EXPLAINING RENEWABLE ENERGY TRANSITION THROUGH HUMAN CAPITAL ANALYSIS IN THE UNITED ARAB EMIRATES

A Dissertation

by

RYAN P. DICCE

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Chair of Committee,	Christian Brannstrom
Committee Members,	Michael Ewers
	Wendy Jepson
	F. Gregory Gause, III
Head of Department,	David Cairns

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ABSTRACT

Concerns over climate change, energy security, and the provision of subsidies to utilities motivated global investments in renewable energy during the early 2000s. Recently, geographers have adopted political economy approaches to better understand the underlying motives and rationale for renewable energy transition. The advent of large-scale renewable energy investment in oil-producing rentier states has prompted theorizations concerning the role of renewable energy in political reproduction of the state through neo-rentierism. To test these predictions/claims, this dissertation examines the human capital dimensions of energy transition in a rentier state – the United Arab Emirates (UAE) – to determine if renewable power represents a reproduction of the rentier state. Countering this claim is the idea the UAE can leverage its advanced oil knowledge to capture value and stimulate local capacity in the emerging renewable power industry. The research relied on a survey instrument designed to elicit important information concerning the human capital elements of renewable energy development and collaboration with state-based actors (n= 51) and interviews of key actors (n=24) in the UAE's renewables industry to expand upon survey responses.

The findings indicate that (1) a global production network (GPN) for photovoltaic (PV) and concentrated solar power (CSP) industries in the UAE shows the centrality of the state as the primary actor in the solar energy industry; (2) market pressures, firm decision making, and individual preference-seeking create local labor markets oriented around the attraction of human capital dimensions from abroad; and (3) firm perspectives on renewable energy transition and collaboration with the state reveal the complex, place-based understandings of renewable energy transition through economic understandings, national identity construction, and technical advances. The findings contribute to geographical literatures in human capital development,

management, and mobility as well as debates concerning economic development, diversification, and renewable energies.

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NOMENCLATURE

ABET	Accreditation Board for Engineering and Technology
ADIA	Abu Dhabi Investment Authority
ADIC	Abu Dhabi Investment Council
ADWEA	Abu Dhabi Water and Electric Authority
ADWEC	Abu Dhabi Water and Electric Company
ADNOC	Abu Dhabi National Oil Company
APS	Advanced producer services
BLS	Bureau of Labor Statistics
BOS	Balance of systems
CEO	Chief Executive Officer
CFO	Chief Financial Officer
COO	Chief Operations Officer
COP	Conference of Parties
CSP	Concentrated solar power
DEWA	Dubai Electric and Water Authority
DNI	Direct normal irradiance
DSCE	Dubai Supreme Council of Energy
EDGAR	Emission Database for Global Atmospheric Research
EGBC	Emirates Green Building Council
ENOC	Emirates National Oil Company
EPC	Engineering, procurement, and construction
EPIA	European Photovoltaic Industry Association

ESIA	Emirates Solar Industry Association
EIA	U.S. Energy Information Administration
EU	European Union
EWEC	Emirates Water and Electric Company
FEWA	Federal Electric and Water Authority
FZE	Free zone establishment
GASCO	Abu Dhabi Gas Industries Limited
GCC	Gulf Cooperation Council
GDP	Gross domestic product
GHI	Global horizontal irradiance
GPN	Global production network
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent power producer
IRB	Institutional Review Board
IRENA	International Renewable Energy Association
LCOE	Levelized cost of electricity
LLC	Limited liability corporation
MBRAM	Mohammad bin Rashid Al Maktoum
MEED	Middle East Economic Digest
MENA	Middle East and North Africa
MESIA	Middle East Solar Industry Association

MSIA	Morocco Solar Industry Association
NGO	Non-governmental organization
O&M	Operations and maintenance
OPEC	Organization of Petroleum Exporting Countries
PSIA	Palestine Solar Industry Association
PV	Photovoltaic solar
ROI	Return on investment
SASIA	Saudi Arabia Solar Industry Association
SEIA	Solar Energy Industries Association
SEWA	Sharjah Electric and Water Authority
UAE	United Arab Emirates
UK	United Kingdom
USA	United States of America
WGBC	World Green Building Council

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1 INTRODUCTION

Although blessed with vast oil and gas resources, the Persian Gulf states – Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE) – have pivoted toward renewable energy investment. Through early 2019, the region has invested over $179 billion dollars in the creation of hydro, geothermal, wind, and solar power generation technologies – 84% of which is solar (MEED 2019). Solar, in particular, represents the largest form of power generation planned or under construction throughout the region, outpacing oil- and gas-fed plants for the first time (MEED 2019). The United Arab Emirates (UAE) is home to 8% of the world's proven oil reserves and responsible for 6.5% of global oil exports (BP Statistical Review 2016). Notable for its enormous wealth (Gimbel 2007), the small desert petrostate remains heavily dependent on oil, which constitutes close to 64% of its revenue (IMF 2016). The 2014-2015 oil bust and subsequent slow recovery, however, provided a prescient reminder of the perils of resource dependence as record low prices corresponded with dramatic budget deficits reaching as high as 6% (Parasie 2016; Saadi 2017). Despite significant budget cuts, the UAE government has unexpectedly invested over $1.5 billion in the installation and construction of 1,135 MW capacity of photovoltaic (PV) and concentrated solar power (CSP) and tendered an additional 1,200 MW (IRENA 2015a; MESIA 2016). With plans for $600 billion AED ($163 billion USD) in further investments over the next two decades, the UAE is staking their energy future on their endless supply of sunshine, rather than its abundant "fossilized" version (Crosby 2006). However, the rationale for large-scale renewable energy investment by a hydrocarbon super power in a centrally planned economy remains poorly understood. Importantly, the relationship between state oil-enterprises and solar energy development requires further investigation.

The size and scope of these large-scale investments has allowed the petrostate to slowly pivot from a "climate antagonist to a low-carbon protagonist" and assume a leadership role in renewable energy development (Michaelowa and Luomi 2012). However, questions remain as to why a hydrocarbon superpower is aggressively pursuing a post-carbon energy system and what impact the presence of a mature oil industry has on renewable energy development. The academic literature offers two possible explanations for the UAE's investment into solar power. Economic and technical arguments highlight the increasing efficiency of solar technologies (MESIA 2016) and the country's immense solar energy potential (Islam et al. 2009) as a powerful incentive for investment. By contrast, social and political arguments point to mounting pressure from economic and social distortions associated with oil driven development (Beblawi 1987) and demand-side shifts in energy security resulting from unconventional oil (Sultan 2013) and climate change (McGlade and Ekins 2015). Renewable energy investment has emerged as a possible means of addressing these issues while reducing the country's reliance on oil and creating a new, sustainable economic base for a post-oil future (Luomi 2016). However, little research has examined how and whether the presence of a mature oil industry impacts renewable energy development. In particular, there remains a need to examine why states pursue certain energy trajectories and the rationales underpinning these transitions, especially in non-Western contexts (Coenen et al. 2012).

This study examines the human capital required for the development, innovation, installation, and implementation of renewable power. In particular, it examines the linkages between the oil and solar industries to determine the human capital crossover from mature oil industries to emerging solar industries. The research examines the spatially stretched, global production networks (GPNs) of solar energy to determine its form and function, and the potential for knowledge spillovers from oil to renewable energy. It combines an innovative survey instrument designed to elicit human capital variables and firm business decisions of renewable energy development with interviews of key actors in the country's renewables industry to provide insight into why UAE is investing in renewable power. Conceptual and analytical tools for understanding the intersection between petroleum-fueled investments in renewable power and the human capital requirements to carry out this vision are found in economic geography (Ernst and Kim 2002; Faulconbridge 2006; Malecki 2010), energy geographies (Calvert 2015; Rignall 2015), and firm analyses of the biofuels sector (Kendron and Bagchi-Sen 2011).

1.1 Research Objectives and Hypotheses

The primary objective of this research is to assess the creation and development of a solar energy industry in a hydrocarbon-rich state through analysis of production networks and linkages between the industries. Moreover, it examines the linkages between oil and solar human capital by testing specific labor needs of the emerging solar industry. I examine whether the skills required for the oil and gas industry provide a pool of highly skilled workers from which the emerging renewable energy industry draws. To accomplish this, the research examines the GPNs of solar energy to determine if there are linkages between oil and renewable energy in the UAE to assess the potential for knowledge spillover. Focusing on the firms and organizations operating in the solar industry, we will understand their practices, rationales, and hiring preferences, as well as the skills and knowledge necessary for creating and sustaining a renewable energy sector.

I hypothesize that the UAE is utilizing its advanced oil industry as a competitive advantage for renewable energy transition. In particular, the expertise and knowledge acquired through oil-driven development are endogenous factors which facilitate the creation of a new energy sector. I hypothesize that many of the skills and knowledge necessary for oil development are transferable to the emerging renewable energy industries in the UAE. While the UAE has been largely successful at promoting post-oil knowledge economies through its ability to attract and retain firms able to mobilize global circuits of highly skilled human capital (Ewers 2017), it is not clear whether it can capitalize on the presence of these firms to stimulate local human capital capacity.

To test assess this hypothesis, the proposed research seeks to answer three questions: (1) who are the key actors in the UAE's emerging solar sector and is there an overlap with the mature oil industry?; (2) how is the knowledge necessary for solar energy development recruited and to what degree is this process knowledge similar or dissimilar to other industries?; and (3) why is an advanced hydrocarbon economy investing heavily in solar energy?

The research objectives are as follows: (1) Construct and assess the GPN for the UAE's solar industry; (2) analyze firm decision making, hiring strategies and human capital dimensions for the solar power industry; and (3) understand industry perspectives of energy transition.

1.2 Dissertation Organization

The dissertation is organized into eight sections. Section 1 introduces the dissertation research and sets out the research objectives and hypotheses. Section 2 provides a survey of the relevant literature for this research, including theorizations of energy transitions, highly skilled human capital mobility, and integrating human capital analysis with energy geographies. Section 3 outlines the methodology employed in this research study. The methodology includes a mixed-methods approach consisting of a global production network (GPN) for the emerging solar industry, as well as surveys and interviews with local industry respondents. Section 4 explores the solar GPN through an analysis of power, value, and embeddedness to highlight the key industry actors. Section 5 examines the local labor market dynamics of the emerging solar energy industry. In particular, the section explores labor market outcomes as a production of firm expectations and constraints and individual preference seeking. Section 6 assesses respondent perspectives of solar energy transition in the UAE to better understand how firms operating in the local solar economy understand the various rationales underpinning investment. Section 7 provides an in-depth discussion of section 4, 5, and 6 and offers concluding remarks on the research.

2 LITERATURE REVIEW

This dissertation addresses gaps in the literature concerning renewable energy, highly-skilled labor mobility and knowledge transfer, and energy transition. Analysis of human capital, firm recruitment and production networks for renewable power provide a unique avenue to advance these literatures. Key advances offered by the research include a broader incorporation of GPN analysis as a means of analyzing emerging industries, an analysis of firm and individual preferences and how their differing incentives condition local labor market outcomes, and a more in-depth understanding of the various economic, environmental, and national identity construction narratives underpinning solar energy transition in a hydrocarbon superpower.

2.1 Theorizing Renewable Energy Transitions

Investment in renewable power owes its origins to concerns for climate change, energy security and provision of subsidies to utilities (Pacala and Socolow 2004; Bird et al. 2005). As the evidence for anthropogenic climate change grows (IPCC 2001), the cities, states, and corporate actors have sought for means of avoiding the most deleterious impacts on the environment. Recent climate assessments highlight the need to limit carbon emissions through a reduction in coal and oil consumption (Fawcett et al. 2015). The achievement of broad global climate goals – specifically the 2 degrees Celsius mark forming the basis of the Paris agreement in December 2015 (COP 21) – requires the creation of stranded hydrocarbon assets (Ansar et al. 2013). Rather than "peak oil" concerns (Bettini and Karaliotas 2013), scientists are increasingly attentive to the estimated 50% of oil reserves and 80% of coal reserves which must be left "unburnt" to meet the goals set forth at COP 21 (McGlade and Ekins 2015).

Paradoxically, some researchers have called for the diversion of a percentage of hydrocarbon consumption to foster renewable energy development. Since energy production necessitates the consumption of energy, the "Sower's way" (Bardi et al. 2016) strategy argues that society must utilize hydrocarbon resources now to build, construct and ease the necessary transition to more sustainable forms of energy production. Despite neoliberal ideologies removing state influence from markets, the tools necessary to force a necessary sustainable transition reside with the state (Rockström et al. 2009). The state plays, or has the ability to play, an integral role in sustainable energy transition through policies differentially enacted to protect or subsidize emerging industries (Nill and Kemp 2009; Witkamp et al. 2011), enact policy change (Jacobs and Mazzucato 2016), or solidify the status of energy industry incumbents (Raven et al. 2015; Johnstone and Newell 2018). Coal, in particular, remains a popular incumbent due to its ubiquity and low cost, which ensure that it remains politically palatable as a key fraction of the state energy mix and ensures energy security (Bradshaw et al. 2015). Energy mix incumbency remains strong despite the global potential to transition to complete global reliance on wind, water, and solar power is possible by 2050 (Jacobson and Delucchi 2011), as the primary remaining barriers to transition are not technical or economic, but social and political (Delucchi and Jacobson 2011). Yet, renewable energy transition may provide a means to overcome these barriers as the geographic distribution or wind, hydro, solar, and geothermal potential ensure that, like coal, many polities are able to increase or maintain energy security through investment in sustainable energy systems (Scholten and Bosman 2016). Although the literature has begun examining large-scale renewable energy transition, it has done so in a distinctly Western context and in places with an overt motive for transition. As such, there remains a need to investigate shifting national energy mixes transitioning towards renewable energy development in non-Western contexts. To fill this gap, this dissertation develops a nuanced examination of the underlying rationale, economics, and environmental considerations for large-scale renewable energy transition in the United Arab Emirates (UAE).

Recently, scholars have proposed political economy explanations for underlying motivations for renewable energy transitions. The "ecological fix" argument is based on an understanding of endogenous crises stemming from contradictions within capitalism. McCarthy (2015) argues that this transition represents a socioecological "fix" that extends the capitalist system by addressing scarcity and climate change without addressing the underlying nature of capital. For McCarthy, capitalism seeks investments in renewable power as a socioecological "fix," allowing it to shift sites of accumulation and reproduce by offering attractive sites for accumulation while assuaging climate concerns.

Luomi (2016) presents a second argument centered around the status of the Gulf States – Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE – as rentier states. Although rentier theory has received criticism due to its limited applicability (Wright and Czelusta 2002), empirical shortcomings (Van der Ploeg and Poelhekke 2010; Brunnschweiler and Bulte 2006), and claims of causality (Ledermann and Maloney 2003; Brunnschweiler 2008), it remains a useful tool for understanding the relatively poor economic performance and internal dynamics of resource dependent states. As classic rentier states, the Gulf States derive 64-88% (IMF 2016) of their revenue through external rents from oil and gas (Beblawi 1987) and redistribute rents through large public expenditures, often in the form of public sector employment in return for political loyalty (Mahdavy 1970; Beblawi and Luciani 1987). Reliance on hydrocarbons means that demand shifts present existential threats to the state (Luomi 2009; Reiche 2010; Sultan 2013). "Neo-rentierism" understandings of renewable energy transition links energy transition with regime (state) survival (Luomi 2016). In particular, energy transition allows for the perpetuation of the state beyond oil as it potentially addresses many of the challenges facing rentier states: economic diversification (Patlizianas et al. 2006), job creation for nationals (Masdar Institute/IRENA 2015), and rising energy demands (Bhutto et al. 2014; Doukas et al. 2006).

While both "socioecological fix" and "neo-rentierism" present deeper explanations for underlying drivers of renewable energy, both theories examine energy transition as an outcome of tensions with oil and oil-driven development. In essence, these theorizations position energy transition as occurring *despite* the presence of advanced oil infrastructure with little consideration as to how this presence *facilitates* transition. The research addresses this gap by analyzing how the local mature oil and energy industry contexts impact the development of renewable energy.

2.2 Highly skilled human capital mobility

Assessing and analyzing the global economy remains complex as globalization has facilitated the rise of a spatially stretched production process that transcends state boundaries (Dicken 2015). Understanding the form and function of new production processes represents a key element of economic geographies (Suder et al. 2015; Peet and Thrift 2014). The global production network (GPN) approach provides a framework for assessing the broader network of actors involved in the production of goods and services (Coe et al. 2003). Moreover, GPNs examine the transnational spaces created by multiscalar actors and how their embeddedness conditions production processes (Ernst and Kim 2002; Yeung and Coe 2015; Coe and Yeung 2015; Levy 2008). As an analytic tool, the GPN moves beyond state-centric conceptualizations of production and examines how these processes operate through understandings of value (creation, enhancement, and capture), power (corporate, institutional, and collective), and embeddedness (territorial and network) (Henderson et al. 2002).

Current GPN analysis incorporates both state actors, as well as financiers, consumers, transnational corporations, professional organizations, and importantly, labor (Dicken 2015). Knowledge, embodied in highly skilled labor, represents a key factor of these production processes (Kenney 1997). Economic geographers have contributed extensively to our understanding of knowledge mobility as an outcome of differential actors operating at different scales to condition migration (Papademetriou et al. 2009). Specifically, the state (Dicken 2015; Millar and Salt 2007; Williams 2009; Basri and Box 2008), the firm (Tamasy et al. 2008; Beaverstock and Boardwell 2000), and the individual (Florida 2012; Storper and Scott 2009; Glaeser and Gotlieb 2009) remain key actors in mediating these processes. In the Gulf States, highly-skilled labor migration is particularly salient as state-led economic development coupled with a small and inadequately trained national population have stimulated demand for highly skilled workers capable of filling local knowledge gaps (Bontis 2004). Abu Dhabi and Dubai's emergence as urban centers connects regional labor migration with global competitions for skill (Beaverstock and Hall 2012; Ewers 2013). Labor research in the Gulf examines the various distinctions between citizens and expatriates (Longva 2005; Rees et al. 2007), skilled and unskilled labor (Malecki and Ewers 2007), and how these individuals live (Walsh 2009, 2012; Vora 2013; Mohammad and Sidaway 2012) and socialize (Sidaway 2007, Walsh 2007). These stark divisions are visible as foreign firms adapt to local labor markets and reproduce migrant divisions of labor through their differential hiring of various ethnicities to occupations (Ewers and Dicce 2016; Nagy 2006; Hermelin 2005). This research remains focused on advanced producer services with minimal attention to PV and CSP.

The research study addresses these gaps utilizing GPN analysis to assess the creation of a renewable energy sector in the context of a country with an advanced oil industry. It examines how renewable energy firms meet local skill demands in renewable energy through the attraction, and retention of highly skilled workers.

2.3 Integrating Human Capital with Energy Geographies

Recent scholarship in energy geographies calls for research at the "academic borderlands" of the field (Calvert 2015). The intersection of knowledge, globalization, and energy remains underdeveloped (Bridge and Wood 2005). The emergence of utility-scale renewable energy represents an important, yet under examined intersection of energy geographies and the human capital and knowledge requirements. In renewable energy, preliminary work has examined the knowledge requirements of the global industry and highlighted its skill gaps (IRENA 2013); however, more in-depth analysis of the industry's knowledge and human capital requirements can contribute to understandings of how local contexts access global knowledge and address local skill gaps. Querying firms represents an important endeavor due to their role in mobilizing knowledge (Beaverstock 2002, 2005; Taylor 2004), managing global knowledge networks (Millar and Salt 2008), conditioning labor flows (Peixoto 2001), and deploying knowledge for project-based work (Williams 2009; Findlay and Li 1998). Recent analysis also explores the agency of individuals in the migration process (Goldin et al. 2012), focusing on their preferences for certain amenities (Glaeser and Gotlieb 2009; Florida 2012), and thick labor markets (Brown and Scott 2012).

Human capital dynamics of renewable energy, previously on the margin of scholarly interest, have received considerable recent attention. In particular, scholars have studied renewable energy employment, known popularly as “green jobs,” in terms of estimated employment in construction and operation phases of wind farms, but skills and knowledge are not included in model estimates and validation procedures (Slattery et al. 2011). Recent studies show that renewable energy development has a significant, positive impact on employment (Kammen et al. 2004) and can offset employment losses in other extractive industries (Moreno and Lopez 2008). Some scholars, however, remain skeptical (Fischer and Preonas 2010), questioning the ability of the industry to generate new employment (Frondel et al. 2010; Michaels and Murphy 2009) in a cost-effective manner (Sorrell and Sijm 2003). Others have highlighted a growing gap between the supply and demand for skilled labor in renewable energy (Blanco and Rodrigues 2009). There remains a need to understand the skill and knowledge dynamics of the renewable power industry.

Importantly, analysis of human capital and knowledge requirements of emerging renewable energy industries contributes to understandings of deep underlying drivers for an emerging energy transition. Robust analysis of the knowledge required for renewable energy informs the role of the state in creating knowledge (Tadros 2015), attracting firms (Bebchuk and Cohen 2002; Haufler and Wooton 2009), utilizing expatriates to fill local skill gaps (Bolino and Feldman 2000; Williams et al. 2004), conditioning and regulating highly skilled labor mobility (Millar and Salt 2007; Findlay and Cranston 2015; Williams and Balaz 2008), and facilitating local knowledge transfers and learning (Bathelt et al. 2004; Ewers 2013). Evaluating these elements contributes to broader theoretical narratives concerning energy transition and economic restructuring in the UAE.

2.4 Synthesis

The academic literature has gone to great lengths to catalogue and analyze renewable energy transition, yet much of focus has centered on Western contexts, in particular, in places that transition in absence of vast quantities of hydrocarbons. Moreover, many of the renewable energy case studies limit analysis to one rationale for energy transition (economic, technical, potential, etc.), which fails to highlight the broad complexity of interrelated rationales which conspire to foster energy transitions. The dissertation's focus on renewable energy transition in the UAE addresses these gaps in two ways. First, the dissertation contributes to the small, but growing body of research which aims to address the Western-centric focus of energy transition. Second, the research examines renewable energy transition in an unexpected candidate – a hydrocarbon superpower. Although the literature has identified links between energy and national identity, the majority of this research focuses on non-renewable sources (Bouzarovski and Bassin 2011). The dissertation research extends this concept to the UAE's reorientation of national identity around renewable energy to foster local energy transition.

Over the past decade, academic interest in human capital mobility and the Gulf States has increased. Yet, much of the research has focused on the FIRE – finance, insurance, and real estate – sectors. While geographers have called for a merger of energy geographies and mobility (Bridge and Wood 2005), most of these studies have centered on hydrocarbon energy production. The dissertation research provides two additions to the literature. First, the research contributes to a growing body of work on knowledge and renewable energy through an examination of local renewable energy labor markets in the UAE. Second, a mixed methods approach consisting of a web-based survey and key informant interviews incorporates local perspectives on labor market developments, local market dynamics, barriers, and opportunities for solar transition.

3 METHODOLOGY*

This section outlines the methodology for the dissertation research. The research supporting this dissertation encompasses three differing and supportive methodologies including the construction of a GPN for the solar industry and a mixed-methods – quantitative and qualitative – component that examines human capital dimensions of solar energy in the UAE. This section elaborates on the three underlying methodologies for this study – GPN creation, survey creation and distribution, and semi-structured interviews. Despite the perceived incompatibility of quantitative and qualitative approaches (Howe 1988), researchers have started to advocate the use of both methods co-constructively to strengthen the quality and findings of research while minimizing the shortcomings of either singular approach (Johnson and Onwuegbuzie 2007; Creswell and Clark 2017). Triangulation has been a welcome addition to economic geographies and methodological practices. These practices aim to situate and validate research through a comparison with other data sets, other investigator's results, and through various methodologies (Yeung 2003). Yet, utilizing mixed-methods may not produce the same conclusions as the qualitative and quantitative results might point to different understandings (Denzin 2010). In these instances, interrogating the differences and understanding why they exist is important to understanding the phenomenon.

The selected methodology is well suited to answer the research questions and objectives. First, the construction of a solar energy GPN incorporates the wide array of production and non-production actors which interact to condition outcomes in the country's emerging solar energy

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industry. GPN analysis reveals both the key industry actors as well as any potential linkages with the oil industry. Second, a mixed-methods approach consisting of a survey instrument and interviews provides insight into the firm hiring practices and preferences. The use of a survey instrument allows for analysis of difference in responses between firm types (foreign vs. local), and the incorporation of interviews allows for additional understandings of survey responses and more in-depth analysis of the "how" and "why" underpinning firm responses. Lastly, the use of interviews and data and investigator triangulations (Yeung 2003), grant insight into how firms understand solar energy transition, how they reproduce state-based narratives, and whether these explanations and understandings square with the existing research.

3.1 Global production network creation

The creation of a solar GPN for the UAE is essential for uncovering the key actors and lead firms operating within the country's emerging industry. GPNs allow researchers to unpack the complexity of global economic processes through the incorporation of all relevant actors in the interlocking and multiscalar production process (Coe et al. 2008). The creation and examination of a solar GPN highlights interlocking production networks of actors operating at various spatial scales both within the UAE and as part of the broader global solar industry.

The creation of the GPN was conducted over two stages. In the first stage (May 2017 to December 2017), I created a database of all major utility scale projects in the UAE that were planned, financed, constructed, or operational. Preliminary research identified ten major solar projects in the UAE, which represent a planned and installed energy capacity of more than 1.6 GW. Following Dicken's (2015) GPN categories, I additionally identified the firm, state, labor, consumer, and civil organizations central to the emerging industry. Technical reports and published documents from international organizations (International Energy Association, Energy Policy Network for the 21st Century, IRENA, and the Middle East Solar Industry Association) and domestic actors (UAE Ministry of Energy, Masdar Institute, Abu Dhabi Water and Electric Authority, Dubai Electric and Water Authority, the Dubai Supreme Council of Energy, and the Emirates Solar Industry Association) were collected and assessed to catalogue actors. The preliminary findings for the solar industry resulted in the creation of an initial solar GPN (Fig. 3.1).

During the interview portion of the research (January 2018 to May 2018; see section 3.3. Qualitative Methodology), the initial solar GPN was shared with one-third of respondents (n=8). These individuals were those who participated in in-person interviews and who agreed to provide feedback on the GPN. At the culmination of these interviews, I presented the initial solar GPN to the respondent and asked him to assess its accuracy and to provide feedback that would improve the figure from their position within the GPN. While this practice is not normal, it potentially overcomes the pitfalls of the "lone researcher" approach identified in the literature (Coe et al. 2008), through an incorporation of multiple stakeholders and industry experts to assess, validate, and alter the GPN. As a prompt, I asked respondents to incorporate new actors, linkages, or structural changes based on their professional experience working in the UAE's solar energy industry. Respondents were given unlimited time to comment on the GPN, yet most took between 15 and 20 minutes to read through the GPN, ask questions, and provide feedback. One individual (D1) helped workshop the GPN on a large whiteboard in his office (a complete list of respondents can be found in Appendix A). The results of these suggestions were aggregated and used to produce a second solar GPN (Fig. 3.2). Respondent insights led to the inclusion of solar rooftop initiatives and contractors and highlighted the importance of regulatory consultants and government utility providers. The new GPN was then assessed with several interview respondents and industry members at the Middle East Electricity Forum Conference in Dubai, who provided minor insights but largely believed the GPN was accurate.

To identify the structure of the GPN, I deployed R Studio's (v.3.3.3. *Another Canoe*) network analysis tool, *igraph*, which determined network centrality based on actor interactions as outlined by respondents. This GPN analysis followed the broad analytical categories outlined by Henderson et al. (2002). In particular, the analysis examined the linkages between actors and their positions within the GPNs in terms of power (corporate, institutional, and collective), value (creation, capture, and enhancement), and embeddedness (network and territorial). This analysis is supplemented with primary data collected during the survey and interview portion of the research and through secondary data published by government organizations.

3.2 Survey development, sample design and analysis

The survey portion of the research gathered information concerning knowledge requirements, talent acquisition, and workforce composition for the UAE's solar energy industry. In particular, the survey instrument queried respondents for the skills required for solar power development and the source of these skills through an examination of firm hiring preferences and strategies. Respondents were given a 27-question survey (Appendix B) designed to gather information on respondent perspectives and constructed through existing surveys.

