esri 2015)

community centered on the Eisenhower Medical Center. Given the Valley's short commute distances this workforce although much scarcer, should be accessible. For lower-skilled wind manufacturing tasks such as assembly, operations, and factory maintenance, pools of *production workers* are needed, and they are seen to be in abundance in the Houston-The Woodlands-Sugar Land MSA, close to all of the wind manufacturing sites, with the exception of one located in the west just south of the I-10 shown in Fig. 5.12. This situation contrasts with the Coachella Valley, which has only moderate numbers of these low-skilled workers in the poorer areas of Desert Hot Springs, Indio, Coachella, and Mecca (See Fig. 4.8), pointing to the need for planners to expand the number and scale of training programs to develop a larger production workforce.

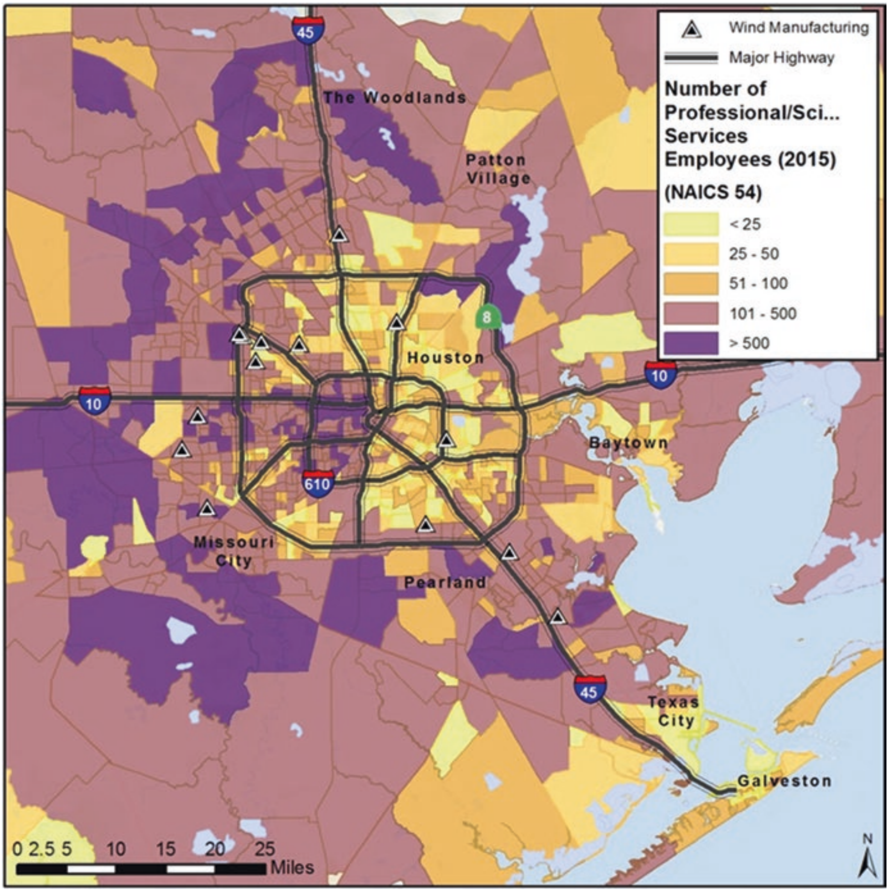

Fig. 5.11 Percent of population 25 years and older, professional, scientific, and technical employees, Houston-The Woodlands-Sugar Land MSA, 2015 (Source: AWEA 2016; modified from Esri 2015)

5.4.3 *Wind Manufacturing Firms and Metrics on Extent of Manufacturing*

The Houston-The Woodlands-Sugar Land MSA has hundreds of *manufacturing firms* that are concentrated along major Interstates, as seen in Fig. 5.13. As shown in Fig. 5.5, most of the wind manufacturers are along Interstates, but about half of those firms do not overlap spatially with manufacturing concentrations. That might be due to wind energy manufacturing being a newer industry, so wind firms look outside the traditional manufacturing area due to high land costs and low availability of real estate. The much lower density of manufacturing in the Coachella Valley (Fig. 4.10) reveals manufacturing concentrated along Interstate-10 or, to a lesser extent, along

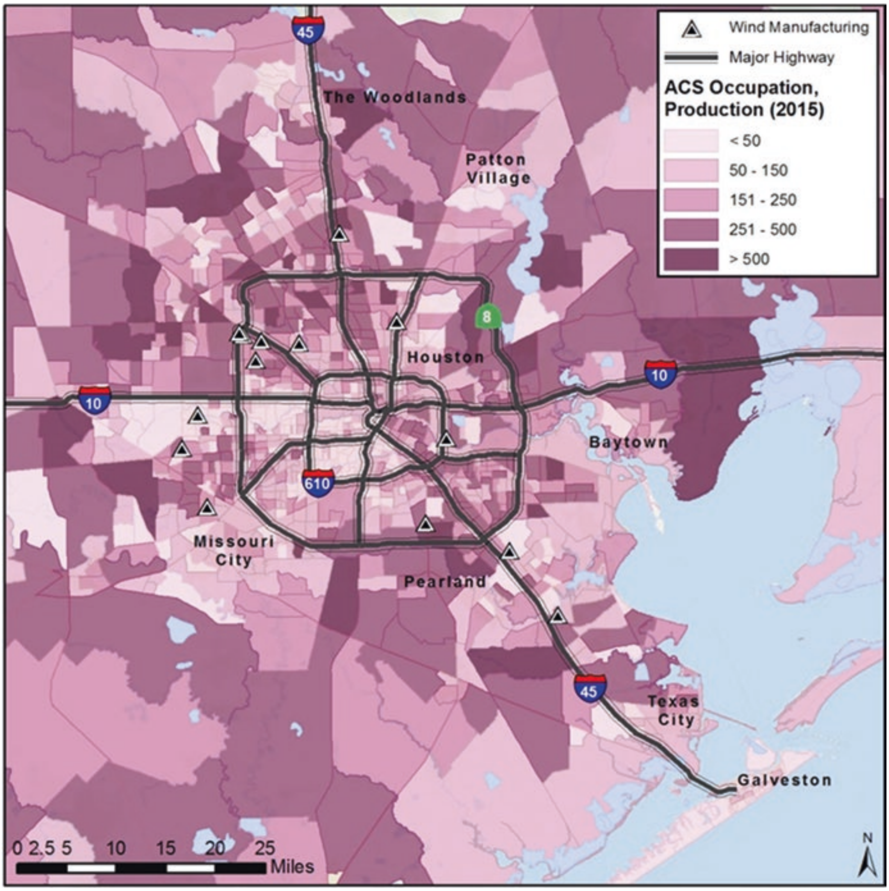

Fig. 5.12 Production workers, Houston-The Woodlands-Sugar Land MSA, 2015 (Source: AWEA 2016; modified from Esri 2015)

State Route 111. It would point to a locational tradeoff between less expensive land and more expensive areas with more skilled workforce and amenities.

By contrast, the areas with high *percent of sales in manufacturing* in the Houston-The Woodlands-Sugar Land MSA tend to be opposite to the location of the wind energy firms seen in Fig. 5.14. Those areas tend to be in the poorer east sections of Houston-The Woodlands-Sugar Land MSA, whereas the wind firms are in the northwest, north, and southwest parts of the city. The areas with over 50% manufacturing sales tend to be less educated, lower in skilled workers, and have fewer amenities, so would be less attractive to firms in a cutting-edge new industry sector. Within Coachella Valley, these manufacturing-dominated areas are in census tracts within a variety of cities, such as Palm Springs, Rancho Mirage, Thousand Palms, and Desert Palms. However, those cities have lower concentrations, less than 20% of sales, and do not approach the many parts of Houston-The Woodlands-Sugar Land MSA with 20% to over 50% proportion of sales in manufacturing.

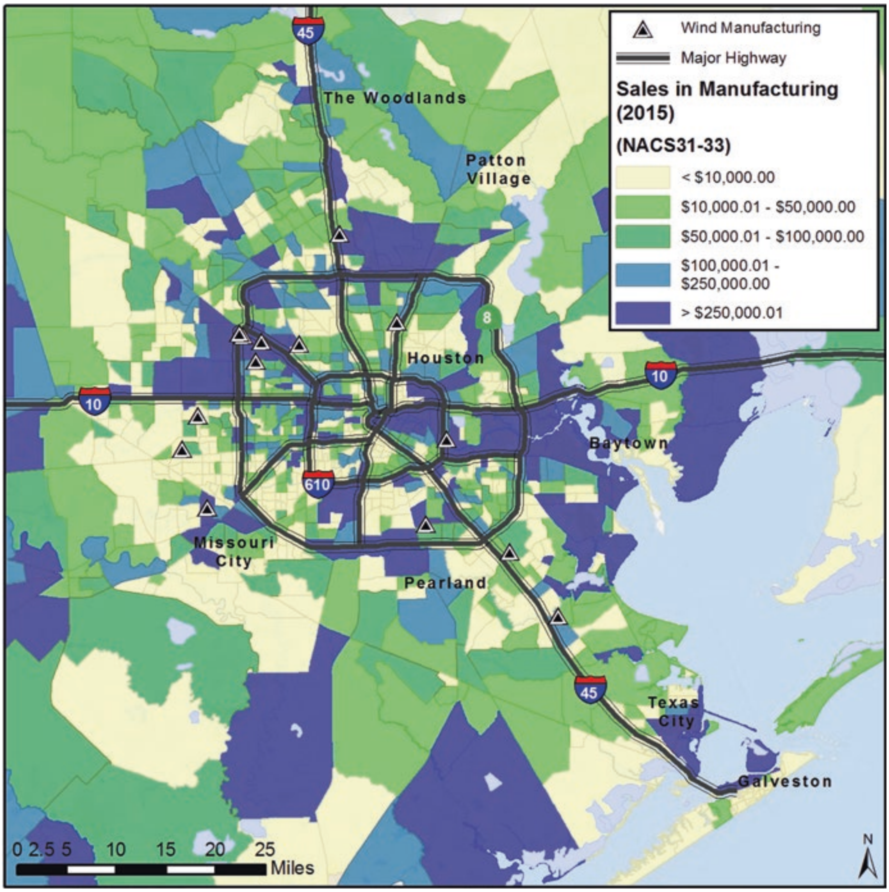

Fig. 5.13 Manufacturing firms, Houston-The Woodlands-Sugar Land MSA, 2015 (Source: AWEA 2016; modified from Esri 2015)

5.4.4 The Internet, Environment, and Crime

This group of variables includes indicators of technology, environmental behavior, and crime. Information technology is an essential aspect of wind energy manufacturing and use, so gauging usage of the Internet in communities surrounding manufacturers in Houston is a helpful indicator. About 60% of the manufacturing facilities are in or bordering areas of high *internet use to make a business purchase*, while the rest are in an area of low percent internet use to make a business purchase shown in Fig. 5.15. An explanation is that the Houston-The Woodlands-Sugar Land MSA's distinctive internet-intensive areas can be useful to wind energy enterprises conducting the business and communicating with the public.

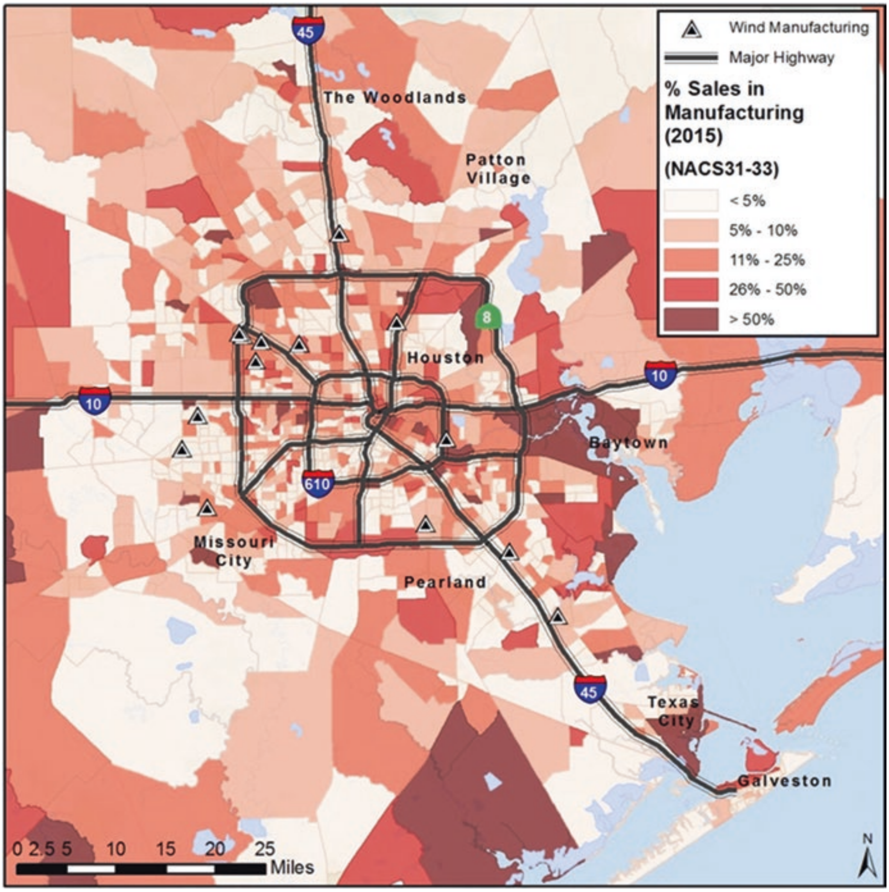

Fig. 5.14 Percent of sales in Manufacturing, Houston-The Woodlands-Sugar Land MSA, 2015 (Source: AWEA 2016; modified from Esri 2015)

In Coachella Valley, as seen in Fig. 4.15, there is an even higher overall level of internet use to make a business purchase, especially areas south of I-10, which are wealthier and more educated. Arguably, internet communications will more easily reach those affluent areas, which also constitute a potential pool of workforce or investors who are technologically conversant.

The wind manufacturers in the Houston-The Woodlands-Sugar Land MSA are located in areas with high numbers of people *participating in an environment cause* or located nearby such areas. Two Houston manufacturers in the northeast and east side of the downtown are in areas with few participants in environmental cause groups (Fig. 5.16). As seen in the case study of the San Gorgonio wind farm in Chap. 4 and in the study of wind farms in Texas by Swofford and Slattery (2010), public opposition to wind energy projects can significantly slow down wind energy development. For the Coachella Valley, participation in an environmental group cause in the last 12 months is widespread throughout the Valley, with the slight

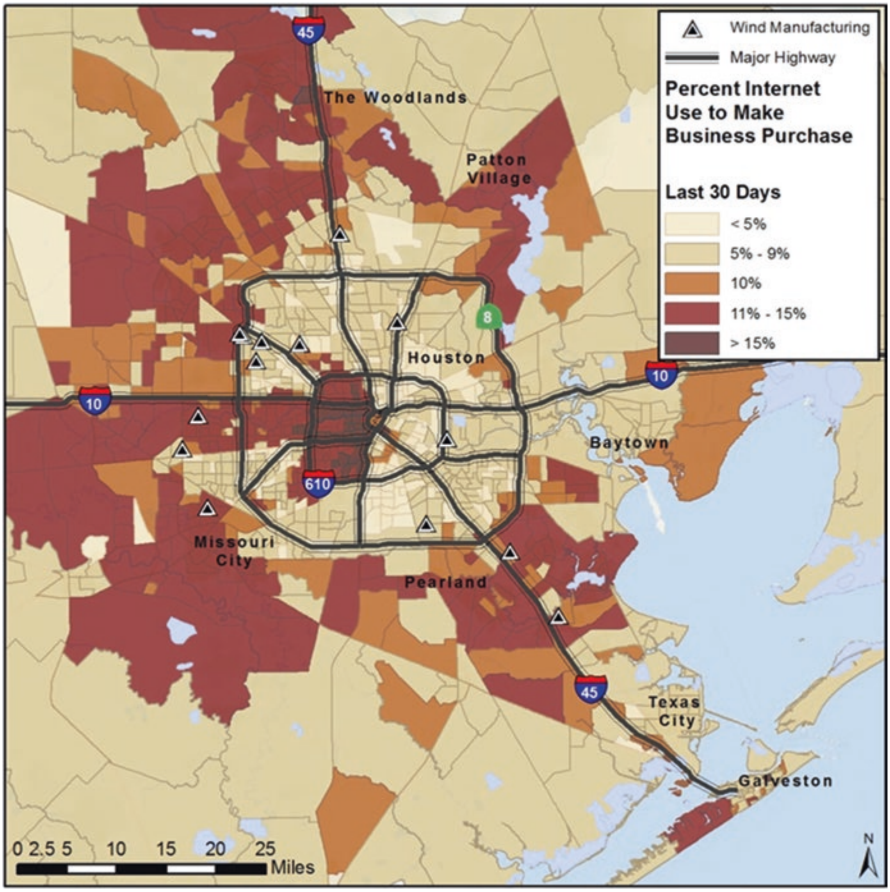

Fig. 5.15 Percent of population internet Use to Make a Business Purchase in Last 30 Days, 2015 (Source: AWEA 2016; modified from Esri 2015)

exception in several tracts in Cathedral City and in north Indio. This strong interest in the environment was ultimately a benefit for San Gorgonio and is a positive factor for citizen support for wind manufacturing in the Valley and prospective new wind farms nearby the Valley.

Crime is rampant in the central, northern, and eastern areas of the Houston-The Woodlands-Sugar Land MSA, which is typical of the central parts of many large metropolises in the U.S. Only three or four of the wind manufacturing firms in the southeast and southwest are engulfed within large areas of high crime index, shown as Fig. 5.17. This is a downside of locating wind manufacturing in the Houston-The Woodlands-Sugar Land MSA, however, it would be offset by many other business advantages that have been examined.

By contrast, in Coachella Valley, parts of Palm Springs and Cathedral City, and Thousand Palms, and most of Rancho Mirage and Palm Desert have a low crime index, while in the south Valley including Indian Wells, La Quinta, Indio Hills, and

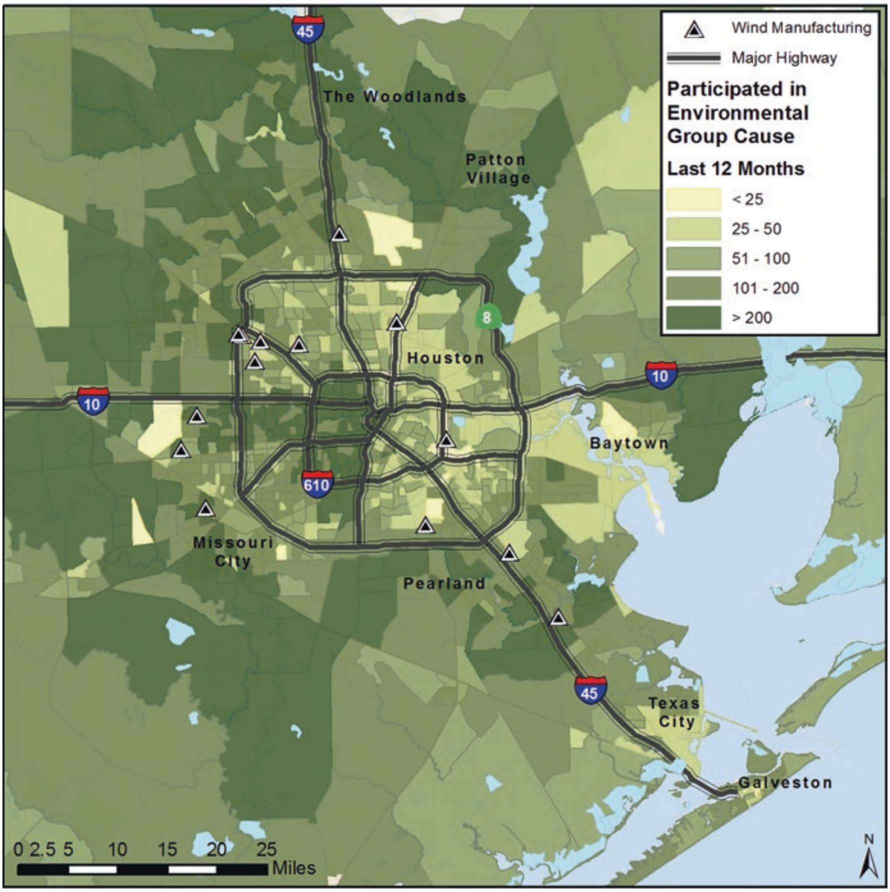

Fig. 5.16 Number of persons who participated in an environmental group cause in last 12 months, Houston-The Woodlands-Sugar Land MSA, 2015

most of Indio and Coachella, the crime index is high. This pattern does not correspond to the geography of the socioeconomic divide that was prominent in the findings of Chap. 3, since some high-income areas also attract criminal activity due to presence of targets. From the standpoint of locating wind energy manufacturing, location from Indian Wells and Indio to the south would be a negative factor from a safety standpoint.