I adapted existing survey questions from 11 prominent surveys in the solar energy and labor mobility literatures to ensure the validity of the survey. Each survey question was borrowed or adapted from the studies in Table 3.1. Validity remains an essential element of survey-based research as it ensures that the questions are received in the manner that the researcher intended, measure the variable accurately, and minimize the time and analytical burdens on both respondents and researchers (Fink 2003; Biemer and Lyberg 2003). The process of survey construction and validation is often time-intensive and costly; therefore, the adaptation of existing constructs from previous studies likely overcomes these barriers while ensuring quality data collection (Hyman et al. 2006). The existing valid labor and skills survey questions were adapted to meet the context of the solar energy development in the UAE. This procedure mirrors survey research methodology in which I participated for a study of Islamic finance (Ewers et al. 2016; Poon et al. 2016). The adaptation of an existing survey maintains the validity of the instrument. In particular, the survey instrument was constructed using previous surveys aimed at examining firm hiring strategies (Ewers and Dicce 2016; IZA 2000; Winkelmann 2001; ECA International 2008), general skill requirements (Nguyen 1998; Gushgari et al. 1997; Zaharim et al. 2009), skills specific for PV and CSP development, installation, and management (BLS 2016; Sooriyaarachchi et al. 2015), as well as the industry perspectives on the existing labor pool and the future needs of the local industry (Pasqualetti and Haag 2011). The sources for each survey question are found in Table 3.1

Table 3.1 Survey questions and constructs

Survey Question	Survey Construct	Source
Q1, Q2, Q3, Q4, Q5, Q8, Q9, Q10	Firm background	Ewers et al. 2016; IZA 2000; Winkelmann 2001
Q11, Q12, Q13, Q14, Q16, Q18,	Human capital, solar energy skills	Nguyen 1998; Gushgari et al. 1997; Zaharim et al. 2009; BLS 2006; Sooriyaarachchi et al. 2015; Ewers et al. 2016
Q21, Q22, Q23	Current and future outlook of labor market	Pasqualetti and Haas 2011; Soorriyaarachchi et al. 2015
Q15, Q17, Q19, Q24, Q25,	Hiring preference and work experience	Ewers et al. 2016; IZA 2000; Winkelmann 2001
Q26, Q27	Firm location requirements	Ewers et al. 2016; ECA International 2008; Poon et al. 2016

Sample design involved the creation of a database of solar energy firms operating in the UAE. Preliminary research, conducted from May 2017 to December 2017 initially identified 182 firms potentially engaged in renewable energy production in the UAE. Undergraduate research assistants helped assess whether the 182 firms met qualifying criteria: (1) presence in the UAE; (2) demonstrable involvement in the UAE's solar energy industry through project acquisition and completion; and (3) position within the UAE's solar energy GPN as a developer or consultant. To apply these criteria, we searched publicly available information on each firm, including industry reports, corporate websites, UAE news articles, and direct contact with firms. Based on the inclusion criteria, 68 firms were identified as being heavily involved in PV and CSP. These firms are important as they represent key actors in the emergence of the UAE's renewable energy sector.

Once the firm database was finalized in December 2017, a random sample of firms was created using R's base() package and sample() function. Using Krejcie and Morgan (1970) a representative sample of firms (n=51) was created. Based on these calculations, the sample has a 90% confidence interval and a 6% margin of error. For each firm in the sample, a list of potential survey recipients – executive and management level individuals – was compiled. Corporate elites are those individuals with access to the knowledge pertinent to the research questions or those with the power to influence business decision-making processes (Rice 2010; Schoenberger 1991). Eliciting information from these individuals grants insight into how firms make strategic geographic decisions concerning firm operations, its supply chain, and hiring preferences in response to local policies to remain profitable. Corporate elites at various firms were identified by consulting listings available on firm websites (this includes email mimicry as outlined in

James (2006))[2], recent local news articles, the LexisNexis Academic database, databases from Dubai Electric and Water Authority (DEWA) and Abu Dhabi Water and Electric Authority (ADWEA), the Emirates Green Business Council, and the professional networking site LinkedIn. The professional networking site, in particular, proved extremely valuable as it allowed for more refined searches of firms and skills, while allowing for the development of large industry-specific professional networks. The use of professional networking services follows several recommendations: maintenance of a professional and up-to-date profile complete with links to appropriate affiliations, utilization of second- and third-degree connections to grow network base, and refined searches through advanced filters by skill, company, and location (Dicce and Ewers 2019).

The recruitment phase yielded 282 potential survey respondents. At each firm, the potential survey recipients were ranked in order of preference based on position within the firm and access to information. This preference ranking was largely based on a "higher is better" recruitment paradigm (Welch et al. 2002). The survey instrument was delivered by email to respondents through Qualtrics. In the event of non-response, two follow up emails were sent approximately one week apart. If non-response continued, individuals where contacted through LinkedIn. This procedure allowed me to utilize professional networks to increase response rates, and ensured that individuals were not excluded from the survey due to old or infrequently checked emails (Dicce and Ewers 2019). After continued non-response or declined survey invitations, the next individual in the ranking was contacted. In all, 206 individuals were invited

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[2] This process relies on the assumption that corporate emails follow distinct patterns. For example, a research may know that Jane Doe's corporate email is jdoe@firm.org. Using email mimicry, the researcher could potentially reach one of Jane's coworkers, John Miller, through mimicking the email pattern: jmiller@firm.org. James (2006) found that this strategy worked the overwhelming majority of the time (~90%).

to take the survey with 24.8% responding within the period of December 2017 to October 2018. This response rate is within normal expected response rates for surveys targeting high level managers and executives (Cycyota and Harrison 2006; Baruch and Holtom 2008; Anseel et al. 2010). The summary statistics for the survey population are displayed in Table 3.2. Survey respondents were asked to respond to the survey using their knowledge of their firm's operations. In particular, these individuals were asked to respond in their capacity as a local solar energy industry expert and were selected as they were the individuals at their firms most likely to possess the required information (Rice 2010).

Table 3.2 Summary statistics for respondents in solar energy survey sample

Metric	**Foreign**				**Local**				**Total**			
Total	21				30				51			
Years of operation in solar	**1-3**	**3-6**	**6-9**	**9<**	**1-3**	**3-6**	**6-9**	**9<**	**1-3**	**3-6**	**6-9**	**9<**
	27.8%	11.1%	22.2%	38.9%	50%	30.8%	7.7%	11.5%	40.9%	22.7%	13.6%	22.7%
Located in special economic zone	**Yes**		**No**		**Yes**		**No**		**Yes**		**No**	
	30.4%		69.6%		24.1%		75.9%		26.9%		73.1%	
# of employees in UAE	**Mean**		**Median**		**Mean**		**Median**		**Mean**		**Median**	
	42.5		27.5		374.4		75		201		45	
% working in solar	57.3%		74%		38.7%		30%		47%		45%	
% Emirati	5.8%		2%		9.3%		5%		7.75%		3%	

3.3 Qualitative data analysis

Data from qualitative interviews reveal the complex firm and individual preferences which condition skilled labor migration to the UAE and firm perspectives on solar energy development in a hydrocarbon superpower. The interviews centered on respondent perspectives and experiences in the UAE's renewable energy industry and gathered information concerning the country's motives for renewable energy transition and local competitive advantage in energy industries. The interviews also generated data concerning firm decision making, hiring practices, collaboration, and embeddedness.

3.3.1 Interview procedures and analysis

Following Schoenberger (1991), I deployed a semi-structured framework and open-ended questions to gain insight on the firm's relationship and collaboration with other entities in the GPN and to understand the firm's learned behavior (Clark 1998). This process was integral to the research because it identified firm rationales for pursuing or investing in renewable energy, firm strategies, relationships with the state, and hiring practices—to the extent that respondents believed that they were not revealing sensitive or proprietary data. Moreover, the establishment of dialogue with key informants assisted understandings of learned behavior and firm choice as firms enter, adapt to, and operate within the UAE's renewable energy industry. The semi-structured framework consisted of 14 base questions (see Appendix C). The questions were asked in order, yet respondents were given freedom to answer the questions in any way they chose and to elaborate on any topic. Often, respondents would answer a future question prior to being asked or their answers would prompt new questions and areas of inquiry. The standard set of 14 questions was developed through altering questions used in previous research (Ewers et al.

2016; Ewers and Dicce 2016) and through new questions designed to elicit responses to the research objectives.

In total, I interviewed 24 executives and managers for approximately 24 hours total by phone (n=11), email (n=1), singular in-person interview (n=10), and in-person group interview (n=2). Purposive sampling was used to identify respondents based on position within their firm, the broader GPN, and accessibility to better understand the firm's key decision-making processes and the broader UAE energy context. Respondents were sourced in three ways. First, interview invitations were extended to select survey respondents. The selected survey respondents were those who held top offices at their firm (CEO, COO, CFO, etc). These individuals were contacted through email and telephone where appropriate. Second, potential interview respondents were identified through LinkedIn. Prospective informants were identified through the platform's advanced search functions which allow researchers to refine searches by geographic area, industry, skill, and keywords. Once identified and contacted, the professional networking platform was then utilized to develop rapport and solicit interviews. This was accomplished through maintaining an up-to-date profile complete with links to institutional affiliations, previous projects and funding, the creation of a broad, well-connected network of industry professionals (Dicce and Ewers 2019). Lastly, I approached well-positioned solar energy executives at two conferences I attended. The Middle East Electricity Forum (March 6 to March 8, 2018) and The Economist's Green Business Summit 2018 (April 17, 2018) provided opportunities for access to high level managers and executives at solar energy firms operating in the UAE. Discounting the email interview, the phone and in-person interviews averaged just over 64 minutes in length with a median interview time of 60 minutes. On average, the in-person interviews – group and single – lasted approximately a half hour longer (79 minutes) than the phone interviews (49 minutes). The email interview lasted only seven exchanges and did not factor significantly into the analysis.

Interviews were not recorded due to cultural sensitivities relating to potential critical comments concerning state actions and policies. In previous research (Ewers et al. 2016), forgoing recorded interviews allowed respondents to openly share their perceptions on the government and its policies without fear of reprisal. Rather than recording, I took detailed notes of every conversation, including my thoughts and reactions to each interview. These notes were later transcribed to recreate interviews with direct quotations. Field notes and transcripts were then analyzed in line with Saldaña (2009). Field notes and transcripts were initially coded through pen and paper and later uploaded to MAXQDA2018 for further analysis. Coding took place in two cycles (Saldaña 2009). In the first cycle, in vivo codes capturing the respondents' thoughts and action in their own words and descriptive coding occurred. This wide-ranging coding system led to the creation of 965 individual codes. Together, these codes provided coverage for approximately 83% of the field notes and transcripts collected in the UAE. In the second cycle, codes were revised, reorganized, and reassessed to create broader categories. Through this process, 96 code sub-categories were identified. Finally, first and second cycle codes were aggregated to draw out broader overarching themes concerning firm perspectives on renewable energy transition and firm behavior. From the analysis, eight categories were formed and discussed in the results section (see Sections 5 and 6). To substantiate the qualitative findings, Yeung's (2003) concepts of investigator and data triangulation, whereby the results are placed in conversation with those of other researchers investigating similar phenomenon and with other forms of data, both industry and survey to challenge or strengthen the findings.

3.3.2 Positionality and reflection

Over the last few decades, geographers have increasingly acknowledged the importance of positionality in conditioning participant responses (Mullings 1999; Adriansen and Madsen 2009). Positionality remains fluid and changes during the course of the research process (Desmond 2004). In an effort to reflect on how my positionality impacted my research findings, the following section outlines my status as an insider and an outsider, and various permutations of both.

3.3.2.1 Research as an outsider

Outsider research occurs when the researcher identifies or is identified as being outside of the community of knowledge. Whereas a large majority of research takes place among insider communities, several authors argue that outsider research possesses several advantages. First, Balogh (2013) finds that outsiders are often able to gain access to research subjects quickly. In geography, the vast distances traveled to conduct research give the appearance that the researcher is serious and has put considerable effort into being in the field. Second, outsiders often appear to be neutral observers and earnest learners (Balogh 2013; Mullings 1999). This allows outsiders to have a greater perceived objectivity when conducting research.

During my fieldwork in the UAE, I often found myself positioned as an outsider. As a Western academic, I was keenly aware that this identity conditioned the participant responses in a number of ways. This was both positive and negative. As an outsider, I found that participants were more willing to engage with me out of curiosity. For many (A1, A3, B1, M1, M3, S3), a Western academic studying solar energy development in a Middle East country was an opportunity to demonstrate the progressive outlook and sustainable development happening in the UAE. While interviewing these individuals, my position as a cultural outsider led to in depth discussions based on the assumption that an outsider has little prior knowledge of the existing industry. Although this assumption was misguided, this positioning allowed for the development of thick descriptions as respondents shared details of local solar energy development. Several respondents (A2, B1, M3), used this insider-outsider dynamic to contextualize local solar development through explaining the history and government rationales behind energy transition. Often, these explanations made explicit reference to my outsider-ness. Respondents used phrases such as, "It is different here than where you are from…" and "what you have to understand about the UAE is…". Early iterations of the GPN further reinforced status. Although the GPN made it clear that I had researched the industry and understood many of the basics, the incompleteness of the early GPNs allowed space for respondents to make suggestions and provide in-depth explanations of the industry as we workshopped the diagram.

As an outsider, I found myself privy to information that might not have been available to insiders. For example, one respondent[3] was eager to share his/her experiences working in the country precisely because I was an outsider. During the interview, I asked a question concerning the changes that would most benefit the development of solar energy in the UAE. This prompted the respondent to share concerns about intellectual property theft, which she/he alleges happened following a meeting with a local university. The respondent shared that he/she was not angry about the alleged transgression, however, wanted me to know about it. When asked why the respondent elected to share this information, she/he responded that I was trustworthy because I was a foreign academic and that this information is important to the future development of the

[3] The respondent code is purposefully withheld. During the interview, the respondent shared considerable detail about the alleged theft of intellectual property. After the interview, the respondent asked that the specific details of the allegation be kept confidential.

industry. For others (A3, O1), my position as an outsider provided them with a means of sharing frustrations concerning UAE policies.

Yet outsider status as a Westerner also proved to be an obstacle to conducting research. Whereas several respondents were more apt to share company details and personal perspectives about the industry, others were more cautious. Several respondents openly questioned my motives for conducting this research. This was particularly true at quasi-governmental firms, where respondents would decline to answer questions concerning their hiring practices or challenge why this information was necessary. One respondent (M4), in particular, often referred me to the information publicly available on his firm's website rather than answer specific questions.

In similar instances, being a Western outsider made it difficult to establish interpersonal trust and familiarity. Some questioned my intentions (K1), challenging why a Western academic would be interested in collecting data on their professional experience and the business practices of their employers. Others, perhaps, were wary that something shared in an interview might ultimately be traced back to them. In these instances, IRB guarantees do not provide much help and despite trying to provide as much transparency as possible, it was not possible to establish trust. The most dramatic instance occurred near the end of field research. I used contact information from a firm's corporate website to call and request an interview. Despite identifying myself, my affiliations, and explaining the research project, the potential respondent denounced me as a corporate spy and refused to speak further without proof that I was not a spy. In an attempt to disprove a negative, I provided extensive supporting material including my CV, IRB approval and protocols, university affiliations, and links to my academic profiles. Ultimately, the individual maintained his distrust and declined to participate or speak further at that time.

Lastly, being an outsider – particularly one from the United States – produced mixed responses from the respondents. The political influence of the United States and the current administration remained popular topics of conversation despite my best efforts to contain the conversation within solar energy in the UAE. Often the respondent would broach the topic through a discussion of the local government and a comparison of governance in his or her home country and in the United States. The introduction of the United States would often spark comments about the aforementioned subjects. While the European and North American respondents did not comment on these issues, the Middle Eastern and Indian respondents often did. The prime of example of this occurred while interviewing a prominent solar energy industry expert who was originally from Syria. During the interview, he mentioned that he previously held a job in an unrelated industry. The stark contrast in expertise between the fields led me to inquire how and why this change was made. He started by explaining that the previous industry was in decline and he saw the future potential of solar energy. However, this was further compounded by the Syrian Civil War, where the informant lost everything as an outcome of his opposition to the Assad Regime and explained that he was unable to return home as a result. Recognizing that I am an American, the respondent became increasingly hostile talking about the role of the United States in the region. Although likely unintentional, I became a conduit for his frustrations at the Obama and Trump administrations, which lasted for a significant amount of time. While we were able to return to the conversation, the answers I received became short and terse before the interview abruptly ended.

In addition to being a cultural outsider, I was also an industry outsider during part of the research. As an academic seeking to enter a professional network of solar energy professionals, I was keenly aware of how this positionality conditioned the treatment and responses I received. I utilized the professional networking service, LinkedIn, to connect with well-positioned potential respondents and grow my presence within the local professional solar energy industry network. My status as an industry outsider was obvious in the early stages of the research and I was dismissed or told that the firm was not hiring at that moment[4]. In some interviews, my position as an industry outsider proved to be a barrier. In several interviews (G1, J2, S6), my position resulted in poor interactions due to condescension and a need to substantiate why the research was both important and worthy of their time. For these respondents, I was an inconvenience, taking time away from their work activities while offering little in return. The outcome was dismissive remarks and comments aimed to move past the questions and to end the interview.

Yet, being an industry outsider also had distinct advantages. For several respondents, my positionality allowed them to give thicker descriptions of the industry. Several (A1, D1, O1) spent additional time beyond the interview to provide descriptions and explanations to ensure that the various contours of the local solar industry were understood and documented. These individuals were particularly helpful when revising the solar GPN (see Section 4), and spent considerable time providing feedback, adding new actors, and underlining the importance of various inter-actor relationships.

3.3.2.2 Research as an insider

Insider research occurs when the researcher identifies (and is identified as) being within the community of knowledge. Advocates of insider research argue that membership to these communities allow researchers to utilize their knowledge and experiences being members to

[4] On several occasions, I was mistaken as a potential job seeker and asked to submit a resume. LinkedIn's primary purpose function is to grow professional networks and solicit jobs, so this initial response was not unexpected.

gather additional insight which might be overlooked or not understood fully by outsiders (Hill-Collins 1990; Adriansen and Madsen 2009). As an American academic conducting field research in the UAE, I am largely positioned outside of the various communities of knowledge. Yet my identity as an expatriate who has previously lived and worked in the country, presence on professional networking sites, and obvious identity as a Westerner all provided insider status in various interviews.

In the UAE, a country characterized by some of the largest percentages of foreign-born individuals (Benton-Short 2005; WCCF 2015), it is not surprising that I am an insider to several expatriate communities. Over the last decade, I have made many trips to the UAE and have worked or resided in the country for about two years in aggregate. This information was often shared with potential respondents through a formal introduction, during the pre-interview discussions, or through my LinkedIn profile and conditioned the various interactions – both online and in person – and information gathered during the process.

My position as an expatriate with previous experience in the UAE was particularly important when discussing labor migration and hiring preferences. Conducting interviews in non-democratic contexts necessitates an understanding of both what is said and what remains unsaid (Koch 2013). Survey and interview-based data collection methods were developed on the underlying notion that opinions can be expressed, if not freely, at least without fear of individual targeting by the state. As this is not the case in authoritarian contexts, researchers need to adopt different strategies. One strategy I utilized was the leveraging of my insider positioning as an expatriate to obtain information on sensitive topics. Participants engaging in these discussions often utilized this common identity to provide information about labor dynamics or government bureaucracy, without having to explicitly comment. During these insider interviews, cautious respondents would deploy these shared knowledges to allude to particular understandings. Respondents would use value-laden phrases, such as "You've lived here before so you know what I'm trying to say" or "You know how it is here". For these respondents, these phrases were another way of alluding to allegations of human rights abuses among migrant labor communities (Human Rights Watch 2017).

In addition to being an insider as an expatriate, I was also an insider as a Westerner. Although this made me a cultural outsider to many of the respondents, it also made me a cultural insider to those respondents from Europe and North America. Several respondents (in particular A4, A5, D1, J2, and G1) utilized this shared background to compare work experiences in Europe and North America to their experiences living and working in the UAE. Unlike other respondents, D1 approached me first and remarked that he had done so due to my position as a Western academic. He had seen my LinkedIn profile and sought to have a meeting specifically because we shared a common identity as Westerners living and working in the UAE. Throughout the interview, D1 would reference our common backgrounds and constantly position it as a foil to local practices, using phrases such as, "It's much different here than it is back home for us" and "You and I are not used to this, but that is the way business is conducted here."

Lastly, in the latter stages of the research project (late-March through May 2018), I found myself positioned as an industry insider due to my presence on LinkedIn. I began to notice this shift as individuals who had previously rejected invitations to participate in the research or who had declined invitations to connect on LinkedIn were now reaching out to me. As mentioned above, I started as an industry outsider on the professional networking platform and was often dismissed entirely or confused as a potential job seeker. Towards the end of this research, however, my positionality had shifted dramatically. Rather than an industry outsider, I was increasingly viewed as heavily connected to the country's emerging industry. During the interview portion of the research, several respondents referenced my numerous LinkedIn connections as one of the contributing factors for accepting an interview request. A4 and S3, for example, shared that one of their motivating factors for meeting was the opportunity to learn more about the project and the preliminary findings. Both parties mentioned that my sheer number of connections and the important industry actors with whom I had connected made me a valuable contact. Utilizing this unique positioning was essential to obtaining and conducting the qualitative research.

The use of professional networking services in research potentially provides a new means of increasing respondent quality. Traditional survey and interview research rely heavily on the presence of "gatekeepers," able to provide access or remains at the mercy of publicly available contact information provided on corporate websites. The prevalence of LinkedIn and high degree of industry coverage allows the research to circumvent traditional gatekeepers and connect directly with the desired individuals. Moreover, persistent use, the maintenance of an up-to-date and informative profile, and the development of a wide-reaching industry network potentially shifts the positionality of the researcher, allowing him or her to gain additional insights through the lifecycle of the project (Dicce and Ewers 2019).

In all, my positionality as an outsider, insider, and a combination of both, impacted both the accuracy and reliability of the data collected. The shift in positions throughout the lifecycle of the research granted different perspectives into the emergence of the UAE's solar energy industry, firm hiring practices, and individual migration preferences. While being an outsider (Balogh 2013) or an insider (Adriansen and Madsen 2009) grants particular insight into place-based phenomenon, shifting positionality provides a unique opportunity to not only understand both perspectives (Mullings 1999), but also self-triangulate between information gleaned as an insider and information obtained as an outsider. Although the information obtained throughout the course of my fieldwork was filtered through these various positionings, the insider and outsider information understandings largely complement each other and grant increased validity to the overall findings.

3.4 Study area

Located along the coast of the Arabian Peninsula, the UAE is a federation of seven emirates and home to the seventh largest proven oil reserve in the world (EIA 2016; BP Statistical Review of World Energy 2016). Rapid economic growth means the UAE must dramatically increase domestic energy production to meet an estimated 9% annual increase in consumption (Asif and Muneer 2007). In particular, the need for air conditioning to create comfortable living spaces in desert environments (Radhi 2009) and energy-intensive desalination industries to provide fresh water stimulate increased domestic energy demand (Dawoud 2005). Despite vast fossil energy sources, the UAE has aggressively pursued renewable energy development with an emphasis on PV and CSP technologies. The UAE receives direct sunlight well above global and regional averages (Alnaser et al. 2004).

Both Abu Dhabi and Dubai have each pledged to provide 7% of their gross energy consumption through renewable energy by 2020 as part of a national plan to have clean energy constitute 25% of the energy mix by early 2030 before climbing to 75% by 2050 (MESIA 2016). To date, the UAE has ten plants greater than 1 MW installed, planned, or under construction. In 2006, the federal government announced the creation of the first carbon-neutral city, Masdar City. Completed in 2010, it is now home to the Masdar Institute of Science and Technology and is the headquarters of the International Renewable Energy Agency (IRENA). Masdar Institute partnered with firms around the world to install over 1,611 MW of wind and solar energy in 19 countries (Masdar 2016).

The labor context of the UAE has changed dramatically as a result of oil-driven development. Since the oil boom of the 1970s, the UAE's population swelled from 557,887 to over 9.4 million in 2014, with most of this growth occurring in the cities (UAE National Bureau of Statistics 2014). Most of the country's population growth stems from the influx of foreign migrants to fill local labor and knowledge gaps (Bontis 2004). The high wages, favorable working hours, access to benefits, and social prestige of public sector employment provides nationals with a powerful incentive to forgo employment in the private sector (Randeree 2009; Shah 2008). The result is a stark division in the labor market whereby nationals are overwhelmingly employed in the public sector (61%) while foreigners occupy positions in the private sector (UAE Labor Force Survey 2009). In an effort to lessen the reliance on foreigners in the private sector, decrease unemployment amongst nationals, and incentivize nationals to seek employment in the private sector, the government has implemented a nationalization initiative known as "Emiratization" (Shah 2008). Although the Emiratization program has been in effect for over a decade, its success remains uncertain as firm hiring practices and individual preference-seeking continue to (re)produce the existing migrant divisions of labor in the country (Ewers and Dicce 2016).

4 SOLAR GPN ANALYSIS

This section analyzes the global production network (GPN) for the UAE's solar power industry. Following Henderson et al. (2002), the analysis includes assessments of power, value, and embeddedness within the GPN as well as the broader network connections between the emerging solar energy industry and other industry networks.

For the GPN, power includes notions of where the locus of power resides both spatially and structurally within the network through three different forms. First, corporate power examines how lead firms exercise influence and power throughout the entire production network. Second, institutional power explores how state and local policies shape both production networks as well as interstate policies and regulations. Third, collective power assesses how power is exercised through collective action within the network.

Value assessments examine how surplus value and economic rents are created, enhanced, and captured throughout the chain. Value creation involves how labor, combined with skill and technology, is utilized to generate rents through production. These rents can either be generated through superior technology which grants economic advantage (technological rents), through brand development and recognition (brand rent), or through interfirm linkages which create special or preferential relationships (relational rent). Value enhancement analysis concerns the degree to which technology transfers within the network and the interaction between lead firms and their suppliers to improve production through increases in technology or quality standards. In contrast, value capture analysis concerns whether local areas are able to benefit from the presence of value-added production in a given location. Value capture concerns not only questions of firm ownership and public-private partnerships, but also the nature of capitalism within national contexts and how these contexts shape production outcomes.

The last area of GPN analysis concerns the embeddedness of the production network and how firms are positioned both functionally and geographically. In particular, GPN analysis highlights territorial embeddedness through uncovering where various elements of the production network are situated geographically and network embeddedness through how individual actors within the network are positioned both within the domestic network and within broader industry networks. In essence, this analysis examines not only where production occurs but also how these places of production connect to broader, global networks. The results of the solar GPN are found in Appendix E. A simplified version of the solar GPN is found in Figure 4.1. In particular, the solar GPN charts both the direct (input-output chain, suppliers, developers, and utility companies) and indirect (government regulators, financial institutions, consultancy firms, university and research facilities, and industry and non-governmental organizations [NGOs]) actors involved in the production of solar energy in the UAE. The GPN displays the complex interaction of these multiscalar actors in the country's emerging PV and CSP industry. The following section assesses the solar GPN in terms of power distribution, value, and embeddedness.

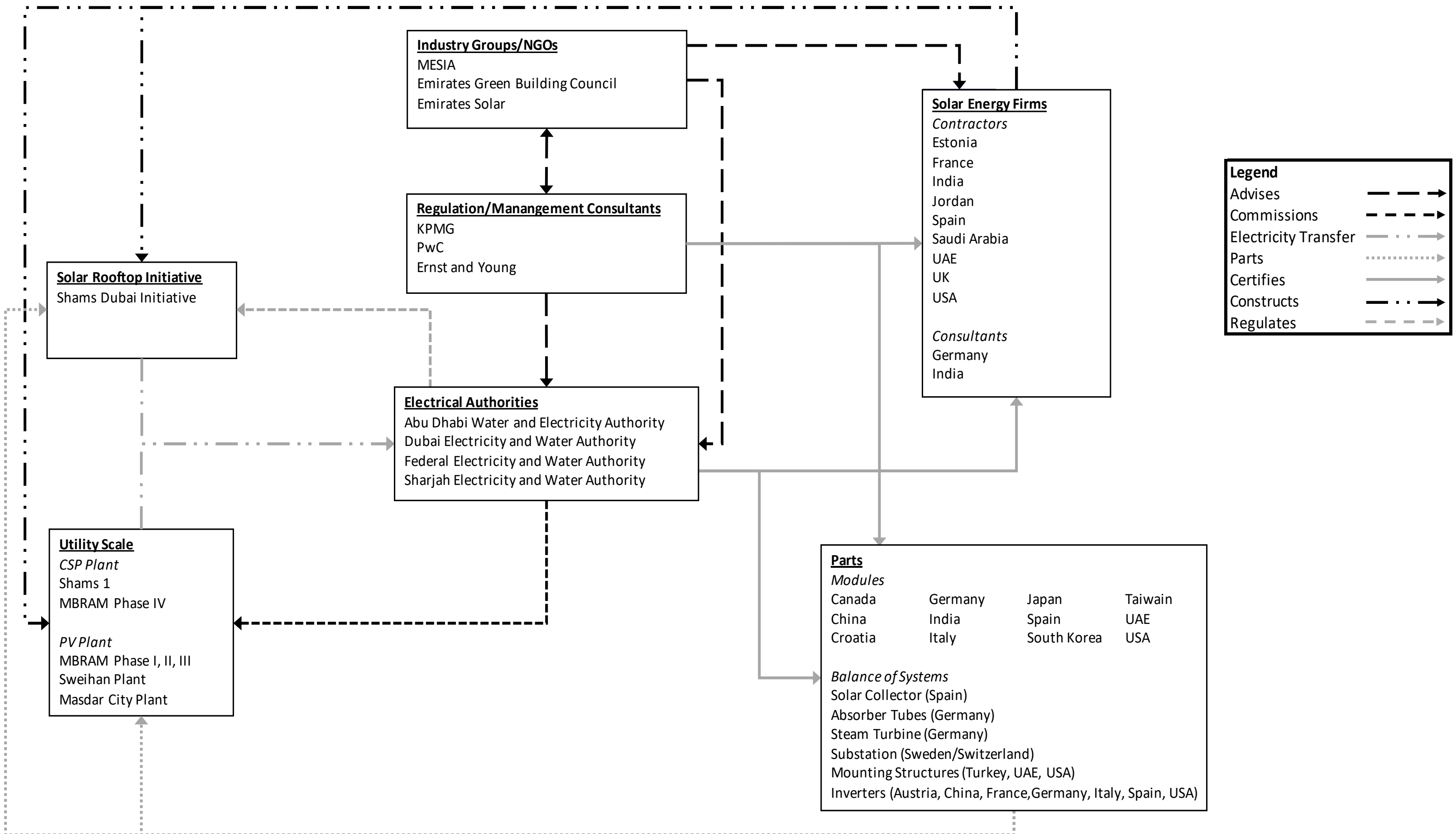

Figure 4.1 Simplified GPN for the UAE's solar industry

4.1 Power within the solar GPN

This section examines the distribution of power within the solar GPN. In particular, it identifies key actors in the solar production network and assesses how these actors exercise power across the network in terms of corporate, institutional, and collective power. The findings highlight the role of the state through direct and indirect exercise of power, thereby positioning the government as the key actor within the country's solar energy industry.