5.5 Background on Maryland Solar Energy

Maryland is largely dependent on out-of-state sources for its energy. It produces one fifth of its energy in-state, drawing on limited natural gas and coal sources in western Maryland. Unlike Texas, Maryland is not a major manufacturing state, and has

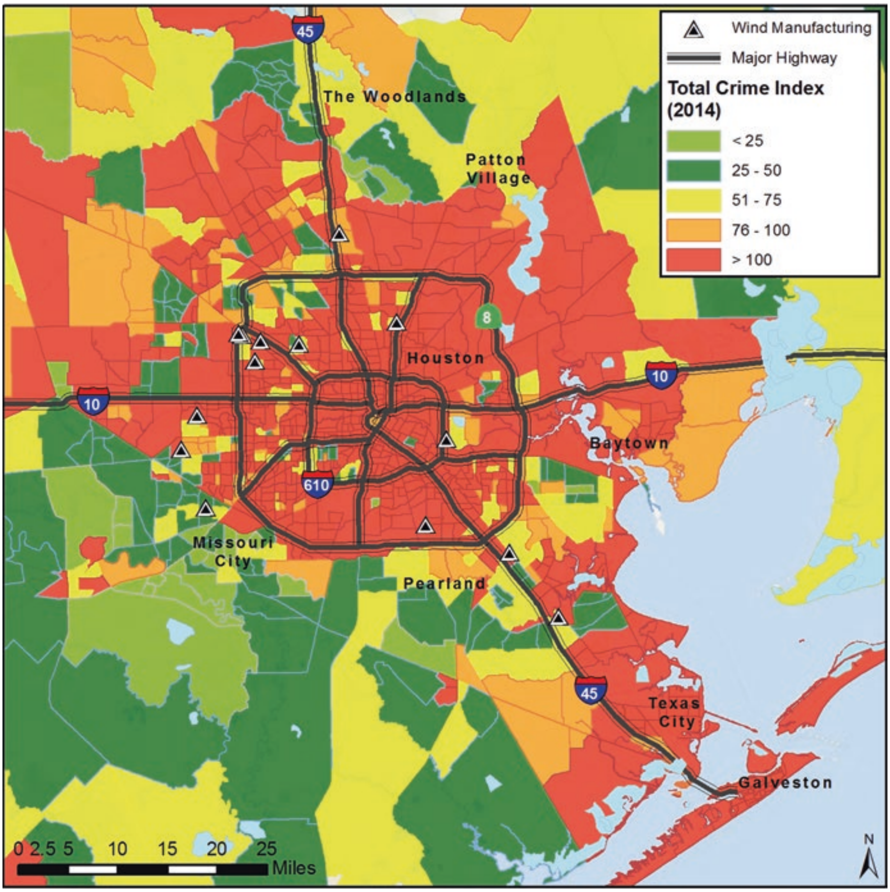

Fig. 5.17 Crime index, Houston-The Woodlands-Sugar Land MSA, 2014 (Source: AWEA 2016; modified from Esri 2015)

large government and professional-business services (EIA 2016c). The Calver Cliffs nuclear plant contributes about a third of the state's electrical energy, with another 50% from coal plants, fueled largely from out-of-state. As more and more coal plants are inactivated, more electricity has to be gridded in to the state from the outside (EIA 2016c). The demise of heavily-polluting coal plants, mostly located in Baltimore, reduces adverse air pollution and health impacts, and helps to make the city attractive by substitution of coal by non-polluting renewable energy sources for coal (Burr et al. 2014).

Maryland is as an upcoming leader on the U.S. East Coast in solar energy. Since the southwestern U.S. has the nation's largest concentration of solar facilities, shown in Fig. 2.4, the solar benchmark was sought outside of that region. There are two roughly evenly-sized concentrations of solar facilities on the East Coast, one centered on Baltimore, Maryland and a second centered on South Carolina.

Maryland was chosen as the solar benchmark for several reasons. First, it had the most rapid growth in total solar photovoltaic capacity at 152% growth from 2010 to 2013 among all the East Coast states, except for South Carolina at 242%; however, Maryland's total photovoltaic capacity in 2013 was at 175.4 MW, much larger the mere 8 MW in South Carolina.

Secondly, Maryland, along with Massachusetts and Oregon tied in first place nationally on the adoption of 11 out of 12 possible solar energy policies (Schneider and Sargent 2014). South Carolina had only adopted one of the dozen policies. Maryland has adopted the following policies: net metering, interconnection, solar rights, renewables and alternative portfolio standards solar carve-out, which are special growth targets for solar, rebates or grants, tax credits, virtual net metering for community solar, third-party solar power purchase agreements (PPAs), property-assessed clean energy (PACE) financing, and solar for public buildings. By comparison, California meets ten of the dozen solar energy policies and ranks fourth place nationally (Schneider and Sargent 2014).

Maryland's RPS standard, first approved in 2004, set the goal that by 2022, 20% of electricity produced in the state must be derived from renewable sources, of which at least 2% must be derived from solar energy sources and 2.5% of the total be from offshore wind (EIA 2016c). Attaining the state's RPS goal is expected by 2016.

Hydro accounts for 6.6% of the net electricity generation, provided by the Conowingo plant, by far the largest renewable source in Maryland, which also has biomass facilities (EIA 2016c). Some wind energy exists in its western mountains and there is aspiration in the RPS to implement some offshore wind energy capacity. Solar production of electricity is rapidly growing. Currently it consists of about 40% from solar factories and 60% from photovoltaic solar in homes or buildings, the latter with capacity of estimated at 300 MW in 2015. Commercial solar farms are of smaller size than the often very large ones in southern California, with the largest solar plant being a photovoltaic solar farm in Hagerstown at capacity of 20 MW (EIA 2016b, c).

Concomitant with the growth in solar capacity, the state's solar industry workforce has grown rapidly (State of Maryland 2009). The 2013-projected state solar workforce is slated to grow from 2342 to 3794 in 2015, and is concentrated in installation with 79%, followed by project developers at 7.5%, sales/distribution at 4.5%, and manufacturing at 4.0% (Solar Foundation 2015). This profile reflects the 60% proportion in Maryland of residential and commercial solar photovoltaic capacity, as opposed to solar utility-level solar electrical capacity (Maryland Energy Administration 2016).

Training in solar jobs is a necessary part of the workforce growth. In 2014, 44.5% of solar industry new hires in Maryland had no prior solar experience. This reinforces the importance of on-the-job training. Unsurprisingly, three quarters of the state's solar employers have on-the-job solar training, which corresponds closely to the nation (Solar Foundation 2015). Other types of solar training take place at community colleges including Allegheny College of Maryland, Frederick Community College, Prince George's Community College and Frostburg State University as well as nonprofit organizations, stimulating further economic benefits. Training, education, and research of highly-skilled solar energy innovators and researchers occur at University of Maryland Energy Research Center and Sustainable Energy Research Facility at Frostburg State University

An example of an unusual nonprofit solar training program is the Baltimore Center for Green Careers (BDGC), part of Civic Works nonprofit organization which assists underserved Baltimore communities with repairing housing, opening access to better jobs, and improving the urban environment (Civic Works 2016). BDGC provides training for unemployed or underemployed residents in areas of solar installation, brownfields remediation, and helping residences become more energy efficient (Stein 2016). Of the over 500 graduates, most are male and Black. Having high unemployment when they enter the program, 85% of trainees have had job placement with seven collaborating retail solar companies that offer above-industry-average wages (Stein 2016).

5.5.1 Maryland's Power Grid and Solar Energy

Maryland is a member of the Eastern Interconnection Grid and in particular of the ReliabiltyFirst Council. This means that solar energy produced in Maryland can be gridded easily out of state to consumers in the 13-state council and the 26-state Eastern Interconnection grid. Because Maryland is a small state with a well-functioning power grid and utilizes photovoltaic solar energy, there is a reduction of challenges related to the connection with the power grid. Photovoltaic panels installed on residential, corporate facilities, and government buildings have grid connection already available. The state's largest solar facility at Hagerstown (20-MW capacity) is already connected to the grid, and there are no projects in development to develop large-scale land-based solar farms in remote areas, as are present in Texas and California. Accordingly, Maryland's solar grid connections do not present an issue.

Maryland's solar industry is significant in size and provides evidence of innovation. In 2014, the state had 157 solar companies employing 3012 workers, and during 2012–2014, there was $971 million in private placement financing for solar, which ranked fourth in the nation (Solar Foundation 2015). Although much of the emphasis is in design and implementation of photovoltaic solar in homes and buildings, some facilities in Maryland represent entrepreneurship and innovation. Case profiles are given of three varied firms: General Motors, Prudent Energy, and Konterra Microgrid, in order to show the breadth of the state's solar section and provide ideas that can serve in planning for solar in the Coachella Valley.

General Motors, one of the largest multinational firms in the world, has become a leader in manufacturing electric vehicles. Under GM Chair and CEO Mary Barra, GM in the past few years considerably raised its initiatives in renewable energy. Among the renewables initiatives at GM have been to use gas from landfills into electricity onsite at several factory sites, conversion of a distribution center in

Rancho Cucamonga, California to solar energy in 2006, and installation of the world's largest industrial rooftop photovoltaic array on a factory in 2012 and other facilities, to reach in 2016 a total of 48 MW of photovoltaic solar installed at 22 facilities (General Motors 2016).

On the outskirts of the city of Baltimore, GM produces the Chevy Volt and other electric vehicles. When the electric vehicle section of the plant expanded to manufacture electric vehicle components, GM added a large solar installation to utilize solar photovoltaic electricity for the added factory area. The environmental contribution was magnified because the electric-car manufacture is now powered by solar energy. The solar feature received plaudits for its design and greenhouse gas savings, leading to the GM Factory receiving a Clean Corporate Citizen Award from the State of Maryland (Triplepundit 2016).

For Coachella Valley, this case provides an example or wind energy, of a worldwide brand-name firm showing interest in producing its own products based on renewables. It highlights that Coachella Valley should, in the longer term, look at a broader range of opportunities, not just small entrepreneurial firms, possibly extending to large firms and even multi-nationals if the right opportunities were to occur. To do so, the Valley would need to develop a larger supply chain base and larger skilled and unskilled manufacturing workforce.

Prudent Energy, privately owned by ten investors and headquartered in Bethesda, Maryland and Beijing, China, has 170 employees in the U.S., Canada, and Asia. It manufactures its principal product, the Vanadium Redox Battery Energy Storage System, a flow battery with a long life that can be installed for megawatt-scale solar photovoltaic projects (Prudent Energy 2016). The battery solves four major issues confronting large-scale solar projects: (1) the management of a complex power grid is improved through more accurate metering from the battery system, (2) power quality is improved since there is greater load balance achieved through use of batteries, which enables the grid to deliver energy better at the right time and place, (3) daily and seasonal unpredictable fluctuations are moderated, and (4) freedom for customers to disconnect partly or entirely from the energy grid, which is allowable in a group of states that includes Maryland (Prudent Energy 2016). For customers, the battery provides stability, back-up, and cost savings by fine tuning energy use to the lowest-cost fluctuating rates (Prudent Energy 2016). This solar firm is among many that seek to emphasize the evolving area of large battery storage for load storage and balancing. It constitutes an example of a successful mid-sized solar firm; which Coachella Valley planners could look at as the next step for entrepreneurial startups already present. Tesla's foray into the solar battery market, as will be seen in the next chapter, had a near miss on locating a large battery plant in the broader region neighboring the Valley.

Konterra Realty, a fairly small commercial real estate firm headquartered in Laurel, Maryland, and founded in 1998, has focused on real estate development, property management, leasing equity, debt financing, and construction management. When Hurricane Sandy hit the Maryland coast in 2012, many electrical lines and networks were knocked out. The Hurricane Sandy Rebuilding Task Force sought to introduce smarter and more adaptable energy systems. As a consequence, Konterra installed an exploratory solar powered micro-grid with capacity of 402 kilowatts, battery storage, two charging stations, and link for parking lot lighting (Wetzel 2013). The system met the policies of Federal Energy Regulatory Commission (FERC) for a more equitable grid storage system, and it included lithium-ion storage batteries and load balancing software (Wetzel 2013). This innovative approach was a success and helped in the rebuilding of an electrical infrastructure. The experience of building and implementing the micro-grid also provided Konterra with important knowledge that can be helpful in the construction side of the firm. For the Coachella Valley, this successful entrepreneurial mini-case supports the need to encourage entrepreneurship and innovation in renewables, a point expanded upon in Chap. 6.

5.6 Locational Aspects of Solar Manufacturers and Baltimore-Columbia-Towson MSA Socio-Demographics

This section explores the spatial locations of solar manufacturers in the Baltimore-Columbia-Townson MSA, henceforth abbreviated as Baltimore-Columbia-Towson MSA, compared to the social and economic dimensions of the MSA. The question to be asked is, what socio-economic features are in proximity to solar manufacturers. As with wind, the discussion is divided into three groups of variables.

5.6.1 Solar Manufacturing and Population, Education, and Wealth

The *population* is quite concentrated in the broad expand across Maryland between the Baltimore-Columbia-Towson MSA and the Washington DC Metropolitan Area shown in Fig. 5.18. There are large Interstate highways ringing the two metropolitan areas and connecting them. In this urban stretch, there seem to be few transportation barriers for solar manufacturing, although because of the build-up of population, there are relatively few rural, sparsely populated census tracts remaining, which constrain the siting of large-scale solar energy plants. *College-educated population* of 16% of population or higher is present in the areas between the Baltimore-Columbia-Towson MSA and Washington Metropolitan area, although low in most of the central city of Baltimore, except for the northern part shown in Fig. 5.19. Overall, the massive college-educated population constitutes a skills base for a vibrant solar-energy industry, which was evident in the last section to be present. Although in the Coachella Valley about half the population resides in similar areas of 16% or more college-educated, the much smaller population size and older age structure, with many retirees, results in a much smaller and less dynamic skills base for renewable energy.

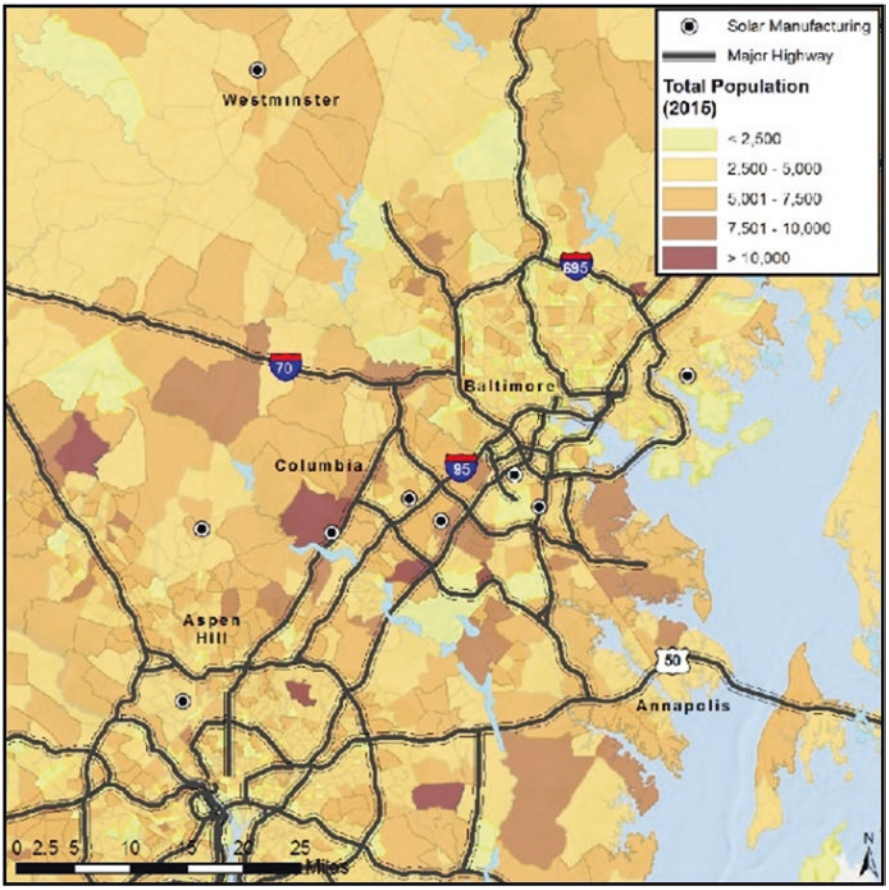

Fig. 5.18 Population in Baltimore-Columbia-Towson MSA, 2015 (Source: Esri, 2015)

5.6.2 Solar Manufacturing and Occupation

The distribution of *median net worth* for the Baltimore-Columbia-Towson MSA, reveals low net worth in the City of Baltimore, except for a northern portion, combined with high net worth of over $250,000 in most of the census tracts in the land area between Baltimore city and Washington DC., with the exception of two low pockets of under $50,000 net worth about half way between the cities. This pattern points to residential solar photovoltaic energy being more affordable outside of the city limits of Baltimore and in most peripheral areas to the north and west of Baltimore city, as well as most of the area between Baltimore and Washington. Regarding Coachella Valley, the areas that can better afford solar energy are in the stretch of affluent tracts in parts of Cathedral City, Rancho Mirage, Plan Desert, Indian Wells and La Quinta. Areas on the far periphery of the Valley, Desert Hot

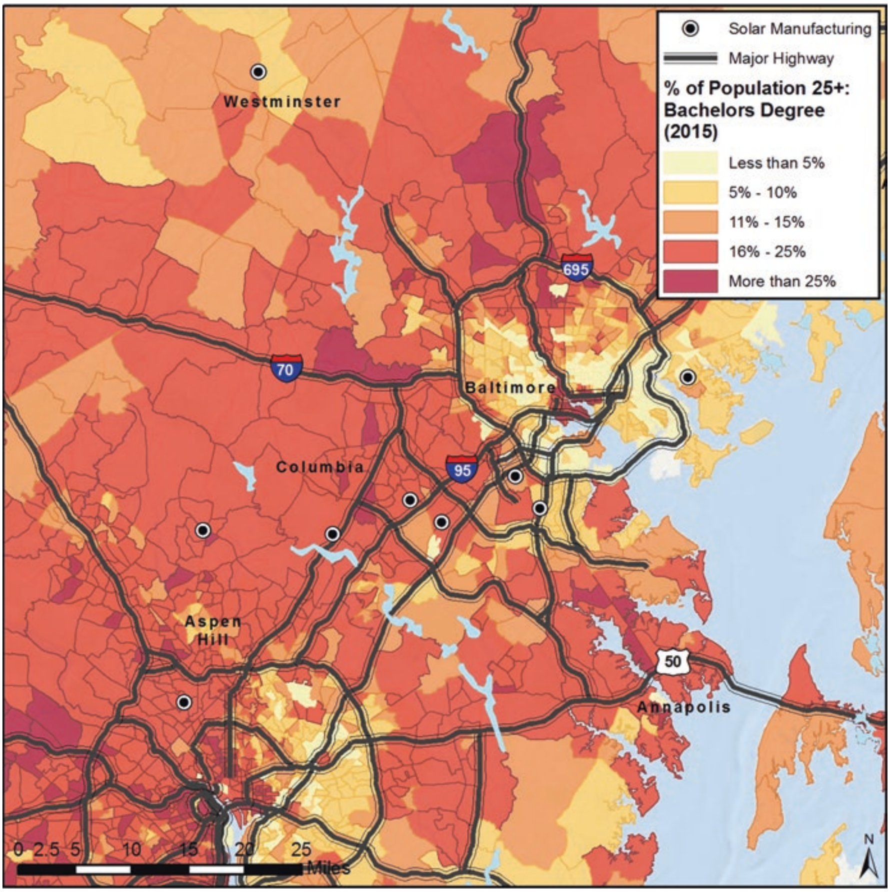

Fig. 5.19 Percent college-educated population, 25 years and older, Baltimore-Columbia-Towson MSA, 2015 (Source: SEIA 2016; Esri 2015)

Springs in the north and Indio, Coachella, and Mecca in the south are poorer and much more challenged to afford residential solar.

Maryland's solar manufacturing firms are located in areas of moderate to high home values, with the exception of one firm located on the east periphery of the Baltimore-Columbia-Towson MSA shown in Fig. 5.20. This pattern also confirms that residential solar installations would be more affordable outside of the central city of Baltimore and the poorer eastern side of the Washington DC metropolitan area. In the connecting corridor in between the two metropolitan areas, home values range from low to very high, over $750,000.

From the standpoint of solar companies, marketing could target the areas of higher home values, since the upfront costs of solar constitute a barrier for lower income households. For Coachella Valley, there is a similar range of home values

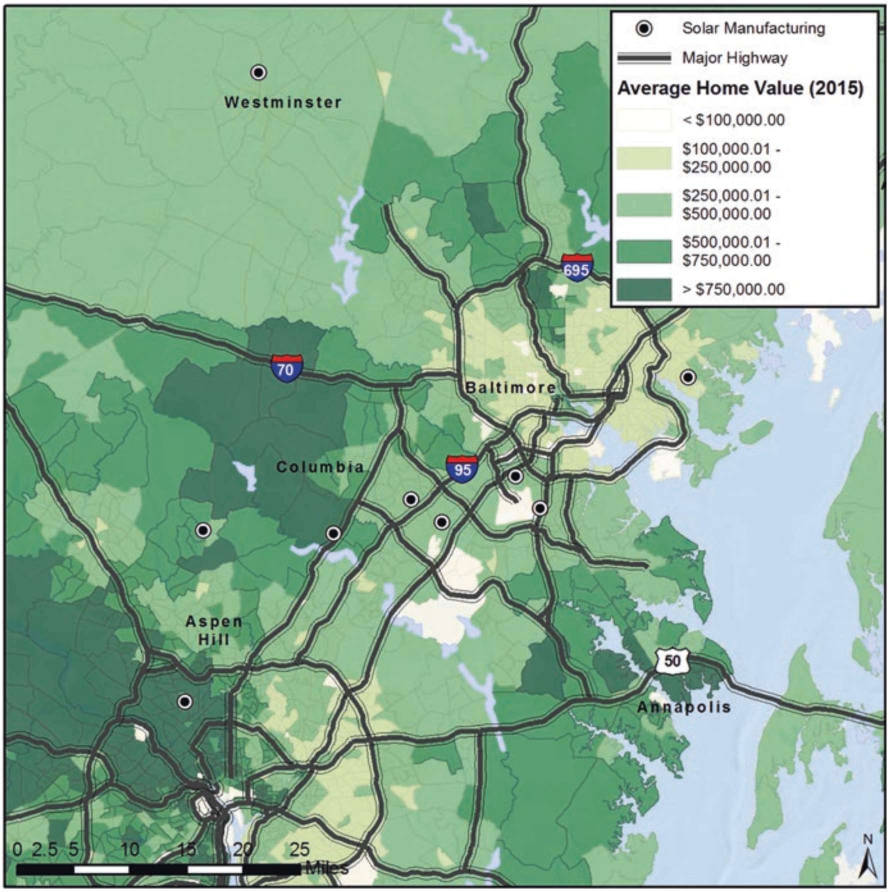

Fig. 5.20. Average home value, Baltimore-Columbia, Towson MSA, 2015 (Source: SEIA 2016; Esri 2015)

from very low to very high, which reflects its aforementioned socioeconomic divide. From a business-marketing standpoint, the same principle would apply. For instance, solar firms could market to tracts with higher-end housing, such as Ranchos Mirage, parts of Palm Desert, Indian Wells and La Quinta, while not marketing in the power areas such as Desert Hot Springs, Thousand Palms, Coachella, and Mecca. Since transportation is less of an issue with solar, location near a major highway is less important than for wind manufacturers, which is exemplified by half of the solar firms in the Baltimore-Columbia-Towson MSA locating away from the interstates. Hence, for Coachella Valley, solar firms could locate flexibly locate, based on affordability of properties and nearness to residential customers.

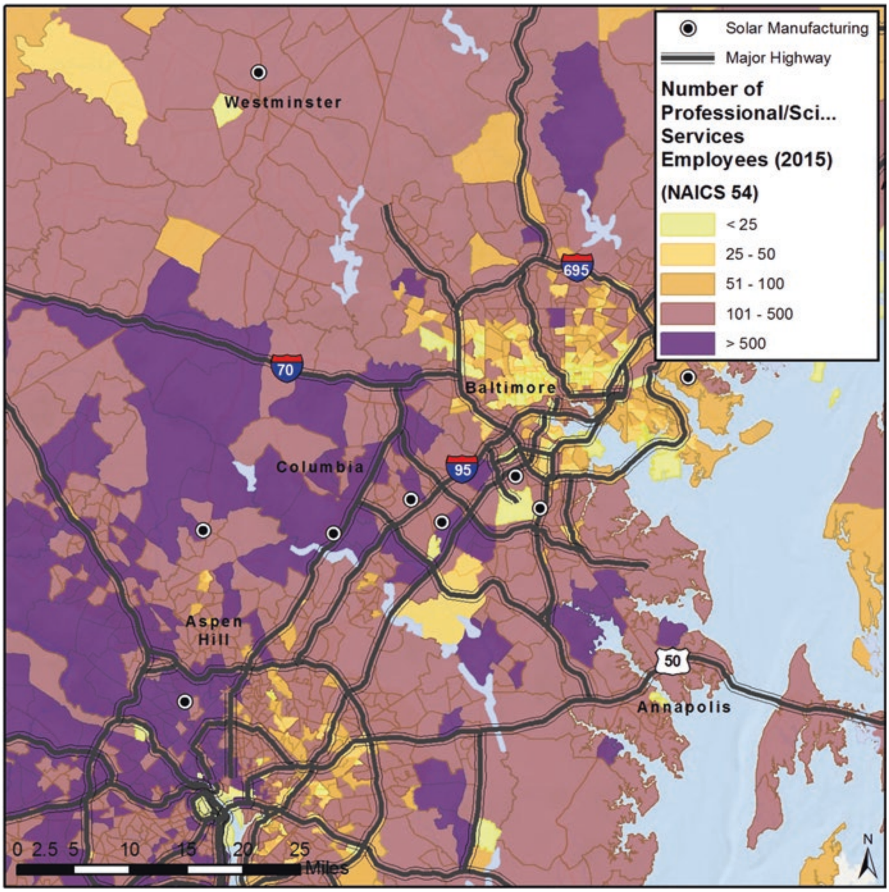

Fig. 5.21 Percent of population 25 years and older, professional, scientific, and technical employees, Baltimore-Columbia-Towson MSA, 2015 (Source: SEIA 2016; Esri 2015)

5.6.3 Solar Manufacturing Firms and Metrics on Extent of Manufacturing

As seen in Fig. 5.21, there is a large complex of *professional/scientific/technical employees* throughout much of the Baltimore-Columbia-Towson MSA with the exception of part of the central city. The solar manufacturing firms, with one exception in east Baltimore are located in large areas of high to very high numbers of these employees. Innovative solar companies such as Prudent Energy and others can benefit by this large complex of highly skilled professionals. Likewise, the many operating residential solar firms in Maryland can be backed up by this large pool. As mentioned with wind, on availability of skilled professionals, the Coachella Valley pales in comparison, with a small workforce numbering in the hundreds and concentrated in the middle south of the Valley.

The *number of manufacturing firms* is much smaller and less concentrated than for Houston. Likewise, the *percent of sales in manufacturing* in the Baltimore rarely exceeds 25%, so also reinforces the light presence of manufacturing in the Baltimore-Columbia-Towson MSA, with only several exceptions, particularly an area of manufacturing sales south of Columbia, Maryland, and another east of Interstate 83, as it extends to the north from the Baltimore central City.

Production workers in the Baltimore-Columbia-Towson MSA are much less numerous than Houston, and are distributed evenly without major concentrations, reflecting that Maryland is not a heavy manufacturing state. For solar energy, most major components such as photovoltaic panels are manufactured in Asia and shipped to the U.S., therefore, a heavy production workforce is not essential. The Coachella Valley is similarly low in manufacturing firms, percent in manufacturing sales, and production workers. The Baltimore case affirms that lack of a plentiful manufacturing workforce should not be a barrier for solar manufacturing in the Coachella Valley, since solar components can be shipped in and assembled.

5.6.4 The Internet, Environment, and Crime

The indicators of technology, environmental behavior, and crime inform on other social and attitudinal dimensions of solar development in the Baltimore-Columbia-Towson MSA. For *Percent Internet Use to Make a Business Purchase* (Fig. 5.22), there is a high level of use. Except for areas in the Baltimore central city and eastern Washington DC, internet use for business purchases is in the range of 11–15%, with exceptions of high use of over 15% in the harbor area of Baltimore and downtown Washington D.C. The latter high levels can be ascribed partly to the nearby Johns Hopkins University and University Maryland Baltimore, and in Washington D.C. to the center of the federal government. As seen earlier in the chapter, the Coachella Valley reveals a technology divide between the wealthier areas southwest of I-10 and most of the poorer areas to the north and south.

The *Total Crime Index* in the Baltimore-Columbia-Towson MSA reveals high crime in and surrounding the city of Baltimore and likewise for the city of Washington D.C. extending to the north and northwest, shown in Fig. 5.23. Areas of low crime are limited and are located mainly in a belt of rural census tracts that includes Columbia, Maryland, and extends to the west and southeast. The solar manufacturers are about equally distributed between high and low crime areas, although they are not located in the solid high crime-ridden central city of Baltimore. Applying the crime findings to locating solar manufacturers in Coachella Valley yields the same tradeoff, noted for wind firms, between the advantages of low crime versus the downside of high property values and rents (see Fig. 4.14). Because of the relatively short commuting distances in the Valley, it could be possible to locate a facility almost anywhere and still enable workers to reside in a low crime area.

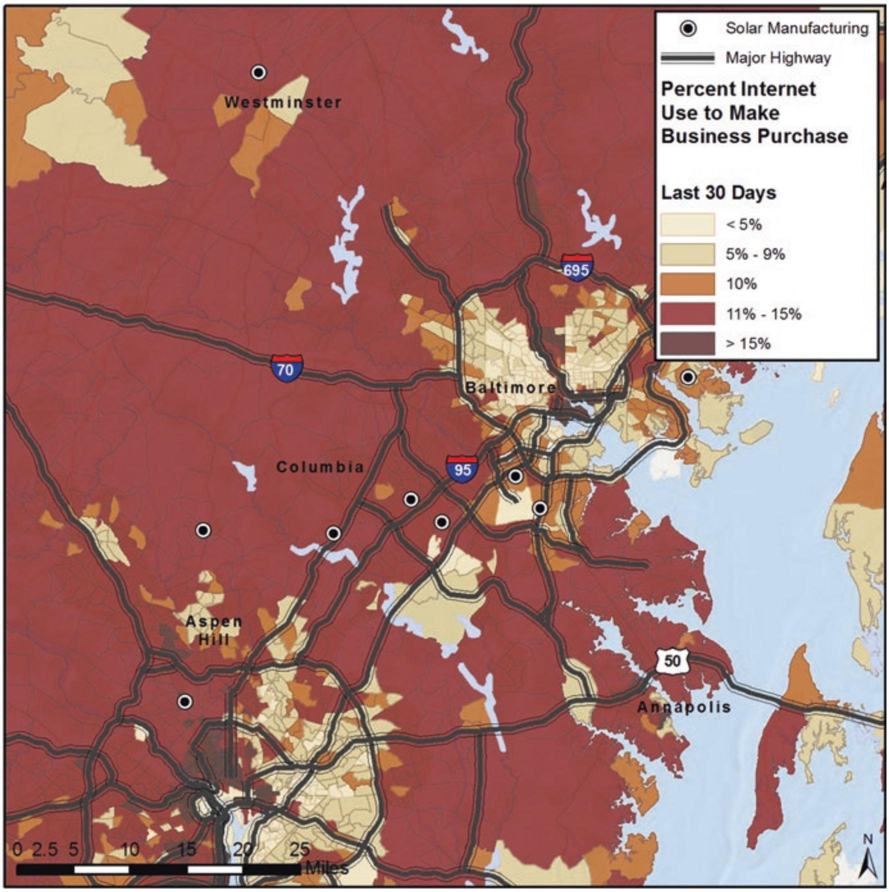

Fig. 5.22 Percent of population, internet use to make a business purchase in last 30 days, Baltimore-Columbia-Towson MSA, 2015 (Source: SEIA 2016; Esri 2015)

Participation in an Environmental Group Cause is high throughout the Baltimore-Columbia-Towson MSA, with the exception of some central tracts in the city of Baltimore and a few large rural tracts in the corridor between Baltimore and Washington, seen in Fig. 5.24. The generally strong motivation of residents towards the environment is encouraging for marketing of residential solar energy. It helps to understand the Baltimore-Columbia-Towson MSA's large upswing in solar adoptions of the past 5 years. The eight solar manufacturers are all located in areas with strong environmental participation, which is advantageous for marketing. Likewise, the strong environmental participation throughout the Coachella Valley points to the potential to expand residential solar in the Valley and also to regard its wealthier citizens as not only prime marketing targets for solar installations but also potential investors in solar energy enterprises (see Fig. 4.13).

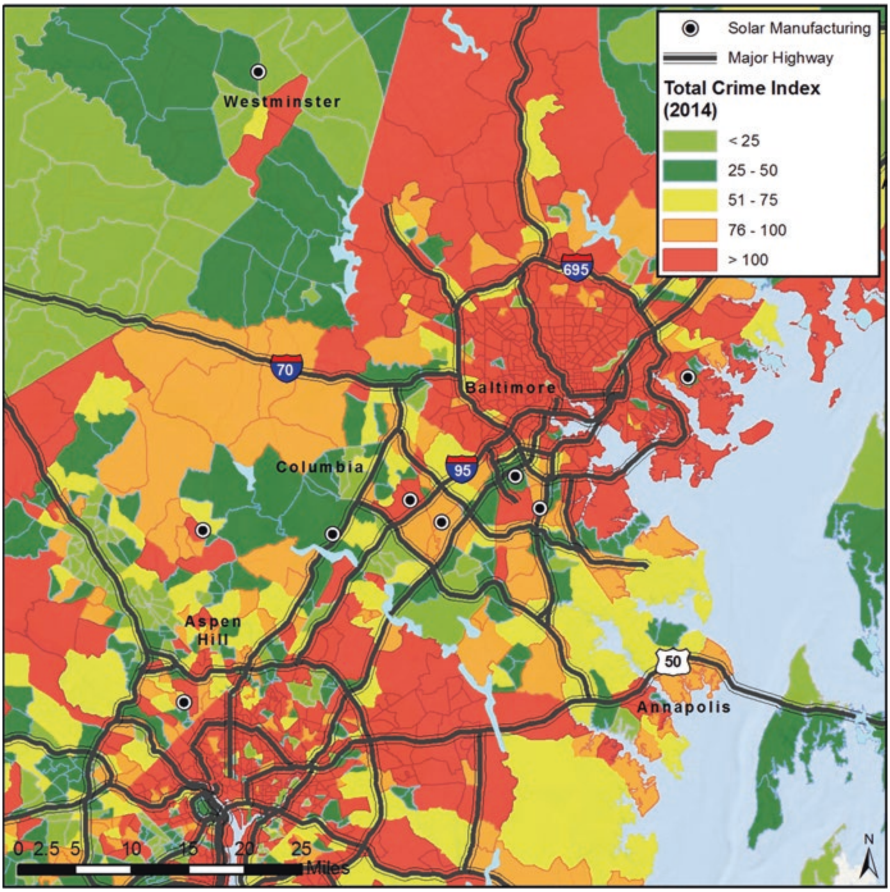

Fig. 5.23 Crime index, Baltimore-Columbia-Towson MSA, 2014 (Source: SEIA 2016; Esri 2015)

5.7 Conclusion

This chapter compared Coachella Valley's wind and solar energy historical and present renewable eneregy profile with the energy profiles of the leading benchmark states of Texas and Maryland, and with the leading metropolitan statistical areas within those states of Houston-The Woodlands-Sugar Land and Baltimore-Columbia-Towson. However, as stated earlier, the intent is not to consider the two MSAs as equivalent to Coachella Valley, but for the "benchmarks" to bring out features that may be advantageous as the Valley progresses to attain a more major renewables sector.

The rise of Texas as a national and global leader in wind energy is not accidental. It came from two decades of emphasis on wind energy development by state and local governments, companies of varied sizes and ownership, collaborating universities and nonprofits, and a citizenry that has mostly been supportive of wind energy

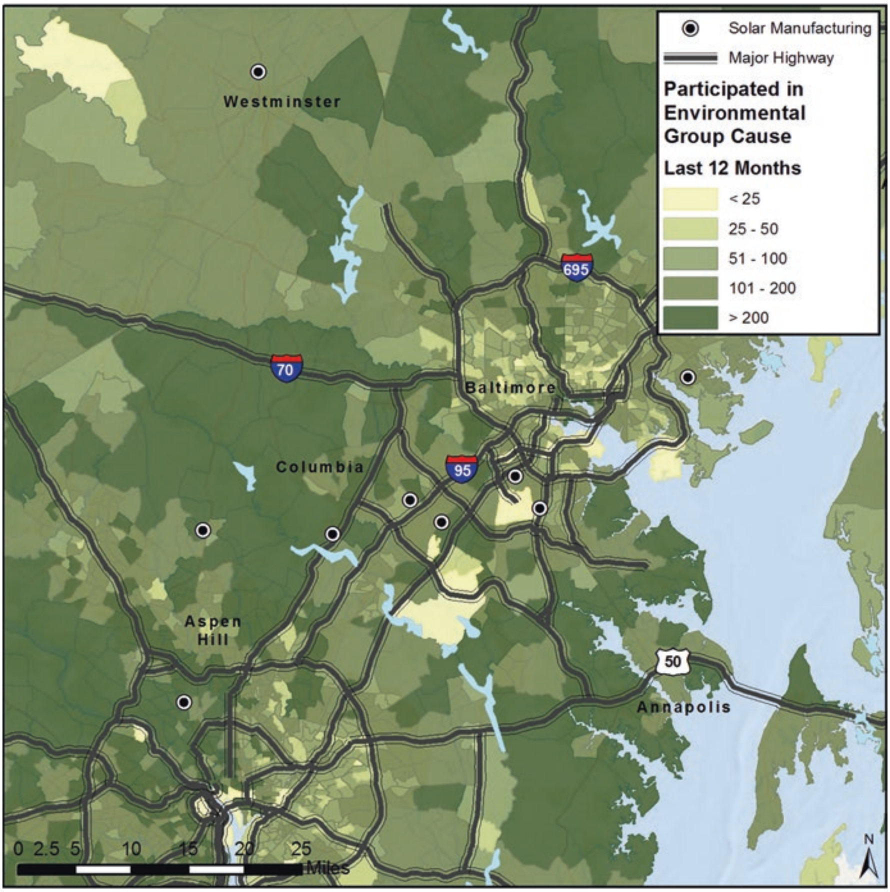

Fig. 5.24 Number of persons who participated in an environmental group cause in last 12 months, Baltimore-Columbia-Towson MSA, 2015 (Source: SEIA 2016; Esri 2015)

over the long term. Some key factors along the way have been proactive government leadership, smart management of the Texas grid including special initiatives for wind energy by ERCOT and CREZ, a vibrant industry sector for wind manufacturing and services, and the collaboration of R&D and innovation centers.

Spatial analysis of the Houston-The Woodlands-Sugar Land MSA explores how location of wind manufacturers relates to the geographical patterns of the surrounding social and economic characteristics. Important proximities and concentrations in Houston can be helpful in informing planning of renewables build-up the Valley.

A similar approach was followed to examine the benchmark state of Maryland and the Baltimore-Columbia-Towson MSA. Although Maryland did not historically have a strong starting base in the solar energy sector, through proactive goal-setting and legislative support, it has set an ambitious solar RPS goal and consequently had nationally-leading growth in residential and commercial solar. Several successful but varied companies were analyzed, as well as an innovative inner-city solar training program. An exploratory locational analysis similar to that for wind energy was conducted of the locations of wind manufacturers and the corresponding socio-economic spatial patterns, which are in turn related to the patterns in Coachella Valley.

Among the important lessons from the chapter's solar benchmark analysis is that vibrant growth in photovoltaic solar does not require a strong manufacturing base since most solar components are imported. Another benefit observed for solar development was Maryland's widespread favorable view by citizenry of the environment. In both Houston and Baltimore, some examples of renewables illustrated innovation within the companies. Innovation appears to be a critical factor in a city or region for attaining a top renewables status. Among the other key stimulating factors are state and local government support and setting ambitious state renewable goals. This chapter not only informs understanding of strengths and weaknesses of Coachella Valley's status, but also provides a broader perspective in the final chapter in formulating the key success factors for the future of renewables in the Valley.

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Chapter 6
Innovation and Entrepreneurship in Renewable Energy: Case Studies from Coachella Valley

Abstract Innovation and entrepreneurship are defined and contextualized through interviews with seven high level executives/owners of renewable energy firms and two important local city officials in the Coachella Valley. The firms are described, based on the interviews and other documentation. As a framework, the renewable energy manufacturing supply chain is presented, showing the progression of steps from raw materials to final product, with associated producers and end users. This framework is compared to the literature on renewables entrepreneurship, which includes consideration of the barriers to entrepreneurs for renewable manufacturing. The seven entrepreneurial firms are analyzed relative to their extent of risk-taking, proactiveness, and innovation. Although a modest start, the products and services being produced by this handful of innovative firms could become a larger and even prominent cluster of renewables manufacturing and services. Furthermore, based on the interviews of city officials, the two cities' approaches to supporting renewable energy manufacturing are presented and contrasted. The findings point to the need for continued support for entrepreneurial activity. The results suggest benefits for the entrepreneurs in developing partnerships with other renewable companies in the supply-value chain to maximize opportunities.

6.1 Introduction

Innovation and entrepreneurship in the renewable energy sector are undoubtedly critical to its growth. However, both concepts are considerably multifaceted in both their definitions and ways in which and degree to which they manifest. In addition to the natural environment, the manifestation of both innovation and entrepreneurship appear to vary, subject to the business people directly involved in the renewable energy sector, as well as those who materially influence the political, economic and financial environment in which renewable energy businesses operate.

Given the importance of innovation and entrepreneurship for the renewable energy sector, we proceed in this chapter to present a more precise definition of entrepreneurship, and then further contextualize those definitions through development of

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meaningful insights from the interviews of business and government leaders in the book's research project. The Interview Project insights are born from a series of in-depth interviews of nine key informants: seven high level executives/owners of renewable energy companies, and two local city officials.

More formally stated, we begin with a Literature Review and Framework section. In the Literature Review we present and discuss a generalized value-chain for renewable energy along with the conceptual, empirical and practical aspects of Entrepreneurial Orientation (EO).

In the second section, *Renewable Energy Project Insights,* we present and draw helpful and relevant conclusions from the Interview Project case studies (personal interviews). As Cato et al. (2008) point out "Research into the nature of entrepreneurship in a context of sustainability is sparse." The methodology for the Interview Project is discussed in greater detail in Chap. 3

The *Insights* section focuses on connecting entrepreneurial orientation characteristics observed in the results of nine in-depth interviews of key informants. The key informants interviewed play a meaningful role in the renewable energy sector of Coachella Valley. Seven of the key informants represented renewable energy companies with significant activities in the Coachella Valley, while the remaining two key informants were city officials cognizant of their city's role and influence on renewable energy. Lastly, we also make occasional mention of background interviews with renewable energy experts outside the Coachella Valley.

The *Literature Review and Framework* section presents a high level description of the renewable energy Supply-Value Chain applicable to the Solar, Wind and Geothermal renewable energy industries. The Supply-Value Chain provides a foundation for the subsequent specific discussion of ways in which key informants enacted or reflected the three related pillars of an Entrepreneurial Orientation (EO): Risk-Taking, Innovation, and Proactiveness (Lumpkin and Dess, 1996; Covin and Lumpkin 2011). Furthermore, in the *Insights* section, we delve deeply into the interviews to draw major conclusions with respect to entrepreneurial characteristics of key informants as well as innovation in various forms and stages in the renewable energy Supply-Value Chain. As the external environment is an unmistakable influence on the renewable energy sector, we also connect relevant characteristics of the natural, logistical (transportation) and political environment to renewable energy innovation in the Coachella Valley.

6.2 Literature Review and Framework

A variety of potential frameworks and literature relevant to renewable energy exists. As renewable energy cannot be discussed without an appreciation for the bigger picture of the socio-technical entities (actors) and processes, we first provide a detailed discussion of the Supply-Value Chain. We do so both generally and specifically to the Interview Project. Subsequently, we focus our discussion on key Entrepreneurial Orientation and Innovation literature selectively combined with general literature on innovation. Combining an understanding of the interrelationships between and among the entities in the Supply-Value Chain, Entrepreneurial Orientation concepts and Innovation provides a strong basis on which to analyze and draw conclusions from the participants in the Interview Project.

6.2.1 The Renewable Energy Supply-Value Chain

Generally speaking, the Supply-Value Chain is the network of organizations involved in a broad set of activities which create products (goods and/or services) that are ultimately for customers or more precisely, end-users (cf. Mentzer et al. (2001). In some descriptions of the Supply-Value Chain, post-customer disposal and recycling is included (Kaplinsky and Morris 2001) or green productivity is addressed (Darmawan et al. 2014). We appreciate the importance of disposal and recycling, however have purposefully excluded them from our discussion.

The simplest Supply-Value Chain description is generic and includes three major bilateral links between activities for:

1. Design & Product Development ↔ Production
2. Production ↔ Marketing/Sales
3. Marketing/Sales ↔ Consumption

There are two additional "feedback" loops from Marketing to Design/Product Development and another from Consumption/Recycling to Design and Product Development. While we acknowledge the feedback loops, we focus our discussion on the three major bilateral links listed above.

Kaplinsky and Morris (2001) further develop their idea of the Supply-Value Chain with a meaningful extended Supply-Value Chain of the furniture industry. They do so by identifying categories of Entities in the Supply-Value Chain from the start, i.e. Raw Materials, such as seeds, machinery through to Consumption/Recycling.