4.1.1 Corporate power

Discussions of corporate power within the solar GPN necessitate the identification of lead actors within the UAE's solar industry. Although the local industry remains divided into two main sectors (residential/commercial installation and utility scale development), the industry's central actors are key to discussions of power. Using R Studio's (v.3.3.3. *Another Canoe*) network analysis tool, *igraph*, it is possible to determine network centrality based on actor interactions. Agnostic of interaction type, Figure 4.2 displays the simplified GPN with a particular emphasis on the industry's central actors. From the figure, it is clear that the industry is structured around the two main sectors: utility and rooftop. Importantly, however, the analysis demonstrates the centrality of the solar energy consultants and contractors as key non-governmental industry actors.

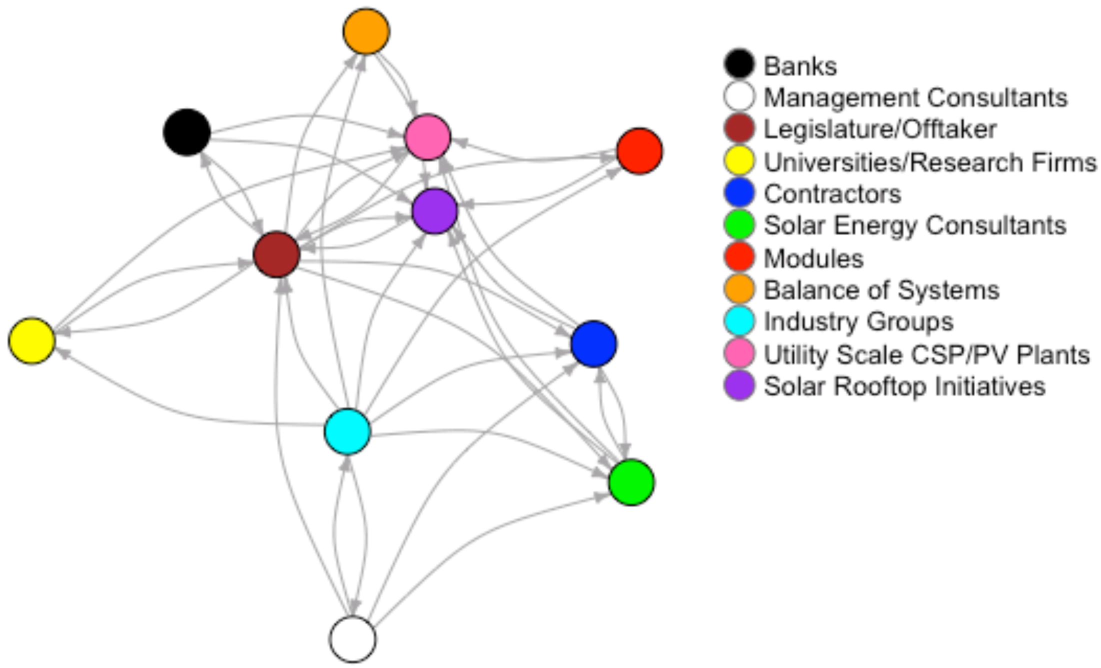

Figure 4.2 Network centrality in the UAE's solar GPN

The solar GPN (Figure 4.1) reveals the geographic origins of central actors involved in solar production in the UAE – suppliers, consultancy firms, and developers. From a utility scale perspective, Table 4.1 identifies the major actors involved in the procurement, development, construction, and ownership of the five utility-scale solar energy projects representing an installed capacity of 2,230 MW of CSP and PV. When combined, the table and figure reveal a roster of firms and locations central to the development of the UAE's solar energy industry. From a developer prospective, local firms such as Environmena and Masdar, as well as foreign firms such as First Solar, Saudi ACWA, TSK, Fotowatio Renewable Ventures, Gransolar Group, Total, Teyma, JinkoSolar Holdings, and Marubeni Corp. feature as prominent actors. The selection of large foreign firms for utility-scale development often occurs at the exclusion of local firms. The Solar Division Head of one local consultancy explained,

> The large projects, like MBRAM solar park, only use the big firms. The government brings in international companies from Europe for these projects. They want the expertise – companies who have done many large projects and have the knowhow – they also want the name attached to the project. Local companies don't get this work, but we should. Right now, it is all European expertise (K1).

This respondent's claim that the UAE government awards projects to experienced foreign multinational companies is reflected in the table. Skill demands, solar energy systems design and experience, and firm name recognition conspire to produce an outcome whereby, with few exceptions, the major actors for utility-scale development of solar energy in the UAE are foreign – predominately European – firms.

Table 4.1 Utility scale solar plants in the UAE

Project	Size (MW)	Location	Developer	Source
Masdar City Solar Plant	10	Abu Dhabi	Environmena (UAE)	Environmena (2018)
MBRAM Solar Park Phase 1	13	Dubai	First Solar (USA) ILF Consulting Eng, (Germany)	DEWA (2018a)
MBRAM Solar Park Phase 2	200	Dubai	ACWA Power (Saudi Arabia) TSK (Spain)	DEWA (2018a)
MBRAM Solar Park Phase 3	800	Dubai	Masdar (UAE) FRV (Spain) Gransolar Group (Spain)	Masdar (2019)
MBRAM Solar Park Phase 4	700	Dubai	ACWA Power (Saudi Arabia) Shanghai Electric (China)	APICORP (2017)
Noor Abu Dhabi Solar PV Plant	1,177	Abu Dhabi	ADWEA (UAE) JinkoSolar Holdings (China) Marubeni Corp (Japan)	Carvalho (2017)
Shams 1	100	Abu Dhabi	Abengoa Solar (Spain) Total (France) Masdar (UAE)	Masdar (2019)

The economic landscape of actors within the country's solar rooftop sector are predominately locally oriented. Available rosters of certified consultants and contractors are available on both ADWEA's and DEWA's websites, with most companies being local. Whereas large multinational firms often secure utility-scale projects, the solar rooftop market is dominated by local firms. Despite the growing number of such projects, the local orientation of the rooftop solar market is likely an outcome of the sector's low profit margins. The Solar Division Manager of a large local firm argued that "one downside to solar is that profits are very low. For a company like mine with a lot of business, solar is small chips" (G1). Colleagues at other firms shared similar sentiments.

A deeper look at the GPN, however, reveals the corporate power of the state and its influence, control, and ownership of various elements of the production network. In particular, the state exercises corporate power through its direct ownership of ADWEA, DEWA and through its holdings in UAE based companies such as Masdar, Etihad ESCO, and Environmena Power Systems. Masdar, which also operates under the title of Abu Dhabi Future Energy Company, is a fully owned subsidiary of Mubadala Development Company. Founded in 2006, the firm is the region's largest exporter of renewable energy – both solar and wind – as well as a major domestic presence in the UAE's solar industry (Masdar 2019). To date, Masdar is involved with the construction and production of close to 1,000 MW of solar energy in the UAE (see Table 4.1 for domestic project involvement). Within the company, there are three separate divisions – Masdar Capital, Masdar City, and Masdar Clean Energy – each of which is responsible for specific functions within the solar production network. The development arm, Masdar Clean Energy, focuses on the design and construction of clean energy with in the UAE and globally, while the investment arm, Masdar Capital, finances the development of state-of-the-art renewable energy technologies with an emphasis on making such technologies more economically competitive. Masdar City, meanwhile, represents the creation of an environmentally, low carbon city which headquarters both IRENA and the Masdar Institute of Science and Technology.

Although Masdar operates with a significant degree of independence, its linkages with the state maintain the government's centrality and corporate power within the emerging solar GPN. As a fully-owned subsidiary of the Mubadala Development Company, Masdar remains an extension of the state. In 2016, Mubadala merged with the UAE-owned International Petroleum Investment Company. Jointly owned by the Abu Dhabi Investment Authority and the Abu Dhabi National Oil Company, Masdar represents the involvement of the state in the development of renewable and solar energy and the training of future skilled labor to meet the growing demands of the industry. The linkages between the state and Masdar's operations are further noted by the firm's board. In addition to being the Chairman of Masdar, His Excellency Dr. Sultan bin Ahmad Al Jaber also serves as the UAE Minister of State and as the Director General of ADNOC. While the linkage between the UAE Cabinet and the thrust for renewable energy underscores the corporate power of the state, the linkage between the UAE's largest oil company, ADNOC, and Masdar highlights the centrality of executive decision making between hydrocarbon and renewable energy industries. This linkage is further noted in Dr. Al Jaber's 2016 appointment of Mohamed Jameel Al Ramahi as the Chief Executive Officer of Masdar. Mr. Ramahi has served Masdar in various capacities since joining the firm in 2008, he was previously the Head of Internal Audit and Risk Management Office at Abu Dhabi Gas Industries Limited (GASCO) – the natural gas arm of ADNOC.

Enviromena Power Systems, meanwhile, was founded in 2007 under the guidance of Sami Khoreibi. Previously a founding partner in the hydrocarbon company, Candax Energy Inc., Mr. Khoreibi has been heavily involved in the development of the UAE's solar energy industry. Although founded as an independent company, Enviromena has become increasingly associated with the state. In March of 2010, the company announced a $15 million investment from Masdar, making government-owned firm the largest shareholder in the company.

Directly through ADWEA and DEWA, and indirectly through Enviromena and Masdar, the corporate power of the state can be seen in the ownership of the major solar energy projects in the UAE. Although each plant is owned in conjunction with other parties, the state maintains controlling interests in the four largest plants: MBRAM Solar Park Phase 2 – 200 MW (DEWA 51%), MBRAM Solar Park Phase 3 – 800 MW (DEWA 60%; Masdar 24%), Noor Abu Dhabi Solar PV Plant – 1,177 MW (ADWEA 60%), and Shams 1 CSP Plant – 100 MW (Masdar 60%). The government of the UAE's involvement through ownership, construction, and research and development underscore the centrality of the state within the country's emerging solar production network. Moreover, state presence throughout all sectors of solar energy production highlights the corporate power of the state and the ability of the state to exercise control and stimulate demand within the network.

4.1.2 Institutional power

To further examine power within the UAE's solar GPN, assessments of institutional power within the network are necessary. While discussions of corporate power revealed the centrality of the state in the country's emerging solar industry, examination of institutional power – the means though which state and local policies condition production outcomes – further reveals the state's key position. Both GPN and qualitative analysis highlight the various means through which the state exercises institutional power. Rather than a single national context, respondents argued that the UAE is better understood as different factions – Abu Dhabi versus Dubai, Abu Dhabi versus Dubai versus the remaining emirates, or Abu Dhabi versus Dubai versus Sharjah vs the remaining Emirates – rather than a singular country (B1, D1, S1, S2). The result is a subnational variation in legislation, tariff regime, and regulation which produces a patchwork landscape which differentially conditions the development of solar. According to respondents, the government has undertaken efforts to remedy these obstacles, yet their presence remains a constraint on the industry's growth and development.

4.1.2.1 Tariffs, Varied Incentives, and Uncertainty

A recurring theme amongst interview respondents was the impact of electricity tariffs on the development of solar energy in the UAE. Almost 30% of key informants argued that geographic (by Emirate) and social (by nationality status) variation creates a complex landscape of incentives that hinder the development of solar energy in the country. Table 4.2 outlines the country's current tariff schedule by usage, industry, and nationality.

Table 4.2 Differences in slab electricity costs for the UAE (fils/kWh). Adapted from ADWEA (2018), DEWA (2019), FEWA (2019), and SEWA (2019)

ADWEA		DEWA		FEWA	
Residential		*Residential/Commercial*		Residential	
National		0-2000 kWh/month	23	National	7.5
Ideal	6.7	2001-4000 kWh/month	28	Expat	
Non-Ideal	7.5	4001-6000 kWh/month	32	<2000 kWh/month	23
Expat		>6001 kWh/month	38	2001-4000 kWh/month	28
Ideal	26.8	*Industrial*		4001-6000 kWh/month	32
Non-Ideal	30.5	0-10000 kWh/month	23	>6001 kWh/month	38
Industrial		>10001 kWh/month	38	Industrial	44
Below 1MW	28.6	**SEWA**		Commercial	
Above 1MW		*Residential*		<2000 kWh/month	23
Off Peak	27.0	National	7.5	2001-4000 kWh/month	38
Peak	36.6	Expat	30	4001-6000 kWh/month	32
Commercial	20.0			>6001 kWh/month	38
Agriculture	4.5			Government	
Government	29.4			<10000 kWh/month	23
ADNOC	28.1			>10000 kWh/month	38

From the table, it is clear that the UAE's electricity sector is highly varied by industry type, location, and nationality status. In Abu Dhabi, both the government and the national oil company, ADNOC, pay the true cost of electricity production. The remaining sectors pay a heavily subsidized tariff based on a myriad of other factors. While the electricity tariffs are often viewed a part of larger social welfare programs (Krane 2014) and have successfully attracted energy intensive industries (Peterson 2009), key informants argued that the subnational variation and expat/national divide create a barrier to the progression of the industry.

From a locational standpoint, variation in tariff subsidy by emirate has, in part, contributed to the dominance of Dubai in the UAE's solar industry. The COO of one local firm argued that low electricity costs – a product of government tariffs – has hindered the industry's growth: "One of the greatest challenges is the artificially low price of electricity. In order for solar to become successful, it needs to provide a means for people to save money. In other words, the price of electricity must be high" (S6). For several respondents, the variation in local tariffs (by emirate, nationality, and industry) has created a diverse national solar landscape which conditions the places where solar has grown (i.e. places where the tariff cost is high enough for solar to offer cost-effective solutions) and places where it has not (i.e. places where the tariff price is too low for solar to be competitive). The Solar Division Head of one firm argued that the difference in solar investment and installation in Dubai and Abu Dhabi is a legacy of oil and its impact on local tariff schedules. For this respondent, the vast quantities of low-cost hydrocarbon resources in Abu Dhabi allow the government to offer tariff schedules which make solar non-competitive (G1). Yet Dubai's lack of hydrocarbon resources and need to import electricity feedstock mean that the tariff schedule is more favorable for solar, which is reflected by the industry's development in the emirate (S6).

In terms of promoting solar energy, governments have two primary financial or legislative mechanisms for spurring growth, which can generally be classified as either punitive or positive measures designed to increase the competitiveness of solar production (El Katiri 2014). Punitive measures include legislative schemes that produce additional costs to existing energy production. One prominent example of punitive schemes is the creation of a tax or cap on carbon emissions. While these measures do not alter the cost-curve of solar energy, they increase the cost of other means of energy production, thereby making solar comparatively more competitive. As a hydrocarbon superpower, however, the UAE does not promote punitive measures on oil and gas production as these industries remain the primary sources of government revenue. In contrast, positive measures encourage the development of solar energy by increasing the competitiveness of energy production. Feed-in tariffs for example, increase solar competitiveness by decreasing the risk of investment in solar energy through a reduction in production costs and a guarantee in revenue streams. These measures are an important avenue through which the state can exercise institutional power and spur growth in emerging renewable energy markets (Alnaser and Alnaser 2009). Despite the popularity and effectiveness of feed-in tariffs, they remain largely absence in the UAE. A joint survey between PriceWaterhouseCoopers (PwC) and the Emirates Solar Industry Association identified the absence of such tariffs as one of the major barriers to the continued development of solar energy in the country (ESIA 2012). Continued absence of feed-in tariffs represents not only a missed opportunity to spur industry growth but also a missed opportunity to strengthen the centrality of the state in solar energy through institutional power within the local production network.

Following the passage of Law No. 2 of 1998, "Concerning the Regulation of the Water and Electricity Sector in the Emirate of Abu Dhabi", ADWEA was enshrined as the single buyer and seller of electricity within the capital emirate. Similarly, Dubai has enshrined the privileged position of DEWA as the single buyer and seller of electricity, most recently reaffirming this position in Law No. 6 of 2011, "Regulating the Participation of the Private Sector in Electricity and Water Production in the Emirate of Dubai." The positioning of the government as both a monopsony and monopoly within the solar, and broader energy, GPN grants a significant amount of institutional power. In particular, the monopoly/monopsony position allows the government to effectively select production for the grid and enables the government to further privilege the development of solar energy through the creation of a guaranteed market. Yet, the government has recently implemented additional positive measures in the form of net-metering programs which are designed to decentralize production and offset electricity costs. Under this system, rooftop installations can sell power to the grid at market price to offset consumption costs with the consumer only being billed for the net difference in cost of production and consumption. Although this represents a decrease in institutional power, it has successfully spurred growth in the industry.

4.1.2.2 Governance and Regulatory Variation

One of the major emergent themes was the issue of the industry's governance and regulation. Half of the interview respondents noted that both bureaucratic obstacles and subnational variation in regulations and standards have created a country-wide landscape of varied policies, frameworks, and outcomes. Respondents divided the country into three distinct areas – Abu Dhabi, Dubai, and the remaining emirates – to discuss how variations in regulation impact development outcomes. Rather than viewing the UAE as a singular state, it is more accurate to view them as independent microstates under a federal umbrella:

> You have to understand that the UAE is a single country to outsiders but it is very different here. It's more like seven different countries, all pursuing their goals. Sure, the federal government makes some decisions for the whole country, but often the decisions are left to each emirate. Because of that, each one approaches things – like solar – differently and you end up with a patchwork of legislation and government aims. Abu Dhabi and Dubai are fine and solar is doing well. Sharjah and the other emirates need greater maturity of governance in solar and they need to develop more favorable schemes so that solar can take off (B1).

Respondents argued that this legislative patchwork has advanced the solar industries in Dubai and – to a degree – Abu Dhabi, yet limited growth elsewhere. In Sharjah and the northern emirates, the lack of appropriate regulation, such as net metering, which has allowed the industry to advance elsewhere, has significantly hurt the industry's growth (A3). In particular, one solar manager (S2) at a firm in the northern emirates shared his frustration with the lack of regulation and perceived unwillingness of the local government to support the industry. Despite proposing several large installations, his company has been constantly frustrated with the lack of support for development.

A broader discussion about the structure of the UAE's utilities schemes provided further context to the subnational variation in solar energy governance. In particular, respondents noted how the involvement, scope and structure of the country's four major utility companies – ADWEA, DEWA, FEWA, and SEWA – impact local solar development outcomes. For example, several respondents (A3, A4, B1) expressed doubt that SEWA has any true interest in solar installations and industry development. While the utility's chairman, Dr. Rashid Al Leem, is on record stating that the emirate strives to diversify its energy mix and promote solar energy (SEWA 2017), little regulation has thus far supported these statements. Unlike Abu Dhabi, Dubai, and Sharjah, the northern emirates do not have their own utility authorities. Instead, the remaining emirates fall under FEWA, which limits the ability of individual emirates to pursue their own solar strategies. A government employee in one of those emirates explained:

> The remaining emirates – Ajman, Fujairah, Umm al Quwain, and Ras al Khaimah – fall under FEWA, which is a federal regulator under the Ministry of Energy. In Dubai, you have DEWA, but they are owned by their government so everything can get done. Here, we do not own the authority and we don't have the ability to make or change regulations. FEWA doesn't currently have any regulations for solar and that is why we need to push the government to make those regulations (A3).

In particular, the inability to install a net metering program or solicit independent power producer (IPP) projects has hampered the development of a solar industry. Accordingly, the emirates with both authority over their utilities and with a desire to create meaningful regulation – largely Abu Dhabi and Dubai – are the emirates with the most advanced solar sector.

Within the two main solar energy producing emirates, a significant amount of regulatory and governance variation remains. Despite both producing solar megaprojects – Shams 1 and Sweihan in Abu Dhabi and MBRAM solar complex in Dubai – each emirate has approached the development of solar differently, leading to varied outcomes and forms of solar projects. The Head of Renewables at a firm involved in ongoing utility scale solar development in the country noted:

> The situation in the UAE is almost like two countries. You have Abu Dhabi and Dubai… In Abu Dhabi, you have ADWEA calling the shots. They decide on a scheme or a type of plant and then search for people to build it. It's an EPC [engineering, procurement, and construction] approach. In Dubai, it's different. Dubai is more of an IPP. They have demand for power but do not care how it is met. Instead, they see who offers the lowest bid regardless of scheme (D1).

Having consulted on the Shams project, he argued that the CSP system has not performed to expectation, leaving the emirate more focused on PV installations and IPP approaches to power plant development – as is the case with the Sweihan project. Although CSP remains popular in Dubai, the comparative lack of transparency concerning cost has hampered the industry's growth according to this respondent.

Beyond EPC and IPP approaches, the control and governance structures vary geographically. In Dubai, respondents widely acknowledged that DEWA was the central authority handling the regulation and enforcement of the emerging solar industry. Yet the central authority in Abu Dhabi was less clear. The presence of both ADWEA and its wholly owned subsidiary, the Abu Dhabi Water and Electric Company (ADWEC), complicates the bureaucratic landscape. As a government-granted monopsony, ADWEC stands as the lone purchaser and distributer of electricity in the emirate. The additional layer of governance was often criticized by respondents who often preferred Dubai's single central authority, DEWA:

> In Abu Dhabi, you have ADWEC and ADWEA. If ADWEA wants to complete a project, they need to go through ADWEC. This slows things down… There are different layers of control in Abu Dhabi's power industry… The difference is that DEWA is the single point of connection, they run everything. If you want to do business in Dubai, it is very simple. Go to their website and you can find everything about the process. Everything is organized. In Abu Dhabi, it is less clear. You may have to go to ADWEA or ADWEC and then to other agencies as well. There isn't a clear path (M1).

Although a number of respondents highlighted the lack of clarity in determining the appropriate government entity for solar regulation and credentialing, the government has taken steps to streamline bureaucracy with the passage of Federal Law No. 20 of 2018. Under the new legislation, the newly formed Emirates Water and Electricity Company (EWEC) will replace ADWEC and power generation will fall under the central authority of the Abu Dhabi Power Corporation. As the name implies, EWEC will soon form bilateral agreements with FEWA to become the centralized power generator for six of the seven emirates (Middle East Utilities 2018).

Respondents highlighted that, regardless of emirate, the speed of approval processes was a limitation to industry growth. Five of the respondents argued that the approval process is too slow and is costing too much time and money to complete. Although both emirates have made efforts to streamline the process (G1, K1), bureaucratic oversight still restricts the industry's growth. One solar expert argued that the massive bureaucracy is a product of the public/private sector divide among nationals and expats, noting:

> The size of the bureaucracy is a big issue. It slows everything down and makes business more difficult. In some of the departments, you have people making very high salaries who feel the need to justify why they are being paid. So, what do they do? They slow down the process and ask questions. They don't have a background in solar and don't understand the industry, but they will ask silly questions just to "prove" they are doing their job (G1).

The complex regulatory environment and intense oversight has created time delays for installation and production times. One informant argued that DEWA visited a single project over twenty times – leading to delays in production (O1). Whereas another informant (A4) shared his frustration that a two-month process for approving solar contractors has taken almost a year and is yet to be completed. Although the approval process for proposals is getting faster – down to only a few weeks from 3-6 months (G1) – solar experts argued that the government could do more to streamline the process.

4.1.3 Collective power

The final element of power within the UAE's solar GPN is collective power which is exercised through collective action of individual actors and groups within the network. In particular, collective power describes how these actors attempt to influence and alter the network through collective action, such as lobby groups and industry organizations. Within the UAE's solar GPN, there are three primary entities which exhibit collective power within the network. Together, these groups certify the quality of solar components, contractors, and consultants and advise the local authorities on the best practices and policies for the industry – often lobbying for legislative change which favors the industry.

The largest and perhaps most influential group in the network is the non-profit, non-governmental Middle East Solar Industry Association (MESIA). Headquartered in Abu Dhabi, the organization was founded in 2009 to promote solar energy in the region, facilitate networking opportunities, create technical and best practices reports, and lobby for policies favorable to local solar energy development. Today, MESIA has over 130 member firms located in the Middle East, North Africa, Europe, East Asia, and North America. MESIA has also developed or is working on developing state-specific industry associations better able to advocate for local industry needs. These include the Emirates Solar Industry Association (ESIA), Saudi Arabia Solar Industry Association (SASIA), Morocco Solar Industry Association (MSIA), and even the Palestine Solar Industry Association (PSIA). In addition to its stated missions, MESIA works with local governments to develop better policies and standards while also assisting in the creation of product quality and certification standards. The group plays an important credentialing role in the region's solar industry.

The second organization exerting collective power in the UAE's solar GPN is the World Green Building Council (WGBC). Based in London, the WGBC is a consortium of green building councils dedicated to sustainable growth, the avoidance of deleterious effects of climate change, and the promotion of net zero emissions buildings (WGBC 2017). In the UAE, the WGBC maintains its presence in two ways. First, the WGBC has created a regional network within the Middle East and North Africa consisting of councils in Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Palestine, Qatar, and the UAE. The regional network aims to coordinate practices across the region and highlights exemplary projects and research in sustainable buildings. The UAE-based Emirates Green Building Council (EGBC), formed in 2006, represents the local iteration of the WGBC. Within the UAE, the EGBC is a collection of local companies and advocates for sustainable and renewable energy outcomes to reduce the country's ecological footprint. The EGBC also occupies an important role in credentialing as it offers training and certification in a number of energy and sustainable building and retrofitting areas.

The third organization demonstrating collective power in the UAE's solar energy GPN is the International Renewable Energy Agency (IRENA). As the United Nations' renewable energy agency, IRENA currently counts 180 countries (153 members and 27 states in accession) and is presently headquartered at Masdar City in Abu Dhabi. As part of its stated mission, the intergovernmental organization is set up to increase cooperation amongst states, transfer best practices around the world, increase awareness and understanding of emerging and current technologies, and to promote the advancement of renewable energy around the world (IRENA 2017). In addition to these aims, IRENA offers a number of services designed to promote the adoption of renewable energy technology, including the creation of annual reviews and cost studies, renewable energy readiness reports on a state-level basis, and a global atlas for renewable potential. IRENA represents an important source of collective power both locally in the UAE and in the global solar energy industry. On a local level, IRENA is embedded in the country's capital. Part of a larger policy shift to increase awareness of sustainability, Abu Dhabi embarked on an extensive campaign to secure the international headquarters, finally doing so in 2009. Today, IRENA collaborates intensely with Masdar and serves as the preeminent renewable and solar energy advocate in the country. On a global level, the presence of the U.N.'s 180 country renewable energy agency in the UAE quite literally places the country at the center of the emerging global industry.

4.2 Value within the solar GPN

This section examines how value is distributed throughout the solar GPN. It examines both surplus value and economic rents through particular attention to how value is created, the means through which value is enhanced, and processes and location through which value is captured in the GPN. The findings reaffirm the centrality of the state to the emerging solar industry. In particular, the state plays an important role in both value capture and enhancement; however, there remains a need to improve local firm value creation within the solar industry. The findings also point to the importance of foreign firms and labor as key components of value creation in the UAE's solar GPN.

4.2.1 Value Creation

The creation of value within GPNs examines a variety of technological, organizational, relational, marketing or brand, and policy elements which differentially condition the ability of firms to garner economic rents within the industry (Henderson et al. 2002). Importantly, variations in these factors allow different actors to leverage comparative advantages to create additional value and excise greater rents. One means of value creation examines how firms leverage technological advantages to generate rents. These *technological rents*, examine the innovations and advances in production and manufacturing which allow certain companies to be more or less competitive. Although the UAE has access to a wide variety of solar energy technologies, those firms able to access premier technologies at lower prices are best able to create value. Within the emerging industry, several solar technologies have gain increased importance in the utility-scale sector, as evidenced by their use in such projects. Table 4.3 outlines these technologies by project.