In applying Kaplinsky and Morris' (2001) Extended Supply-Value Chain, we must recognize that the specific entities (organizations, groups of individuals such as households and individuals) will vary for different types of renewable energy. Those differences are pronounced with regard to raw materials as well as semi-processed and even processed materials, in addition to the processes themselves. The processes encompass actions and interactions involving the upstream and/or downstream flow of goods/services, information, and exchange currency (most often money). As a result, we focus on a somewhat generic description of the Supply-Value Chain with broad classes of entities. However, we do include processes and organizations that **directly** become part of the end-user customer's product. Similarly, we include major facilitating processes and related entities that **indirectly** influence the realized and intended benefits of product offerings for end-user customers but do not become part of the product itself.

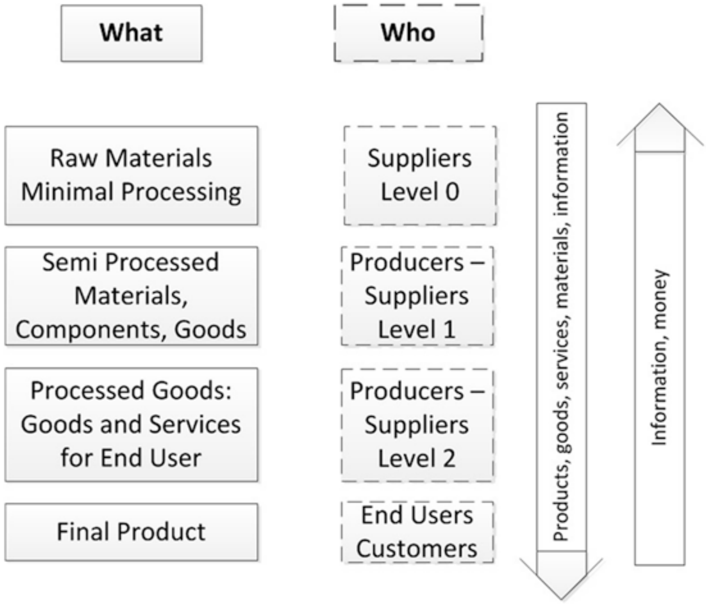

Fig. 6.1 Simplified supply-value chain (Modified from Porter 2001)

Our generic model of the supply-value chain (modified from Porter 2001) is shown in Fig. 6.1. There are four steps that go from raw materials to finished product. At each step the product becomes more complete through assembly and processing of components. Although there are goods and services at each step, in the figure, we indicate "services" at Producers-Suppliers Level 2, since they tend to be more prominent downstream. In the model the "Who" are the companies or individual actors who make that part of the supply chain function. For instance at the raw materials stage, the actor is the supplier, whereas in the final stage the actor is an end user or customer.

The companies interviewed are described briefly as follows:

Indy Power Systems. This firm focuses on balancing power across combined or hybrid systems that need to store energy in a battery. For instance, for a car that has a solar refreshed battery and another mechanical power battery, Indy would create the unique software and system to achieve an even, balanced flow. Another example would be to balance the energy locally over time for a large off-line micro-grid with renewable power sources and batteries, which has military and corporate customers. Although headquartered in Indiana, the firm makes use of Coachella Valley Economic Partnership's (C's) iHub facilities for product testing. iHub is a State-of-California-designated business incubator, that is operated by CVEP in the fields of renewable energy, advanced manufacturing, medical technology, and digital media, with current sponsorship from the cities of Palm Springs, Wells Fargo, and Desert Healthcare District (CVEP 2015b). It has sponsored 30 start-up firms from 2010 to 2015.

Fig. 6.2 Solaris Sun Cart, Solaris Power Cells, Palm Springs, CA

Solaris Power Systems. Solaris manufactures storage solutions for renewable energy products and systems, an example being a solar golf cart which is entirely solar powered, as seen in Fig. 6.2. Since the Coachella Valley has many golf courses, Solaris can market-test the product readily in Coachella Valley. Solaris is also producing low-voltage solar lighting installations for farming applications. Solaris, a member of iHub, is small but has an expert CEO with many years of experience in the fast-moving disk storage business.

EV Enterprises. The small firm creates and manufactures specialized electronic components for lithium batteries and solar powered products. EV Enterprises built the electronics to connect a large array of solar panels with a critical water pump for a large citrus farm in the Valley's unincorporated area of Mecca. They have also created customized components for Solaris's golf cart products. The firm's president is the "chief designer" of its innovative products.

Hot Purple Energy. The company provides photovoltaic systems and service for mostly affluent customers in the Coachella Valley. The firm has construction expertise in high-end residential construction from prior employment of the president as a contractor for high-priced, complex homes in Los Angeles. The firm tries to keep on the cutting edge of solar residential systems including battery storage. It is very customer-centric and community-centric in providing a lot of visible in-kind support for community nonprofits and events in the Valley.

Renova Solar. It is a growing and dynamic firm that installs rooftop solar on residences and business buildings, for the latter offering the idea of a decentralized or disconnected power plant. Other divisions include maintenance and operations of solar facilities, and the Renova Energy Academy to train solar installers. For solar equipment, Renova utilizes SunPower as its major supplier, which provides lease financing for customers and manufactures its solar modules.

Simbol Inc. This firm formerly designed and operated a pilot plant for extraction of lithium from geothermal brines but was not successful as is detailed in a Box in the chapter. It has been succeeded by Alger Alternative Energy, headed up by a former Simbol executive. Lithium is a key component in batteries used to store solar energy.

Desert GeoExchange (DGE). This is a small subsidiary of the Geothermal Resource Group. DGE offers residential ground source heat pumps (Lund et al. 2004) for cooling homes in the summer and heating them in the winter. DGE is discussed later in this section as an example. The parent company with a small team of well-known geologists is distinguished worldwide in geophysical exploration and drilling consulting in the planning and construction of large geothermal power plants.

In essence, renewable energy has a constellation of entities involved in the processes and activities which provide renewable energy to end-user customers, whether those customers are organizational buyers or consumers (individuals or households). The starting point of the renewable energy Supply-Value Chain (*upstream*) is suppliers and distributors who focus on identifying sources of and extracting a variety of raw materials. The raw materials are those necessary for downstream entities to produce, combine and distribute semi-processed, processed goods and components which ultimately produce the specific renewable energy. For example, Lithium is a raw material necessary for the production of batteries that power electric vehicles but also store energy from renewable sources for later or remote use. For solar energy, batteries are increasingly being included in solar systems to store energy from sunlight during the daylight hours for use during the nighttime hours.

There are flows of materials/products, information, and money up and down the supply chain that keep it functioning. Going down the supply chain are flows of materials, goods, services, and information, while flow going upwards are generally limited to information and money. For example, wind turbines have flows of components from raw materials to component manufacturers to product manufacturers and finally to finished product. This spatial view of southern California, shown in Fig. 6.3, indicates the location of wind manufacturers and concentrated locations of wind operating plants in the Tehachapi Pass, the San Gorgonio Pass and in the El Centro area near the Mexican border (AWEA 2016).

The Coachella Valley possesses considerable geothermal energy sources and is also one of the few geographic regions in the world with a relatively large source of geothermal brines located to the south of the Salton Sea in Fig. 6.3. With respect to the Supply-Value Chain, organizations that identify and extract geothermal energy (in raw form) and brines are at the most upstream end of the value chain (Raw Materials).

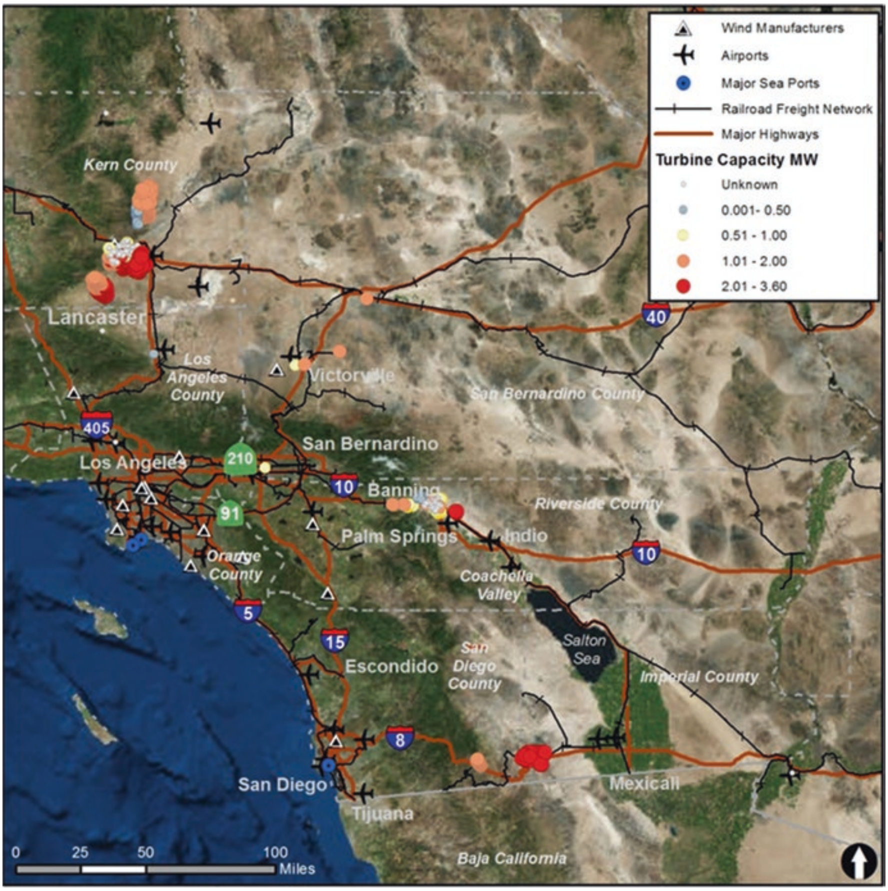

Fig. 6.3 Southern California Wind Manufacturers and Wind Plants, with Salton Sea and Northern Imperial County, the Location of the Salton Sea Geothermal Field, 2013 (Source: AWEA 2016)

Immediately following the Raw Materials stage in the Supply-Value Chain for geothermal are those firms that process the output of the Raw Materials for further use by themselves or others. These geothermal brines contain various minerals of value to many industries, but are of considerable value to the Solar Energy sector. In particular, Lithium minerals in the brines are an essential component for the Lithium Ion battery, which is the leading form of solar battery. Geothermal brines in the Salton Sea geothermal field, underneath and to the south of the Salton Sea, have high content of minerals including lithium, manganese, zinc, and potassium. The lithium was sought after as a key component for solar battery manufacturing in a case study of Simbol Inc., and its successor firm, Alger Alternative Energy. This case illustrates the renewables supply chain and is included as a detailed case study later in the chapter. In a generic sense for now, entities processing or extracting rich minerals in geothermal brines are categorized at the start of a Supply-Value Chain, in other words, the most upstream entities.

At the later parts of the first stage of the Supply-Value Chain, entities further process, combine, distribute and assemble raw materials, semi-processed materials and components from these extracted minerals. One of our Interview Project participants explores processing of the rich source of Lithium present in the Salton Sea area (Simbol Inc.).

The Interview Project company, Desert GeoExchange, subsidiary of Geothermal Resource, is focused on developing the ground-source heat pump, explained in Chap. 2, and introducing it for heating in the winter and cooling in the summer for the residential market in Coachella Valley. The parent firm Geothermal Resource Group (GRG), is a worldwide consultant on high-temperature drilling and geological resource assessment for geothermal power plants. In the renewable energy Supply-Value Chain, GRG focuses primarily on the geochemical engineering consulting and the process of drilling for geothermal energy exchange. Hence, GRG is participating in Level 0, the supply of raw materials, in this case the geothermal brines. Desert GeoExchange is a supplier at Levels 0, 1, and 2 because it consults on what resource is present, puts together components such as piping and heat pumps, and produces a ground source geo-heat system for a residential or commercial consumers.

Generally speaking, the ultimate downstream organizations in the Supply-Value Chain are adjacent to the customers, Suppliers and Producers at Level 2. At that stage the activities include services to assemble, distribute, sell and/or install, and repair/maintain finished goods for renewable energy products directly to customers. In our case studies, we interviewed executives from companies ranging from those helping to explore for raw materials to those primarily focused on manufacturing to those primarily focused on assembling finished renewable energy products. Others are selling renewable goods and services and then installing renewable energy finished goods to consumers and organizational customers. The fact that a considerable range of renewable energy companies exists in Coachella Valley speaks to its considerably fertile environment for renewable energy at all stages in the Supply-Value Chain, from raw materials to installation and delivery of renewable energy to end-user customers.

The modified Supply-Value Chain shown as Fig. 6.4 illustrates the interviewed case study companies at the appropriate levels. As is evident, several of the case study companies reach across two of the producers-supplier levels. This completed diagram will be helpful in the entrepreneurship orientation framework introduced later in this chapter. Next, the chapter turns to the extended example of Simbol.

The Coachella Valley is a particularly abundant area of resources for renewable energy, as has been described previously in Chaps. 1 and 2. This was so evident to the billionaire technology entrepreneur and CEO of Tesla, Elon Musk, that in 2014 he seriously considered the Coachella Valley as a potential location for Tesla's solar battery manufacturing plant. While Tesla ultimately chose a manufacturing location

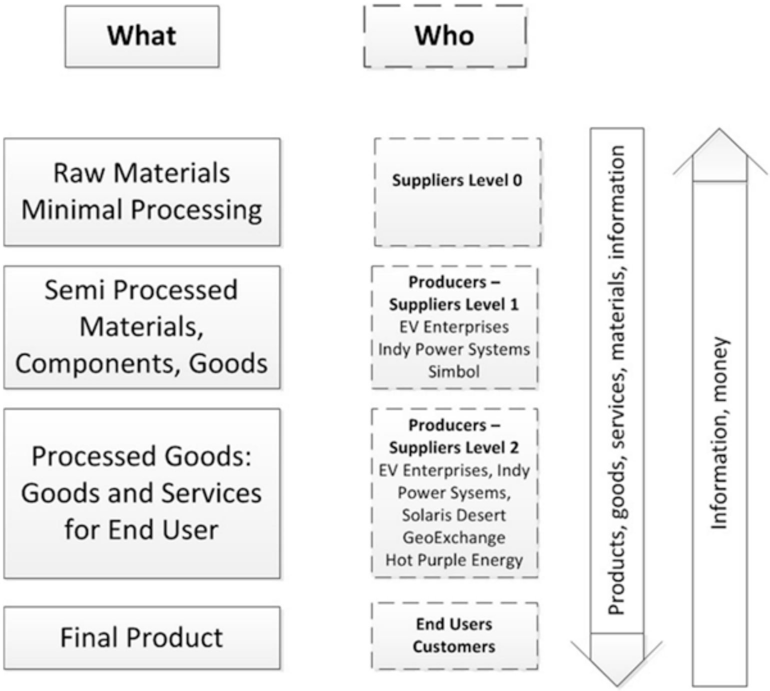

Fig. 6.4 Simplified supply-value chain with case study companies

in Nevada, the fact remains that Coachella Valley continues to be an attractive geographic area for renewable energy entrepreneurs and innovation.

BOX Simbol and Tesla Gigafactory; Failed Deal on Lithium Battery Supply Simbol, a private firm based in Pleasanton, California, was founded in 2009 to develop the processes to extract minerals from geothermal brines. Earlier attempts had failed because the minerals in heated brines were also highly corrosive to the pipes bringing them to the surface, making their extraction too expensive. Simbol discovered and patented a non-corrosive process for brines (Sizemore 2014) and constructed a pilot extraction plant to test the process in Calipatria in Imperial County, California, located 10 miles southeast of the Salton Sea, which the Coachella Valley borders to the north. Simbol was able to successfully extract lithium, manganese and other minerals, while the very hot water in the brine was utilized by a partnering energy producer, Hudson Ranch One plant to generate electricity. Simbol's patented process converted the lithium chloride in the brine to lithium carbonate and then to lithium hydroxide. Both final forms of lithium are utilized in the manufacturing of different types of lithium batteries, with the latter especially sought after for electric car batteries (Sizemore 2014).

With the market demand increasing greatly for solar energy, including for lithium batteries, and with the electric car market expanding rapidly which also called for lithium batteries, Simbol foresaw spectacular opportunities to expand its Calipatria pilot plant to construct a full-scale geothermal brine and energy operation and grow the company to support a very large production of lithium. This process would have limited environmental impacts—those of geothermal plants presented in Chap. 2—including possible land subsidence, which can be mitigated by reinjecting spent brines in the earth, some noise, and limited land use incursion. Simbol had competitive advantage because the other major world producers of lithium for batteries extract lithium in ways that are environmentally very harmful and they are located in few locations and at great distance from the U.S. in Chile, Argentina, and Australia. (Roth 2016).

In June of 2014, Elon Musk, CEO of Tesla Motors offered to purchase Simbol for $325 million (Roth 2016). This was because Musk sought a nearby source of high-purity lithium for Tesla's car and solar batteries. Musk was eyeing locating the Tesla gigafactory, its giant planned battery and car manufacturing plant, in northern Imperial County.

Simbol's CEO however rejected this offer, after being advised by outside experts that the price tag should be in the billions of dollars, and the deal fell through. Musk lost interest in the geothermal production of lithium and decided to locate the gigafactory near Reno, Nevada, after being offered huge incentives from the state of Nevada (Roth 2016). Subsequently, Simbol returned to seek investor funding but was unable to obtain it, laid off nearly all its staff, and currently is in a court proceeding to sell its remains, most likely to Alger Alternative Energy, founded by a former Simbol executive. The patented processes and working pilot plant would be transferred to Alger, but the challenge of how to raise the now $400–500 million needed to build a full-scale geothermal and lithium extraction plant would remain.

This case relates to Coachella Valley in a number of ways. First, a potential scale-up to a large lithium extraction industry would lead to local workforce demand, which would be evident in the nearest large urban complex of the Coachella Valley. A significant industry could also lead to suppliers of different types being needed locally, again pointing to existing or new firms in the Valley. This innovative and entrepreneurial venture would also bring attention to, and provide stimulus for the entire community of innovators within Coachella Valley.

From the standpoint of supply chains this case emphasizes that innovation can take place at any level of the supply chain, in this case at the beginning Level 0 of raw materials, a resource embedded in the earth of the Coachella Valley region. Once extracted, the lithium could be competitively shipped to Tesla's gigafactory located near Reno, Nevada, with shipping costing much less than from Chile or Australia.

As emphasized in Chap. 2, the solar energy sector is most active one for renewables in Coachella Valley. This is because photovoltaic residential solar installations are increasing rapidly in the Valley as well as the state as a whole. Moreover, commercial-scale solar plants located to the east of the Valley are growing in number and size. Wind energy, although large in the San Gorgonio wind farms, has almost no residential or direct business adoption in the Valley and it is not expanding significantly at utility-scale in the region beyond San Gorgonio.

As mentioned in Chap. 1, with respect to the geothermal energy sector, the Coachella Valley is one of few places in the country where the raw material for geothermal are abundant and feasible to extract.

6.3 Entrepreneurial Orientation

We begin defining the three pillars of Entrepreneurial Orientation (EO), then discuss in more depth what is meant by an Entrepreneurial Orientation with respect to its conceptualization, i.e. the logic of how to apply EO in practice (empirical settings) including but not limited to radical versus incremental innovation. Broadly speaking, EO reflects a wide variety of combinations of an entrepreneur's processes, structures or behaviors (Lumpkin and Dess 1996).

The literature addressing entrepreneurial activity in the renewable energy sector is a nascent field of business research; however, we discuss relevant literature on renewable energy with linkages to EO, and subsequently in the Insights Section that follows the literature review. To that end, we include both conceptual and empirical works connecting renewable energy and aspects of entrepreneurial elements. We introduce and discuss the relevant findings from a few of the relevant existing empirical articles which utilized EO in the context of renewable energy. In our review of both the conceptual and empirical works, we keep in mind both radical and incremental innovations in the renewable energy sector.

In 1996, Lumpkin and Dess (1996) formally established EO as composed of three constructs:

1. Risk-Taking,
2. Proactiveness and
3. Innovativeness.

Risk-taking centers on resources and how entrepreneurs differentially apply resources to projects with substantial uncertainty. The projects may involve a wide range of intra-organizational processes (internal Value Chain) and/or external individuals/organizations and processes with them. Michael Porter's original Value Chain (Porter 1985) involved an organization's internal activities as intra-organizational activities. This is opposed to our more in-depth discussion of the Supply/Value Chain as inter-organizational and thus involving multiple organizations. Of most relevance to the Interview Project is the application of relationships with other organizations or individuals within the existing Supply-Value Chain.

It would appear that most commonly, internal processes focusing on development of the product offering are central to entrepreneurs.

These types of internal processes include the new product development (NPD) processes whether the entrepreneur engages in a traditional gate-stage NPD process, a modified traditional NPD process, which will skip or truncate stages, or an ad-hoc NPD process. Of particular interest for entrepreneurs in renewable energy are radical innovations, and radical quality and production manufacturing and assembly processes. At the tail end of the NPD process, the Marketing and Sales Strategy or execution may also be relatively radical or innovative. Such innovation requires a "leap of faith" in assigning resources to that radical strategy, as the strategy is yet unproven in the marketplace.

We acknowledge Lumpkin and Dess' (1996) and important others' in the field of entrepreneurship centering on financial resources. Moreover, financial resources can realistically impact the degree to which opportunities for human and physical resources exist. However, we make explicit in our context the relevance of a more nuanced application of how renewable energy entrepreneurs differentially apply and use human and physical resources. Based on the Resource-Based View (RBV) in the strategic management literature we explicitly include financial, human and/or physical resources.

Lumpkin and Dess (1996) go further than simply suggesting the application of resources. They also describe risk-taking as a strong willingness to enter into unfamiliar markets. What is meant by unfamiliar markets? Unfamiliar markets to whom? In the minor sense, it is those markets or buyers which are unfamiliar only to the entrepreneur. Thus the "learning curve" is steep for that particular entrepreneur in developing and executing an appropriate strategy for the marketplace. Thus there is some risk for the entrepreneur; however, it is relatively minor as knowledge can be gained from researching the marketplace of buyers and sellers. In other words, the risk of unfamiliarity is addressable although specific to the entrepreneur.

At the opposite end of the continuum, a heightened level of risk occurs when the market itself is highly uncertain. It is the risk associated with entities and activities upstream and downstream to the entrepreneur in the Supply-Value Chain. This seems often the case with radical or significantly modified innovations, including those in the renewable energy context. Upstream from the entrepreneur might mean entities in the Supply-Value Chain may be unknown, unavailable and/or unable to deliver the desired quantities or level of quality as the market is uncertain to them as well as the entrepreneur. As such, the entrepreneur likely experiences a lack of availability of appropriate suppliers for the entrepreneurs' inputs.