Table 4.3 Inputs for UAE solar projects

Project	Inputs
Masdar City Solar Plant	Thin film modules (First Solar, USA) Poly crystalline modules (Suntech, China)
Shams 1	Parabolic trough (Abengoa Solar, Spain) Absorber Tubes (Schott, Germany) Mirrors (Flabeg, Germany)
MBRAM Solar Park Phase I	Solar Panels (First Solar, USA) Substation (ABB, Switzerland/Sweden)
MBRAM Solar Park Phase II	Solar Panels (First Solar, USA) Substation (ABB, Switzerland, Sweden)
MBRAM Solar Park Phase III	Solar Panels (Canadian Solar, Canada)
Other projects and rooftop installations	Polysilicon (REC Silicon, Norway; IDEA Polysilicon, Saudi Arabia) Inverters (SMA, Germany; Fronius, Austria; Scneider, Germany; KACO New Energy, Germany; AEC, Saudi Arabia) Mounting structures (Al Jazira, UAE; PanelClaw, USA; Tiger Profiles, UAE) Modules (Jinko, China; Solon, Germany; Almaden, UAE/China; Dusol, UAE) Cables (ABB, Switzerland/Sweden; Ducab, UAE)

Source: Power-technology (2017); Author's interviews

Table 4.3 shows that foreign companies maintain a competitive edge, allowing them to create value through technological rents. In terms of module technology, foreign firms such as the American company, First Solar, possess an advantage reflected by market selection. Of the major solar projects in the country, First Solar provides its FS Series 3 Black PV module to three different projects in the two main emirates – Masdar City Solar Plant (Abu Dhabi), MBRAM Solar Park Phase I (Dubai), and MBRAM Solar Park Phase II (Dubai) (DEWA 2019). Most recently, Canadian Solar's double-glass Dymond modules were selected for MBRAM Solar Park Phase III, thereby highlighting the technological rents captured by North American companies. Although the UAE has solar module producers in DuSol Industries LLC and Almaden Mena FZE, these modules have yet to be selected for utility scale solar projects. Similarly, the substation construction (ABB/Switzerland), inverter technology (AEC/Saudi Arabia, KACO New Energy/Germany), and poly silicon technologies (REC Silicon/Norway, IDEA

Polysilicon/Saudi Arabia) utilized in the UAE's solar industry stem from foreign suppliers. One area where the UAE has successfully captured value through technological rents is through the local production of mounting structures for solar modules. Both Al Jazira Metal Industries and Tiger Profiles represent important local businesses within the industry. Additionally, the local emergence of Ducab as a prominent cable provider has further boosted local value creation.

A second axis of value creation concerns *organizational rents* whereby firms create value through optimal decision-making strategies. According to key informants, the UAE's solar industry is marked by low profit margins; therefore, cost cutting represents an essential means of maintaining competitiveness. Traditionally, firms may create organizational rents by lowering the costs of their material inputs or labor. In the UAE's solar industry, lowering the cost of material inputs is difficult as firms must select from an approved list of products and suppliers. The acquisition of human capital is the primary means of staying competitive and collecting organizational rents.

Within the emerging industry, key informants highlighted three primary means through which firms can create organizational rents through their hiring practices. First, firms may decide to hire young, inexperienced talent able to perform necessary tasks, yet lack the experience necessary to command higher salaries. Although a few firms have adopted this approach, the vast majority of respondents shared their concerns about the local development of young human capital (see 5.2.1 A Very "Green" Labor Market). Second, firms capture rents through differential hiring practices of certain nationalities to certain positions. As discussed elsewhere (see 5.3.2 Local Outcomes of Firm Decisions), firms (re)produce existing labor market divisions through their hiring strategies, thereby mirroring the labor outcomes present in other industries (Ewers and Dicce 2016): skilled Western expatriates are hired for management level positions, mid-level positions are filled by those from Arab countries, and lower level positions are filled by skilled labor from Pakistan, India and the Philippines (A2, S5). The differences in wage expectations allows firms to source the necessary talent while maintaining small profit margins. Lastly, respondents argued that there is greater need for dynamic skilled talent able to accomplish an array of tasks. The Solar Head of a major local firm highlighted this need while reflecting on his own firm:

> One of the issues I see is that companies, including mine, hire too many people. I oversee over 100 people, but I don't need that many. Give me half or even a quarter of that staff from Europe and we could do an even better job…People would rather hire a lot of workers at very low salaries than only a few at very competitive salaries (G1).

From a labor recruitment perspective, there is an industry-wide shift towards those skilled individuals with experience in and exposure to the broader life cycle development of solar projects. A labor recruiter shared that firms are willing to pay a premium for those with demonstrable technical and business skills who are able to fill several firm needs. Meanwhile, he noted that the demand for those with only a particular expertise has declined (S5).

A third area of value creation entails the creation of *relational rents* whereby firms create value by leveraging relationships and collaborating with key actors in the production network. Table 4.4 displays the survey response data for firm collaboration. Both foreign and local firms highlighted the importance of collaborating with the national utilities – ADWEA and DEWA. Although collaboration with the government is likely in part due to the certification and approval process, several respondents pointed to other rationales for maintaining close relationships with government entities. The CEO of one consulting firm argued that these relationships allow certain firms to create value:

> Projects are not awarded based on merit. They are awarded based on more political things. *Wasta*[5] is a thing! You can have a lower cost project, as low as one fifth of another project, or a better-quality project and still lose the project because someone else had a connection. It is not a meritocracy and it can be very frustrating from a business perspective (S3).

Both foreign and local firms acknowledged the importance of relationships for creating value in the UAE's solar industry. Many foreign firms shared frustration that local firms whom they believed were less qualified or had suboptimal proposals were still selected based on their connections. One firm shared that they had recently hired a well-connected but non-solar employee for the explicit purpose of creating relational rents (A4). Meanwhile, local firms offered that the ability to leverage these relationships to create value was less about *wasta* and more about understanding the bureaucratic inner workings of the government which allows projects to move faster (G1, Y1).

[5] The respondent asked me to circle and underline *wasta* several times in my notes. *Wasta* is best translated from the Arabic to English as "clout" or "who you know" but is often associated with nepotism.

Table 4.4 Firm collaboration

	Do Not Collaborate	Collaborate with Infrequently	Collaborate with Moderately	Collaborate with Intensely
DEWA	4.5%	15.9%	27.3%	52.3%
ADWEA	27.3%	25.0%	25.0%	22.7%
Other Solar Energy Firms	6.8%	22.7%	47.7%	22.7%
Masdar	29.5%	18.2%	31.8%	20.5%
ADNOC	43.2%	18.2%	18.2%	20.5%
IRENA	29.5%	22.7%	34.1%	13.6%
UAE University	45.5%	20.5%	20.5%	13.6%
Mubadala	38.6%	27.3%	20.5%	13.6%
ENOC	45.5%	20.5%	20.5%	13.6%
Ministry of Energy	29.5%	18.2%	38.6%	13.6%
Petroleum Institute	59.1%	15.9%	13.6%	11.4%
Dubai Supreme Council of Energy	36.4%	20.5%	31.8%	11.4%
IPIC	62.8%	14.0%	14.0%	9.3%
Abu Dhabi Investment Authority	56.8%	15.9%	18.2%	9.1%
Other Universities	43.2%	27.3%	20.5%	9.1%

Interestingly, the survey and interview responses highlight two sectors which have surprisingly little collaboration with the emerging solar sector. First, local universities rank particularly low in terms of collaboration with firms. Masdar remains a central actor and collaborates moderately or intensely with 52.3% of the survey population, yet two-thirds of firms surveyed have little or no collaboration with UAE University, three-quarters have no collaboration with the Petroleum Institute, and 70% have no collaboration with other UAE Universities – including University of Sharjah. Many of the key informants argued that the local universities are failing to train human capital necessary for solar energy development (see 5.2.1. A Very "Green" Labor Market). Yet, several informants argued that industry needs partner with firms to produce better quality, low cost labor able to meet the growing demands of the sector (W1).

Second, the country's national oil producers, ADNOC and ENOC, are rare collaborators with solar firms, despite their importance to the UAE's energy production. Despite their primacy in the energy industry, the domestic oil majors play small roles in the development of solar energy and rarely collaborate with solar energy firms. Over 40% of respondents shared that their firm rarely, if ever, collaborates with ADNOC and ENOC. Although several firms noted that the oil companies have started to enter solar (K2, M2, S6, W1), much of the interest and investment has gone towards covering existing petrol stations with solar panels (*The National* 2017). For some, the lack of collaboration stems from the global prominence of the UAE as a hydrocarbon superpower. These individuals argued that while solar can provide electricity domestically, it offers little beyond the UAE as an economic base; therefore, ADNOC and ENOC have little interest (M2). Yet others noted that prominent global oil companies – Total, Shell, etc. – are collaborating intensely and lending their energy production expertise to the emerging solar energy companies (J2). The divide between global and domestic oil companies stems from the domestic and shareholder context of each entity. The Chief Operating Officer of one solar firm noted:

> All of the oil companies are starting to wade into solar. European oil companies, in particular, are expecting revenues to decline. In order to maintain their current revenue levels, they must diversify their portfolio. Increasingly, this also means they must internationalize these efforts, leading to a global patchwork of projects and investments in various forms of energy. The local oil companies – ADNOC and ENOC – don't face these same pressures and continue to be inward facing. There is a lack of long-term strategic thinking in this regard as oil revenues will not last forever. As a national oil company, however, their leaders are not beholden to shareholders so the mentality is different (S6).

For this, and several other informants, the nature of nationalized oil companies negates the need to pursue diversification strategies to maintain revenue streams. Although it is growing, several of the firms noted that the solar sector remains comparatively small and that the low profit margins are "basically peanuts," in the words of a foreign renewable energy specialist (D1), to the oil majors. As such, the national oil companies have largely remained uninvolved in the development of the solar industry.

A fourth component of value creation concerns the extraction of *brand rents*, which examine how certain companies are able to leverage their reputation through the creation of brands. The creation of a brand allows the company to capitalize on its reputation and obtain higher rents for similar products. Table 4.3 highlights the major brands used in the UAE's solar energy sector and many of these brands are international. The interviews, however, revealed a larger geographic brand that certain countries or regions have been able to create. Rather than refer to brand names, respondents would often speak of the quality and cost-effectiveness of Chinese solar panels (A1, A2, B1, M1, M2, M4, J1, S3, W1) or German inverters (A1, A2, A4). The creation of geographic brands has allowed certain regions to create and capture value in the UAE's solar industry. One key informant (A2) shared that customer perceptions of brand quality often impacts decision-making. He noted that, "They may say that they only want solar parts from one place or company. The government, for example, only wants German brands. They believe these brands are best for their projects." Reputation and origin cuts both ways, however. One CEO argued that consumer biases also impact reputation, noting, "We get our panels from China and Taiwan; however, some people have a bias against products from Southeast Asia. They think they aren't as well made. In this case, we get panels for these customers from South Africa because they make good products at low costs." The association of product quality and product origin is well documented in the academic literature (see Thakor and Lavack 2003) and appears to have reproduced in the UAE's solar sector. Both European countries and China have successfully created quality reputations and are thereby better able to create and capture value through brand rents.

Lastly, actors in the UAE's solar GPN create value through *trade policy rents*. These rents refer to the ability of firms to create value as an outcome of local, national, or global trade policies. Within Abu Dhabi and Dubai, all solar inputs used in projects must come from ADWEA's and DEWA's list of approved and certified products. Table 4.5 summarizes the national origins of approved solar panels and inverters in the UAE.

Table 4.5 Approved solar products by origin

Solar Panels				**Inverters**	
Austria	1	Jordan	1	Germany	4
Canada	1	South Korea	3	China	3
China	39	Spain	3	Italy	2
Croatia	1	Switzerland	1	USA	1
Germany	14	Taiwan	3	France	1
India	10	UAE	3		
Italy	4	USA	8		
Japan	4				

Source: DEWA (2018)

Due to the exclusionary nature, the product approval process acts as a non-tariff licensing barrier which allows approved firms to create value. Although foreign solar companies enter the UAE market with preferred products, they often have to adapt to the local context as the approval process for new products can be both expensive and time consuming. As an individual at a foreign company explained:

> Normally we use panels from Germany. They are of excellent quality, but these panels are not approved here. It costs about €20,000 to get the products tested and certified by DEWA. Our choice is to either pay that cost or make do with that is available. In the past, we would want these panels, but now I say, "okay, we can use the approved ones because they are cheaper" (A4).

Firms able to navigate the costly and time-consuming approval process are then able to generate rents and create value through their special status. In particular, approved products from select countries further reinforce the brand quality and geographic origin through certification from ADWEA and DEWA and subsequent availability.

4.2.2 Value Enhancement

This section charts the enhancement of value within the GPN. Broadly speaking, value enhancement examines the transfer of technology, how and whether lead firms engage with suppliers to improve overall product quality and changes in demand for highly skilled labor (Henderson et al. 2002). The UAE's solar GPN reveals that actors engage in value enhancement through their collaboration with both universities and suppliers. Industry organizations, such as MESIA, enhance value through their collaboration with local government. In particular, the industry organization publishes reports detailing the latest standards, certifications, and technological innovations central to the industry (MESIA 2018). Through these efforts, MESIA is able to enhance value through collaboration with ADWEA and DEWA to increase standards and put forth best practices.

A second means through which value could be enhanced in the local solar GPN through the supply chain and local manufacturing. Although the UAE has access to Tier 1 suppliers, respondents noted issues concerning stock and supply times. One respondent shared frustration about the availability of key components, noting that lead times still exceed twelve to eighteen weeks in some cases (J1). Long lead times create an opportunity for value enhancement through better coordination of the supply chain to increase the speed of installation. Local manufacturers, then, have an opportunity to capture value due to immediate availability and convenience of their products, yet respondents were skeptical that this could be accomplished. A Senior Project Engineer pointed to the quality of local solar panels:

> … there are really only two solar producers in Dubai. I think that one is about to close because their panels are not of good quality… In terms of price, they are comparable to Jinko, but the quality isn't there. The other supplier has panels of good quality, but I often find panels quality panels for much cheaper from international sources. It is tough for them to stay competitive (O1).

Others (K2, M1, M2, W1) shared similar sentiments arguing that if the consumer and firm confidence in the durability and efficiency of panels increased or the cost of quality panels decreased, they would prefer to buy locally – yet not all products are locally produced, such as inverters (A4, J1, J2, M1, O1, S3, W1). The potential for value enhancement for local producers stems from a contractor preference to pay more for better quality with decreased lead times (J1, M1) or the ability of local producers to certify warranties, give customer support or technical help (M2).

4.2.3 Value Capture

The last element of value within the GPN concerns value capture. This analysis examines how and whether places are able to not only create and enhance value, but also capture it to benefit local areas. According to Henderson et al. (2002), value capture broadly encompasses state policies as well as issues concerning corporate governance and ownership. States, as the key regulating body, act as containers for economic activity (Dicken 2015) – dictating the "rules and regulations" by which economic activity is conditioned. The highly varied nature of state law and government forms leads to a wide array of national capitalisms within the global economy (Pontusson 2005; Lane and Myant 2006; Jessop 2006). More recently, "variegated capitalisms" is used as a nuanced means of incorporating sub-national and local forms of states control and conditioning into the broader patchwork of national capitalisms (Peck and Theodore 2007). Understanding the national and local manifestation of capitalism in the UAE grants insight as to how the country does (or does not) capture value within the emerging solar energy industry.

The UAE is a federal absolute monarchy composed of seven formerly independent British Trucial States. Today, the Federal Supreme Council – composed of the emirs of the seven emirates – oversees the governance of the federal government with all matters not outlined under the federal constitution delegated to the individual emirates. Despite broader regional turmoil, the UAE remains remarkably stable due, in part, to the creation of strategic domestic coalitions through redistribution of oil rents. These stakeholders, then, have a vested interest in the perpetuation of and support for the monarchy. Under the guidance of Sheikh Khalifa bin Zayed bin Sultan Al Nahyan (Abu Dhabi) and Sheikh Mohammed bin Rashid Al Maktoum (Dubai), the country has embarked on a period of unprecedented economic growth and diversification through the attraction and retention of foreign firms and skill. However, the country has created policies and procedures that ensure that the local citizens continue to benefit from the country's rapid growth and development.

For the UAE, sustaining the strategic coalition aligns with the means through which value is captured locally and is explicitly codified through legal ownership systems. For solar energy development, Federal Law No. 2 of 2015, "On Commercial Companies," serves as an important legal framework for corporate structure and incorporation within the UAE. While the law adds several new provisions, it maintains many of the principles and policies set forth in earlier legislation, particularly those concerning firm ownership. Under Law No. 2 of 2015, there are five classifications of companies: joint liability company, simple commandite company, limited liability company, public joint stock company, and private joint stock company. According to Title 1, Chapter 1, Article 10, "Rate of National Contribution," foreign companies must form a partnership with a local (i.e., Emirati) partners whereby the local partner maintains a 51% capital share. Although the profits may be split in a variety of ways, the designation of a local partner with 51% share capital creates a legal ownership of the local incorporation. The legal considerations surrounding incorporation present an opportunity for value capture.

Law No. 2 of 2015 contains two exemptions key to the solar energy industry. One exemption (Title 1, Chapter 1, Article 4, Section 1, Subsection C) shields for companies involved in oil or power generation in which the government – federal or local – maintains at least a 25% share of the company. Although far below the 51% stake for commercial companies, the 25% stake represents a key element of control for the government. As noted in Table 4.1, government-owned entities control large shares of all the major solar energy production companies. A second exemption (Title 1, Chapter 1, Article 5) is for firms incorporated within designated economic free trade zones. The establishment of free trade zones have played an important part in the region's efforts to spur economic diversification (Moore 2004). Complete foreign ownership, repatriation of profits, exemptions from both personal and corporate taxes, large energy subsidies and other business considerations have made these areas attractive business locations (UAE Free Zone 2018). These free zones have increased the competitiveness of the country while providing a limited economic liberalism contained to designated spaces. Although the Solar GPN does not identify the importance of economic free zones exempt from the provisions of Law No. 2 of 2015, almost 27% of respondent firms operate within these areas. Future research should investigate the role of these economic spaces in the local production of solar energy technologies.

Beyond geographic differences in the tariff schedule, respondents pointed to the varied incentives between nationals and expatriates and the capture of value as a key factor limiting solar investment. Similar to the geographic differences, the low electricity prices for nationals make solar non-competitive from an investment and savings perspective. One local solar expert noted that low electricity costs have thus far stunted the industries growth:

> The tariff price for electricity is too low here and needs to be addressed. You have two tariffs, one for locals and one for everyone else. For locals, the tariff is so low that solar isn't reasonable [profitable]. Some locals still want it [solar power], but they don't need it. Those that get it have it mainly for show. It covers maybe 10% of their energy costs, which isn't very much, but it looks green. It is for show. In general, the cost of solar is low, but the tariff price [for locals] is even lower. The government needs to remove or alter the tariff and then solar will thrive… Other customers, especially locals, are fine with the cheap subsidized energy and don't see the need for solar (K1).

With the exception of Dubai, the comparatively low electricity tariff for nationals in the other emirates– for example, 6.7 fils ($0.018 USD) in Abu Dhabi and 7.5 fils ($0.075 USD) in Sharjah, Ajman, Umm al Quwain, Fujairah, and Ras al Khaimah – means that nationals have little economic incentive to invest in solar installations. One individual shared that due to the low electricity costs, he rarely cites the financial benefits of solar installation when pitching to nationals – appealing instead to broader notions of assisting the government to achieve its clean energy goals (A2). In this way, it is perhaps best to promote the link of solar energy and national image (see 6.3 Climate Change and National Identity in Energy Transitions) than economic arguments (see 6.2 Economic and Technical Rationales for Solar Energy Transition).

Yet, the comparatively high tariffs for expatriates (26.8 to 30.5 fils in Abu Dhabi and 23 to 38 fils elsewhere) and for commercial/industrial properties means that demand for solar is present. Despite this, the uncertainty regarding international assignments and the time needed to see a return on investment complicate investment decisions. A local Dubai-based firm solidified this point, noting:

> There is an Emirati-expat divide. Expats don't know how long they will be here, so it makes the decision to invest difficult. The return on solar panels is as low as 6 years but many expats won't stay that long. For Emiratis, the tariff is so low that they won't invest for their homes and since the tenant pays the bill for the rental properties, they have no reason to invest either (Y1).

The lack of certainty and often transient nature of global assignments means that those with the greatest incentive to invest in solar – expatriates – are reluctant to invest. Respondent A2, ever the salesman, shared that his pitch to expatriate consists of likening solar to furniture. Although difficult to take with you when you move, it can be done. He has found this argument less than compelling, however, and finds that expats largely avoid investing in residential solar installations.

Respondents also shared that the commercial and industrial sectors face similar investment challenges. As firms shift towards a more flexible presence in the global economy marked by a divestment of fixed assets in favor of short-term contracts, the number of firms owning their properties has decreased (Dicken 2015). Although these structures are the source of flat roofs prime for solar installations (see 6.1.2 Open Spaces, Rooftop Places, and the Power Density Rationale), issues concerning ownership, utility payment, and incentives, create a lack of investment. One CEO argued that the mismatch of incentives between the owners of the property and the payer of the utility bill limits investment potential:

> Another issue is that the viable rooftop space for solar is often not owned by the inhabitant. In the residential sector, a lot of people are renting houses. In the commercial sector, many companies are leasing space. With both being uncertain how long they will remain in the UAE, businesses and people are reluctant to invest in a project that takes years to recoup. There isn't a strong incentive for them (S3).

Taken together, the transient nature of firms and labor in the UAE, coupled with variation in electricity tariff by geographic location and nationality, create a complex set of often contradictory incentives. Rather than driving investment in solar energy, the gap between individuals and firms with an incentive to invest (expats and commercial/industrial ventures), those with long-term locational certainty (nationals and local firms), and those who own the flat roof spaces (mainly nationals) creates an incentive mismatch. While altering the tariff schedule was almost universally recommended, respondents shared concerns about how the financial benefits of solar investment would be distributed. As one respondent noted, should the savings return to the owner of the property or go towards paying the current tenant's electricity (J1)? For the industry to develop further, these questions will need to be addressed.

4.3 Embeddedness in the Solar GPN

This section charts the functional and geographic positionality of actors operating within the UAE's solar GPN. In particular, it examines how this emerging industry is embedded in place as well as how the actors in the network are enmeshed in broader global circuits and networks. The findings demonstrate two themes. First, the UAE has successfully leveraged its ability to attract firms, learned through oil driven development (Ewers 2017), to create and maintain an emerging solar energy industry. Importantly, the attraction and retention of foreign firms and expertise connects the UAE with the broader global solar energy economy. Second, the UAE's strategic planning has moved the federal monarchy beyond simple connections to the global solar industry. The presence of firms such as the Abu Dhabi Future Energy Company (Masdar) increase the global profile of the UAE's solar energy sector and make the country a key player in the global renewable energy industry.

4.3.1 Territorial Embeddedness

Within the GPN framework, territorial embeddedness refers to how economic activities become enmeshed in, and take on the characteristics of, the places in which they locate. More than simply locating in a place, firms become a part of and reliant on the larger local community and labor market, often adopting the local norms and business standards (Coe and Yeung 2015; Faulconbridge 2008). Within the UAE, firms operating in the solar industry have largely reproduced the existing labor market dynamics and migrant division of labor through their differential hiring practices and preferences. Echoing findings from Ewers and Dicce (2016, 2018), respondents highlight a sorting of nationalities to certain employment levels – managers (Europe and Emirati), senior level (Arab countries and India), mid-level professionals (Philippines, India, and low-skill labor (Nepal, Sri Lanka, Pakistan and India) (A1, A2, A3, B1, G1, J1, K2, M1, M2, S3, S5, T1, W1, Y1).

Moreover, territorial embeddedness examines the degree to which firms are tied to a particular place and whether firms are likely to divest from the region, thereby becoming less territorially embedded. Although the survey and interviews did not elicit data concerning the degree to which firms are territorially embedded, they did collect data concerning past involvement and future plans for local solar development. Specifically, firms were asked to assess the present and future importance of various energy-related economic activities – solar energy, other renewable energy, other energy (non-renewable), solar product design and development, and solar energy consultation – to their firm. A Wilcoxon Signed-Rank Test indicated that median future ranks for "solar energy contracting" were significantly higher than median present ranks for all firms (Table 4.6).

Table 4.6 Wilcoxon signed-rank test for UAE firms

Local	**Foreign**	**All**
Solar Energy Contracting	Solar Energy Contracting**	Solar Energy Contracting**
Solar Energy Consultation	Ren. Energy (non-solar)	Solar Energy Consultation
Solar product design/development	Solar Energy Consultation**	Ren. Energy (non-solar)
Ren. Energy (non-solar) **	Solar product design /development	Solar product design /development
Other Energy (non-renewable)	Other Energy (non-renewable)	Other Energy (non-renewable)

Significance: * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table 4.6 further notes the foreign and local differences between how firms value the importance of each activity to their future. Foreign firms, in particular, project a significant increase in the portion of their firm activities dedicated to solar energy contracting and solar energy consultation. Meanwhile, local firms project a significant portion of their renewable energy (non-solar) activities to increase. In both cases, foreign and local firms projected solar energy contracting and solar energy consultation to remain at the same or higher level than the present. These findings suggest that, under current growth and economic conditions, firms will continue or increase their levels of solar activity in the UAE.

Foreign companies operating in the local solar industry were transnational firms whose primary interest is solar and renewable energy, according to respondents. For local firms, however, respondents noted that development of solar energy firms is an outcome of three types of firms, each connected to the GPN in different ways. The majority of local firms identified as solar-specific companies that entered the local solar industry as it developed. Beyond these firms, two different evolutionary trajectories are prominent in the UAE's solar GPN. First, respondents (J1, K2, M2, Y1) shared that their firm's involvement in solar was an outcome of local economic and competitive pressures. In each of these cases, the firm's primary economic activity was development and construction with solar representing an evolution of the firm. The Associate Director at a local firm noted that

> 3-4 years ago, we decided that the construction market was really competitive and we needed to find a niche. We explored a number of options and decided that we should open a solar division and focus on solar contracting… At the time, there was little experience in the industry, even more so in terms of contracting. As we entered the solar

business, we realized there are a bunch of players coming in as developers, consultants, designers, and financiers but very few with contracting ability (J1).

For these companies, the perceived deficiency of contractor skills required to carry out solar energy installations coupled with growing competition in the domestic construction market provided an opportunity to diversify firm activities and enter into a new sector. Several firms attempted to internationalize their operations (K2, M2, Y1) yet have diversified into solar to remain competitive in the local market.

A second trajectory was described by interview respondents (G1, K1, W1) who shared that their firms (predominately electromechanical companies) are primarily involved in the energy sector — and have since added solar as part of their firm offerings. In the UAE's solar sector, electromechanical firms represent a significant portion of the approved solar companies (19 firms). Respondents from these firms shared feelings that the development of solar is not difficult as they see it as an extension of the electrical work they already perform. Rather than a new industry or sector, several of the respondents viewed the growth of solar as a diversified product which electromechanical companies are best suited carryout. Low profit margins make firms see solar as a "favor" for clients (G1, K1) in conjunction with their broader projects.

4.3.2 Network Embeddedness

The concept of network embeddedness within the GPN refers to the interconnectedness of actors both to each other as well as to the broader transnational solar GPN. As the central actor within the UAE's local GPN, the state demonstrates key areas of network embeddedness both within the local GPN and within the broader global solar and renewable energy economy. The GPN analysis demonstrates the importance of the government as the key actor in the local solar production network, as well as the broader, global solar production sphere. The analysis of network embeddedness demonstrates the centrality, presence, and influence of the government at each stage of the local GPN. More specifically, the government occupies key roles as a major financier (ADIC maintains a 70% ownership of the National Bank of Abu Dhabi), as a regulator and offtaker (through ADWEA, DEWA, SEWA, and FEWA), as a research provider through (Khalifa University, Masdar, and University of Sharjah), and as a consultant and contractor (through Masdar, Etihad ESCO, and Environmena). Although the government is notably absent in several key areas – industry groups, module manufacturers, and balance of system providers – government entities work intensively with these parts of the production process, exercise power, and create value through their regulatory functions and consumer preferences. In sum, the emerging industry's GPN represents a high degree of vertical integration as the government assumes key roles at almost every stage of the production process.

From a global perspective, the UAE government is increasingly integrating into the global renewable energy GPN through Masdar. As of 2019, Masdar has assisted in projects in over 25 countries and installed a solar capacity of over 476 MW and a wind capacity of 1,466 MW (Masdar 2019). Despite importing the knowledge necessary for domestic solar energy production and relying on foreign firms for utility scale installations, the UAE is increasingly exporting renewable energy expertise to places around the world.

4.4 Conclusion

The solar GPN analysis revealed several key insights into the major actors, connections between various parties, and obstacles to future development through an analysis of power, value, and embeddedness. For the UAE's solar energy industry, the government remains the primary industry actor. Despite the lack of linkages between the emerging solar energy industry and the mature, state-owned oil industry, the government maintains a strong presence in solar energy. Analysis of corporate and institutional power in the UAE's solar GPN reveals the centrality of the state through its importance to financing, tendering, and constructing projects, as well as through its legislative ability to alter tariff schedules, sanction net metering, and its function as the primary electricity offtaker. Analysis of network embeddedness additionally shows the importance of the UAE to the global renewable energy industry. Through its controlling holdings in Masdar, the UAE has helped finance, design, and construct almost 2 GW of solar and wind energy capacity in more than 25 states. Although the research focuses on the domestic development of solar energy, it is clear that the UAE deploys expertise and knowledge through its state-owned enterprises. Yet, the state is only one of the important actors in the UAE's emerging solar energy industry. Analysis of collective power in the GPN revealed that transnational industry groups, such as MESIA, exercise considerable influence through their ability to lobby local governments to enact favorable solar energy regulations and to increase local standards and training. In terms of value, private firms have worked to create, enhance, and capture value through leveraging their strategic locational, technological, and technical advantages.