Beyond the Supply-Value Chain uncertainty, risk-taking by the entrepreneur also reflects the choices made internally by the entrepreneur. How does risk-taking for renewable energy manifest differentially between organizations? Wagner (2012) sums up the essence of the difference. In much of renewable energy, traditional "business cases" cannot be made. It is a "logical paradox" as it is especially difficult to establish a strong business case for much investment in sustainable energy products and markets. By extension, those in the field of renewable energy who invest human, financial and physical assets for a very uncertain payoff are taking a considerable risk of losing those assets. As a result, renewable energy entrepreneurs high on the risk-taking EO pillar typically make asset allocation decisions that cannot be readily or easily justified with traditional go/no go business case analysis. Such analysis relies on reasonable certainty in data, information and forecasts which are either absent or range considerably between worst case, best case and most likely case with respect to measureable outcomes.

The second pillar, *Proactiveness*, reflects a future oriented entrepreneur who possesses forward-looking, aggressive and profound preference to shape the environment in which the entrepreneur and her/his organization operates. A penchant or bias towards action is exhibited by entrepreneurs high in Proactiveness as they prefer to act to influence the environment in their favor rather than wait for it to settle at an equilibrium or simply react as the environment changes. That high level of Proactiveness persists irrespective of whether the environment presents impediments—problems that an entrepreneur tries to address—or opportunities.

In the context of renewable energy, the environment encompasses traditional, strategic macro elements that determine to a large degree whether a business will be or is in a favorable or unfavorable setting. Macro characteristics include the Political, Economic, Socio-Cultural, Natural and Technological dimensions of a settings not traditionally under the entrepreneur's direct control. What differs with entrepreneurs versus typical incumbent firm decision-making is how entrepreneurs high on Proactiveness actively seek to shape the environment, rather than passively accepting the macro environment as is.

In addition, the macro-characteristics of the setting relate to the Supply-Value Chain Actors/Organizations to further influence whether the particular market is favorable or unfavorable for all those interested in entering the marketplace. Entrepreneurs high on Proactiveness act—well in advance of others—to shape, mold and take control of Supply-Value Chain opportunities, rather than waiting for the Supply-Value Chain to adjust. In other words, they exert proactiveness in either their penchant for, or timing of action as well as their choices of what actions to take.

The traditional view of Proactiveness also includes being aggressive with rivals, those important organizations competing at the same level in the Supply-Value Chain as the entrepreneur. However, given the increasing degree of cooperation among competitors, and the importance of coopetition early in the product life cycle, rivalry is viewed as much less relevant in the context of renewable energy entrepreneurs. An example of coopetition is that Solaris and EV Enterprises have become comfortable with EV producing the custom electronic products that Solaris needs for its solar golf carts, averting being direct competitors. Entrepreneurs high on Proactiveness may seek out a variety of types of alliances with the few competitors available early in the product life-cycle for renewable energy.

While coopetition addresses cooperative relationships or alliances between organizations at the same level in the Supply-Value Chain, entrepreneurs high on Proactiveness may also selectively seek out cooperative relationships with those downstream. In other words, they make use of their own customers or their customers' customers in the case where the entrepreneur's offering is not the ultimate user of renewable energy. It is in this way renewable energy entrepreneurs may off set the higher risk of their offerings through proactively taking advantage of downstream relationships. Discussion by Schaltegger and Wagner (2011) and Wagner (2007) addresses innovation and renewable energy with one particular strategy, niche markets. Of particular interest for our discussion of renewable energy entrepreneurs is the idea of niche markets which clearly illustrates that entrepreneurs can begin developing offerings with one or both of the following: (1) New offerings of goods and services, and/or (2) offerings to new customers at the same supply-value chain level or upstream.

How might these two approaches to niche markets reduce the effective risk of renewable energy innovations? New markets are inherently riskier given both the uncertainty of product and customer related characteristics and preferences. With respect to customers and new products, renewable energy sellers often have little to no knowledge of acceptance or adoption by consumers as either individuals, as households, or by organizational buyers. In particular, two critical questions arise:

1. Will the renewable energy be adopted at all?
2. In the event it is adopted, how quickly or slowly will an innovative renewable energy product diffuse in the marketplace?

The question of relatively slow diffusion of renewable energy is far from trivial. More specifically the reasons for the relatively slow diffusion of renewable energy have been addressed in depth by Gibbs and O'Neill (2012) and in considerably greater depth by Alkemade et al. (2011) and Negro et al. (2012). Gibbs and O'Neill (2012) discussion addresses what they refer to as "green entrepreneurship". They posit that the slow diffusion of green energy by entrepreneurs is a function of the nature of the sociotechnical transitions of major systems. Their discussion is consistent with our previous identification of the renewable energy Supply-Value Chain with respect to the "socio" elements being the actors/organizations in the Supply-Value Chain and the "technical" aspects focusing on technology and operational interrelationships between and amongst the individuals/organizations. Gibbs and O'Neill (2012) go further by comparing and contrasting the sociotechnical aspects of traditional energy with the green energy Supply-Value Chain. They identify what they refer to as blockages or impediments which occur by switching over from traditional energy to green energy. These impediments hinder what they refer to as smooth "transitions". In other words, one of the major impediments to a smooth transition is the often powerful incumbent suppliers invested in traditional energy business relationships coming into significant conflict with entrepreneurs leading the charge for green energy. Farthest down-stream in the Supply-Value Chain for energy, potential end-user customers may also be hesitant and invested in the traditional energy Supply-Value Chain.

A similar but more in-depth treatment of the impediments to rapid diffusion of renewable energy markets was conducted by Negro et al. (2012). They categorize the impediments in four categories:

1. Infrastructure Problems
2. Institutional Problems
3. Interaction Problems
4. Capability Problems

With respect to Market Structure Problems, Negro et al. (2012) address a major issue for innovation in the renewable energy systems, that is the selection criteria by which incumbent entities in the Supply-Value Chain for traditional energy systems decide if and when to adopt an innovation. They go further to describe how the typical decision by incumbents is biased towards the existing traditional energy system given relatively high returns and thus greater utility for those incumbents. Innovations typically must recoup their initial investment in product development prior to the first “sales” revenue. As a result, the thinking by incumbents is that renewable energy innovations costs are particularly higher in the introductory stage of the product life cycle than the traditional energy options which are further along the product life cycle. In addition to the potentially lower initial returns of new renewable energy options, the dominant incumbents in traditional energy may have “locked-in” customers such that the switching costs for the end-user customers are considerable.

The second hindrance to diffusion of renewable energy involves physical and knowledge infrastructure problems. As Negro et al. (2012) describe it, the physical infrastructure reflects the meta-technical or system-wide structures necessary for widespread adoption of the renewable energy. In other words, are there significant investment costs required by those in the Supply-Value Chain for the particular renewable energy? Are new, different and/or drastic coordinating mechanisms necessary across, between and among, the energy Supply-Value Chain entities? And in line with Wagner (2012), are many or all of these coordinating mechanisms necessary for transitioning from the physical infrastructure of the existing energy system to the renewable energy system? Are specialized physical assets and related know-how (scientific and applied knowledge) required at the individual, organizational and inter-organizational level? Renewable energy systems that require considerable change, on all these infrastructure dimensions, result in a particularly high hurdle for the renewable energy to overcome. Thus a relatively quick and smooth diffusion of the renewable energy to end-users is unlikely.

The third category impeding diffusion of renewable energy is the institutional context that defines the structural elements in the system. Hard institutional issues, such as technical standards, which represent formal written documentation as well as consciously created rules, other standards, and procedures which must be followed. Soft institutional issues are informal “rules of the game” which are often implicit norms, values and culture. These types of institutional problems may be difficult to change if “hard,” and nearly impossible to change, if “soft.”

For example, a cultural norm in the Supply-Value Chain whereupon entities are rarely proactive or willing to share relevant information with other entities in the Supply-Value Chain may decrease the potential perceived efficiency and effectiveness of new renewable energy systems.

In the renewable energy sector, institutional context problems relate to the fourth category in Negro et al.'s categorization of impediments as "Interaction Problems." Interaction problems in this case involve the market relationships in the Supply-Value Chain. They aptly describe the Interaction Problems as too strong/too weak and capability problems. The simplest is capability problems, where the organizations in the Supply-Value Chain lack the requisite competencies, capabilities and/or resources to make the transition from an old to a new technology or paradigm for energy.

The more complex issue is market relationships, links between entities in the Supply-Value Chain, being too strong or too weak. In the case of relationships that are too strong, one or more of the entities provide erroneous guidance to another and/or to potential new entrants are handicapped or in extreme cases prevented from participating in any meaningful way in the Supply-Value Chain. Given the strength of the relationship, the receiving entity may be reluctant to disagree with the stronger partner or group. In contrast when interactions are too weak, there is no "shared vision" at all which makes adapting the complementary technologies subpar and learning by entities in the renewable energy system almost nonexistent.

Markets for new products always contain some risk; however in the case of renewable energy and entrepreneurs, it is heightened due to the lack of market definition early in the product life cycle for the particular renewable energy innovation. As such the renewable energy entrepreneur (or any seller) lacks or has a very limited knowledge of customers' requirements and preferences, competitors and distribution/sales. Savvy entrepreneurs with respect to being proactive may be able to offset some of that risk by proactively searching for under or unserved markets with which they are already familiar. In other words, proactive renewable energy entrepreneurs address a niche market from "customers from a specific milieu or peer community" (p. 2, Wagner 2012). These entrepreneurs can potentially gain knowledge in advance of other actual or potential competitors, including incumbents in the renewable energy sector. As such, renewable energy entrepreneurs, in essence, make markets rather than simply addressing widely-acknowledged existing market opportunities—where those opportunities are acknowledged by incumbents. It is part and parcel of a critical illustration of the Proactiveness pillar of an entrepreneurial orientation for the renewable energy sector.

Lastly, the third pillar, Innovativeness, is described as embracing creativity and novelty, technological leadership and willful experimentation (Lyon et al. 2000). Related literature on Innovation is consistent with the EO definition, and some have begun connecting Innovation with a distinct Supply-Value Chain, referred to as the "Innovation Value Chain". In 2007, Harvard Business Review (Hansen and

Birkinshaw 2007) strongly suggested that a more tailored approach to the innovation was more productive than one not tailored for the specific organization. In other words, they suggested and made the case for selective use in the process of creating innovation. That idea is consistent with the conceptual idea of EO.

In a different, but related treatment of the Innovation Value Chain, Roper et al. (2008) explicitly acknowledge how introducing new products and processes reflects a multilayered innovative process of knowledge acquisition AND transformation. They suggest, and we concur, that the ability to exploit knowledge is to a considerable degree central to actualized innovativeness. Interestingly, while related, the three pillars of EO are viewed conceptually and empirically as independent constructs. In other words, being strongly entrepreneurially oriented does not necessarily require being strong on ALL three pillars simultaneously. Equally relevant is the idea that dimensions can and often will vary independently with regard to their strength. What has been illustrated as highly relevant to understanding and applying EO empirically is the temporal consistency of any particular EO pillar, almost irrespective of the particular circumstances at different points in time. In other words, to describe an entrepreneur as possessing a strong EO requires a persistence and consistency of exhibiting high levels of one or more pillars over an extended period of time and under varying circumstances.

Given the prior discussion on innovation, how has EO—Innovativeness in particular—been applied to empirical literature in the renewable energy sector? Nanda et al. (2013) conducted a study of renewable energy firms based on their patent activity. Nanda et al. (2013) included the three renewable energy types also in our Interview Project (Solar, Wind, Geothermal) but also added hydro-electric and biofuels. They used patent data from the US Trade and Patent Office as well as a highly-structured, valid, systematic and replicable methodology for selecting and analyzing patent data and categorizing the organizations into start-up versus incumbents in the renewable energy field.

They found that renewable energy startups were significantly more engaged in innovative patents than incumbents in the renewable energy sector. Whereas startups were primarily engaged in novel innovations for renewable energy, the bulk of innovation by incumbents—illustrated by patent characteristics—were incremental innovations at best. Incremental innovations are described as being less risky (low uncertainty) when compared to highly risky breakthrough (novel with high uncertainty) renewable energy innovations.

6.4 Coachella Valley Renewable Energy Project Insights

As previously discussed, Risk-Taking, Innovation, and Proactiveness are the main pillars of an Entrepreneurial Orientation (EO). In this section, we present our findings from seven in-depth interviews of renewable energy entrepreneurs and two city government officials in the Coachella Valley. Before delving into our findings, we reiterate the three elements of an EO.

1. *Risk-taking* reflects a willingness and to act boldly when compared to similar others.
2. *Proactiveness* is a palatable willingness to act well in advance of future needs, problems and changes in the marketplace; to plan projects ahead of time; and exhibit a strong preference to "get going" rather wait for others to start projects.
3. *Innovation* reflects a very strong preference for atypical or unique, original new or unusual activities and approaches. A distinct behavioral aspect of Innovation is a penchant for considerable experimentation.

We selected those three aspects given the extensive body of supporting research, which almost unilaterally support that an entrepreneurial orientation facilitates product and process innovations in the marketplace, irrespective of the specific industry. As Cato et al. (2008) note "Research into the nature of entrepreneurship in a context of sustainability is sparse." (p. 315). Thus applying the entrepreneurial orientation to renewable energy is a burgeoning and important field, and so we present our discussion of our case studies to further understand and facilitate innovation in the renewable energy sector.

The seven renewable companies interviewed can be classified by the three pillars, as shown in Table 6.1. Overall, we found a considerable wealth of each of the three elements of Entrepreneurial Orientation in participants from the Interview Project. What differed somewhat was the way the elements manifested (particular instantiations of an EO element). As mentioned in the preceding Literature Review, the EO specifics ranged from different ways of generating or acquiring new ideas with which to experiment, to developing structures and supporting services to generate human and financial resources unavailable through existing providers.

While we focus on Entrepreneurial Orientation, we must note that in contrast to many studies of entrepreneurship and innovation, not all of our renewable energy companies were start-ups or in the early business stage. For example, Nanda et al.'s (2013) study of innovation in renewable energy focused solely on renewable energy start-ups. An important element of their research was on venture capital, and thus their choice made sense. They focused on innovation related to a specific organization rather than innovativeness as illustrated by a specific entrepreneur per se.

While our Interview Project included some start-up firms, all but one of the renewable energy key informants had held executive positions in organizations prior to the current firms which were the focus of our study (Table 6.2). Some of our key informants had no or limited prior experience in renewable energy. As such, our results are suggestive of two broad competitive advantage implications:

1. Gaining benefits from an Entrepreneurial Orientation in the renewable energy sector is a significant potential competitive advantage for organizations in the renewable energy Supply-Value Chain irrespective of business stage.
2. Human resources/talent acquisition for start-up renewable energy companies are likely to benefit from one or some combination of the following:

   (a) When noticeable Entrepreneurial Orientation deficits exist, the organization must consider:

Table 6.1 Summary of major entrepreneurial orientation (EO) activities by renewable energy participant companies

Company	EO: Risk-Taking	EO: Proactiveness	EO: Innovation
Indy Power Systems		*Outbound Logistics, Marketing-Sales* Seeking Partnerships with VAR to promote turnkey solar solutions	*Technology/Product Development*: Customized Products
Solaris Power Cells	*Product Development/ Firm Infrastructure*: Aggressive growth/ product performance objectives for 1 year old startup (2013) *Product/Technology Development:* Considerable investment in nonstationary solar collection/storage	*Operations/Product Development*:Main component supplier iHub company (EV Enterprises) *Firm Infrastructure:* Capital generation via public funding at start (2013)	*Technology/Product Development & Sales*: Experimentation with solar/battery backup in Agriculture (Citrus Farmer)
EV Enterprises	*Operations/Outbound Logistics* Supplier to start-up solar company (Solaris), for standard & customized components	*Technology/Product Development*: Quick Strategy Change from Elec. Car Conversions to Components *Operations*: Acquisition of Company assets for manufacturing	*Technology/Product Development & Sales*: Experimentation with solar/battery backup in Agriculture (Citrus Farmer)
Hot Purple Energy	*Product Development/ Service:* Transfer of general contracting skills to Solar Design/Installations *Product/Technology Development:* Investing in unconventional potential energy storage solutions *Marketing:* Nontraditional Corporate Branding & Marketing Communications, including Public Relations.(Non-traditional for solar companies)	*Marketing & Service:* Deep, active embedding in community (Corporate Branding, Sponsorships) Asset purchase of competitor on brink of business dissolution	*Marketing:* Sponsorships to signal community commitment as well as to demonstrate solar products (Band)

(continued)

Table 6.1 (continued)

Company	EO: Risk-Taking	EO: Proactiveness	EO: Innovation
Renova Solar	*Firm Infrastructure*: Private funds from sole investor	*Firm Infrastructure*: Sought/acquired private funds when bank funding unavailable *Human Resources:* Renova Energy Academy	*Product/Technology Development*: Experimenting with Micrgrids @ facility
Simbol Inc.	*Tech/Product Development:*Significant Investment in Disruptive Technology for Lithium Extraction	*Inbound Logistics/ Operations*:Contract with Hudson Ranch One plant for Geothermal Brine.	*Tech/Product Development:* • Unique 1-step process—Lithium Extraction from Geothermal Brine • Patent for Process AND Equipment
Geothermal Resource Group & Desert GeoExchange	*Marketing/Sales:* Entry into unfamiliar market for residential geothermal heating & cooling *Product Development:* Transfer and exploit drilling consulting skills to geothermal environment. (minor risk)	*Marketing/Sales:* Early entry into Coachella Valley market for residential geothermal heating & cooling	

Italicized categories indicate Porter's (1985) *Internal Value Chain Activities*

Table 6.2 List of participant companies and respondents in the interview study

	Title	Company	Headquarters
Solar companies			
Steve Tolen	President and CEO	Indy Power Systems	Indianapolis, IN
Lenny Caprino	President	Solaris Power Cells	Palm Springs, CA
Bill Schlanger	President	EV Enterprises	Palm Springs, CA
Nate Otto	President	Hot Purple Energy	Palm Springs, CA
Vincent Battaglia	CEO and President	Renova Solar	Palm Desert, CA
Tracey Sizemore	Vice President of Business Development	Simbol Inc.[a]	Pleasanton, CA
Geothermal company			
Will Osborn	Vice President Operations	Geothermal Resource Group and *its wholly owned subsidary* Desert GeoExchange	Palm Desert, CA

[a]Note: For the purposes of our Interview Project we focused on Simbol's use of output from the Geothermal Supply-Value Chain for Lithium extraction for solar batteries but acknowledge Simbol's other offerings in the geo thermal energy Supply-Value Chain.

- Hiring managers and/or key executives with transferable EO skills and abilities. This persists even in cases where these individuals may have limited renewable energy experience.
- Similarly, incorporating managers or key executives with EO skills and abilities as consultants, contract personnel and/or on the board of advisors may also yield similarly positive results. The reasonable assumption being that these individuals are capable of effectively translating their EO to the renewable energy context. When faced with difficult human resource markets that becomes an especially viable and necessary option.

(b) Where experimentation in innovation for a particular renewable energy field is predicated on very specific in–depth technical knowledge and direct experience:

- Serious consideration should be given to the availability of an adequate supply of technically qualified executives before proceeding AND, when availability is lacking, proactive support to develop the specific renewable energy technical skills in the community where the firm operates.

In the prior Literature Review, we discussed the four stages of a generalized Supply-Value Chain. As we focus on insights of the Interview Project participant companies, we again present the four stage Supply-Value Chain by including additional detail on participant companies' dominant activities and customers.

As noted earlier, each of the participant renewable energy companies was part of the CVEP iHub. As such, the participating companies may not be indicative of all renewable energy companies, particularly incumbents. However, as our focus is on entrepreneurial orientation, the participating iHub companies were indeed most relevant organizations as subjects for our Interview Project. Similarly, given the intensive resources required for in-depth personal interviews, we were not able to conduct interviews with all renewable energy iHub companies, but in the book we have selectively supplemented our discussion with information from non-participating companies, such as Sactec Solar, which produces a mobile trailer that can track the sun and containerized solar systems for the U.S. military and emergency agencies. Sactec innovators are seen in Fig. 6.5, which shows portable solar panels and the mobile trailer in the background (CVEP 2015a).

6.5 Entrepreneurial Orientation and Innovation in iHub Participants

6.5.1 Risk-Taking

We found risk taking present in each of our participant companies. As a reminder, while we did not select these companies based on any prior knowledge of their EO behavior, it should be noted that all of these companies were and are currently

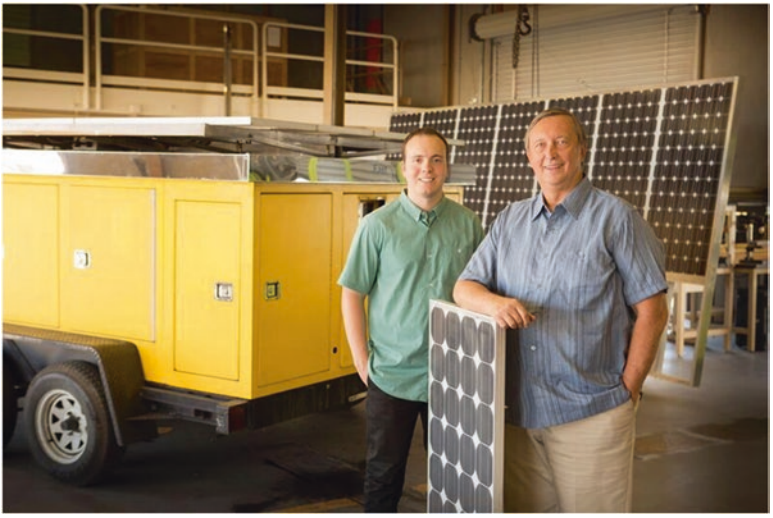

Fig. 6.5 Innovators at Sactec Solar, in front of solar mobile trailer and portable solar panels (Source: Ethan Kaminsky 2015)

participants in CVEP's iHub (Innovation Hub). While we have discussed all three forms of renewable energy in this book, the participating interviewees' companies were limited to solar and geothermal renewable energy.

The Interview Project participants focused on geothermal energy in the Coachella Valley included, the Geothermal Resource Group (GRG) and its wholly owned subsidiary, Desert GeoExchange (DGE). In general, GRG clearly illustrated the risk-taking aspect of entrepreneurial orientation. While considerable potential for geothermal energy exists in the Coachella Valley, as of yet the realization of that potential is limited. One estimate of the Salton Sea geothermal field places its current total capacity at 2900 megawatts (Matek and Gawell 2014), while another estimate indicated long-term capacity at 75% more (Lovekin et al. 2004).

More specifically in our Project, GRG provides drilling services and engineering-development/operational consulting for commercial geothermal systems while Desert GeoExchange focuses on residential geothermal heating and cooling systems. The risk-taking appears greatest in the residential geothermal systems market. Generally speaking, residential heating and cooling systems have existed in the U.S. for quite some time, however significant barriers to rapid and widespread diffusion continue to exist (Liu et al. 2015). Thus DGE, located in Palm Desert, CA undertakes a considerable risk to address and potentially develop the embryonic residential market for geothermal heating and cooling in the Coachella Valley.

The two related geothermal industry participants in our study have and continue to pursue relatively risky markets in the geothermal industry, another of our participants—Simbol—makes use of the geothermal industry output to pursue a somewhat risky strategy ultimately for the solar industry. Although Simbol was headquartered in Pleasanton, California, its successor Alger Alternative Energy should take advantage of geothermal brine to explore Lithium extraction based on their particular knowledge and skill sets.

In Simbol's case, access to the unique natural Lithium resources in the Salton Sea led them to apply their technical skills—and ultimately develop a patent—for the process of extracting Lithium and other minerals from the geothermal brine. Geothermal extraction is considered one of the newest disruptive technologies for Lithium extraction and even though Simbol failed, its successor Alger Alternative Energy aspires to succeed in the disruptive technologies of Lithium extraction at a large scale (Roth 2016; Bohlsen n.d.).

As with developing any disruptive technology, one of the risks is that the technology will fail to consistently outperform existing technologies or other disruptive technologies. Other disruptive technologies include electrolysis and leaching. Since there are multiple disruptive technologies, it remains unclear which, if any, will ultimately take the lead. An additional potential risk combines what Negro et al. (2012) describe as (1) Structural problems and (2) Soft Institutional Problems. Dominant traditional incumbents may lock-in customers such that new technology is slowly accepted, if at all, and/or the norms or informal "rules of the game" are such that those entities in the Supply-Value Chain where Lithium is central may not be willing to share information necessary for the disruptive technology to be sufficiently accepted to receive the necessary start-up financial funding.

6.5.2 Proactiveness

All of the participant companies engaged extensively in "taking action" to either take advantage of potential emerging opportunities or to create various types of resources needed but lacking in Coachella Valley. The clearest example of the development of financial and human resources within the Solar Energy Sector was by Renova Solar, headquartered in Palm Desert, California shown in Fig. 6.6. Renova installs both residential and commercial rooftop solar power plants. They also have an operations and maintenance division and, of most relevance to the Proactive pillar, the "Renova Energy Academy." Initially, Renova's CEO experienced difficulty finding sufficient number of installers in the Coachella Valley, so he created the Renova Energy Academy to educate and train installers. It includes both classroom and hands-on components focused primarily on installation, but also design and maintenance of solar systems. The formal education is provided by 14 solar energy professionals, and now includes education and training on solar electric, solar thermal, energy efficiencies and electric vehicles which have evolved to be open to customers and the public.

The other company near the end of the solar energy Supply-Value Chain design/installation in our study, Hot Purple Energy (HPE) illustrated Proactiveness in their

Fig. 6.6 Renova Solar Headquarters, Palm Desert, CA

growth strategy in two ways. First, HPE actively sought out acquisition opportunities. In order to expand in the Coachella Valley, Hot Purple Energy initiated a friendly acquisition of Potere's assets, including their customers (Hot Purple Energy 2016). Secondly, Hot Purple Energy formed a formal partnership with a high-end real-estate developing company, Alta Verde Group, for its foray into the Coachella Valley (Globe Newswire 2012).

Other examples of Proactiveness included Indy Power Systems aggressive pursuit of a growth strategy by emphasizing the balancing of battery storage and renewable power in micro grids and vehicle systems, in coordination with value-added resellers of turnkey solar solutions. Moreover, the buyer-supplier relationship between Solaris and EV Enterprises buyer-supplier relationship went beyond traditional buyer-supplier contracts. EV supplies custom components for Solaris's finished products. In addition to being geographically adjacent, they also worked collaboratively to experiment with different products. Independently, both Solaris and EV Enterprises exhibited Proactiveness.

Solaris began their first year as a public company on the stock exchange. EV Enterprises began as a company whose main product was converting standard automobiles to electric. However, it became clear that the latter product had a sputtering market at best. As a result of quickly "seeing the handwriting on the wall" EV Enterprises changed marketing strategies to focus on the business-to-business side of solar, through development and sale of components.

6.5.3 Innovation

Innovation was present in all participant companies. In the majority of the cases innovation involved experimentation and major improvements to the core product offering. In one case—Hot Purple Energy—the primary innovation was focused on their strategic corporate marketing activities, including public relations. While it is common in consumer packed goods companies to spend considerable efforts on marketing communications, including corporate and brand image, and event sponsorship, it is fairly uncommon in the renewable energy sector.

Moreover, Hot Purple Energy's positioning is unique, most notably starting with the name of the company. The entrepreneur's daughter came up with that term, and it remained. Beyond simply Hot Purple Energy's (HPE) name, innovation manifests in the relatively extensive strategic marketing choices in Coachella Valley. The type, consistency and overall level of Hot Purple's resources invested in corporate branded/sponsored activities in Coachella Valley community represent a marketing strategy atypical of other solar energy firms, and thus is a considerably new way of marketing to retail and commercial customers in this sector, as well as creating a good-citizen image in the community.

Of particular note are the variations in how innovation manifested across firms within the Solar sector. For example, Solaris Power Cells' innovation was illustrated in the context of their financing. Solaris Power Cells is a relatively small company. Unlike some small companies in the solar energy sector, they did not seek private venture capitalists for funding. Instead they became a public company to provide the bulk of their start-up financing. We might add that being a public company, potentially responsible to a variety of shareholders, can certainly complicate management for small companies but especially start-ups. As such, being publicly financed suggests not only an innovative aspect to Solaris Systems, but also the increased risk. A small company with a potentially more complex—and perhaps fickle—set of investors may have a more diverse set of investors for whom they are accountable.

We interviewed four of the five solar company participants at the companies' location in the Coachella Valley. While we captured considerable data from the interviews which were recorded, transcribed and analyzed, tours of the facilities provided additional observational data relevant to EO components. In particular, we observed the experimentation aspect of innovativeness in the facilities of EV Enterprises, Solaris and Renova. Indy Power and Solaris have utilized their physical resources, with assistance from CVEP, to bolster their development, prototyping and test marketing. They benefit from proximity to geographic locations where their solar end products are salient, such as significant golf courses with numerous golf carts, as well as Coachella Valley infrastructure for charging, and infrastructure for low-speed electric vehicles on the CV Link pathway connecting cities.

6.6 Other Stakeholders: Local Government

Whether the business environment for the renewable energy sector is conducive to entrepreneurial activity overall largely depends on the actions or inactions of other stakeholders. We had a general idea of this prior to conducting the Interview Project. Through the project we confirmed the critical importance of governments and nonprofits. All but one participant had or would seek support or incentives for their renewable energy efforts in cases where they were available. However, none of the participants indicated that a lack of government incentives would be problematic. That reinforces the Proactive and Risk-Taking willingness of this set of entrepreneurs.

Equally as interesting was that four, just over half, of the company participants noted it was relatively important that government simply stay out of the way of renewable energy commerce. More specifically, two participants noted specific examples of barriers and challenges that government policy had created to hinder or mute efforts by renewable energy companies. As a result, we confirmed the critical role of Federal, State and Local government policy and decisions on renewable energy in the Coachella Valley.

In the Interview Project, we interviewed knowledgeable Government Officials from two of the nine cities in Coachella Valley: City Manager for City of Coachella and the Economic Development Administrator for City of Palm Springs. The significant differences between the socio-demographics of the population for each provided a useful contrast as to varying efforts applied to facilitation of renewable energy. The City Manager noted the City of Coachella was primarily a working class community with year round residents, and that it is a relatively young community, with a significant proportion of young households, 3–4 person households with children in the household. As such, the city of Coachella experiences a relatively high demand on public goods and services, and thus—to appropriately serve its constituents—emphasizes schools and recreation.

When asked about the City's role in encouraging renewable energy, the civic priorities previously noted, were reinforced. Encouraging renewable energy companies to locate in Coachella was not a critical priority, nor a guiding principle in their strategic vision/plans. That being said, the City of Coachella does use solar and tries to source 30% of their energy needs from alternative energy sources. In summary, renewable energy was not hindered in any noticeable way, however it was also not proactively supported with any specific initiatives.

In contrast, the more affluent and educated population of Palm Springs, appeared to have provided the City of Palm Springs some opportunity to develop interest and support for renewable energy. The City Administrator was not aware of any specific monetary incentives to support renewable energy, however Palm Springs provided and facilitated other types of support. Their active, purposeful facilitation of renewable energy ranged from strategic to tactical support. For example, the City of Palm Springs willingly has provided peripheral support to renewable energy companies through CVEP initiatives. As pointed out in Chap. 2, the City has implemented solar energy in a number of its facilities and buildings. In addition, it is designated as a Foreign Trade Zone, which provides opportunities for renewable energy company's sourcing materials on a global basis. Although Palm Springs may not actively apply resources to scout for renewable energy companies to locate in Palm Springs, they are especially encouraging in solving problems once a renewable energy company shows interest in locating in Palm Springs.

In addition, the Palm Springs Administrator was aware of other facilitating activities in the community which the city supports. An example of Palm Spring's awareness is CVEP's Career College Pathway Readiness program. It is a collaboration with the school districts that exposes students to various industries, including renewable energy. That, in combination with Palm Springs support of the state's "Employee Training Panel" suggest a positive view and supportive role for Palm Springs, even if they have not actively focused extensive resources on attracting renewable energy companies to their city.

Despite the contrast between the City of Coachella and the City of Palm Springs, what was clear from our discussions with both government officials for these very different cities was that that neither City appeared to actively create significant barriers for renewable energy companies. While that may appear to be irrelevant, it is not. Each of the renewable energy key informants specifically identified government policies and actions as one of the major factors that can hinder robust development of renewable energy.

6.7 Summary

Through analysis of in-depth interviews with key participants in the renewable energy Supply-Value Chains within Coachella Valley and supplementary analysis of related secondary sources, we were able to identify significant Risk-taking, Proactiveness and Innovation. While we had a relatively small sample of participants, the results certainly point in the direction of support for continued entrepreneurial activity in the renewable energy sector. In particular, minimizing policies deleterious to renewable energy start-ups may open up critical economic opportunities for regions and cities, given basic services for their communities are met.

In conjunction with minimizing destructive policy, it is also useful to simultaneously visibly support and encourage innovative renewable energy companies. From the perspective of the entrepreneurs themselves, our results are suggestive of increased focus on partnerships with other renewable energy companies in the Supply-Value Chain to maximize opportunities for experimentation with innovation. Such innovation is likely to allow entrepreneurs to be competitive with incumbent firms both in renewable energy and competing traditional energy markets. Further discussion of the implications of the larger environment for renewable energy is provided in detail in the final chapter.

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Chapter 7
Prospects and Problems for Growth of Renewable Manufacturing, Assembly, and Operations in Coachella Valley

Abstract The problems and opportunities for renewable development in Coachella Valley are discussed. Findings are compared to the model of Integrated Policy assessment of Local and Regional Renewable Development (IPALRED). Following a section that reviews prior studies of the future of renewable energy, an evaluation indicates the IPALRED model is largely applicable to the Coachella Valley, albeit based only on the single case of Coachella Valley. The prospects and opportunities are summarized which include, for example, the stimulus of California's ambitious Renewables Portfolio Standard, Coachella Valley education initiatives in renewables, Valley nonprofit organizations' support for renewables initiatives, and federal tax credits. On the other hand, problems and barriers are examined, for instance barriers in California of extending transmission lines, inconsistent city regulations, limited entrepreneurial financing for renewable energy manufacturing, and resistance by major utilities. For the future success of Valley renewables development, leadership in local government and businesses may be the key.

7.1 Introduction

Based on the book's findings, this concluding chapter considers the problems and opportunities of renewable development in Coachella Valley. The book emphasized advantages and disadvantages of solar energy, wind energy, and ground source geoheat for consumers and businesses in the Valley. After a literature review section on several policy-oriented studies of renewable energy, the book's findings are compared to the Integrated Policy Assessment of Local and Regional Renewable Development (IPALRED) model from Chap. 3. In the next sections, the chapter looks toward the future by offering a perspective based the book's findings regarding the prospects and opportunities, as well as problems and barriers, in developing the renewables economic sector in the Coachella Valley. The final section emphasizes the importance of leadership for planners and policymakers as they consider, evaluate and plan for a growing renewable energy sector.

J.B. Pick, *Renewable Energy: Problems and Prospects in Coachella Valley, California*, SpringerBriefs in Geography, DOI 10.1007/978-3-319-51526-7_7

7.2 Studies of the Future of Renewable Energy: Implications

Several prior studies offer perspectives on U.S. renewables policymaking, which provided a backdrop for this chapter. In an analysis of a dozen leading wind power states, key factors for achieving wind power development were found to be Renewable Portfolio Standard (RPS) targets, federal and state financial incentives, swings in natural gas pricing, and the market factors of green power (Bird et al. 2005). RPS standards have been long mandated by the states and provide clear goals for states. They have been hugely influential in California, since their initial signing into law in 2002 (Bird et al. 2005). Federal financial incentives have included the Production Tax Credit, financially encouraging renewables companies, and the Investment Tax Credit, encouraging solar domestic consumers, while some states including California offer a voluntary cap and trade program for renewables firms (Bird et al. 2005). The State of California has provided credit programs for solar consumers such as the California Solar Initiative (CSI) to make credit for solar installations easier to afford, as well as the New Homes Solar Partnership (NHSP) incentive for domestic solar installers (CEC 2015). State employment training programs provide funding for renewables training, and public universities have allocated funding to support state renewables research and training centers.

The swings in the pricing of natural gas and other competing energy types impact the competitiveness of renewable energy (Bird et al. 2005). An historical example of this was evident in the decline of development and adoption of renewable energy during the Reagan Administration in 1981, a time concurrent with the reduction in fossil fuel pricing causing renewable energy to become much less competitive.

Another U.S. issue is the weakness of consistent federal policy on renewable energy (Moe 2015). This is due to major mandated targets such as RPSs and regulatory policies. For example, public utility commissions are institutionalized at the state level, but with weak institutionalization at the federal level. The U.S. has been the world leader in R&D on renewables with federal support; however, little federal attention has been given to the demand side of renewables (Moe 2015). A positive factor, which does not represent a widely known federal initiative, is that the U.S. military has been a strong and significant adopter of renewable energy, due to its competitive cost in the military supply chain and the military advantage of being freed from dependency on transmission grids.

Social, economic, and political factors that influence the U.S. residential solar photovoltaic, for small areas such as ZIP codes, have been studied through regression analysis and mapping (Kwan 2012). Nationally, results indicate that the most important attribute associated with residential solar adoption, for ZIP codes, is the amount of solar radiation arriving on the earth's surface, electricity cost, and available financial incentives. Since the entire nation was studied, ZIP codes that underperformed expectations were identified which included the U.S. Southwest and state of Florida. This data-intensive and GIS-driven micro analysis is impressive and augurs well for new, powerful planning tools for local governments. However, the Kwan (2012) model was limited largely to census-based independent variables and lacked economic, regulatory, and political independent factors, lowering its practical utility. Altogether these four studies provide a backdrop for the chapter, with regard to renewable energy.

7.3 Extent of Support for Integrated Policy Assessment Theory for Renewable Development

The Integrated Policy Assessment for Local/Regional Renewable Energy Development (IPALED) model from Chap. 3 has been found in the book's study to be largely applicable to the development of renewable energy in Coachella Valley. This section briefly reviews the major parts of the model to compare the results on the single case of the Coachella Valley to the conceptual model (see the model in Fig. 3.1). Since only one renewables setting has been investigated, this instance does not give validation of the model, but rather should be viewed as an exploratory case example. The model must be tested quantitatively with data on dozens of renewable energy regions around the country, to be properly validated.

The model's factor of "federal and state conditions," which include federal and state laws, environmental standards, political structures, and markets, was studied for the State of California, and U.S. in Chaps. 1, 3, 4, and 5. This included the state governor's office, legislature, and regulatory agencies, and the U.S. Congress, executive branch, and agencies such as U.S. Bureau of the Census, Department of Energy, and others. Laws came into play mostly at the state level, including the RPGs and environmental laws. The cost of renewable energy was discussed briefly in Chap. 2. Since costs of the renewable energies and competing fossil energies have varied unpredictably with market conditions, it is beyond the scope of this book to do a detailed cost study.

The model's factor of "renewable site-specific conditions," consisting of physical, geographical, socioeconomic, supply chain, and citizen attitudes that characterize the local area, applies to Coachella Valley and somewhat to the surrounding areas for utility-scale production of renewable energy. The physical environment, geographical environment, demographic, social and economic attributes were analyzed in Chaps. 1, 3, and 4, and studied comparatively in Chap. 5. The analysis indicates that sites in the Valley and surroundings contain a wealth of solar, wind, and geothermal resources that potentially can yield substantial electricity that could be transmitted widely on the power grid in California and neighboring states. Some energy could be used directly for residences, buildings, and corporate manufacturing facilities. The demographic, social, and economic characteristics of Coachella Valley, examined numerically well as spatially, offer a plethora of useful perspectives and insights for policy setting. The physical environment of solar, wind, and geological processes was explained in general terms by energy type in Chap. 2. Site-specific physical environmental information is collected partly on a proprietary basis, including local wind velocities, and detailed sub-surface geology. In addition, data on the supply and demand for renewable energy in Coachella Valley are not available.

The model's outcome factor of "policies for regional political systems" includes local and regional decision-making processes and the policies of local and regional governments, nonprofit organizations, and businesses. It is examined in the present chapter and recommendations are made for strengthening the policies. Even though this book could not analyze every part of the Integrated Policy Assessment for Local/Regional Renewable Energy Development (IPALED) model, the information gathered provided a strong data-driven basis for more informed policy decision-making by governments, corporations, and nonprofit organizations. The unfulfilled segments of the model offer opportunities in this or other renewable regions to have an even stronger and broader information support for renewables decision-making.

7.4 Prospects and Opportunities

This and the subsequent sections seek to identify favorable aspects that Coachella Valley leaders should consider, as well as pitfalls to try to mitigate or avoid. While some changes can take place quickly, other changes representing solutions to realize opportunities and overcome barriers will require a longer timeframe.

A summary of these future problems and prospects, shown in Table 7.1, involve a variety of initiatives and actions that can be taken by citizens, nonprofits, and levels of government.

7.4.1 Federal Government's Evolving 30% Investment Tax Credit

The federal government's renewable energy investment tax credits were first enacted with the Energy Policy Act of 2005, which led to the Energy Improvement and Extension Act of 2008. In late 2015, the Consolidated Appropriations Act was signed. Currently, the Energy Investment Tax Credit (ITC), which stands in 2016 at 30% for solar and large wind, and 10% for ground source geo-heat, will be incrementally phased out on different time schedules. The solar energy ITC will remain at 30% until the end of 2019 and end be stepped down gradually reaching zero at the start of 2023 (DOE 2016a, b).

The large wind energy ITC will be reduced each year from 2017 until it reaches zero at the start of 2020. Meanwhile, small wind energy ITC will remain at 30% until it is zeroed out at the start of 2017. Ground source geo-heat which in 2016 was at 30% ITC will reach zero at the start of 2017, while geothermal electric ITC will continue at 10% through the end of 2022 (DOE 2016a, b). Although the acts have

Table 7.1 Prospects/opportunities and problems/barriers to growth and development of the renewable energy operations, assembly, and manufacturing in Coachella Valley

Prospects/opportunities	Problems/barriers
Federal government evolving 30% investment tax credit	State of California regulatory environment
State of California Renewables Portfolio Standard (RPS)	Inconsistent county and city regulations, with varying barriers
City of Palm Springs Foreign Trade Zone	State of California barriers in extending transmission lines for renewable energy
Nonprofits supporting renewable energy	Limited entrepreneurial financing for renewable manufacturing in Coachella Valley
Local city and county government interest in renewable energy	Limited financing for home owners and small enterprises to fund long-payback-cycle renewables
Semi-skilled labor force availability within the Coachella Valley	Resistance by major utilities, including restrictions on home owners for net metering of solar energy and contract approvals for supply of Salton Sea geothermal electricity
Renewable energy supply chain and focused, niche manufacturing and assembly	Limited resident engineering/scientific workforce for R&D and design
Supply chain: a successful Coachella-based manufacturer gains from worldwide transport and distribution of supply parts	Supply chain: Major competition for Coachella-based renewables manufacturing from ease of worldwide transport and distribution of finished renewables manufacturing equipment
Coachella Valley Educational and Training initiatives in renewable energy	

had many provisions, their impact on the wind, solar, and geothermal industries are the focus of this study.

The Federal Acts have indeed served as a business stimulus to companies of varying sizes, types of ownership, and roles in the renewables supply-value chain. Some of the solar CEOs interviewed in our study cited this federal tax credit as essential. One solar CEO stated, [Government policies that support the firm's goals include] "the solar tax initiative the federal government has until 2019. I'd like to see those expand." (Subsequently, the initiative was extended to 2023).

The cut-off date of 2023 provides a multi-year window for Coachella Valley government and nonprofit leaders to emphasize the important ITC incentive and stimulate interest and investment among existing or new stakeholders in the renewables sector. In particular, the results of the Entrepreneurial Pillars (Chap. 6) strongly suggest such an emphasis would gain traction. Such an emphasis by leaders would clearly provide additional opportunities for entrepreneurial firms to engage in Proactive and Innovative actions to the economic benefit of the Coachella Valley.

7.4.2 State of California Renewables Portfolio Standard (RPS)

Another opportunity for development of the renewable energy sector in Coachella Valley is the stimulus of the State of California's Renewables Portfolio Standard (RPS) program. The state's RPS, originally enacted in 2002, was modified by Governor Brown and the state legislature to set more ambitious targets. Since 2002, the state's renewable energy capacity has doubled, with cost of the generation of the energy remaining stable (Union of Concerned Scientists 2014). Over 200 new renewable generation projects have been completed in California since 2002, with the RPS standards as a driving factor (Union of Concerned Scientists 2014).