5 NEGOTIATING GLOBAL AND LOCAL SOLAR LABOR MARKETS

This section outlines the findings of the mixed-methods survey and interview portion of the research. The survey portion of the research granted insight into the firms' perspectives of local labor markets, skill availability, and hiring preferences and practices. Interviews (n = 24) shed light on the emerging labor and skill considerations for the emerging solar industry. Labor related issues were the second largest code, covering approximately 23% of the qualitative data. The respondents provided nuanced insight into the global solar labor market, how the state accesses the labor required to design and construct solar installations and how foreign and local firms adapt to local labor market contexts. The outcome of this multiscalar labor recruitment process is a highly varied labor market which (re)produces existing market dynamics through adaptation to a new and emerging industry.

Coding revealed three themes. First, respondents noted the individual preferences underpinning the large expatriate contribution to the growth and development of solar energy. For many, the UAE's development of solar energy provides a unique access to opportunity from a personal and career development perspective, allowing participants to gain experience or serve in positions not available in their home country. Second, firm hiring practices broadly reproduce existing migrant divisions of labor. Rather than representing a new labor market trajectory, the development of the solar industry exists within, and largely reproduces, the status quo through differential hiring of certain by workers to positions (Ewers and Dicce 2016). Lastly, key informants provided nuanced understandings of the skills and human capital necessary for the creation of a domestic solar energy industry. The supply of qualified workers both locally and globally combined with local demand reinforces existing hiring patterns. More specifically, respondents identified skill, knowledge, and experience gaps present within the domestic industry and how local firms, universities, and government seek to address these short comings. Taken together, the interview data supports the expected findings of a complex labor market predicated on foreign labor and conditioned by local hiring practices and individual decision making.

5.1 Quantitative measures of human capital in the UAE's solar sector

This section charts the survey response data from the quantitative portion of the research. Firms were queried using a survey instrument concerning their employees' skill and education levels, their perceptions of the local labor markets, and their hiring and recruitment practices.

5.1.1 Knowledge requirements for solar energy development in the UAE

Survey respondents were asked to provide information concerning the skills and knowledge necessary for employment in the UAE's growing solar energy sector. In particular, respondents were asked to rate the importance of a variety of communication, business, and technical skills to the industry. There were no significant differences between how foreign and local firms rated the importance of each skill. Table 5.1 displays the respondent ranking of each skill subset for each of the broader skill set categories (communication, business, and technical skills).

Table 5.1 Skill requirements of solar energy professionals

Technical Skills	**Important**	**Neither Important nor Unimportant**	**Unimportant**
Technical engineering	100%	0%	0%
Computer skills	94.9%	5.1%	0%
Analysis/synthesis skills	84.6%	15.4%	0%
Product design skills	69.2%	23.1%	7.7%
Math and stats skills	65.8%	26.3%	7.9%
Research/development skills	53.9%	33.3%	12.8%
Programming skills	38.5%	30.9%	30.8%
Communication Skills	**Important**	**Neither Important nor Unimportant**	**Unimportant**
English fluency	100%	0%	0%
Presentation skills	92.3%	7.7%	0%
Written/verbal skills	89.7%	10.3%	0%
Multilingual	74.4%	18%	7.7%
Arabic fluency	28.2%	59%	12.8%
Business Skills	**Important**	**Neither Important nor Unimportant**	**Unimportant**
Problem solving skills	97.4%	2.6%	0%
Teamwork skills	97.4%	2.6%	0%
Leadership skills	87.2%	12.8%	0%
Managerial/supervisory skills	87.2%	12.8%	0%
Critical thinking skills	87.2%	10.5%	2.6%
Marketing skills	61.5%	25.6%	12.8%

Interestingly, respondents rated technical skills as the least important of the three categories. Within the skill set, technical engineering was rated as the most important skill set with unanimous agreement amongst firms (51% of firms rated it “Extremely Important”). This is not altogether surprising as these skills represent the key engineering skills necessary to carry out the day-to-day operations of solar energy firms. Computer skills, in particular Computer-Aided Design (CAD)[6], rated as highly important amongst solar energy firms, yet computer programming was considered unimportant by 30.77% of the surveyed firms. Despite the importance of design-based software, only 69.23% of respondents rated product design skills as important.

[6] This information came from the interviews rather than the survey.

Respondents rated communication skills as the second most important set of skills. Both the ability to present (92.31%) and proficient written and verbal communication skills (89.74%) rated very highly. The premium placed on these skills likely reflects the importance of communicating the potential costs and benefits of solar energy technology adoption. During the interview portion of the research, respondents shared their experiences and frustrations with customer decision making (see 6.1.2.2 Smart Investments, Solar Suitability, and Technological Adaptation). Individuals who possess effective presentation, written, and verbal communication skills are highly valued due to their potential to assist firms in overcoming these barriers. In terms of language skills, respondents unanimously agreed that English fluency is an essential skill for success in the industry. Although Arabic is the country's official language, it rated last among communication skills with only 28.21% of respondents believing Arabic fluency to be important. Interestingly, being multilingual (74.36%) rated higher than Arabic fluency. From the survey data, it is unclear why this is the case; however, interview respondents highlighted the need for employees to speak the language of business – predominately English – and have proficiency in the languages spoken by the labor force – predominately Hindi, Urdu, Tagalog, and Bengali.

Business skills rated as the most important skill set amongst respondents. Respondents rated leadership skills and managerial and supervisory skills equally. The premium placed on these skills is at least somewhat unexpected given the low number of managers employed at solar energy firms (see 5.1.2. Current Labor Pool and Firm Perspectives). Both teamwork skills and problem-solving skills were rated as highly important (61.54% of respondents rated both of these skills as "Extremely important"). Teamwork, in particular, was stressed in the interview portion of the research. One respondent explained how his firm looks to construct a solar energy team of professionals:

> We try to find people who have broad experience in a number of different areas. We look for those with training in electrical engineering, solar experience, civil engineer, and experience working with the local authorities…With this mix of people and experience, we try to build a long-term team of professionals. We offer them additional training so that the team is well-rounded and technically sound (Y1).

The respondent further shared that this team approach is essential to their business structure as it strengthens the quality of their offerings and ensures long-term stability as the firm is not dependent on the skills of only a few individuals.

In addition to the necessary skills for solar energy employment, respondents were queried about the university degrees of current employees and the necessary coursework for future market entrants. Considering respondents from firms operating in the UAE, 90% stated that their employees had obtained degrees in electrical engineering. This finding both supports information gleaned during the interview process and sheds light on the educational and skill challenges facing the emergent industry. While several respondents highlighted the importance of electrical engineering as a key knowledge base for the industry and as the foundational coursework needed (see 5.2.1 A Very "Green" Labor Market), others argued that the reliance on a broad educational field neglects the specificities pertinent to solar energy. Respondents highlighted the presence of mechanical engineers (43%), engineering systems and managers (29%), and sustainable infrastructure specialists (18%) in addition to electrical engineers in the local labor pools.

The survey further elicited data concerning the coursework deemed necessary for success in the UAE's solar energy sector. Using Pasqualetti and Haag (2011), the survey obtained information concerning firm perspectives on essential coursework and training necessary for success. The results are displayed in Table 5.2. Mann-Whitney-Wilcoxon Signed Rank Tests were performed to determine differences between foreign and local firms and to assess potential differences between an established solar industry sector in the American Southwest (Pasqualetti and Haag 2011) and the emerging solar sector in the UAE.

Table 5.2 Course requirements for solar energy professionals in UAE

	Local		Foreign		Total
1	Solar engineering principles	1	Solar engineering principles	1	Solar engineering principles ***
2	Power electrics (AC/DC power conversion)	2	Power electrics (AC/DC power conversion) *	2	Power electrics (AC/DC power conversion)
3	Solar applications: Industrial	3	Solar applications: Industrial	3	Solar applications: Industrial
4	Solar energy and sustainability	4	Solar energy and sustainability	4	Solar energy and sustainability**
5	Solar energy and society	5	Solar Energy Policy	5	Solar Energy Policy
T6	Solar energy finance	T6	Solar energy finance	T6	Solar energy supply chain and logistics
T6	Solar energy policy	T6	Solar energy supply chain and logistics	T6	Solar energy finance
8	Solar energy supply chain and logistics	8	Solar energy and society	8	Solar energy and society**
9	Solar thermal power systems	9	Solar thermal power systems	9	Solar thermal power systems
10	Semiconductor theory	10	Semiconductor theory	10	Semiconductor theory

Significance: * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Both foreign and local firms demonstrated preferences for those individuals with training in solar engineering principles, power conversions, industrial solar applications, and energy and sustainability. Although the ranking differs slightly between foreign and local firms, only power electrics (AC/DC power conversion) is significantly different with foreign firms placing a higher importance on that skill. When compared with the data from Pasqualetti and Haag (2011), however, a number of significant differences emerge. Although solar engineering principles remain important, firms in the USA placed a higher degree of importance on this skill set. This is not to say that firms operating in the UAE's solar industry do not value solar engineering principles, rather it is likely a reflection of firm perceptions of the local labor market (See 5.1.2. Current Labor Pool and Firm Perspectives). While respondents highlighted the importance of solar engineering principles, few believed that the employees will receive the necessary training at local (18%) or foreign (21%) universities. Respondents were further asked where their employees will receive the training necessary to carry out job expectations (Table 5.3). Since 92% of firms provide on-the-job training for employees, the significant difference in importance for solar engineer principles could reflect the expectations for solar firms working in the UAE. Interestingly, there exists significant differences for both solar energy and society and solar energy and sustainability with the UAE placing a higher importance on both sets of knowledge. It remains unclear why this difference exists, yet it may speak to national identity rationales for transition (see 6.3. Climate and National Identity in Energy Transitions).

Table 5.3 Response to question: "How will new solar energy employees be trained?"

Training Type	
On-the-job or on-site training	92%
Off-site training within the Gulf (GCC)	29%
Training internationally (outside of GCC) at another branch of your firm	29%
Training internationally (outside of GCC) at a different firm	26%
Courses outside of the GCC at foreign universities	21%
Courses at local universities	18%

5.1.2 Current labor pool and firm perspectives

Respondents were asked questions concerning their employee composition, the current state of the local labor market, and the future labor needs of the industry. In particular, respondents were asked to share their perspectives surrounding employee education, experience in the region, and how well the current market meets the labor demands of a growing industry. Surveyed firms in the UAE tended to have smaller employee bases. While several solar energy firms had hundreds of employees, these firms often did not specialize solely in solar energy production. Rather, these firms were large local and multinational organizations who had opened solar branches to capitalize on the growing solar industry (see 4.1.3.1. Territorial Embeddedness). The majority of firms had far smaller numbers of employees. The median number of employees per firm was 45 in the sample and an average of 45% of these employees directly involved in the production of solar energy. Despite the rapid growth in solar energy, Emirati participation in the solar energy labor force remains low (median = 3%). Moreover, 69% of firms reported that fewer than 5% of their employees are Emirati. These findings appear to confirm the qualitative data findings (see 5.2.2. The Local (Emirati) Labor Market), yet grant little insight into the types of jobs Emiratis at solar energy firms hold. The survey findings support decade-old findings regarding nationwide employment trends for Emiratis: the citizen content of the solar power labor force is similar to mining and quarrying, health and social work, and real estate, renting and business activities (Labor Force Survey 2009). Interestingly, the content of Emirati workers employed in solar is higher than 2009 government figures for electricity, gas, and water supply, but further research is needed to uncover the underlying reasons.

Respondents were queried concerning their perceptions about the state of the current labor market. In particular, respondents from foreign and local firms were asked about the availability of employees with the necessary knowledge, whether new employees possessed previous solar experience, and whether firms would provide the necessary training on-the-job (Table 5.4). 75% of respondents agreed that the UAE has a shortage of potential employees with the necessary engineering knowledge and 68% agreed that few new hires have prior training in solar energy. These results largely support qualitative interviews, in which respondents shared frustrations concerning the lack of qualified labor locally available (see 5.2.1. A Very "Green" Labor Market). The shortage of qualified potential employees resulted from shortcomings of the local university system, which has fallen behind industry demands and failed to adequately train graduates.

Table 5.4 Responses to question: "To what degree do you agree with the following statements?"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
There are shortages of potential employees with engineering knowledge in solar technologies	41%	34%	7%	16%	2%
New hires that lack formal solar training will learn the appropriate skills with on-the-job training	30%	55%	11%	0%	5%
Before hiring, few of our solar engineering workforce had specific solar energy training	32%	36%	20%	9%	2%

Yet the majority of employees with a four-year (71%) or Master's (55%) degrees – the two most popular employee educational levels among respondents (Figure 5.1) –obtained their qualifications abroad. While the high presence of employees who obtained their degree abroad may reflect negative firm perception of local university training, 85% of survey respondents agreed that new hires, regardless of where they obtained their degree, would learn the appropriate skills through on-the-job training. Although the survey and interview respondents agreed on the need for on-the-job training, this finding speaks to a broader knowledge gap within the local industry. As the majority of new hires obtained their credentials abroad, the blame for an inexperienced and skill deficient labor force cannot fall solely on local universities. Rather, it reflects larger skill and experience gaps both for those who are trained locally and those recruited to the region by firms. This is further supported by the significant portion of employees with Master's degrees who obtain these degrees locally (45%). This finding runs counter to firm perceptions of local university offerings. A plausible explanation could be that firms hire workers internationally, who then receive further education once employed in the UAE to advance their careers. Further research is needed to confirm or deny this explanation.

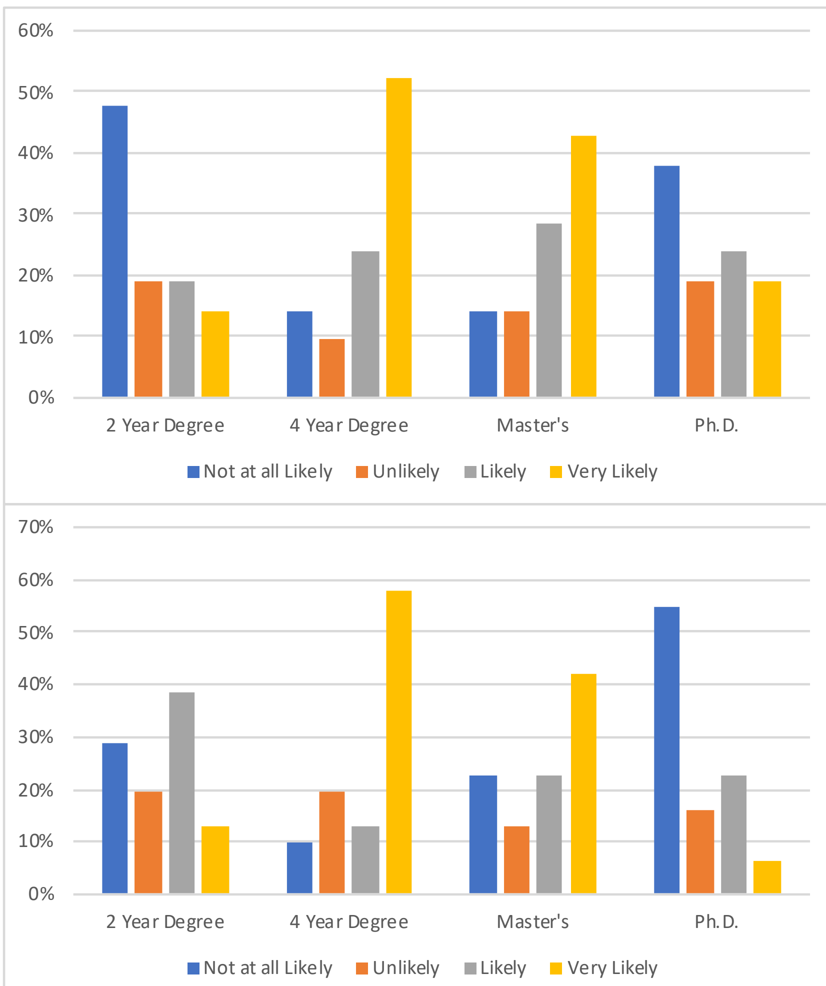

Figure 5.1 Likelihood that an employee specializing in solar holds the following degrees
Top: Foreign firms. Bottom: Local firms.

In addition to questions concerning the knowledge and coursework necessary for employment in the industry, respondents were queried about the educational attainment of their current employees. Figure 5.1 displays the educational attainment of employees at both foreign (top) and local (bottom) firms. Although firm responses highlighted the importance of education at each level, the majority of firms highlighted the likelihood that employees hold either a 4 year or Master's degree. This was consistent for both local and foreign firms. Although it remains unclear which fields correspond with which degrees, the qualitative data grants some insight into firm preference. In particular, respondents noted the preference for those with a background in electrical engineering who then obtain a solar energy specific Master's degree (W1).

5.1.3 Labor Recruitment and Firm Hiring Practices

The firm survey obtained information concerning firm recruitment practices and hiring preferences for current and future employees working in the UAE's solar energy industry. In particular, firms were queried about their hiring preferences for various employment positions. The aggregated results for foreign and local firms are displayed in Figure 5.2. From the figure, it is clear that solar energy firms operating in the UAE search globally for talent. With the exception of executives and managers (foreign firms) and installation and maintenance (local firms), solar energy firms overwhelmingly search for talent both locally and internationally. The findings compliment the qualitative data, where 58% of interview respondents shared that their firms search internationally for talent as they perceive the local labor force to be small and inadequately prepared.

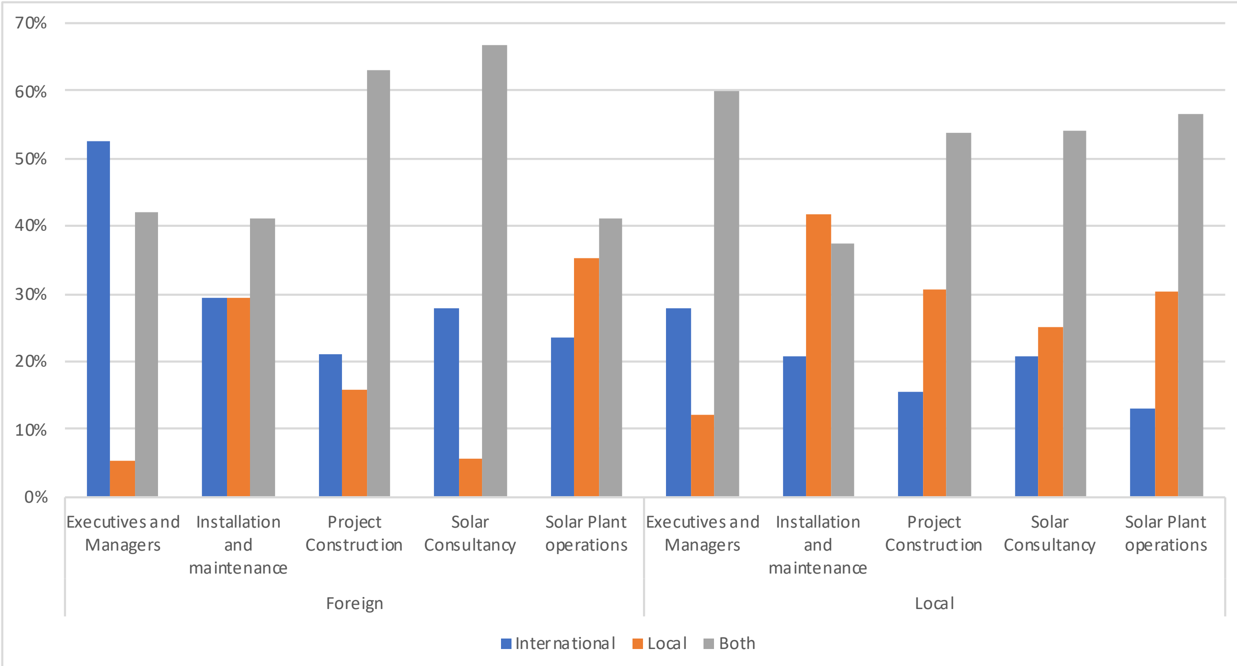

Figure 5.2 Summary of answers to survey question: "For which of the following positions does your firm always search internationally, locally, or both?"

Despite a general preference for searching globally for talent, several specific patterns emerge from the data. First, both foreign and local firms demonstrate a preference for searching internationally for executive and managerial positions. While local firms, on average, search both locally and internationally, neither foreign nor local firms demonstrate a preference for hiring locally for these positions. For foreign firms, the preference for international expertise in executive and managerial positions reflects the existing labor market divisions (Ewers and Dicce 2017) and the reproduction of firm work cultures (Faulconbridge 2008). Local firms, meanwhile, adapt to local employment and skill contexts while attempting to mirror the practices of international firms (Ewers and Dicce 2016). Second, firms operating in the UAE demonstrate local hiring preferences for both installation and maintenance and solar plant operations. Possible explanations for this local preference could be the availability of sufficiently trained local labor and the routinized process of installation and management of sites. Whereas business oversight and solar energy system design may necessitate global sourcing of talent, the installation and maintenance of systems is more straightforward, thus the skills necessary are more easily found locally. More broadly, the differential hiring preferences for various positions underscore the qualitative findings outlined earlier (see 5.3.1. Firm Rationales for Hiring Practices).

In addition to firm hiring preferences, the survey collected information about the local and regional experience of solar energy employees living and working in the UAE. Table 5.5 provides significant insights into the levels of solar energy employee experience. Firms were asked how long, on average, solar specialists had been employed in the UAE and in the broader Middle East (exclusive of time in UAE). According to respondents, approximately 62% of employees have been working in solar in the UAE for between one to five years, with 60% of employees having between one to five years of additional solar energy experience in the broader Middle East. The results reflect more limited international recruiting. Although firms are searching globally for talent, many of the employees possess significant experience in the broader GCC region. Rather than a purely global source of skilled employees, the UAE is accessing broader regional knowledge bases to build and sustain its emerging solar energy industry. The majority of respondents (72.7%) noted that previous experience working in the Middle East (non-UAE) was an essential consideration for new hires. This was higher than experience in North America and Europe (44.2%), South and Southeast Asia (33.3%) and previous experience working in the UAE (70.5%). Qualitative data collected during the interview portion of the research shed additional insight into the regional experiences of current solar energy employees. Prior to working in the UAE, several respondents shared that they had previously worked in Egypt (A3), Kuwait (A1, M2), Jordan (M1, M2) and Saudi Arabia (D1).

Whereas some of these employees possessed this experience as these locations represented their countries of origin (A3, M1), others gained regional experience as part of larger career arcs (see 5.4.2. Transnational Solar Mobility).

Table 5.5 Summary of answers to survey question: "How much experience does the average solar specialist have in the following locations?"

	UAE	**Middle East (non-UAE)**
Less than 6 months	2%	2%
6 months to 1 year	18%	16%
1 to 2 years	27%	27%
2 to 5 years	35%	33%
Greater than 5 years	18%	22%

Further supplementing the solar energy experience findings are firm recruitment sources for solar energy employees. Respondents were asked about their primary sources of new hires. A series of options, including a write-in option for other sources (12%), helped guide answers. Table 5.7 displays the recruitment sources for all firms (both local and foreign). At 44%, the primary source of hires for solar energy firms operating in the UAE is other solar energy firms outside of the Middle East. The recruitment of individuals from firms outside of the Middle East reflects how these firms access global circuits of labor to fill local skill needs. Yet, the high percentage of firms who source employees from other solar energy firms in the Middle East further supports the narrower regional recruitment discussed above. Moreover, this source of recruiting reaffirms the high percentage of employees with solar energy experience in the region. Beyond other solar energy firms, universities remain a large source of recruitment. The high content of firms recruiting from local UAE universities mirrors the findings of Figure 5.1 (see

5.1.2. Current Labor Pool and Firm Perspectives). While firms sometimes recruit from international universities, a larger percentage of firms recruit locally produced skilled labor.

Table 5.6 Recruitment sources for solar energy firms in the UAE

Recruitment Source	Percentage
Other solar energy firms outside of the Middle East	44%
Other solar energy firms in the Middle East (outside of UAE)	40%
Recruitment firms	40%
Local UAE universities	37%
Other solar energy firms in the UAE	35%
Universities in the Middle East (outside UAE)	26%
Energy (non-solar) companies in the UAE	16%
Energy (non-solar) companies outside of the Middle East	16%
Universities in South or Southeast Asia	16%
Universities in North America or Europe	14%
Energy (non-solar) companies in the Middle East (outside UAE)	9%
Oil companies	7%
Local government organizations	2%

5.2 Human capital endowment, skill gaps, and local production of knowledge

To better understand both individual preferences and firm hiring practices, it is first necessary to understand the local labor market dynamics and local human capital offerings. During the interview process, key informants offered a wide variety of opinions concerning the state of available human capital for solar energy production. As a young and emerging industry, respondents noted the comparative lack of both experience and skill locally available, and acknowledged that local universities are starting to fill these gaps. Small profit margins for solar power mean that decreasing labor costs is a key facet of local firms' strategy. The insufficient supply of adequate skill and experience, combined with a preference amongst nationals (Emiratis) for public sector work, has spurred demand, pricing many firms out of the available local human capital necessary to be successful. Together, these factors offer a strong rationale for why local solar firms seek to access global circuits of labor to fill experience and skill needs at affordable costs.

5.2.1 A very "green" labor market

With the merger of Khalifa University of Science, Technology, and Research, Petroleum Institute, and Masdar Institute in 2017, the UAE has only 15 universities (Abu Dhabi n= 4; Dubai n= 5; Sharjah n=4; Fujairah n=1; Ras al Khaimah n=1) offering 56 courses (mean = 3.7; median = 1) in renewable energy – of which, only 32% are solar-focused (Al Kaaki et al. 2015). Although the course offerings and number of enrolled students has increased dramatically – University of Sharjah has witnessed an incoming class size change of over 275% since 2011 (University of Sharjah 2018) – the impact on the labor has yet to be felt.

Throughout the interview process a majority of the respondents (13 of 24) shared thoughts concerning the immaturity of the local solar labor market and the need to develop a broader base of skills and experience to meet the demands of a growing market. Although 38% (5 of 13) of these respondents believe that the overall quality is improving, there was widespread belief that far more – especially improving the quality of the universities – could be done. In general, the lack of available skill and adequate experience was largely viewed as a function of the industry's recent emergence. The Associate Director of an international firm shared this frustration:

> Originally, we couldn't find what we considered to be appropriate technical personnel so we imported and recruited from outside of the UAE. In fact, as much as 50% were imported from the Philippines and Pakistan because they have very good solar experience. Since then, we've trained people in-house and do more contract work with

people in the UAE, but there is still a lack of experience and necessary skill for solar installation. We struggle with the general education of the workforce and it makes it hard to find competent personnel (J1).

The Associate Director's frustration at the lack of locally available skilled workers was shared widely amongst respondents (A1, A2, B1, G1, M1, O1, S3, S6, W1) and broke down along two narratives: 1) universities are failing to produce the appropriately skilled solar labor; and, 2) the lack of solar experience and particulars of solar power generated electricity result in substandard or costly outcomes. As a result of these experience and skill gaps, local firms have had to shoulder an increasingly large portion of safety and training.

In terms of local production of human capital, four of the key informants argued that the local universities are not adequately preparing the workforce for the demands of the industry. The Chief Operating Officer of one firm was well-positioned to speak about this as his firm has developed a reputation for hiring local graduates to fill positions in an effort to keep costs low. Despite this, he shared frustrations at the level of preparedness and general knowledge of students entering the workforce:

> I often try and ask students about the various benefits of CSP versus PV. Despite their education, a lot of students struggle with this. In my opinion, the local studies focus too broadly on renewable energy in general. They focus on wind, hydro, and solar but never really on the specifics of solar. The students end up with a broad background but don't have the solar-specific knowledge necessary for the industry… Something that has surprised me is the students' lack of knowledge about local solar developments. Most have heard that solar is ongoing but if I ask a question about the Shams program or MBRAM park, less than 5% know what I am talking about. How is it that their education

> hasn't informed them about what is going on in their own country? There needs to be relationships between academia and industry (S6).

The COO of this firm additionally lamented the inclusion of hydro and wind power in the local renewable energy curriculum as neither is significant – currently or in future projections – in the UAE's energy mix. In general, the COO (S6) does not believe in learning or receiving training beyond what is practically necessary for an occupation. This was made more explicit during our background interview where he challenged the usefulness of academia and a degree in geography – arguing that education should only serve the purpose of producing qualified workers (defined by what he sees as useful) and that additional training or other forms of education are wasteful. It is unsurprising, then, that he views training in wind or hydro energies as useless in the context of the UAE.

Similar to the COO, several respondents highlighted the lack of practical experience available amongst recent graduates. The lack of experience and practical training led one CEO to state that he would hire renewable and solar energy students as interns to give them experience but would not hire any recent graduates as he felt they were largely unprepared. Notions that "the education system is behind what the industry needs" (S3) in terms of skill production and that "the local universities aren't meeting the labor demands" (W1) were common. The result is that a portion of the interview population argued that a significant amount of their time and resources are dedicated to retraining the local labor force or helping them to gain meaningful work experience in the industry (A2, J1, S3, S6, W1). The division leader at one firm (respondent G1) shared that he views the development of solar energy professionals as part of helping the overall industry: "The industry here is still young. There are a lot of people from India and Egypt working in solar, but they don't have the experience or the knowledge. Our job is to give them that knowledge and to help them gain the experience." Not content to simply help those at his firm, he also shared that he had recently started teaching classes at a local university to help augment the skills of future industry professionals. Similarly, another Solar Division Head argued that there was a need to provide young professionals with practical experience opportunities, yet also a need for:

> people who receive an undergraduate degree in electrical engineering and then a masters in solar energy engineering … Electrical engineering is very broad… This way they are familiar with the core concepts but have solar specific training. We have people with a strength in one or the other, but few with strengths in both (W1).

Labor market concerns regarding expertise in either solar or electrical engineering was a common concern amongst solar energy professionals. As outlined in Section 3, a significant portion of solar energy companies operating in the UAE are current or former electromechanical firms venturing into the renewable energy market. For those respondents entering solar through electromechanical firm diversification, the application of existing knowledge and expertise to the new industry is unproblematic. For those respondents trained in solar, however, the application of existing electrical engineering skills is not as straight forward, as one respondent noted:

> There are lots of people – electrical engineers – working in solar without any previous experience in solar. The problem is that they were trained in and work in AC, but we work in DC. They make designs based on AC and this makes a problem down the road. Beyond that, I feel there is not enough understanding about the particulars of solar. When I ask some designers about the number of units they will need, the voltage, the amps, etc. and they don't know the answers. This is a problem, also, because it costs money. What capacity inverter do I need? Do I need the one that costs $10,000 or the one that costs

> $3,000? I see a lot of people who misunderstand the basic principles and how systems work. This leads to overestimating and high costs (A3).

For engineers with solar specific training, like respondent A3, the lack of basic solar knowledge is both dangerous for system designers and costly for potential clients. The need for qualified individuals with the appropriate backgrounds in solar design and installation was a common theme amongst interview respondents (A3, B1, O1, T1). More than just solar specific knowledge, however, key informants called for the development of more dynamic human capital able to address not only the solar design and installation, but also the business operations of the firm (A1, B1, O1, S5, W1).

While negative views concerning the skill and competency of the local solar labor market were widespread, this view was not unanimous. A quarter of the interview population argued that both the education system and the local labor market have made significant strides and now offer access to highly qualified human capital. Whereas the necessary skill and experience may not have been available in the past (M4), the growth and development of the industry has created, attracted, and sustained a highly capable local labor market (A2, B1, J2, M2, M4, S5). In Dubai, DEWA has played a large role through its certification of Junior and Senior Solar PV Experts. The program requires those working in the solar energy field to obtain an appropriate degree, gain experience working on the design, building, and verification of solar plants, as well as additional practical work experience (DEWA 2018b). For the interview population, this system created local standards through regulating labor while also increasing consumer confidence through enforcement (A2). The result is an increasingly competent (J2), qualified (J1), and credentialed (B1, M2) workforce from which firms can draw.

5.2.2 The local (Emirati) labor market

A significant amount of literature has noted the local labor market divide in the UAE, characterized by a split between nationals employed in the public sector and expatriates employed in the private sector (see Forstenlechner and Rutledge 2010; Shah 2008; Randeree 2009). Traditional analysis of the local labor market reveals a labor market characterized by public sector-seeking locals (Randeree 2012) and private firms reluctant to hire nationals due to a myriad of reasons (Forstenlechner et al. 2012). On the surface, some respondents argued that UAE nationals are largely absent from the renewable energy sector and that it would be difficult to find a national working in any capacity other than the senior level (J1). Similarly, respondents argued that barriers to hiring locals – more broadly defined as those who grew up in the UAE regardless of nationality – remain. For some firms, local recruitment remains impractical because, "… they are not used to the work ethic expectations of the job. Often, they live in a bubble and aren't prepared for the demands of the job. Many of them need to gather experience – work ethic experience rather than technical experience – before we would consider hiring them" (S6). Although this respondent extends the concept of "local" to include expatriates born and raised in the UAE, private firm perceptions of work ethic, ability to manage, and mismatch of firm and labor expectations mirror the findings of other regional labor studies (Forstenlechner et al. 2012; Forstenlechner and Routledge 2010; Randeree 2009; Randeree 2012).

Yet several respondents provided more nuanced understandings of local – defined as Emirati – participation within the emerging industry. Although industry labor data is difficult to obtain, nationwide data suggests that expatriates have an outsized impact on the economy – composing up to 98% of the private sector (Shah 2008). Rather than a new labor trajectory, respondents argued that national/expatriate divides are reproduced in the emerging solar industry. Several respondents noted that locals are largely absent in the private sector (S5) or largely employed as government regulators (M2). The comparative lack of presence in the private sector led several respondents to suggest that nationals play little role in the industry's development. However, a larger portion of the interview population argued that nationals occupy a different, yet important role within the emerging solar sector. A respondent at a firm owned by a well-placed Emirati with ties to the Dubai royal family noted the role of Emiratis in regulatory aspects:

> I wouldn't say that locals aren't involved in solar energy. In fact, they are very involved. As you know, the local population is very small here, maybe 10% of the population, and most of them work in the government. Yes, there are few Emiratis in the private solar sector, but that doesn't mean they aren't involved. They are very involved from a government standpoint. They are regulators and legislators who help the industry and many of them have high training and receive continuing education. The locals working in solar are very passionate and have key positions in the government (B1).

A 2017 Labor Force Survey, reveals that over 54% of Emiratis in Dubai are gainfully employed in public administration occupations (Dubai Statistics Centre 2017); therefore, the presence of local labor in government regulators, such as DEWA, is not surprising, yet the absence of locals in the private sector does not equate with an absence of locals in the solar sector. Instead, several respondents argued that locals are heavily involved in solar energy production through enacting local regulations (B1, M2).

Moreover, the unique local context of a hydrocarbon superpower with a small, local population creates a labor market dramatically different than other regional counterparts. A leading labor market recruiter shared this perspective:

> It is interesting because, at least in the UAE, the level of engagement from the local Emirati population is very different than in most other countries. For example, in places like Morocco or Jordan, there is a very active engagement from locals in renewable energy companies… This is very different that if you look at the UAE, where the number of Emiratis employed in solar or renewable energy is fundamentally lower. They are rarely involved in O&M or manufacturing, instead they come at renewable from a much different perspective. They look at how it fits within the wider vision and economic diversification of the country than what is in it for them. It's less about getting a "better" job and more about these grander goals (S5).

Local rentier state dynamics, in particular, large public expenditures in the form of social welfare programs and public sector employment have created a unique local context in the UAE. The concentration of locals in high paying government positions means that few locals are drawn to the emerging solar energy industry as a means of securing better compensation. Instead, key informant responses describe a situation in which locals are drawn to the industry due to non-compensation factors. Rather, locals are drawn to solar energy through government regulation as a means of achieving the national image and vision energy transition rationales outlined in 6.3.1.

5.3 Firm hiring practices and local labor markets

With the exception of two respondents, key informants were candid about their firm's labor hiring preferences and practices. Of the two informants that were reluctant to share information concerning their firm's hiring practices, one questioned my motives in wanting to know this information and took offense at the line of questioning (K1), while the other insisted that his – and all other firms – do not have any hiring patterns and only seek to recruit talent

(M4). A more in-depth discussion of their reluctance is discussed in Section 3: Methodology. Beyond these two individuals, local experts were happy to share their firm's hiring practices. Respondents noted that the local labor market context (outlined in 5.2. Human Capital Endowment, Skill Gaps, and Local Production of Knowledge) necessitates sourcing labor globally. Firms access these global circuits of knowledge through their hiring practices and preferences, often reproducing local labor market dynamics.

5.3.1 Firm rationales for hiring practices

Amongst key informants, two local labor market concerns emerged from the research. First, respondents expressed concern at the availability of skilled solar energy labor available locally (see 5.2. Human Capital Endowment, Skill Gaps, and Local Production of Knowledge). Second, local experts shared cost considerations which factor into firm hiring practices. Although the UAE projects the creation of 100,000 new renewable energy jobs by 2030 (Dennehy 2018), the local labor market remains dependent on a small, yet growing number of qualified solar energy professionals with the necessary training and experience. The increasing demand on a relatively small, qualified local labor market inflates wages as skilled labor holds considerable leverage – able to move between jobs and projects at increasingly higher salaries (S3). For firms, this creates an issue:

> With the local EPC [engineering, procurement, and construction] companies, my perception is that their margins are extremely thin and tight. This makes it incredibly difficult for them to hire the best possible staff… We have to have a candid conversation with the companies about what they want and at what price. We need to figure out if they can get that locally and if they can, is the cost acceptable? Often there is a premium of

> 10-15% on the cost of hiring someone who is already working here as compared with someone who moves to the UAE for the first time. It's a function of supply and demand…Realistically, are they going to move jobs for the same salary? Most likely not, you'll have to pay them more to get them to move (S5).

Due to tariff prices, several respondents noted that the profit margins on solar installations are rather small (A1, A4, G1, K1, M1, W1, Y1). Low profit margins and escalating local skilled labor costs leave some firms facing a choice between "cost and competency" (B1) of local engineers or sacrificing "quality for costs" in terms of components (A4). Unwilling to sacrifice the quality of the components (A4, B1, J1), one respondent noted that firms are often "squeezed here and have to make decisions to bring people on board… Therefore, if a company wants to hire on the cheap to keep those margins, there are literally thousands and thousands of people who will come over from India, the Philippines, or parts of Europe where the local markets or opportunities have dried up" (S5).

The small supply of local labor and available skills combined with a small profit margins and high local salaries has forced local firms to search "everywhere for talent" (S3). Although several respondents preferred to hire locally (M1, M2) as recruiting is often, "an exercise in risk mitigation and finding someone who is already here mitigates much of those relocation risks" (S5), more than 58% of the interview population argued that local factors and firm preferences resulted in an internationally – rather than locally – oriented recruiting system. Table 5.7 displays the geographic recruitment pipelines outlined by the interview respondents based on the nationalities of individuals currently employed at their firm.

Table 5.7 Nationalities of solar energy employees at UAE firms reported by respondents

Nationality/Geographic Location	**Number of Respondents**
International (general)	*7*
Asia (general)	*2*
China	2
India	11
Nepal	1
Pakistan	8
Philippines	3
Sri Lanka	1
Arab (general)	*3*
Egypt	3
Jordan	4
Lebanon	2
Europe (general)	*3*
Estonia	1
Germany	5
Greece	1
Italy	2
Spain	3
UK	2
Western (non-European)	*2*
Australia	1
Canada	2
United States	1
Sub-Saharan Africa (general)	*2*
Ethiopia	1
Kenya	1
Nigeria	1
Sudan	1

From the table, it is clear that solar energy firms are looking globally – twenty-two named countries spanning five continents – for talent to build and sustain the emerging solar industry. The Senior Business Development Manager (M2) at a local firm explained that due to the skills necessary and the cost considerations present in the industry, "we don't even consider looking locally, we immediately go international." Due to the Emirati/expatriate public/private sector divide, the UAE is attempting to construct an emerging post-oil economy built on globally sourced labor. The practice of accessing global knowledge circuits to fill labor and skill gaps is not a new concept (see Al-Kibsi et al. 2007) and the UAE appears to be adapting this migration trajectory to spur development in the emerging solar energy sector.

Whereas a majority of the respondents argued that the local labor market context necessitates an internationally oriented recruiting framework, several respondents presented more nuanced understandings of international recruiting practices and business rationales. Acknowledging that foreign experts are needed to fill skill gaps, some respondents argued that the UAE's ability to access highly skilled global labor circuits to attract and retain solar expertise gives the country the "advantage of learning from the mistakes of others. We can see what has been successful elsewhere and apply it here. There is no need to make the same mistakes. We can bring in experts from around the world to jump us forward and help us develop faster" (B1). The concept deploying global knowledge and expertise to solve local problems is common in the Gulf countries. In the UAE, a local legal consultant argued that this practice stems from the country's leadership:

> The UAE leaders are very intelligent and capable managers. They intelligently see the future and act now… importantly, they are aware of their capabilities and expertise and have no problem delegating authority to experts – often internationals – when they don't know. The leaders are always tapping into international expertise. The general sense is that there is no pride at stake or embarrassment for not knowing. Instead, let's bring in the expertise. It's good leadership (S1).

The use of foreign consultants is widespread in the emerging industry. While local regulation is carried out by Emiratis employed in the public sector, these regulations are constructed by foreign consulting firms such as Ernst and Young, KPMG, and PwC (A5, S4, S5). Similarly, the local solar industry utilizes management and strategy consultants (Booz Allen Hamilton and

McKinsey) and engineering consultants (Fitchner, ILS, and DNV GL) to further supplement local engineering needs (S5).

A second rationale for globally sourcing skills and labor stems from the local competitive balance and small local skilled labor pool. The CEO of a leading solar energy firm argued that the available labor – both at other companies and graduates of local universities – is able to meet the needs of the local industry. Despite the presence of a skilled labor market, his firm continues to look internationally for skills and expertise:

> As practice, we avoid hiring from our competition as it isn't great for the development of relationships and for the local market. Therefore, we tend to look at companies positioned outside of the UAE and target individuals with an incentive – familial or otherwise – to move here (J2).

For this key informant, actively recruiting from the available skilled labor does little to advance the industry. Acknowledging the cost/profit issues previously outlined, the respondent proceeded to share that importing skilled labor helps grow the local knowledge base, which helps the industry grow more than firms competing over the limited skilled labor supply. Ultimately, he believes that the UAE solar market will become saturated and that the most successful companies will be those able to export their expertise abroad. As such, he often recruits individuals with dual passports – one Western and one other – to maintain a dynamic workforce able to tackle the industry's future challenges.

Despite a widely recognized need for global expertise and skill, a growing contingent of local firms argued that there is a greater need for the application of local knowledge if the industry is to grow. Although technical skill gaps remain, several respondents argued that reliance on purely foreign labor creates a different skill gap which needs to be addressed. The Head of Solar for a local firm explained:

> Right now, it is all European expertise. You have companies from Portugal saying that "since it is hot and sunny [in Portugal], we can use the same systems for projects in the UAE." Hot and sunny [in Portugal] last for one month. Can we really take that experience and apply it here when temperatures are above 40 degrees with the dirt and sand issues for 4-5 months?... We need more local knowledge used (K1).

For this individual, solar energy design and installation are not universal concepts and local development requires local knowledge. As mentioned elsewhere (6.1.1.), the UAE's climate presents near ideal conditions for solar development. Yet the combination of hot temperatures and airborne sand particles, which can coat solar panels, can decrease solar efficiency. Therefore, implementing solar in the UAE requires a more nuanced understanding of the local conditions.

The importance of local knowledge in energy industries is well documented in the literature (Bridge and Wood 2005). Increasingly, foreign firms are realizing the importance of hiring workers with local industry knowledge and established connections with regulators. One respondent argued that, "for business development managers, you really need people who are plugged into the local market. You need people with connections so you have to look locally. For engineers and labor, which don't require local knowledge, we hire from India" (M2). Similarly, a respondent at a firm that exclusively hires from its home country shared that his company had recently broken with that practice. "We recently hired a guy from Pakistan who has ties to DEWA. We are hoping he can get things moving for us. He is very smart and competent but not great with solar, but he is connected and that is very important" (A4). The need for local knowledge which understands the culture (W1), languages (S3), and bureaucratic workings of the UAE (G1, Y1) was widely recognized by respondents and brings a local element to a largely internationally oriented hiring system.

5.3.2 Local outcomes of firm decisions

A local context marked by higher than average wage costs coupled with small profit margins often means that firms must make tough business decisions. Often, this means paying a premium for skilled labor and finding cost effective unskilled labor solutions to maintain profit margins. The labor market recruiter argued that one of the reasons why companies in the UAE have successfully attracted skilled labor is comparatively higher wages offered locally. However, higher wages have not necessarily resulted in higher quality skilled labor. The Head of Renewable Power at a large multinational firm argued:

> The people here have found a home. They are not the top of their field but they are paid like it. Their knowledge of solar is only okay to not great. There is this belief that just because we have money and high wages, we will attract the best people. This is not necessarily the case. Are some people excellent? Yes, but money hasn't translated into getting the best, most capable people (D1).

Based on his extensive experience spanning two decades and five continents, the respondent went on to further explain that while the pay is similar to the top end of the field, those at the top have little incentive to leave where they currently reside. He likened it to the financial sector, stating that simply offering salaries comparable to London or New York is not enough to attract the best and brightest as those individuals want to be at the center of the industry – for solar, the perceived center is parts of Europe and the American southwest. Since the center of the industry is not the UAE, the high salaries do not necessarily correspond with the attracting the top of the field.

In an effort to cut costs and remain competitive, several firms have adopted different strategies. One firm explained that they do not maintain a permanent staff in the UAE. Rather, they rotate employees between their home country and the UAE to maintain active visas (A4). Other firms predominately rely on a small, talented workforce supplemented by subcontracted labor able to carry out solar installations (A1, A2, B1, J1, S3). While this practice cuts costs for local firms, respondents shared concerns about the preparedness and training of this labor. While key informants were reluctant to talk about unskilled labor conditions, many shared their concerns through what they did, and more importantly did not, say (see Section 3 for discussions of positionality). One informant shared a personal experience concerning a project he or she had recently completed where a subcontracted worker was nearly electrocuted due to lack of training. Such experiences have led other informants to suggest that the government should offer training for subcontracted labor:

> I think DEWA could offer better training for the builders and installers beyond those who are certified. Health and safety are big issues on many projects and people need training. I have been on jobs where people are doing dangerous things because they don't understand the risks of working with electricity or have the proper training in how to use safety harnesses when working on high roof tops (A2).

In absence of general subcontractor training, several firms have started offering their training ranging from a single day (A2) to an entire week (J1) to ensure that all employees – subcontracted and otherwise – understand the fundamentals of working with electricity and are aware of the best practices to promote safety on the job.

Beyond their locations for globally sourcing skill and knowledge, firms shared insight into their division of labor. In a broad sense, solar energy firms operating in the context of the UAE reproduce existing labor market dynamics through their hiring practices in preferences. Contra binary migration patterns marked by high skill, high wage creative workers from Europe and North America and low skill, low wage service workers from South and Southeast Asia (Pacione 2005), the academic literature has more accurately framed the segmentation of the local labor force as a "kaleidoscope" of multiple layers of skilled/unskilled, expatriate/national, male/female divisions of labor (Malecki and Ewers 2007, 477).

In the UAE's solar sector, reproductions of the labor division are often linked with national identity. For some firms the link of national identity and hiring preference is an outcome of the firm's country of origin. Several key informants reflected on how this link plays out within their own firm, noting that "the owner of the company is Indian so most of the labor comes from India" (M2) or that "a lot of companies you see have a national identity. They might be the Indian solar company or the Pakistani solar company and they hire a lot from their home" (T1). Although some of this practice may be attributed to an individual firm's established recruiting pipelines, cultural familiarity, or the desire to reproduce firm culture in a local context (Faulconbridge 2008), the linking of occupation with national identity is common in the Gulf States (Longva 2005).

More interestingly, firms shared information concerning their differential hiring of certain nationalities to certain positions within the firm. When pressed on their hiring practices, firm respondents noted that while they search globally for talent, they source from specific areas/countries for specific functions within the company. For example, one specialist explained:

> In solar, it is mainly people from India, Egypt and other Arab countries. The top management people are all from Europe. They are people from Spain, Germany, and the UK. At the senior level, you have many Arabs and Indians and some engineers from Europe, mainly Germany. At the middle level you have mostly Indians and at the labor level you have people from Pakistan and people from India – especially from Kerala (A2).

This division of labor by nationality was a common refrain amongst respondents (A2, A3, B1, Y1). Similar to Ewers and Dicce (2016), local companies are reproducing existing migrant divisions of labor through their hiring practices and preferences. Moreover, these companies are engaging in *pay-by-passport* (Ewers and Dicce 2016, 16) recruiting frameworks whereby certain nationalities are favored due to client expectations and demands. A respondent at a local firm expounded on this practice:

> Engineers are hired as contractors on a project basis from the Philippines, India, Nepal, and Pakistan. Those with more managerial and business experience are hired from the Middle East – Egypt, Jordan, and others. Westerners also make up a large percentage. Cultural profiling exists here. Clients often expect to see certain nationalities in certain positions (B1).

When pressed about which nationalities clients expect in certain positions, the respondent revealed that clients often prefer to see Westerners – particularly Europeans – in management positions as it gives them a greater degree of confidence in the quality of the work. Underscoring this notion, a respondent shared an experience where several firms reached out to him about recruiting people from Spain as, “they had heard that Spanish people were good at solar” (D1).

As a Spaniard, himself, the respondent was familiar with this characterization yet questioned why these companies' requests were framed as a matter of nationality rather than competency.

5.4 Individual agency and global skilled migration

One-quarter of respondents elaborated on the individual decision-making processes that differentially attract highly skilled migrants to the UAE's growing solar industry. Similar to other individual-level studies (for a review, see Ewers and Dicce 2018), respondents highlighted a complex assortment of factors contributing to relocation outcomes. Within the interview population two main themes emerged. First, key informants argued that the decision to relocate to the UAE is a function of lifestyle preferences and personal beliefs. According to respondents, the decision to relocate to the UAE is primarily a function of the opportunities afforded in their home country, the high quality of living in the UAE, and the chance to obtain meaningful employment in a field that aligns with their personal values. Second, informants posited that the decision to relocate is part of a larger career arc within the solar energy industry. In this view, the growth and development of solar energy in the UAE is an important career step – offering access to opportunity that will further their career once they leave the country. In both cases, the UAE's emerging solar industry presents a unique opportunity for personal and professional satisfaction.

5.4.1 The "glitz and glamour" of the UAE

Due in part to oil-driven development, the UAE has grown at a rapid pace (mean GDP growth rate of 4.48% since 2010) over the last few decades. The emergence of both Abu Dhabi and Dubai as regional nodes and global cities has made the UAE a prime competitive business location – currently ranked 17th in the world (Schwab 2018). The growth and development of the

UAE, and the global presence of Dubai, have positioned the country as a key destination for skilled labor. One solar firm respondent noted that the international reputation of Dubai has made it easier to attract highly skilled labor: “We find that most people have a desire to be in Dubai. In the past, you may have had to pay a premium to attract someone to the city but that is no longer the case. People want to move here in the same way that people want to move to London or New York” (J2). The local draw is not unique to the emerging solar industry, with several studies noting the attractiveness of the country to highly skilled labor (Shaham 2009; Baldwin-Edwards 2011).

Moreover, the academic literature has gone to great lengths to chart the attractiveness of places to the highly skilled. Floridian notions of the “creative class” – a skilled subsection of the global labor force – explores how places can attract “creatives” to spur local development (Florida 2012). Florida and his acolytes argue that so-called “creatives” are drawn to technologically advanced, open, and accepting locations. Additionally, locations with access to leisure activities and amenities, favorable climate, high qualities of life and low housing costs are best suited to attract human capital (Clark et al. 2002; Glaeser et al. 2004; Glaeser and Gottlieb 2009). The UAE’s construction of world-class transportation, urban spectacle and development, amenity-rich environments, affordable living and comparative openness position the country as a regional and global destination for highly skilled human capital.

Solar firms in the UAE highlighted many of these traits as reasons why highly skilled solar energy human capital is drawn to the emerging industry. For some, the “glitz and glamour” (S5) of the UAE provide an incentive to relocate to the country. The country’s track record of being a secure, tax free location, with excellent quality of life enables a powerful pull factor for global circuits of knowledge. Simply put, “many people want to come to the UAE to work” (S3).

Highly skilled Western expatriates, in particular, find high personal and professional value in relocating to the region. The labor recruitment specialist shared that:

> Every day, I get emails from people all over the world – Hong Kong, Europe, Australia, the United States – looking to come work here. Many people still rightly have a perception that the salaries here are higher than back home… They may be paying taxes back home or find that there is a different cost of living here that provides an incentive to move here at a given salary. The appeal of coming to and working in the Middle East still exists (S5).

The relative cost coupled with the high quality of life – both Abu Dhabi (77) and Dubai (74) rank within Mercer's (2018) top 100 cities by quality of life – provide a strong impetus for highly skilled migrants to immigrate. Further, the higher average salaries, low tax rate, and cost of living endow the UAE with a competitive advantage in terms of recruiting and retaining highly skilled migrants.

Beyond cost and quality of life considerations, firms noted access to opportunity as a key driver of individual locational preferences. As an emerging industry with ambitious solar and clean energy aspirations, the UAE provides a unique opportunity for individuals seeking to become important players in the local solar industry. Speaking from his own experience, one respondent noted that:

> One of the biggest attractions and reasons why people come from overseas to work here is the opportunity to influence things and get involved in these large dynamic projects. It is an opportunity to get involved in and get exposure to something they may not back home. That fundamental motivation and appeal is the same for myself. I have the opportunity to work with the key agencies driving the climate change agenda in the

> Middle East. By contrast, I may not have this opportunity back home. The pace of change and development gives me the chance to play an interesting and important role in the local industry (S5).

From an individual perspective, the immaturity of the local industry presents the opportunity to help shape the important policy decisions. Adapting Maslow's *Hierarchy of Needs* (Maslow 1943), urban regional migration research has examined the attractiveness of locations by their provisions of "basic needs." The Place Pyramid (Florida 2008) argues that there is a hierarchy of location-specific needs for the so-called "creative class." At a basic level, there is a need for places to provide basic personal security and wider access to economic and employment opportunity. Once these needs are met, people focus on the provision of basics services, the quality of the local leadership, the openness and tolerance of a location and how well they align with personal values, and the general aesthetics of the location (Florida 2008). Taken in full, the UAE has successfully attracted and retained highly skilled workers for solar energy through its provision of safety (especially compared with broader regional instability), world class services, a comparatively progressive society and the opportunity to play a meaningful role in an industry that aligns with individual values, and a beautiful, modern built environment at an affordable cost.

5.4.2 Transnational Solar Mobility

In addition to place-based arguments for highly skilled human capital attraction and retention, respondents shared insight concerning how global circuits of solar knowledge leverage the growth and development of the UAE's local solar industry to further promote their careers. While the UAE is deploying global knowledge to spur solar's industrial growth, the same global knowledge is utilizing the rapid growth and development of the local industry as strategic aspects of career arcs. At a basic level, solar energy professionals are drawn to the sheer number of available projects and growing demand in the country. As one respondent explained, "[employees] hear stories about the opportunities, they see headlines about the world records and prices here. They see the potential of the Saudi market and the development of CSP in Dubai" (S5). While the importance of record setting projects for national image has been discussed elsewhere (see 6.3.2 The Solar Megaproject), it is also a powerful means of labor recruitment. The CEO of one company argued that these projects are a key driver of skilled labor to the country as: "the large number of projects means you can quickly add to your resume. Installed capacity is a line on the resume and people working here can quickly increase that number" (S3). More aptly, installed capacity is the key line on a prospective employee's resume and was reflected during survey and interview recruitment on LinkedIn, where many profiles prominently display total or current capacity of their projects (see Figure 5.3).

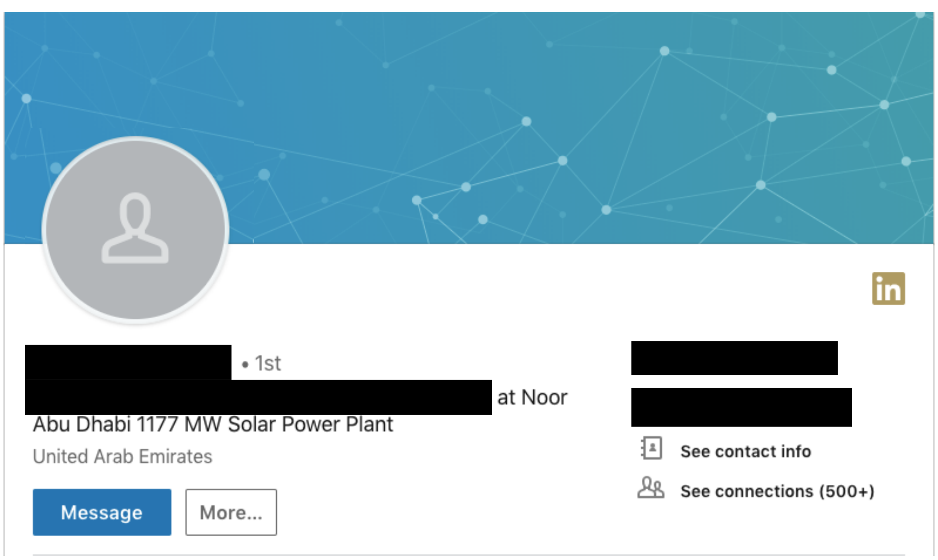

Figure 5.3 Example LinkedIn profile for solar energy in the UAE

Rather than simple opportunity seeking, key informants argued that individual rationales varied considerably with country of origin. For some, like those from Jordan, the oversaturation of the Jordanian solar market provides an impetus to search for solar opportunities elsewhere (M1). Highly skilled workers from Europe, however, are drawn for the opportunity to play a key role in the industry’s development (D1, G1). The local labor recruiter argued that both where a person emigrates from and where he or she intends to go next factor into individual rationales for working in the UAE:

> It depends on where they are coming from. Last year, we helped a local company hire a bunch of lower level staff to carry out their day-to-day functions. For the people who came on board - mainly from India and the Philippines - the appeal was the growing appetite for solar back home in the coming years. They know a job here will have them well positioned to transition back home and be able to say that they've got international experience in a more developed market. For these individuals, the chance to work with leading companies and learn international best practices is very appealing. If we hire people from Spain, however, it's a bit different. Historically, Spain is a big market from a solar perspective but the economy has had some recent troubles that has caused the market to slow down a bit. Now you see a bunch of Spaniards working at solar firms here in the UAE, but how many of them will be able to go back to Spain and point to this experience as something that will help the company get to the next level? That appeal and this exposure doesn't really translate in the same way that it might for someone returning to an area with a more developing market. I suggest that the usefulness of this experience for obtaining the next job is dependent on where someone wants to go after the UAE (S5).