California's current goal for 2020 is for 33% of electrical generation to come from renewables, including wind, solar, geothermal, small hydro, biogas, and biomass. Enacted in 2011, this goal now includes not only commercial utilities but also municipal ones. All providers of electrical energy are required to submit annual compliance reports, and the state is on track to achieve the 2020 goal. Longer term RPS goals in California are 40% by 2024, 45% by 2027, and 50% by 2030 (National Conference of State Legislatures 2016).

The strong RPS-motivated trend, year after year, towards larger renewables capacity is positive for all aspects of the Valley's renewables sector. For instance in 2015 California added 560 MW of new solar photovoltaic capacity and in 2016, will add an estimated 1076 MW of capacity, for a total photovoltaic capacity of 6197 MW by the end of 2016 (CEC 2015). As more gigawatts of renewables are added over the next 6 years, market demand will concomitantly expand in the business sector for solar operators, assemblers, and manufacturers.

In summary, the Valley can participate in this huge statewide growth by continuing to encourage research and innovation to channel some of that demand surge into its own businesses. Through leadership in the Valley's enterprises and organizations, ambitious state RPS targets can be leveraged to the advantage of the Valley's renewable sector.

7.4.3 City of Palm Springs Foreign Trade Zone

The existence of a US Foreign Trade Zone (FTZ) in the Coachella Valley is likely to be relevant for renewable energy companies. For attracting start-up companies to the Coachella Valley, opportunities stemming from the FTZ to reduce costs would increase the region's desirability. While several of the renewable energy companies interviewed preferred domestic manufacturers for parts and components, nearly all the companies indicated some need to source components globally. For instance, electronic components and circuit boards were cited by interviewees as globally sourced.

The FTZ would also provide improved cash flow for a start-up by allowing a deferral of duty payments in addition to federal excise taxes. With respect to reducing costs, use of the FTZ provides potential opportunity for a reduction of duty payments as well as reductions in the processing fees associated with imported foreign goods. Reduction of duty payments may result when the imported good is used in the domestic production of a finished product with a lower duty than importing the finished good. There are also indirect cost benefits to the FTZ by allowing immediate or expedited physical delivery of goods to the local manufacturing facility. Companies utilizing the foreign trade zone can reduce the time for order fulfillment, thus reducing inventory costs as goods are immediately available to a company.

While many of the participants in the current study indicated a general preference for domestic manufacturers of components and parts, that is not always possible. For example, there are no lithium ion battery manufacturers in the U.S. As a result, companies that assemble microgrid battery storage for solar energy could benefit significantly from the FTZ.

For the solar-energy benchmark state of Maryland Baltimore MSA, there is a successful FTZ zone in the Baltimore MSA with 18 operating locations serving 153 businesses that represents as a model in offering lower costing and speeded-up delivery (Maryland Department of Business and Economic Development 2014). Altogether, the existence of an FTZ constitutes a feature that can attract renewable energy companies to the Valley.

7.4.4 Nonprofits Supporting Renewable Energy

Several Coachella Valley nonprofit organizations provide support for renewables businesses in Coachella Valley. They include a small-business development center, a regional economic partnership, and a business incubator centered on technology and innovation.

The Coachella Valley Economic Partnership (CVEP), along with its iHub incubator that focuses on emerging businesses in growth industries, actively serve the Coachella Valley. CVEP provides a broad array of support to the cities, educational institutions and businesses in the Valley, including workforce training, technical advice, and networking with the business community. The iHub provides significant and varied types of support for entrepreneurial early stage companies, including office and industrial space for operations, management training, technical assistance, and advising on capital and financing. The iHub currently provides assistance to seven companies involved in the renewable energy related sectors (CVEP 2016). When queried about factors that make the Coachella Valley desirable for their companies, several of the book's interviewees pointed to the support from the iHub as a significant and favorable factor for businesses as well as the role of CVEP in providing valuable networking connections with other firms in the Coachella Valley. In total, the nonprofits' assistance and resources to businesses are positive factors in informing, assisting, and supporting renewable energy companies.

Nonprofits were critical to the Texas success story on wind energy and helpful to Baltimore's solar energy development. Examples from Chap. 5 include the National Institute of Renewable Energy (NIRE) in Lubbock, a nonprofit to accelerate early-stage energy technologies including renewables. Additionally, the Texas Tech's National Wind Resource Center, fosters wind power education and research and ERCOT is a membership-based nonprofit enterprise that manages the Texas power grid. Similarly, within Maryland, the Baltimore Center for Green Careers provides renewables training and the Solar Foundation in Washington D.C., supports solar initiatives within Maryland and elsewhere. These examples represent practical, results-driven organizations that fill in gaps between government and corporations, as well as foster start-ups and coordinate between stakeholders. They provide a reminder that over the long term, effective renewable energy nonprofit organizations within Coachella Valley will require participation from the public and support from the local governments, corporations, and donors.

7.4.5 Local City and County Government Interest in Renewable Energy

The present study indicates a reasonable interest in renewable energy at the city and county levels. Riverside County exhibits considerable support for renewable energy though its activities and programs. Riverside County is part of the Salton Sea Authority and provides an array of commercial and residential incentives and programs to support renewable energy (DSIRE Solar 2014), while cities in Riverside County actively provide renewables financing through the HERO program (Western Riverside Council of Governments 2014.

The HERO program is adopted by a city to provide 100% financing on projects for renewables, energy efficiency, and water efficiency, with the financing to be made up over several decades through small, tax-deductible payments. Cities obtain HERO funding through state and federal PACE (Property Assessed Clean Energy) Legislation, which provides the legal basis. HERO also provides services to the homeowner considering solar, such as locating contractors and receiving information on how energy can be saved. The HERO program started in Riverside County in December of 2011 (Western Riverside Council of Governments 2014), and it is now adopted by all the major cities in Coachella Valley and most of its unincorporated areas (PRNewswire 2016)

Riverside County has commenced the eRED Planning initiative for renewable energy. eRED, funded by the California Energy Commission, with the goal for Riverside County to gain deep understanding of its renewable resources and existing needs, in order to add an element on renewables to the County General Plan. In addition to studying the renewable resources in the Coachella Valley and the desert areas extending west to the Arizona border, the eRED project is studying the eastern county region, with respect to biogas/fuel cell facilities connected to wastewater plants, hydro facilities, and biomass facilities that capture methane from landfills (Riverside County 2016). eRED is intended to create and implement policies to meet the state's RPS goals, help to develop renewable energy, contribute a renewable energy component to the County General Plan, and coordinate the Plan with the Desert Renewable Energy Conservation Plan (DRECP) (Bureau of Land Management 2015).

The DRECP was initial drafted by a state and federal consortium of agencies in 2015 to plan the environmental conservation, renewable energy production, and energy transmission in the vast southeastern California desert area that includes parts of Riverside County as well as Imperial, Inyo, Kern, Los Angeles, San Bernardino and San Diego Counties (Riverside County 2016).

The county's commitment to achieve comprehensive renewables plan represents a long-term, data-driven approach to provide coordination and benefits to the cities and agencies in the Coachella Valley, as long as there is implementation after approval. There are parallels with the careful long-term, integrated planning by ERCOT for most of Texas, and by the CREZ organization of transmission line extensions in central and north Texas.

San Bernardino County exhibits relatively positive support for renewable energy as evidenced by its inclusion in the general county plan, in addition to the San Bernardino County Partnership for Renewable Energy and Conservation (SPARC) initiative (Land Use Services Department 2013).

At the city level as well, there is support for renewable energy. Overall, cities in the Coachella Valley have displayed considerable interest in renewable energy, with some cross-city initiatives as well as particular cities taking the lead in a variety of initiatives. As seen in Chap. 3, the City of Palm Springs has become a leader in the development of the San Gorgonio Pass wind farms and with the utilization of solar energy within city buildings. Even though at times there were setbacks and even public protests. The City of Coachella, much lesser in economic prosperity, has included renewable energy in its General Plan and has incorporated limited solar capability in its buildings and facilities.

The CV Link is a proposed multi-purpose pathway connecting cities in the Coachella Valley, which would be accessible to low-speed neighborhood electric vehicles (CVAG 2013). The proposal is based on an independent study on electric vehicle readiness for The Coachella Valley Association of Governments (ICF International 2014), sponsored by the California Energy Commission and the Coachella Valley cities, illustrates the commitment of Palm Desert and Palm Springs to renewable energy. Both cities have already invested in and developed public electric vehicle charging stations to support electric vehicles. Most of the other Valley cities have supported the pathway proposal. However, CV Link eventually was blocked by the City of Rancho Mirage, a topic that will be returned to under "barriers."

City representatives interviewed for this book indicated their respective cities of Palm Springs or Coachella did not have explicit programs exclusive to local renewable energy companies. However, there was recognition of the (1) importance of renewable energy companies locating in the cities, (2) availability of support for renewable energy goods and services through the conversion of some portion of city power to solar energy and (3) application and promotion of general incentives and one-time fee waivers for development to residential and commercial developers utilizing renewable technologies, with an emphasis on commercial and/or commercial solar energy. As mentioned in Chap. 5, during 2015 the City of Palm Springs fell under heavy criticism for not considering local firms to install photovoltaic solar within their city buildings. However, following the bankruptcy of the City's first-choice external firm, they did consider the local photovoltaic firm, Renova Energy. Although the outcome is not yet certain, the shift towards local businesses is an example of how local municipalities can directly support the local renewables industry.

7.4.6 Semi-Skilled Labor Force Availability within the Coachella Valley

The Valley's labor force, estimated at 327,000 in 2013, is varied. About a fifth of the 25+ year old population is college educated, and about 75% have high school education; however those percentages vary considerable across the 9 cities, census designated places, and unincorporated areas (see Tables 4.1 and 4.5). The five affluent cities with 34–54% college educated residents, also tend to have more retired population.

Interviewees from the book's sample of seven renewable companies were generally quite satisfied with the supply of lower-skilled and semi-skilled employees within Coachella Valley. Nevertheless, most of them emphasized the need to train the employees in skills particular to renewables. For example, Simbol Inc. pointed to its exemplary semi-skilled workforce, achieved through intensive in-house training.

Both Renova and Hot Purple Energy stressed the need to train and develop semi-skilled workers. Semi-skilled solar installers from Renova Solar are seen installing panels on a rooftop in Palm Springs shown in Fig. 7.1. Renova has connected with a national training organization, and offers training on solar energy to its internal staff and to the public. At Solaris Energy, a lot of attention was focused on developing the skills and imparting knowledge to its workers who have high school and college education.

The Valley's ample supply of semi-skilled labor force is a positive factor for supporting expansion of the renewables energy sector. At the same time, local renewable firms are hiring very carefully and improving recruits' skill levels through conscientious in-house training. Some interviewees pointed to paucity of local government job training for renewables-related skills. Accordingly, there is an opportunity for county government and nonprofit leadership to encourage high schools, community colleges, and state training programs to offer more job training that relates to the palette of skills needed for renewable energy.

Fig. 7.1 Semi-skilled solar installers on a roof installing solar panels, Palm Springs, CA

7.4.7 Renewable Energy Supply Chain and Focused Manufacturing or Assembly

As seen in Chap. 6, the supply chains for renewable energy are complex. Unsurprisingly, the existing Coachella Valley renewable energy companies strongly indicate potential opportunities for development of clusters of manufacturing and component assembly, enabling supply chains to be more locally agglomerated. One interviewee indicated a strong preference for utilizing local manufacturers to help achieve its aggressive growth goals. Similarly, another interviewee stated a strong interest in backward integration by expanding the business to include manufacturing or assembly of energy storage products.

The presence of EnergySource's Hudson Ranch 1 geothermal power plant generated an opportunity for lithium extraction by Simbol. Furthermore, Simbol's lithium products created a focused opportunity for Tesla to produce lithium ion batteries for its electric vehicles in the Coachella Valley. Unfortunately, this did not come to fruition largely because Tesla and Simbol could not reach a satisfactory merger or takeover arrangement (Wallace 2016).

The Valley's nearby lithium production would have been favorable for production of a variety of lithium ion batteries used for solar energy storage or production, which is expected to grow globally at 100% per year, reaching $19B in 2017 (Beetz 2013). Agglomerating the manufacturing and distribution of parts and components for renewable energy storage solutions could have presented a wealth of opportunities. The synergies and payoffs of having an agglomerated renewables manufacturing complex were seen in Chap. 5 in the benefits of the cooperation and competition engendered by the concentration of wind-energy manufacturing firms in the Houston MSA.

Opportunities for renewable energy manufacturing and assembly in Coachella Valley exist when local entrepreneurs take advantage of niche opportunities. For instance, solar storage solutions for electric vehicles, such as those offered by Indy Power and as part of Solaris' solar power offerings, require various components that could be assembled in the Coachella Valley. EV Enterprises, also located in Coachella Valley, assembles electronic components for Solaris' solar power products. Solar-related lithium ion batteries for storage present focused opportunities for manufacturing in Coachella Valley. As the demand is expected to expand for solar energy storage solutions, Coachella Valley can build on its niche start-up firms to take advantage of manufacturing and assembly of components and finished goods for solar energy storage.

7.4.8 Coachella Valley Educational Initiatives in Renewables

A considerable range of educational initiatives, programs and activities in the Coachella Valley involve renewable energy. University of California Riverside's Palm Desert Center regularly provides learning opportunities through free public lectures by renewable energy experts, sponsored through the Boyd Deep Canyon Lecture Series as well as lectures in the Green Lecture Series, such as 2014's lecture addressing solar, wind, and geothermal energy opportunities in the Coachella Valley (Living Green Lecture Series 2014).

Varied educational initiatives have included work by, and partnerships with CVEP, Coachella Valley Cities, College of the Desert and School Districts, including the Advanced Technology Industry Council (ATIC). In part, the ATIC supports programs and partnerships that connect workforce needs of renewable energy businesses with schools and college courses and programs. The College of the Desert has a well-articulated and developed program focused on solar and wind renewable energy through an active training program at their Desert Energy Enterprise Center (DEEC) (College of the Desert 2016). Solar energy training courses through DEEC prepare students to become North American Board of Certified Energy Practitioners (College of the Desert 2016). California State University San Bernardino's College of Extended Learning offers online training courses to develop solar and wind energy professionals (CSUBS 2014).

Both the existing programs and the willingness of schools and colleges to develop programs relevant to renewable energy are favorable for existing renewable energy companies and those considering locating in the Coachella Valley. Palm Springs is exploring assisting renewable energy manufacturing companies with potential funding for workforce training through California's Employee Training Panel (ETP)

(Van Horn 2014). Although renewable energy is not necessarily a priority industry for the ETP, manufacturing is a priority industry.

The benchmark cases support the need for education and training. In Texas's well-developed wind energy ecosystem, university education and training played a critical role, both to increase the supply of middle-skilled workers and highly skilled professionals, and also to train students at the cutting edge of knowledge in a fast-moving field. In the Maryland benchmark case, a number of universities and community colleges provided essential training, although more for solar operations and service jobs, rather than highly-skilled solar professionals. The benchmarks suggest that the Coachella Valley leaders and planners should be proactive to support, collaborate with, and fund educational and training programs in renewables to support the hiring needs of companies.

7.5 Problems and Barriers

7.5.1 State of California Regulatory Environment

California's renewable regulatory environment is mixed, with problems and opportunities. For solar energy the California Solar Initiative (CSI), under the state's Public Utility Commission (PUC) ruling, has provided rebates and performance-based incentives to homes, as well as to smaller-scale buildings on nonprofit and commercial properties, located within utility provider territories, which include most of the state.

Consumers receive these incentives through specific rules set up for regional areas of a particular utility. Although the CSI program has encouraged expansion of solar energy, it is winding down for several reasons. One is that the cost per kilowatt of installed small photovoltaic systems has been substantially declining. For residential photovoltaic, the median installed costs of $11.50 per kilowatt in 2000 declined to $4.60 per kilowatt in 2014 (CEC 2015), so the CSI rebates became much less attractive.

Another reason for CSI's decline is that residential solar firms have for several years been offering an option for customers, in which the firm owns the system and the customer pays the solar firm for the energy, with an escalation amounts built in, an arrangement avoiding the customer's high up-front cost of installing solar (Borenstein 2013). For the customer, this spreads the cost over time like a mortgage and averts responsibility for maintenance and reliability issues.

As the CSI program has been phased out, the New Solar Homes Partnership (NSHP) has grown, to a cumulative level in 2015 of 141 MW spread over 44,000 systems. NSHP encourages home builders to construct energy efficient homes including solar for new buyers, saving them costs, and provided considerable benefits especially for low-income home buyers (CEC 2015).

Utility-scale solar and wind energy projects have been slow to gain regulatory approvals in California. Two reasons are: approvals for plants and associated infrastructure such as new or upgraded transmission lines must come from several local and state agencies and meet federal standards (CEC 2015). One key hurdle is the licensing of the California Energy Commission for thermal power plants of 50 or more megawatts. The licensing is typically a 1 year or longer process conducted by panels of experts as well as requiring public participation (CEC 2015).

Since 2000, the California Energy Commission (CEC) approved three large solar thermal plants and has one large photovoltaic plant, with other plant proposals in earlier stages. An example of the need for CED scrutiny is the Ivanpah solar thermal plant with 370 MW of capacity located in the California desert near Primm, Nevada. In spring of 2016, a fire erupted in one of the three central towers, caused by control errors in the mechanical focusing of thousands of mirrors on the ground, leading to intense heat focused on the wrong point on one of the three towers rather than on the thermal boiler (Zhang 2016). In addition, Ivanpah is becoming economically uncompetitive. This is because the plant has mostly steel and glass components that are not dropping in price in line with the dramatic drop in photovoltaic panels's prices. This example points to the necessity for time-consuming regulatory scrutiny of renewable large-scale plants.

Another regulatory step for a private utility in California is approval by the California Public Utilities Commission (PUC). The PUC acts on the basis of state legislation, as well as on behalf of the state for federal regulation and regulations (PUC 2016). Industrial solar power plants must go through intensive scrutiny and approval by the PUC. This process can increase the expenses and delay large solar projects, including the need to meet environmental regulations. In 2015, the California PUC established an incentive program to encourage distributed energy resources, sources partially or fully disconnected from the grid (PUC 2016). Industrial-level wind farms also experience a similar approval process.

Although present in the past, today there is no equivalent rebate or performance-based incentives for wind energy for residences. These rebates were stopped, largely because of paucity of local approvals for home-based wind energy.

In geothermal, the state regulatory approvals are quite time consuming, and a significant barrier for developing the geothermal sector. For this reason, those geothermal plants that have been brought to the PUC in recent years mostly limit their proposed size to just under 50 MW capacity, since that is the threshold above which PUC approval is required. However, two much larger EnergySource geothermal plants were put into the PUC review, but for that reason they are delayed.

On balance, state regulation is presently more a barrier than an opportunity. What could alter this problem in the future would be more budget, human resources, and professional reviewers for the PUC and CEC as well as streamlined regulations, allowing them to expedite decisions regarding regulatory approvals. This regulatory issue is in the state political arena, and is not alterable by Coachella Valley. One advantage the Valley has for renewables' plants is that, at its relatively small population size, it can be served well by plants under the 50 MW limit for PUC and CEC scrutiny.

7.5.2 The State of California's Barriers in Extending Transmission Lines for Renewable Energy

The issues and barriers of extending transmission lines were discussed in Chap. 5 with examples from the solar Sunrise Project. , which opened up controversy in the gaining approved by the Public Utilities Commission to extend transmission lines from Imperial County to San Diego County (Wang 2008). Likewise, the long-awaited RETI 2.0 multi-agency planning process has been time-consuming in seeking to reach a consensus on the project priorities for transmission line improvements to extend to renewable facilities in parts of the southern California desert (RETI 2.0 Management Team 2016; Campopiano et al. 2016; Wang 2008).

Another example of a tedious regulatory approval process is Southern California Edison (SCE)'s application for the West of Devers project, a power grid enhancement impacting Coachella Valley and western Riverside County (Cassell 2016). West of Devers seeks to upgrade or replace the transmission portions of the existing transmission line that are located along segments of the route from the cities of Riverside and San Bernardino to the east across hills and desert, including parts of the Morongo Indian Reservation and through the San Gorgonio Pass wind farms to finally reach the Devers Substation fairly close to Desert Hot Springs.

The application to the PUC met the environmental impact provisions regarding effects on nature, visual resources, cultural resources, noise, air pollution, and economic justifications that it could serve well the new solar plants being built in the broad desert expanse between Indio and the Arizona border and locate the transmission lines on existing rights-of-way (Cassell 2016).

However, in spite of gaining PUC approval of these aspects, the project was stopped cold because the Morongo Indian Tribe objected to the route. The Morongo Indian Tribe's objection illustrates one of the impediments to renewable energy expansion, that of organizations in the renewable Supply-Value Chain that are "too strong" (Negro et al. 2012). Fortunately, his objection is now cleared up by an agreement between the Morongo Tribe and SCE. The agreement, which requires federal approval, allows the Morongo Tribe to lease the land for 30 years in exchange for an option to invest $400 million in the project at time of its operation (Cassell 2016). If the agreement obtains federal and PUC approval, it will move forward. This example not only bears directly on renewables in the Coachella Valley region, but it also highlights that utility-scale renewables may be delayed considerably or even stopped in the regulatory approval process by complex factors, some that appear unexpectedly along the way.

7.5.3 Inconsistent City Regulations, with Varying Barriers

Coachella Valley consists of nine cities, each with its own planners, city manager, planning commission, and city council. Cities have varying enthusiasm and support for renewable energy and renewable manufacturing firms. For instance, the City of Coachella has many pressing issues that it considers more important than supporting renewables (Garcia 2014). The city has no incentives of its own to support renewables companies. Rather, the City Council has prioritized that its incentive packages are oriented towards hotels, medical offices buildings, and class A office space, for which there would be discounted fees or direct rebates to developers (Garcia 2014). The City of Palm Springs indicates its focus is on redevelopment of the downtown and strengthening the City's economy. Its incentives for renewable energy manufacturers consist of possible waiving of fees for new companies that have promise to create new jobs, but that incentive has rarely been used (Van Horn 2014).

An example of the difficulty in coordinated planning is the CV Link Project mentioned earlier (CVAG 2016). As mentioned earlier in the chapter, CV Link is a project coordinated by the Coachella Valley Association of Governments (CVAG) and seven of the nine cities in Coachella Valley and three tribal reservations. The CV Link Project intends to plan and implement a transportation pathway from Palm Springs to Coachella that will be suitable for golf carts, low-speed, light-weight electric vehicles, bicycles, and walkers/runners (CVAG 2016).