For those coming from less developed solar energy markets, the UAE offers access to opportunity through the chance to gain experience with international companies working on large projects – something often not available at home (A1, S5). However, the rapid growth and development of the local solar industry, characterized by record setting projects, offers the chance to further individual careers beyond the UAE.

An anecdote about an Egyptian-Australian working in the country underscores this point. The individual had moved from Australia to the UAE to obtain a management position at one of the solar megaprojects. Following the completion of the project, he intends to relocate to Australia as a competitive candidate who has managed projects the size of which are found few other places (S5). The development of solar in the UAE, then, represents one stop on the larger global career arc of the solar energy professional. During conversations with key informants, a large portion revealed the geographic mobility of the industry from one location to the next throughout the career arc. One individual shared how he had moved from Spain, to Chile, the United States, South Africa, Saudi Arabia, and finally the UAE as part of project-based work and international career assignments (D1). While perhaps more pronounced than other industries, firm behaviors are responsive to changes in the global solar market whereby firms elect who to send and where as part of their broader corporate strategies (Tamásy et al. 2008).

Yet, the global mobility of the transnational solar elite may be lessening. In the past, government subsidies led to a geographic pattern of highly skilled mobility whereby human capital chased opportunity around the globe. While many of the respondents shared these experiences, the CEO of a major solar firm believes that this will no longer be the norm:

> In the past, you used to see a distinct "flight pattern" of solar energy professionals from one development site to another as different areas opened up and attracted business. I

> used to be one of them. You go from place to place and see the same people again and again. That is slowing down, however. The global industry is less dependent on subsidies so the boom/bust cycles which perpetuated that movement aren't as dramatic. The circulation of those individuals is slowing down and you are seeing fewer members of that globe-trotting cadre. Most are settling down or staying in place (J2).

The respondent further noted that as solar becomes more cost competitive, the need to chase subsidies decreases – leading to the growth of local markets less dependent on the global cadre of highly skilled solar professionals. While the increasing efficiency and decreasing price of solar (see 6.2. Economic and Technical Rationales for Solar Energy Transition) represent important factors in the growth and development of the UAE's local solar industry, it also potentially alters the global circulation of highly skilled human capital mobility as firms and individuals are less respondent to local institutional changes. Rather, this trend perhaps represents a larger industry shift whereby economic arguments for solar replace or complement environmental arguments.

5.5 Conclusion

The main findings of this section are as follows: (1) both foreign and local firms perceive the local labor market to be inadequately endowed with the skill and experience necessary to carry out solar development and installation; (2) there exists divergent firm and individual incentives to hire Emiratis; (3) due to local price controls, solar profit margins are extremely thin; (4) hiring locally often incurs a salary premium; (5) highly skilled labor exercises agency and demonstrates preference seeking for the amenities and salaries offered in the UAE; and (6) individuals utilize the rapid growth and development of the UAE's solar energy industry to advance their careers through adding installed capacity, gaining experience, and occupying key positions in the industry. These firm perceptions, market constraints, and skill needs ensure that firms continue to source knowledge globally to meet increasing demand. Highly skilled labor, meanwhile, possesses significant incentive to utilize the unique context of the UAE to advance careers, live comfortably, and gain higher salaries. Together, these firm and individual incentives ensure that demand for global skilled labor remains high and is matched by an equal supply of skilled global labor willing to relocate.

6 RATIONALES FOR THE UAE ENERGY TRANSITION

This section presents results from the interview portion of the research. The findings focus on rationales for the UAE's energy transition. It argues that energy transition in the UAE is best examined through multiple and complex interrelated rationales, arguments, and identities, which produce a place-specific energy transition explanation. The interview findings support technical and economic (MESIA 2016; Sultan 2013), solar potential (Alnaser et al. 2004; Islam et al. 2009), "social gap" (Bell et al. 2013), and power density arguments (Smil 2000) for transition. Yet, respondents also described the perceived importance of the co-construction of national identity and clean energy (Bouzarovski and Bassen 2011; Loumi 2016) and opportunity cost arguments for transition. The section contributes to academic discourse concerning energy transitions through its attention to both space and place (Huber 2015). Moreover, the section explores the complex assemblage of economic, technical, solar potential, cultural, and climate-based rationales for renewable energy transition.

The results of the interview analysis granted insight into the complex rationales underpinning renewable, in particular solar, energy transition within the UAE. One of largest code coverages in the data set (27%), energy transition rationales represented one of the major points of interest during conversations with industry experts. Although explanations for the UAE's unprecedented pivot towards solar energy received considerable attention, experts highlighted a wide range of reasons for why the country has aggressively pursued renewable energy despite vast deposits of hydrocarbons capable of powering the country for the foreseeable future.

Four main themes emerged from the research analysis. First, key informants argued that solar energy development in the UAE naturally happens due to the immense solar potential of the region. Many respondents highlighted the plentiful and predictable nature of the country's incoming solar radiation as a primary factor for increased investment in solar. Second, informants highlighted economic, technical, and business arguments for the transition to solar energy. These arguments emphasize economic and technical aspects concerning the falling cost of solar installation and increased efficiency, locational and fixed investment arguments, and business decisions stemming from cost-cutting and cost-offsetting measures. Third, respondents repeatedly pointed to national image as a key factor in solar energy production and development. In particular, these arguments underscored the importance of cultural imagery and identity strategically crafted by the government in altering the world's perception of the UAE and the importance of the megaproject as a domestic and global strategy. Lastly, key informants noted the political and social elements of solar energy transition in the UAE. These respondents noted the recent and historical, local and global context of oil prices and the actions of the government to move beyond oil dependency and the threat of climate change to the long-term viability of oil.

6.1 Solar potential as a catalyst for transition

Interview respondents almost unanimously pointed to the immense solar potential of the region as a primary rationale for solar energy development. In fact, more than half of all respondents – regardless of interview form – referenced this potential when discussing their views of the reasons for transition. The argument for solar transition as an outcome of potential is well documented in the academic literature (see Alnaser et al. 2004; Alnaser and Alnaser 2009; Islam et al. 2009); however, the key informants provided depth, clarity, and nuance to these discussions. The respondents noted not only the potential stemming from incoming solar radiation, but also the predictability of solar in the UAE, locational advantages due to large open spaces, and the advantages of local solar development compared to issues facing the regional and global industry. Together, these insights grant broader understanding into the various meanings of solar potential and how these forms of potential potentially facilitate local industry growth.

6.1.1 Solar radiation, predictability and supply/demand agreement

Perhaps the most obvious rationale for solar energy development is the high amount of incoming solar radiation in the UAE. More than 58% of respondents noted the importance of the country's solar energy potential as a contributing factor to the development of a local industry. When asked about the UAE's decision to pursue solar energy, the Lead Solar Engineer of one local firm questioned why anyone would be surprised. "You ask, 'why are they pursuing solar?' You should ask, 'Why should they not?' We are talking about an area with ten months of sun with more than 12 hours of sun per day. It makes sense to pursue solar and it shouldn't have taken this long." Acknowledgement of the country's vast solar potential coupled with frustration at the comparatively slow pace of development was a common theme amongst respondents. Statements such as: "the solar radiation has always been here and has always been high, yet development has remained low" (S6) and "There is opportunity for renewables here. The potential is massive but people are reluctant to develop solar…My concern is that progress is extremely slow. You can go to the talks in Abu Dhabi and Dubai and hear how solar is the way we are going and that we are pursuing renewable energy, but no one really seems to take a lead - an aggressive lead - on it" (A5) underscore the tension between high potential and slow development.

While the tension concerning the pace of development relative to the country's potential will be discussed later in this section, there was near unanimous agreement amongst the respondents concerning the vast solar potential of the country. The CEO of a local solar energy technology firm described the immense solar potential as the leading factor of renewable energy transition in the UAE:

> The number of hours of solar energy is very good for the region, especially in the UAE. It is probably one of the highest in the world. The large amount allows you to provide energy for the country rather than turning to nuclear or other sources to generate power.[7] The UAE has a great hunger for energy and there is a growing need every day. Solar can help meet this demand (M1).

Residing in the global "sunbelt," the UAE receives a high amount of solar irradiation each year. Table 6.1 displays the CSP direct normal irradiance (DNI) and PV global horizontal irradiance (GHI) for the GCC countries. From a CSP standpoint, the UAE receives the second most DNI in the region with 2200 kWh/m^2/y – trailing only Saudi Arabia and tied with Oman and Qatar. Meanwhile, from a PV perspective, the UAE rates as having the highest GHI with 2360 kWh/m^2/y, far greater than the closest regional competitor in Bahrain (2160 kWh/m^2/y). The combination of DNI and GHI places the UAE as one of the two best candidates – along with

[7] While solar has the potential to supply electricity to the UAE on a large-scale basis, the country is still actively pursuing nuclear energy and plans to open the first reactors at the Barakah Nuclear Power Plant later in 2018 (Kumar 2018). The topic of nuclear energy arose in six of the interviews with a wide range of opinions. Some solar experts argued that nuclear could help diversify the energy mix and achieve the government visions for a greater clean energy mix (M4, S2), while others questioned the mixed messages and lack of clear direction from the government (A5). Lastly, two of the respondents questioned the logic of nuclear installations in an area of the world with limited water available for cooling towers (K1) and in a semi-closed environment – the Gulf – where water takes years to circulate and where a Fukushima-type disaster could potentially render the area unlivable (S6).

Saudi Arabia – for solar energy potential in the region. From a global perspective, data from SolarGIS compares the Photovoltaic Power Potential for the UAE and the world. What immediately stands out from the data, particularly the global data, is the position of the UAE directly inside of the "sunbelt" between the mid-latitudes. With a PV potential greater than 1,800 kWh/kWp in some areas, the UAE is among the most desirable solar locations worldwide.

Table 6.1 Solar irradiance for CSP and PV in the Gulf States. Adapted from Alnaser and Alnaser (2009)

Country	**CSP Direct Normal Irradiance ($kWh/m^2/y$)**	**PV Global Horizontal Irradiance ($kWh/m^2/y$)**
Bahrain	2050	2160
Kuwait	2100	1900
Oman	2200	2020
Qatar	2200	2140
KSA	2500	2130
UAE	2200	2360

Beyond the vast amount of solar radiation, the UAE maintains a distinct advantage due to the predictability of climate conditions in the country. Several of the key informants highlighted this when discussing the rationale for locating solar energy operations in the UAE. One respondent pointed to the quantity of optimal days for solar production: "Solar energy is the most convenient energy source for the UAE because of the empty areas and long solar days. There are over 300 good solar days per year because the UAE is located in the "solar belt". This makes it easy to implement and become a leader" (M2). A Business Development Manager at a local firm similarly noted, "In the UAE, there is tons of sun and this gives us a strong and constant advantage. Here the sun is predictable, far more than wind. Therefore, it makes sense to invest in solar" (B1).

Consistency and predictability were echoed amongst many of the respondents. While these factors are important, respondents consistently compared the local benefits and predictability of other solar energy locales to boost the UAE's advantages. One respondent, a Senior Project Manager for a foreign company, explained the UAE's advantageous factors with the Mediterranean Middle East and Europe:

> The UAE has good weather all year round, except for the summer. The sun is always shining and you are able to get high gigawatts all year. This makes it possible harvest energy from the sun year-round…This is different than Europe, where they don't have the same sunlight and have to deal with winter. The Levant [which is where the informant was prior to the UAE and where his company headquarters resides] is similar. This makes it harder to harvest solar energy than in Abu Dhabi and Dubai (A1).

The UAE maintains a predictable mean range of temperatures between 18ºC in January and 33.7ºC (Climate Change Knowledge Portal 2018). Although extreme highs decrease solar panel efficiency – 10 to 25% due to reductions in voltage output (King et al. 1997) – in the summer months (May through September), the comparatively cooler winter months provide a prime climate for solar collection. Similarly, the country's dry climate – high rainfall of 19.2mm in February with ten of twelve months experiencing less than 8.2mm (Climate Change Knowledge Portal 2018) – ensures an optimal number of "solar days."

Moreover, the strength of the UAE's solar potential resides not only in the amount of incoming solar radiation, but also in the peak demand for electricity. As a subtropical country residing in the Arabian Desert, temperatures can routinely exceed 40°C between May and

October with humidity reaching upwards of 80%; large amounts of energy are required to cool buildings and provide comfortable indoor environments. The relationship between the country's temperature – and by extension its electricity demands – and incoming solar radiation for solar energy production was expounded as a reason for the UAE's success adoption of the industry:

> A major benefit is the overlap of supply and demand. In the UAE, one of the largest energy demands is cooling systems. Due to the extremely hot summers, there is a demand peak for energy during these months – especially during the day-time heat. Solar is well suited to meet these demands. The peak demand occurs during the day – while the sun is shining – and is less at night – when the sun is not shining. The high radiation and demand peak match nicely with what solar can provide (S6).

As S6 points out, the overlapping supply and demand make the UAE well positioned to benefit from solar technology. In Dubai, for example, peak demand ranges from 12pm and 6pm and reaches its highest points during the summer months (DEWA 2018c). More specifically, Griffiths (2013) argues that countries where this overlap occur are uniquely positioned to benefit from PV technologies, which is the predominate solar energy form found in the UAE and broader GCC, whereas countries where this overlap do not occur are better suited for CSP technologies.

6.1.2 Open spaces, rooftop places, and power density

The development of solar energy in the UAE is further aided by the high population density in urban areas, large tracts of unused land, and the growing number of flat, empty roof top spaces. Respondents emphasized the immense solar potential owing to these factors. More than half of the key informants noted that the UAE's solar sector is best understood as two different industries – utility scale and rooftop – with one informant drawing attention to the distinct geographic divide between the two as the utility scale work is carried about by large multinational companies and the rooftop contracts by UAE based firms.

In terms of large-scale utility projects, respondents noted that the county's unique population, climate, and land dynamics make the UAE an attractive location for solar production. One Solar Division Head explained, "There is so much land in the Middle East and there is a lot of solar potential. The [interconnected] grid means that we can produce everywhere and trade, which means lower price." From a land use and population density perspective, it is easy to understand why the UAE represents an attractive option for utility, commercial, and residential solar power development. The UAE has a population density of 111 per km^2, however, this is misleading as a majority – 86.1% of the population – reside in urban areas with most individuals living in Abu Dhabi, Dubai, and Sharjah (World Bank 2019). This leaves most of the country's 83,600 km^2 open and flat – mean elevation of 149 m – land available for utility scale solar energy development (CIA World Factbook 2019).

The UAE has taken full advantage of this land availability while selecting utility scale plants. The three largest solar projects in the country reside a considerable distance outside of major cities and out of sight of major population areas. In Dubai, the MBRAM Solar Complex resides about 60.5 km inland of the city center. In Abu Dhabi, the Shams 1 Plant is a located 171 km southwest of Abu Dhabi and the Sweihan Plant is located 121 km from the capital and almost 70 km from Al Ain. The location of these plants in predominately remote and unpopulated areas helps mitigate power density (Scheidel and Sorman 2012; Smil 2008) and "social gap" problems (Bell et al. 2013) stemming from landscape effects (Pasqualetti 2000).

Although these large, utility-scale solar installations have accelerated the industry's development, several respondents called for greater attention to the rooftop solar market as an important source of energy and investment. As previously mentioned, the UAE is an extremely dry country with median average monthly rainfall of 4.9 mm (Climate Change Knowledge Portal 2018). The lack of rainfall allows for the construction of flat roofs which grant flexibility to the installation of panels. A 2014 study of Khalifa City and Raha Gardens – both districts in Abu Dhabi – revealed a potential rooftop area of 13,169 m^2 capable of producing an estimated average capacity of 987.79 kW to 1,975.57 kW depending on the type of solar panel – monocrystalline, polycrystalline, or thin film cells (Joshi et al. 2014). Due to the unrealized potential of these spaces, many of the key informants highlighted their importance to the future development of solar. The Business Development Manager of an Emirati owned solar company argued that developing these spaces is key to monetizing the investment:

> I think that a large area that needs development in solar is the residential and commercial rooftops. These places have the demand and the spaces are empty, so they can put panels here. The commercial properties and warehouses, in particular, have immense potential. Why not use that space to generate savings? For some places, the savings can offset the cost of production, or at least bring it close to zero. That saves a lot of money (B1).

Although framed around economic arguments for decreasing production costs, the informant highlights the importance of open rooftop spaces as a key, and underexploited avenue for greater solar energy production. A second respondent echoed this importance, arguing that the small-scale local market is increasingly important and that, "the flat roofs can host solar panels and this provides a big platform for solar." The predictable weather and low precipitation allow for the construction of flat rooftops primed for solar panel installation.

Throughout my conversations with respondents, I noticed a distinct divide between the rooftop solar practitioners and the utility scale practitioners. One rooftop solar expert (K1) argued that the large international firms were given exclusive domain to carry out the large-scale projects so that the government could associate the megaproject with a leading multinational corporation and that this came at the expense of local companies who are, in effect, undeservedly shut out of that market and not given an opportunity. Meanwhile a utility-scale practitioner (D1), argued that these megaprojects are best suited for large multinational companies as they have the experience and expertise not available locally to deliver on the project.

A different approach to the rooftop-utility scale divide came from respondent B1, who viewed the government's support for and celebration of large-scale solar plants as opposed to rooftop installations as a quasi-zero sum:

> But a key question is "are [solar] plants at the expense of rooftops? Does the plant preclude greater attention to personal responsibility?" I fear that installing these plants makes people think, "we are already doing something, why should we do more?" It promotes or continues the electricity consumption habits but doesn't change them. We definitely need the federal plants. Don't get me wrong, they are a good thing. But we need residential panels on rooftops, too.

In her view, the focus on headline-grabbing utility scale plants potentially comes at the detriment of a push for smaller scale investment. Although the move towards greener energy sources is positive, the optics of large plants gives the impression that government action can offset personal responsibility or cloud advantageous business practices. There is scant evidence to support this fear and many of the key informants believe that rooftop solar is the future.

> Rooftop solar installations represent the future. This is an opportunity for business, warehouses, and residential property owners to invest now to improve the value of their properties and gain a return on investment. There will always be the big projects and they get most of the attention. However, these projects only last 3-4 years. After that, they are installed and the work is done. You can only have so many of these projects and only a few companies are able to get this kind of work. With solar rooftop installations, there are more companies able to carry out the demands and there are far more rooftops. The individual installations may not be much, but when you add it all up, it is a good amount (G1).

The above quote from the Head of the Solar Division for a local construction company echoes position of many rooftop solar practitioners. Whereas respondent K1 lamented the exclusionary nature of the country's utility scale award process, these solar industry experts celebrated the creation of a growing and largely untapped market capable of advancing the UAE's clean energy goals. While the individual projects remain small, less than 5 MW, the aggregate total and potential future development could contribute to the growth of a distributed solar generation network that could substantial contribute to the country's energy mix.

For their part, the UAE government has taken note of the solar potential of building rooftops and has sought to couple large-scale utility projects with distributed power installations which serve local needs and feed extra generation into the grid. Dubai, in particular, has been proactive in promoting the adoption of small-scale commercial and residential solar panel installation. As part of the Dubai's Clean Energy Strategy 2050, Sheikh Mohammad bin Rashid Al Maktoum announced the creation of the Shams Dubai Initiative aimed at incentivizing small-scale installation of solar panels with an aim of having panels on all roofs by 2030 (DEWA

2015). As of 2017, over 435 buildings in Dubai have adopted the initiative, adding an additional 15.6 MW of installed capacity to the grid (Graves 2016). By 2021, one key informant predicted that 20% of all warehouses in Dubai would contain solar installations. Although similar initiatives have not been as successful in Abu Dhabi, there are signs that the rooftop industry is beginning to expand. For example, the Ministry of Energy projects a country-wide installed capacity of 200 MW from rooftop solar installations by the end of 2018 (Abdul Kader 2018). This mirrors broader regional trends towards a more distributed network of solar power generation (MESIA 2018). Although "every rooftop" proclamations are part of the government's vision, one industry CEO remained reluctant to endorse such views without revision, arguing that while residential and industrial rooftop goals are possible, commercial properties are not currently feasible as the comparatively small roof space to the size of the building would only offset a fraction of the cost; thereby, making solar economically disadvantageous (J2).

6.2 Economic and technical rationales for solar energy transition

In addition to arguments stemming from solar potential, a large number of interview respondents shared economic and technical rationales for the development of solar energy in the UAE. In the literature, economic and technical arguments highlight both the increasing efficiency of solar panels and the decreasing costs associated with solar production (MESIA 2016). Informants expounded on both of these rationales within the interviews. In particular, respondents pointed to the falling cost of solar production in contrast with conventional production, decreasing cost-recovery times for solar investments, solar-oil opportunity costs, and maximization of space provided through fixed investments. These insights present further depth to understandings of energy transition and, when combined with the region's immense solar potential, lead to a broader understanding of why the UAE is electing to pursue a solar energy development trajectory.

6.2.1 Increasing efficiency, decreasing costs and electricity tariffs

Around 80% of the respondents highlighted economic factors as a key component of the UAE's shift towards solar energy. While "green" and "sustainable" narratives featured prominently in the discussions, 13 of the 24 informants pointed to the declining cost of solar panels and high energy tariff as the primary motivators facilitating the transition. One solar expert explained that, "the price of solar is declining. Over the last few years, solar has dropped by almost 50%. That makes it very attractive." The rapid decline in solar pricing has not only decreased the initial cost of installation, but also the time horizon for a return on investment making the energy source an increasingly attractive option.

The trend towards cheaper solar energy costs is not unique to the UAE, however. According to IRENA (2016), the global levelized cost of electricity (LCOE) for solar PV systems has declined rapidly from an average of 0.347 USD/kWh in 2010 to only 0.131 USD/kWh in 2016 – a far greater decrease (0.216 USD/kWh) than offshore (0.01 USD/kWh) and onshore wind (0.015 USD/kWh), and solar thermal energy (0.059 USD/kWh) as well as biomass, geothermal, and hydropower, which increased over that time. Within the UAE, the largest input cost for solar PV systems for both utility scale and rooftop installations stems from the cost of the solar panels (see Figure 6.1). From 2010 through 2015, the price of these solar panels – largely imported from China – decreased by as much as 80% (IRENA 2015b), thereby drastically reducing the cost of the most expensive input into solar PV systems in the UAE.

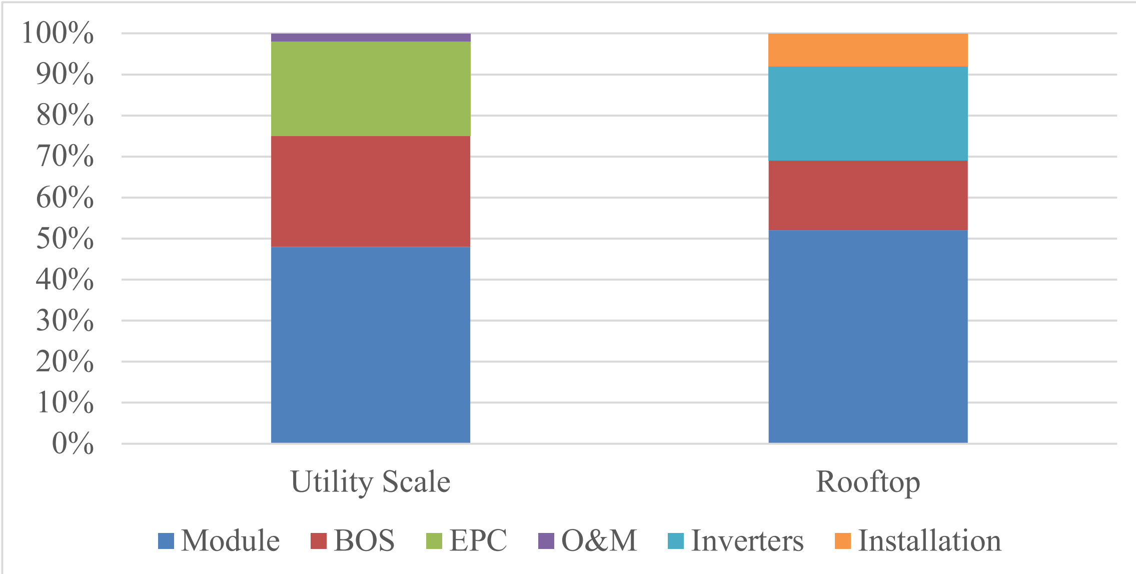

Figure 6.1 Cost distribution of solar inputs for the UAE. Graph created from data contained in Singh (2016)

In addition to the falling costs of solar, ten of the key informants highlighted the role of energy tariffs in shaping the emerging solar market. In the UAE, the government subsidizes electricity costs with nationals capturing significant concessions. Within the UAE there are four distinct utility authorities which control the prices for electricity. In Dubai, DEWA is the central authority and its tariff prices vary with consumption and building type. In general, the tariff varies with consumption between 23 and 38 fils/kWh ($0.063 and $0.10 USD/kWh) depending on whether the building is commercial, residential, or industrial (DEWA 2019). In Abu Dhabi, ADWEA sets electricity prices even lower with nationals paying between 6.7 and 7.5 fils/kWh ($0.018 and $0.02 USD/kWh) and expats paying between 26.8 and 30.5 fils/kWh ($0.07 and $0.083 USD/kWh) (Dajani 2016). In Sharjah, SEWA implemented a 7.5 fils/kWh tariff for nationals while expatriates are subject to a tariff of 30 fils/kWh ($0.082 USD/kWh) (El Sadafy 2014). FEWA, who oversees Ajman, Fujairah, Ras al Khaimah, and Umm al-Quwain, maintains tariffs of 7.5 fils/kWh for nationals and 44 fils/kWh ($0.12 USD/kWh) for industrial properties regardless of consumption and tariffs of 28 to 43 fils/kWh ($0.076 to $0.12 USD/kWh) for expatriates and commercial properties based on consumption levels (FEWA 2019).

The low cost of electricity in the UAE does not reflect the cost of production as the government holds prices artificially low, yet tariffs factor significantly into the country's ability to attract and retain energy-intensive industries (Peterson 2009). The attraction of such industries to special economic zones has formed a key component of what Buckley and Hanieh (2014) deem "diversification by urbanisation", whereby the local government leverages low electricity prices to create economic spaces which encourage investment and foster diversification of the economy. Although electricity tariffs have been an integral segment of this development, several of the key informants noted that the state's price controls distort the market and create unintended outcomes – often to the detriment of solar energy development.

Two of the respondents argued that recent tariff reforms were largely responsible for the recent growth of solar in the UAE. A Solar Business Development Manager succinctly noted the growth of solar as a dual outcome of cost and tariff prices: "The very simple answer is price. The LCOE of solar allows the industry to be profitable. [In Dubai], the tariff is low, but high enough that we can make a margin" (G1). The confluence of raising tariffs and declining solar prices has facilitated the growth and development of the local industry. Similarly, respondent S6 argued that until these two factors aligned, solar simply was not economically viable despite the vast solar potential:

> Solar is commercially viable at this time. The solar radiation has always been here and it has always been high, yet development has remained low. If you look at European countries like Germany, for example, you will see much higher levels of solar investment

> despite a lower amount of solar radiation. Why is that? In Germany, electricity is expensive and the prices are high. Therefore, there is an incentive to invest in solar to offset these costs. Here the cost is much cheaper and there are a lot of subsidies holding prices low. The economics of solar energy development in the UAE haven't made sense until recently. Today you can see the impact of electricity prices impacting how solar has developed within the country.

For this respondent, the historical context of the UAE's electricity market has stifled growth potential for the industry. As part of large-scale efforts to diversify the economy, the UAE has sought to open markets to foreign trade and leverage its comparative advantage of low-cost energy to spur investment. Although strategies concerning the attraction of energy-intensive industries for development have been successful (James 2008), the local price controls have stifled solar development by eliminating the financial incentives to invest in the technology. As a result, countries with less favorable solar potential, yet higher energy costs possess stronger incentives for developing renewable technology.