The goal is to build a safe, carbon-free, and scenic pathway extending 50 miles winding through nine of the Valley cities. The Master Plan and other supporting documents such as the CV Link health plan are complete and have been discussed by the mayors and planning officials of the cities and tribal areas. CV Link will mostly be constructed on the top of existing levees and on the top of slopes of storm water channels (CVAG 2016). The route map, shown in Fig. 7.2, illustrates how CV Link winds around often following the levees and channels and crossing the boundaries of the cities, which have a jigsaw-like pattern, shown in Fig. 4.3. CV Link includes renewable energy elements, such as the incorporation of solar energy panels into light-weight vehicles for the pathway. Solaris Power, an interviewee in this study, has designed a solar-powered golf cart.

The CV Link project has brought together leaders of the cities and tribal areas in a coordinated Valley-wide project that includes renewable energy features, but also highlights conflicts among the cities. In particular, the City of Rancho Mirage strenuously objected to the CV Link. The CV Link was to cross it about a third of the way south along the route from Palm Springs through Rancho Mirage to end in Indio.

Rancho Mirage did not want the CV Link running through its land area. It also opposed the ongoing cost of CV Link's operation and maintenance, including the question of who pays, and the routing choice of CV Link for the 5 miles stretching through the city, since the storm water channel in Rancho Mirage is mostly built out (Barkas 2016b). Rancho Mirage put the CV Link project to a public vote in spring of 2016, which resulted in a resounding "no" for going ahead (Barkas 2016a). Similarly, The City of Indian Wells also objects to the route planned and is so far unable to find an acceptable route through its land.

The dissension by the two cities is being addressed by the other cities, which are willing accept that no portion of the newly built pathway will extend through Rancho Mirage, but instead bike riders and drivers would be on their own to navigate through the streets and pick up CV Link at the other end (Barkas 2016b). This example warns of problems that may build up with other renewables-related projects, involving uncooperating cities, in the future. A possible solution would be for the Coachella Valley community and its leaders to agree to support to strengthening of the deci-

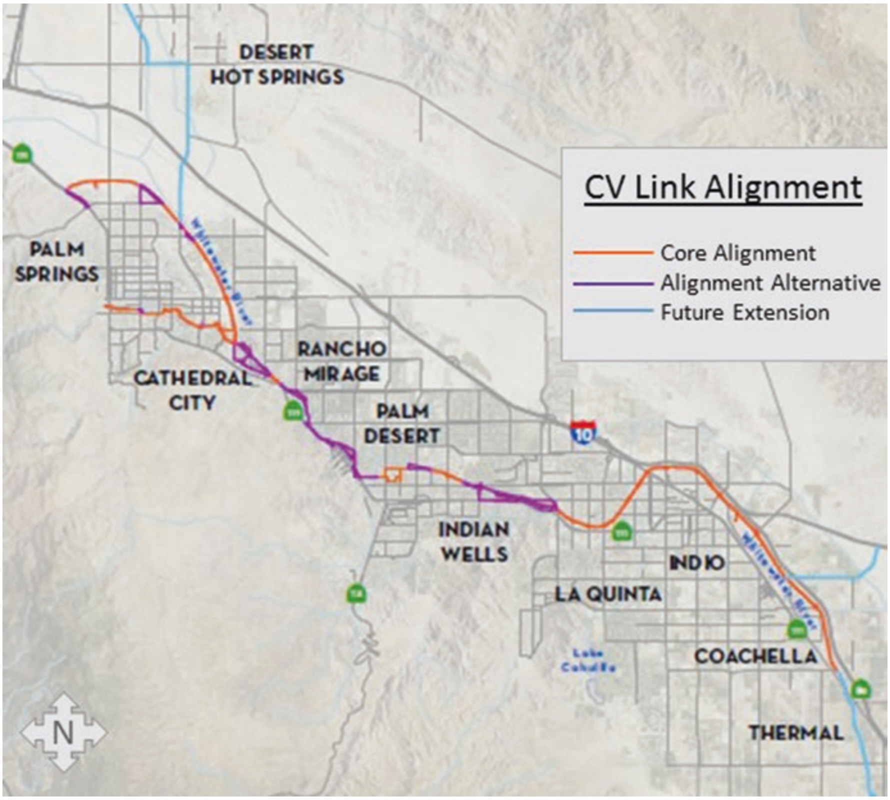

Fig. 7.2 Planned CV link low-speed transportation pathway, Coachella Valley, 2015 (Source: CVAG 2016)

sion-making power of CVAG, as has occurred with the Southern California Association of Governments (SCAG) for greater Los Angeles, and the San Diego Association of Governments (SANDAG) for greater San Diego.

For renewable energy companies evaluating whether or not to locate in the Valley, learning the complexity of different city policies could be overly time-consuming and expensive, and represents a barrier. Valley government and non-profit leaders collaborating and agreeing on a standard package of incentives for prospective renewables firms could streamline and lower costs of entry into the Valley as a business location.

7.5.4 Limited Entrepreneurial Financing for Renewable Manufacturing in Coachella Valley

Not surprisingly, several early-stage residential solar energy firms indicated, in the interviews, that financing as a constraint to their growth and expansion in the Coachella Valley. One entrepreneurial firm indicated a consistent need to self-fund as a result of denial of financing from traditional banking sources. However, another early stage renewable energy firm considered the Coachella Valley to have sufficient capital, presumably from the concentration of high-net-worth individuals in Palm Springs and surrounding cities. Given the somewhat uneven nature of entrepreneurial financing, additional formal efforts to assist entrepreneurs to access capital from sources inside and outside Coachella Valley would help existing renewable firms reach their growth goals and make the Valley more attractive for new entrepreneurs.

7.5.5 Limited Financing for Home Owners and Small Enterprises to Fund Long-Payback- Cycle Renewables

This subsection concerns solar energy, and mentions ground source heat pumps, but does not concern wind energy since it is rarely used residentially in California. Since the up-front cost of residential solar is high to the consumer, often financing is needed, and commonly is as a lease. However, for the local solar installation/maintenance firm, the lease agreement usually specifies that rebates go to the larger statewide provider of the solar equipment, such as SunPower. In that case, the small local installation firm serves in the role of contractor, with the lessor being the large equipment company. This also constitutes a barrier for the solar installation companies. It does not impact directly a solar manufacturer, although that impact is marginally positive, since the manufacturer provides equipment to the state-wide provider. The local installation firm increasingly is owner of the solar installation and charges the homeowner at negotiated rates, which over the long term may favor one or the other party depending on the energy market and the contract details.

From the homeowner's standpoint, solar financing has mixed pluses and minuses. For the uninformed owner, loans are often disadvantageous and at high rates. However, in the background is the substantial lowering of solar cost per kilowatt, in 2015 reaching $4.5 per kilowatt (CEC 2015) and continuing to trend downwards. Over the past 10 years the state's CSI program was important in providing rebates, although it is going away and being replaced for some by the state's NSHP program that provides incentives to home builders, lowering the consumer's electric bill and increasing the average quality of the work by the contractor. The HERO program, when adopted by a city, benefits the homeowner by allowing the solar payments to be spread out over many years in tax-deductible amounts.

Another financing program available in California is the federal PACE (Property Assessed Clean Energy) program, originally available only to businesses, but now to homeowners as well. The customer can borrow money for a renewable system from Fannie Mae, Freddie Mac or private banks based on his/her home equity, and receive bills every 6 months to pay back the loan. An advantage of PACE is that credit requirements are not as stringent. The load will be passed along as a lien in case the home is sold. These loans require long-term commitment and their availability varies by location.

In summary, obtaining financing for the solar consumer or small business remains a challenge and is risky. Greater education and awareness by the consumer are needed.

Similar challenges apply for consumers considering a ground source heat pump. A geo-heat firm interviewed indicated that it markets these heat pumps mainly to affluent customers, who are able to avoid outside financing entirely (Osborn 2014).

7.5.6 Resistance by Major Utilities, Including Restrictions on Home Owners for Net Metering of Solar Energy and Contract Approvals for Supply of Salton Sea Geothermal Electricity

The California Energy Commission has mandated that any business or home with a solar electrical generation system must be interconnected with the California energy grid. Consequently, the solar generation system is either contributing net electricity to the grid or drawing net electricity form the grid if the local solar system use exceeds the solar system's capacity.

The net metering rule has been required in the state for many years for the three major investor-owned utilities: Southern California Edison, San Diego Gas and Electric, and Pacific Gas and Electric. This billing arrangement for electricity provides the solar customer of an investor-owned utility with a credit at the utility company for the net electricity the customer's home system generates. In March of 2014, California's net metering rules were extended for 20 years following date of installation for existing systems, and in 2016 net metering was extended for new systems at retail rates until 2019, a decision opposed by all the major investor owned utilities that claimed net metering would end up increasing the utility's rates for non-solar customers.

The net metering issue erupted unexpectedly in winter of 2016 through a decision of the Imperial Irrigation District (IID) in the southeast part of the Valley. The IID, a publicly owned utility based in Imperial County, provides water and electricity in a district that includes the southeastern cities of Coachella Valley. California's publicly-owned utilities are only compelled to offer net metering until their amount of solar power with net metering exceeds 5% of their peak load, although some of them offer it above 5%. In February of 2016, the IID shocked its solar customers by disallowing net metering. The impacts vibrated to solar companies and customers throughout the IID's territories that include parts of the Coachella Valley, many of whom had invested in solar installations with cost-benefit calculations that were forced into the red (Roth 2016a). Some customers disconnected and abandoned their solar equipment. Others complained bitterly to the IID, which was unresponsive except to indicate it had exceeded its 5% threshold, so would exclude all new customers. A compromise finally was achieved between the IID and state legislature that sill left 15–20% of the new homeowners without net metering (Roth 2016b).

An example of customers left high and dry were some of the new solar homeowners in a new 750-unit development, Trilogy at the Polo Club, in Indio, shown in Fig. 7.3. Fifty five of those homeowners had just closed escrow on their new solar-

Fig. 7.3 Residence impacted by IID's Cessation of Net Metering, at Trilogy at the Polo Club, Indio, CA

powered home when the IID declared its decision, and were angered and some sought compensation (Roth 2016a). This is an extreme example of how the net metering can divide utilities from their customers. Future disputes could be resolved by all parties recognizing that solar is a form of decentralized energy and the regulations need to fairly recognize this trend.

Another issue arising from utilities that affects the Valley is the reluctance of utilities to sign energy provision contracts with geothermal developers in Imperial County. Utilities regard geothermal as more risky, less well proven, and, for each additional geothermal location, a diminishing resource. This reluctance has kept Salton Sea geothermal production way below its known capacity. This issue does not have major direct impact on Coachella Valley, but if it is resolved, the capacity growth of geothermal plants in the Salton Sea zone will spill over to the economy of Coachella Valley through the opportunity to provide services for the enlarged complex of plants.

7.5.7 *Limited Resident Engineering/Scientific Workforce for R&D and Design*

As examined in Chaps. 4 and 6, limited engineering/scientific/technical workforce currently exists in the Valley. Moreover it remains somewhat problematic in attracting such talent for R&D and engineering positions in renewable manufacturing firms. So far, the few such positions have been filled by special means such as attracting back Valley-born engineers and retraining them as solar engineers, or paying above market rates with supplemental training after arrival. The Valley leaders in renewables should consider being more proactive in attracting scientific talent, or growing it regionally.

Some ideas might be collaborating between Valley Community Colleges and engineering schools to lead to a degree in solar engineering, with jobs lined up ahead of time for graduates in Valley companies. Government scholarship support could be provided to offset the costs of existing employees whom obtain an engineering degree through part-time or online degree programs. Success in such programs will depend on the Valley's growth, need for advanced renewables research, and corresponding expanded demand for scientific/technical workforce.

7.5.8 Supply Chain: Major Competition for Coachella-Based Renewables Manufacturing from Ease of Worldwide Transport and Distribution of Finished Renewables Manufacturing Equipment

The well-developed transportation corridor, including freeway and rail access, in the Coachella Valley is a positive for existing and potential renewable manufacturers located in the Valley. The transportation corridor provides reasonably easy access for inbound raw materials, parts and components as well as outbound components and finished goods to renewable energy markets. However, the same can be said with respect to renewable energy suppliers outside the Coachella Valley, including extra-local supplier firms competing in the energy markets in the Valley. One of the solar firms interviewed indicated that a major supplier of a critical component was located in New York.

As indicated by the solar benchmark analysis for the Baltimore MSA, manufacturers of finished goods do not necessarily locate near their major installations. U.S. and global competitors for finished renewable energy equipment have access to major markets with similar transportation capabilities as those in the Coachella Valley. As a result, manufacturers in the Coachella Valley would have limited comparative advantage based simply on transportation access. Equipment for new installations of utility-scale solar, wind or geothermal energy in the Coachella Valley could be equally well-served by existing manufacturers in California, other U.S. states, as well as from abroad.

Nevertheless, once renewable facilities are installed and operating, selective opportunities would be present to provide replacement goods and parts, such as gears, panels, and electrical hardware. Some potential exists for renewable companies to assemble, inventory and provide repair and maintenance parts to existing utility-scale solar, wind or geothermal installations in and around the Coachella Valley. In summary, the Coachella Valley economy is too small in the foreseeable future to fulfill significant steps in the solar or wind energy supply chains. However, the opportunity is present for firms to choose small, niche parts of those supply chains, for which the Valley has comparative advantage.

7.6 Leadership

This book has detailed the present incipient status of renewables facilities and industry in Coachella Valley and surrounding areas. Endowed with great renewable resources, there is potential to grow selective manufacturing, services, and knowledge to enable the Valley to become a significant location for a high quality and productive renewables economy. A challenge will be to motivate renewable energy companies, government planners, nonprofit innovation centers, and colleges and universities to work together strategically to build up a respected competency and productivity in renewables commerce and industry. Instances have already been shown in this book of leadership that has moved the Coachella Valley to where it is today. Leadership may be the most important future ingredient in arriving at a strong, renewables-based urban complex of national distinction.

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ERRATUM

Renewable Energy: Problems and Prospects in Coachella Valley, California

James Pick

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The figures 4.9, 4.14 and 5.18 were published with a wrong version. The original chapters were corrected.

Chapter 4: Socioeconomic and Urban Profile of Coachella Valley
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Figures 4.9 and 4.14 were inadvertently published with a wrong version. The correct versions of the Figures 4.9 and 4.14 are shown below.

The updated original online version for this book can be found at
http://dx.doi.org/10.1007/978-3-319-51526-7

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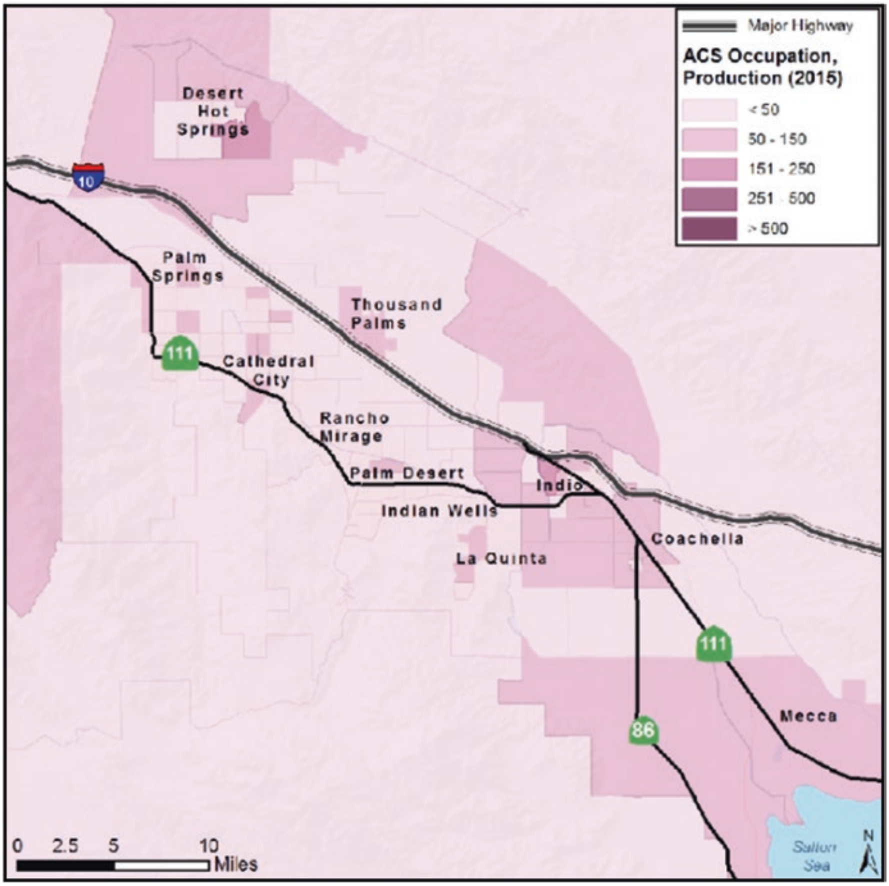

Fig. 4.9 Number of manufacturing employees, Coachella Valley, 2015 (Modified from Esri 2015)

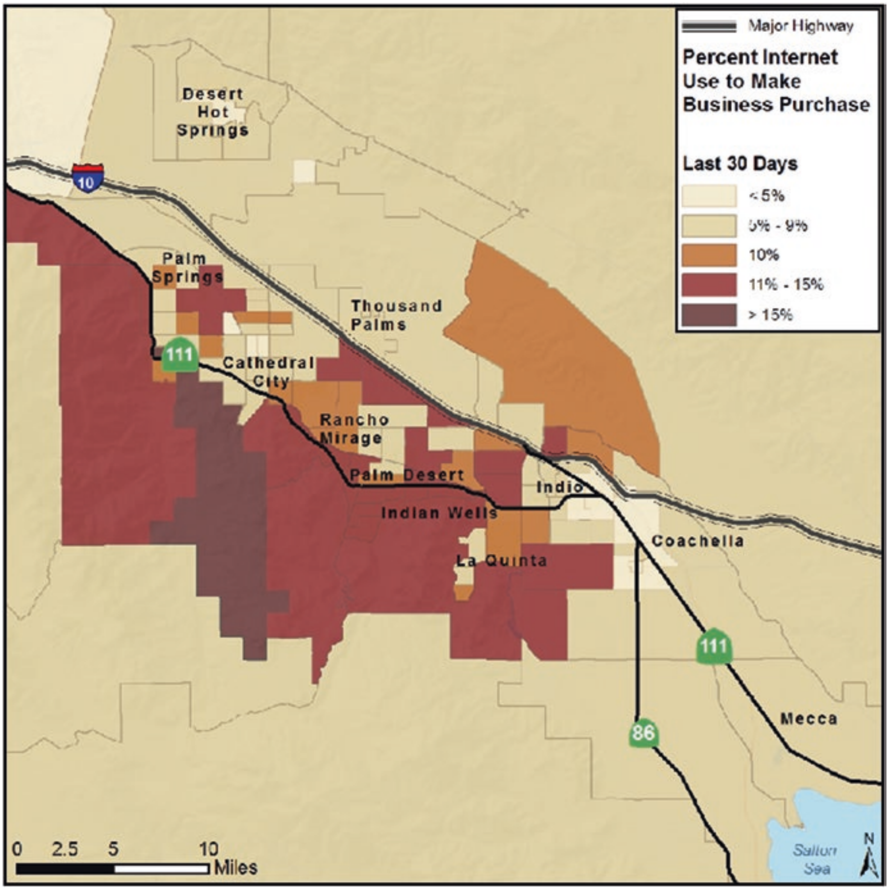

Fig. 4.14 Population with internet use to make a business purchase, percent of population in last 30 days, 2015 (Modified from Esri 2015)

Chapter 5: Benchmark Comparisons of Leading Wind and Solar Areas with the Coachella Valley: Implications
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Figure 5.18 in this chapter was inadvertently published with a wrong version. The correct version of the Figure 5.18 is shown below.

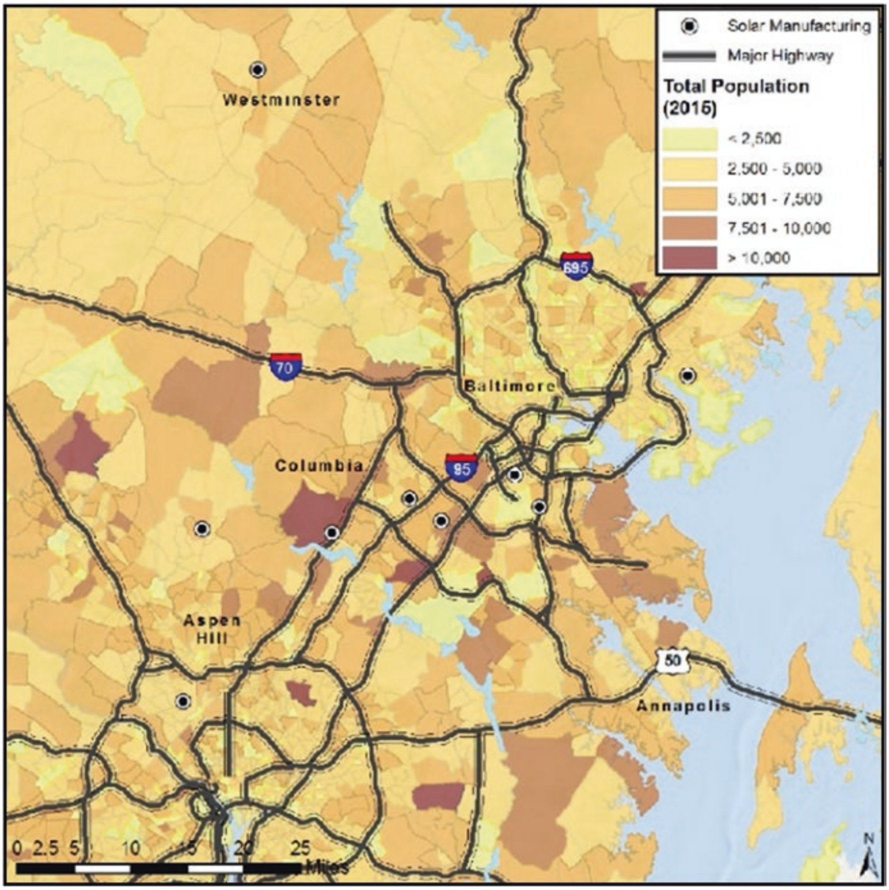

Fig. 5.18 Population in Baltimore-Columbia-Towson MSA, 2015 (Source: Esri, 2015)

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