In light of this, CEOs such as respondent J2 have argued against the tariffs stating, "If you put a cost on energy, businesses will adapt to it. Right now, the cost of energy is artificially low due to the tariffs. If you alter or remove the tariffs, businesses will adapt, perhaps through solar, and become more globally competitive." Despite this simple prescription, utility tariffs remain a sensitive issue as part of a larger "cradle-to-grave welfare" system, whereby the Gulf monarchies provide services and concessions for free or well below market costs (Beblawi 1987). The necessity and importance of these tariffs and importance remains a point of debate, however. Surveying local elites and regional experts, Krane (2014) finds that 80% of respondents believe that electricity subsidies are part of the ruling bargain; however, only 40% of citizens view these subsidies as part of any “bargain.” Importantly, half of the sample population was willing to exchange these subsidies for other concessions and framing a reduction in subsidies as a means of helping the country decreased the number of “strongly opposed” citizens by 16%. Similarly, Gengler and Lambert (2016) find that the GCC states have gradually rolled back these concessions through framing the cuts as necessary to the survival of the state while faced with budget shortfalls and regional instability. While utility scale solar energy generation is still feasible, the low tariff cost is stifling development in the commercial, industrial, and residential sectors – particularly in Abu Dhabi (Griffiths and Mills 2016). The government has gradually decreased electricity tariffs with Abu Dhabi altering its schedule in 2014, 2016 and most recently in 2017, while Dubai decreased its tariff schedule in 2011. Although the alteration of the electricity and water tariffs garnered attention in the local papers, residents and businesses quickly adapted to the new energy context with little resistance. In both the academic literature (Abdullah et al. 2015) and the press (Graves 2016), there is growing recognition for the need to address the tariffs, thereby shortening the return on investment and increasing the viability of a distributed network.

6.2.2 Smart investments, solar suitability, and technological adaptation

Similar to the plunging price of solar, the increased efficiency of solar technology and government regulatory support were viewed by respondents as motivating solar energy. The greater levels of solar efficiency and rising tariff schedule allow commercial and industrial properties to gain a return on investment from solar installations. As one solar advocate put it, solar is an obvious solution for buildings with large, open roofs:

> For companies, the logic is that you have a big rooftop and it is earning you nothing. It just sits there empty. Why not invest and make it work for you? Sure, it is an investment, but within 10 years it has paid for itself… [Solar] offsets their consumption and the panels create some shade, which shields the roof and decreases the amount of sun heating the building directly. A lot of electricity costs go to keeping buildings cool. Solar reduces that heat, reduces CO_2 emissions, and is a good long-term investment. This is an opportunity for business, warehouses, and residential property owners to invest now to improve the value of their properties and gain a return on investment (G1).

In 2015, Dubai – followed by Abu Dhabi in 2017 – announced a new net-metering policy aimed at incentivizing investment in solar panels. Similar to policies in other parts of the world, net-metering is a billing system whereby a customer is billed based on their net usage – regular consumption minus solar electricity production (SEIA 2018). Generally, net-metering allows property owners to offset some of their energy costs through electricity production. Since the panels are linked to the grid, properties which produce more electricity than they consume "sell" the additional electricity to the grid to credit their accounts. In essence, net-metering allows property owners save money and eventually obtain a return on the initial solar panel investment.

Nine of the key informants argued that the ability to save money and gain a return on investment is primary reason for the UAE's solar energy development. These savings were often noted by the key informants. One solar specialist working at a quasi-governmental firm argued that the financial element is the most important factor underpinning solar energy development:

> The most important thing is return on investment. Every investor wants a good return. Most clients are less concerned with other things. They just want a good investment. This

is a major requirement now. People want to know how much savings they will get from installing solar (M4).

Other informants similarly argued that investment is purely a “cost saving measure” (B1) and that development would not occur without ROI as people are “concerned with money… less concerned with decreasing the CO_2 footprint for the country” (M2). The savings from solar can be substantial with the potential to offset as much as 50-90% of energy needs depending on the stability and size of the load (Enerwhere 2018). Although ROI for solar increasingly favors growth, the industry may still be constrained by the finite amount of available capital when pitted against other, non-energy investment opportunities with better ROI or shorter time horizons (de Groot et al. 2001).

From a government perspective, such investment from the business and residential sector helps achieve the aims of ambitious energy initiatives outlined in emirate and national development plans. As part of a broader plan to position the UAE as a global leader, the UAE Vision 2021 plan seeks to advance the contribution of clean energy to the grid from only 0.35% to 25% by 2030 and 75% by 2050 (UAE Vision 2021). Much of this shift is expected to occur in the leading emirates of Abu Dhabi and Dubai, who have each pledged to meet 7% of their gross power consumption through renewable energy (MESIA 2016). Much of the attention has focused on the large solar megaprojects - MBRAM Solar Park, Sweihan Plant, and Shams, together representing almost 3 GW. However, solar rooftop installations are becoming increasingly important as these governments, in particular Dubai, seek to add capacity to the grid while shifting towards more distributed networks (MESIA 2018).

Although the programs and policies are in place to foster solar energy growth, eight of respondents noted that local businesses remained either unaware or skeptical of potential benefits. Amongst these respondents there was almost unanimous agreement that the information gap between industry practitioners and local businesses is one of the largest obstacles to large scale solar energy adoption in the UAE. Almost a fifth of respondents highlighted lack of consumer awareness as a barrier to development. The Senior Project Engineer at a local firm shared his experience working with potential customers:

> What I have found is that people and companies are not investing in solar because they just aren't aware. I met with a very high officer at one company and he was not even aware of the net-metering program… Companies want to invest in solar, but they don't know enough…. They are hesitant as investors. They aren't as confident that it is a good investment and want to know if they will get their money back and how long it will take… The obstacle is getting information about what solar can offer to the client (O1).

Similar sentiments concerning the overall lack of awareness solar programs (K2), the potential returns to investment and cost savings (M4), and general skepticism of the industry (A4) were prevalent. A 2012 survey of solar professionals had similar conclusions with almost 50% of respondents noting that lack of awareness is a "significant to major challenge" facing the industry (ESIA 2012). With under five years of experience, the solar industry in the UAE remains in its infancy and such hesitance to adopt emerging technologies and embrace the industry should not come as a surprise.

Diffusion of innovation theory argues that the adaptation of new technology follows a normal distribution composed of: (1) risk-seeking innovators who see the appeal of new technologies; (2) industry-leading early adopters who recognize the growth and potential of the technology; (3) early majority adopters who add momentum to the emerging technology once they are certain of lower risk; (4) the later, more conservative majority who adopt the technology once it has a demonstrable track record and is widely deployed; and, (5) the so-called "laggards" who are resistant to change and last to adopt (Rogers 2010). As a young, emerging industry employing a new technology, potential customers are likely those best classified as "innovators" or "early adopters." Respondents in the UAE's solar energy industry alluded to diffusion of innovation as a current barrier to wide-scale adoption. Elsewhere, social interaction, or peer effects, have been shown to play an important role in the adaptation of solar energy technology (Bollinger and Gillingham 2012). Of yet, solar has yet to reach the critical mass necessary to attract the larger majority.

Under diffusion of innovation theory, the rate of adoption is further aided or restrained by five factors. The *relative advantage* of a new technology is positively correlated with its adoption and refers to the new technologies perceived advantages over the status quo. For the UAE's solar industry, the primary obstacle – knowledge of solar and its advantages – continues to be an outcome of its immaturity. As knowledge of the industry spreads and the majority of businesses adopt the technology, the relative advantages of solar will become clear to the industrial and commercial sector. *Compatibility* refers to the degree to which new technologies fit within the adopter's value system and needs and is positively correlated with adoption. The adoption of solar broadly fits within two value/need systems: cost savings/ROI and sustainability. Solar's cost saving potential has already been discussed and the appeal to sustainability will be discussed in a later section. *Trialability* highlights whether or not a new technology can be trialed prior to adoption so as to minimize risk, whereas *observability* examines the degree to which the new technology delivers measurable results. Both are positively correlated with adoption.

The last factor impacting rate of adoption is *complexity*. This factor concerns the degree of difficulty for understanding a new technology and is inversely related to adoption. According to several key informants, the perceived complexity of solar has a profound and negative effect on wide-scale adoption. One solar expert lamented that companies were often prone to "change things entirely because they found some product they want to use or heard about some idea they want to mirror. A lot of times these changes don't make sense from a project standpoint and from a financial standpoint." Similarly, the Head of Renewables for a major international engineering firm shared his frustration at what he called "Youtube/Google research leading the way":

> You'd be surprised at how many times someone tells me they saw some video about some technology or found something via Google and now want to do that. Doesn't matter the cost or the feasibility or the appropriateness, they want to replicate it. You would never do that with ports or airports. You would never do that with roads or bridges, why should that happen in solar? (D1).

Although straight forward to industry experts, the relative complexity of solar installations and the knowledge gap between the industry and the broader economy has stunted the growth of renewable energy. Lack of understanding concerning the basics of solar energy within the broader economy has resulted in suboptimal outcomes as potential clients attempt to gather as much information as possible. This process led a number of respondents to share frustrations concerning the time it takes businesses to make a final decision (G1), review proposals (O1), and gain business trust (A4).

While acknowledging that uncertainty is hurting the industry, one respondent believed that this is a temporary and expected outcome for any new technology and likened the experience to purchasing a new car:

> For many companies, this is their first time. I think about it like when I bought my first car. I didn't know anything about cars. I wanted to ask everyone I knew what they thought about different cars so that I could make the best decision. After three or four cars, I wasn't as nervous. I knew what to look for and what to ask. At this one company, the project manager had a lot of questions. He wanted to know about the warranties, the performance of the panels, the return on investment, and he wanted to shop around and make sure he was getting a good deal. Right now, companies are in the learning phase and want to know that their investment is safe. Once these big companies do two or three projects, they will be better informed and have more confidence (O1).

For this informant, the process of purchasing, installing, and utilizing a new technology breaks down future barriers to adoption. From a theoretical perspective, the process of confidence stemming from multiple purchases speaks to three of the aforementioned factors. From a *complexity* perspective, experience with solar "demystifies" the technology, allowing it to be more easily understood by potential clients. Moreover, the actual purchase and use of solar technologies contribute to both the *trialability* and *observability* of the technology by allowing the consumer to slowly implement the technology while accruing the benefits over time.

6.2.3 Business climate and leveraging location

One-third of all respondents noted the unique geographic location and local business climate as primary contributors to the shift towards renewable energy, thereby supplementing the economic and technical arguments for transition. In particular, experts argued that the UAE has positioned itself as a regional innovator, often providing the leadership and example by which the surrounding countries follow (S5). Geographically, key informants pointed to the UAE's location at the nexus of Europe, Africa, and Asia as a contributing factor to its solar success. One otherwise highly critical expert noted, “many places want to be leaders in solar: China, South America, Europe, Asia, United States. The UAE has an advantage, though. It can leverage its location to become number one. It is at the crossroads of Europe, Africa, and Asia and already has the built infrastructure.” Other informants further expounded the geographic location advantages of the UAE by arguing that locating in the country allows ease of access to company business in neighboring countries (T1).

Location has long been a facet of economic development in the UAE, with the country leveraging its vast oil wealth to create spaces for economic development to position itself as a regional, and increasingly global, leader (Ewers 2016; 2017). One respondent, a local recruitment specialist, pointed out that international firms seeking to “break into the Middle East” will often look to open headquarters in the UAE, in particularly in Dubai (S5). Firm decisions to locate operations within the country reflect not only geographic location advantages but also agglomeration incentives, with a CEO pointing out that a legacy of the UAE’s business success is the colocation of Tier 1 suppliers – the key manufacturers in a supply chain – and “the advanced logistics sector make it very easy to obtain the items you need in a short period of time" (S3).

Both the geographic locational advantages and agglomeration effects have fostered a business climate conducive to the growth of solar power. Table 6.2 outlines findings from the World Bank's "Doing Business Report." From the table, it is clear that the UAE's policies and practices have endowed the country with a competitive advantage over its regional competitors. In particular, the UAE leads the region in ease of business, ability to start a business, obtain credit, and the enforcement of contracts. More impressively, the country ranks as the global leader in access to electricity and favorable tax environments while ranking second in obtaining construction permits. Although the country lags regional and global competition in terms of easing trade across borders (6^{th} and 91^{st} respectively), its advantages elsewhere favorably position the country as a regional business leader.

Table 6.2 Business climate for GCC and select MENA countries. Adapted from World Bank (2018c)

Country	Ease of Doing Business	Starting a Business	Dealing w/ Construction Permits	Getting Electricity	Getting Credit	Protecting Minority Investors	Paying Taxes	Trading Across Borders	Enforcing Contracts
UAE	21	51	2	1	90	10	1	91	12
Bahrain	66	75	47	79	105	108	5	78	111
Morocco	69	35	17	72	105	62	25	65	57
Oman	71	31	60	61	133	124	11	72	67
Qatar	83	89	19	65	133	177	1	90	123
Saudi Arabia	92	135	38	59	90	10	76	161	83
Kuwait	96	149	129	97	133	81	6	154	73
Jordan	103	105	110	40	159	146	97	53	118
Egypt	128	103	66	89	90	81	167	170	160

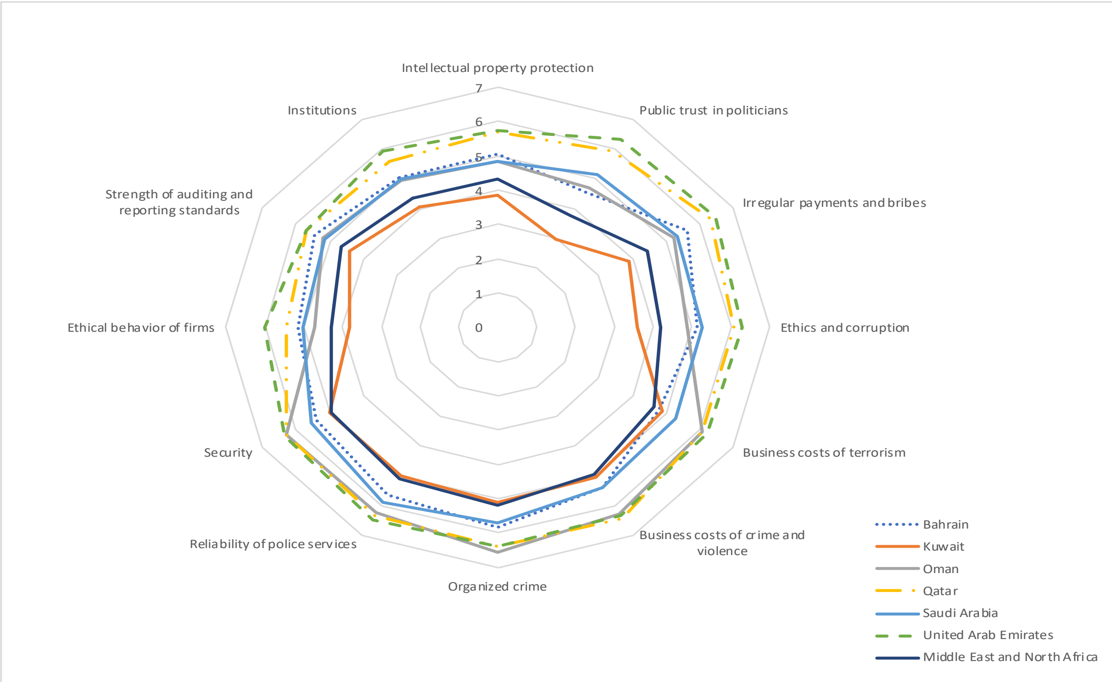

Figure 6.2 Security and stability of GCC countries (1-7 with 7 being the best). Graph created from data contained in Schwab (2018)

Complementing the country's business climate is the UAE's comparative stability and security to neighboring and nearby countries. According to the World Economic Forum's Global Competitiveness Report (Figure 6.2), the UAE is both a regional and global leader in terms of security and stability. Regionally, the country ranks first or second across all categories, often in conjunction with Qatar and occasionally Oman. Globally, the UAE performs admirably, ranking amongst the top countries in the world in terms of institutions (5th), public trust in politicians (2nd), prevention of irregular payments and bribes (6th), ethical behavior of firms (6th), business costs of terrorism (7th), business costs of crime and violence (4th), prevention of organized crime (7th), and reliability of police services (5th).

Six of the respondents highlighted the political stability of the country, often noting the country's proven track record of being a secure destination (S3, S5). Despite regional political unrest in late 2010 and early 2011, the GCC as a whole has remained remarkably stable. Even Bahrain, the notable exception, has remained a prominent regional banking hub in part due to its ability to weather the protests and maintain an environment conducive to business (Ewers et al. 2016). Two solar energy CEOs noted that they elected to locate their business operations in the UAE largely due to the political stability and security. J2, for example, explained: "politically, the country is extremely stable. This facilitates long-term thinking and investment confidence. Our reasons for locating here are very similar. We are able to operate in a strong, stable business climate and are able to attract the necessary human capital resources and inputs." Similarly, the founder of another firm maintained that "the most important advantage is the political security. [The UAE] is very safe and very stable. If you, as a customer, want to start a 20 year or long-term investment, you want to be confident that the area is safe." In this sense, the local stability, combined with the country's business climate provide an excellent incentive for companies to develop and invest in solar technologies.

In a larger sense, the UAE's transition towards solar energy is an outcome of technical, economic, locational, and business arguments. Whereas the country exceeds many solar potential metrics, thereby making it a prime candidate for solar, its solar potential does not give it a competitive advantage over neighboring states. As Table 6.1 shows, the UAE remains a prime location for both PV and CSP solar technologies; however, this alone does not explain the rapid growth of the industry and relative dominance compared with the other Gulf States. As a group, the GCC state have similar energy needs (the exception being Saudi Arabia) and similar potential solar energy profiles which correlate with peak demand. Where the UAE gains a distinct regional advantage is it business climate, stability, and ability to leverage its location at the crossroads of three continents. When assessed together, local solar potential and the favorable business environment provide a unique context positioning the UAE as one of the most favorable solar energy countries in the world (see Figure 6.3).

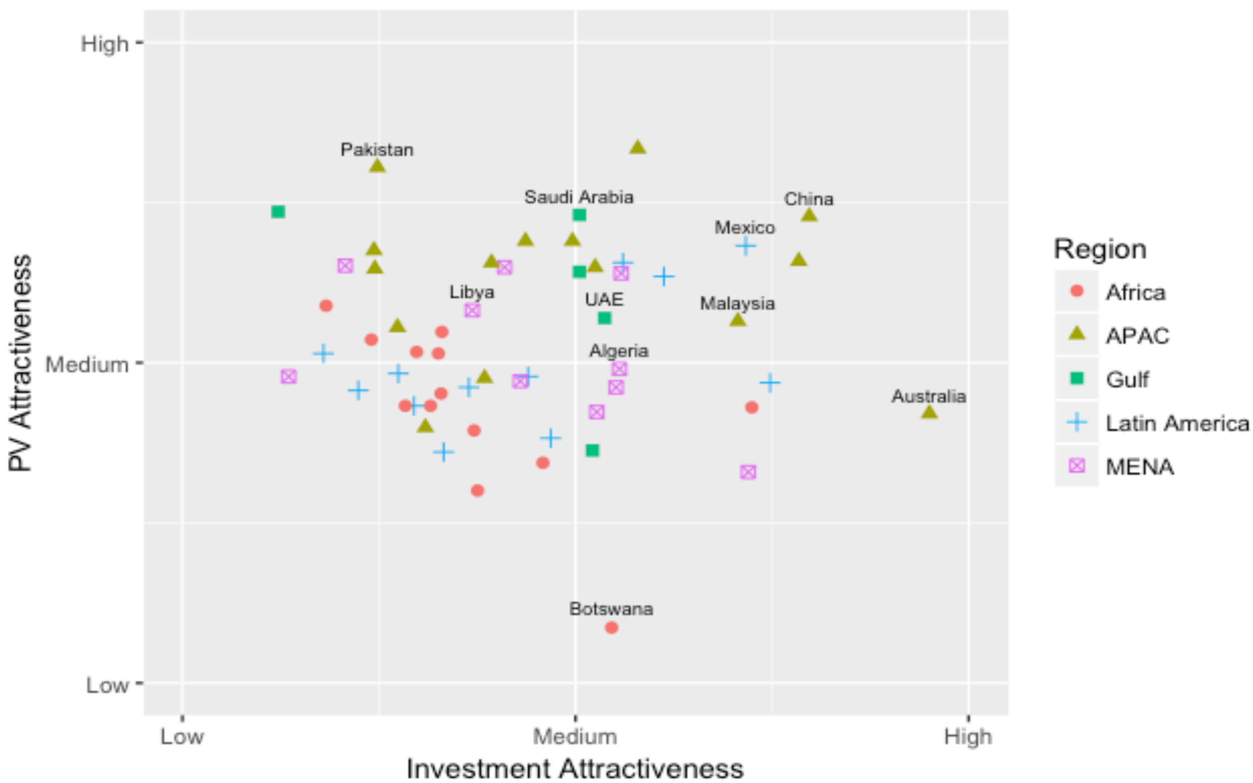

Figure 6.3 Solar opportunity for "Sun Belt" countries. Graph created with data contained in MESIA (2017)

6.3 Climate Change and National Identity in Energy Transitions

Beyond technical, economic, and business-based arguments for solar energy transition, arguments from both climate and local culture emerged during the interview process. Climate-based arguments for energy transition have featured prominently in the academic literature with advocates noting that a large-scale shift towards renewable energy could abate the most pessimistic climate change projections (Jacobson and Delucchi 2011; Delucchi and Jacobson 2011). Global discourse on climate change inevitably includes the UAE, which is an oil major with one of the highest per capita carbon footprints. Respondents acknowledged perceptions that the country is wasteful, yet used these perceptions to demonstrate how the government used such narratives to incentivize the development of solar energy. Key informants argued that the historical climate "antagonism" provides the country with an opportunity to become a clean energy and sustainability leader; thereby setting a global example.

As part of a shift towards more sustainable urban development, the UAE emphasized the "green" legacy of its founder, H.H. Sheikh Zayed bin Sultan Al Nahyan (discussed in 6.3.1. National Image and Solar Narratives). This "green" legacy helps elites establish a national identity constructed around the former president and centered on sustainability rather than the prevailing narrative of excess per capita carbon emissions. The linkage between national identity and energy narratives are found elsewhere in the academic literature (Bouzarovski and Bassin 2011). During the interview process, a number of respondents used the H.H. Sheikh Zayed "green" legacy link to underscore the importance of investing in solar and renewable energy despite possessing vast quantities of hydrocarbons.

Yet, contrary to national sustainability narratives, respondents shared insights on a broader national narrative concerning the country's use of megaprojects to grab global headlines (see 6.3.2. The Solar Mega Project). Often referencing construction marvels such as the Burj Al Arab, Palm Jumeriah, and Burj Khalifa, several experts argued that large-scale solar investments and construction represent the latest iteration of the country's desire to possess the "biggest" (A2), "best" (B1), and "tallest" (K2). For some, the interest in solar strives from a growing global appreciation for the technology and local posturing to be at the center of the global industry, while others argued that such rationales make the local industry vulnerable to "going out of fashion" in favor of the next *en vogue* global trend (D1).

6.3.1 National Image and Solar Narratives

Historically, the relationship between the UAE and the broader OPEC states and climate change has been adversarial. Home to roughly one-third of the world's proven oil reserves (OPEC 2017), these petrostates have long possessed an incentive to cast doubt on climate research supporting mainstream views on global warming (Luomi 2016). In addition to their status as oil majors, the GCC countries have gained further notoriety as the top per capita carbon emitting states in the world: Qatar (1^{st}), Kuwait (4^{th}), Bahrain (5^{th}), UAE (6^{th}), Saudi Arabia (8^{th}), and Oman (13^{th}) (World Bank 2018b). Increasingly, there is a nation-wide recognition for the need to decrease carbon emissions from power generation (Vision 2021 outlines a 70% reduction by 2050) and become a more sustainable society. This viewpoint was largely reflected in interviews with several respondents noting that the oil legacy of the country necessitates a bold carbon-friendly future (B1). In 2005, the UAE became one of the first oil majors to ratify the Kyoto Protocol and, in 2015, reaffirmed its commitment to low-carbon technologies through pledges to increase its share of clean energy at the COP21. A former environmental consultant posited that this acknowledgement of anthropogenic climate change compels the country to act:

> Climate change is at the heart of the issue. Everywhere you look, people are talking about climate change and it puts a lot of pressure and heat on the oil producing countries. Everyone blames the hydrocarbon producers for climate change, so the UAE is look at like they are at fault. Rather than accept this, the UAE is trying to become a renewable energy leader. It's a rebranding (S1).

From a domestic and global perspective, this "rebranding" effort has been largely successful in creating a revised national identity as the country has made inroads towards amending its image as simply a hydrocarbon superpower – thus largely responsible for climate change. Internationally, the UAE has grabbed headlines with world records for the largest (Ponce de Leon 2017) and lowest LCOE (Ponce de Leon 2018). More importantly, following the creation of the International Renewable Energy Agency (IRENA) in 2009, the UAE successfully negotiated Abu Dhabi to become the global headquarters. Symbolically, the selection of Abu Dhabi reaffirmed the country's commitment to deploying its vast oil wealth to promote renewable energy transitions (Luomi 2009). Yet the respondent's cynicism likely reflects the lack of decrease in CO_2 emissions to match the announcements.

On the domestic front, the UAE has sought to tie the shift toward solar energy to the ambitions and legacies of the country's former ruler. In popular accounts, the late president, H.H. Sheikh Zayed (1918-2004) is often positioned as a conservationist deeply concerned for protecting the local environment with a strong belief that it is the obligation of current generations to sustain the environment for future ones (Abu Dhabi Digital Government 2018). Famously, the late leader argued that environmentalism is a duty to both country and humanity:

> We cherish environment because it is an integral part of our country, our history and our heritage… our forefathers lived and survived in this environment. They were able to do so only because they recognized the need to conserve it, to take from it only what they needed to live, and to preserve it for succeeding generations. With God's will, we shall continue to work to protect our environment and our wildlife, as did our forefathers before us. It is a duty, and, if we fail, our children, rightly, will reproach us for

> squandering an essential part of their inheritance, and of our heritage (Sheikh Zayed in a 1998 speech during the UAE's first Environment Day)

Amongst some solar energy experts, the recent shift towards sustainable and renewable energy is an extension of H.H. Sheikh Zayed's conservation legacy. Respondent B1, for example, argued that:

> The local interest in solar goes back to the UAE's first leader, His Highness Sheikh Zayed al-Nahyan. He believed that agriculture was one of the most important things and wanted to develop green areas in the UAE. He was always trying to find how we can be environmentally friendly. That legacy has led to the current thinking of how can we be sustainable; how can we change consumer behavior to be more "green"? The answer is through education and leadership.

Other respondents shared similar sentiments, noting the late leader's broad vision for a green economy (D1) and government vision for the country (K2). Official government statements have further linked the revered leader with environmental consciousness. The National Archives contain information on Sheikh Zayed's conservation efforts, highlighting his efforts to protect local species and culminating in global conservation awards such as the World Wildlife Fund's Golden Panda and the United Nations Environment Program's Champion of Earth (Ministry of Presidential Affairs 2018).

The sociopolitical co-construction of national identity and energy is not a new concept in geography. For example, Bouzarovski and Bassin (2011) underscore the blending of national discourses and energy in the construction of a hydrocarbon superpower identity for Putinist Russians. Such research often examines the context of hydrocarbon super powers and the production of national identity through resource abundance and importance within the global economy and the attainment of *derzhava*, or "Great Power" status (Bouzarovski and Bassin 2011). The linking of identity and the pursuit of renewable energy has been examined at the local level (Brannstrom et al. 2011), yet received scant attention at the national level; however, scholars are beginning to examine how geopolitical dimensions and energy security are deployed to produce national narratives designed to market sustainable energies (Fischendler et al. 2015).

Although centered on clean and renewable energy, rather than hydrocarbon dominance, the UAE's co-construction of national identity and solar energy follow similar pathways as the Russian example. The country has long fashioned itself as an aspiring global leader. Solar energy development, characterized by large-scale, world-record utility projects, represents one means of asserting global leadership (Alrawi 2018). The President and Founder of the TRENDS Research & Advisory and consultant for the UAE government, D. Ahmed Al Hamli, notes that the record-breaking prices have placed the country in the center of global discussion of renewable energy and allowed the country to assume a global leadership role (Weatherby et al. 2018). Domestically, the shift toward renewable energy has been centered around the life and legacy of Sheikh Zayed, who often espoused environmental conservation as an "Islamic duty," caring for Allah's creation, necessary for increased intergenerational justice (Luomi 2016). More aptly, the country has sought to link environmental sustainability and conservation with "modernity" and "progress" (Ouis 2002); thereby creating foundation for a later national narrative concerning the development of solar.

Environmental and climate-based arguments for solar energy transition have been largely successful in the UAE as many respondents – none of whom where Emirati – reproduced national narratives concerning sustainability. Several respondents highlighted the adoption of solar as part of the government's vision to commit to "clean" (S2) and "green" (M1) energy production and the desire to become a world leader (Y1), set a global example (M2), and lead through action by meeting the goals of the Paris Accords (K1). In particular, several respondents noted that commitment to the government's vision by the local population and climate concerns – rather than power generation needs – are essential to understanding the country's energy transition (B1, D1, J2, O1). Moreover, key informants highlighted the importance of culture, national narratives, and identity in convincing the local population to embrace solar.

> The leaders are trendsetters in the country. Once they do something, invest in something, buy something, everyone else wants to do it as well. They all follow. For example, Sheikh Mohammed [bin Rashid Al Maktoum] purchased this German car[8] that wasn't being produced much and now everyone wants one. It shows that you "belong," it shows you are "in the know." This car is very popular here now. The same thing is happening with solar. The leaders are investing in solar so everyone else is taking note. Everyone wants to be a part of it (A2).

Those informants directly involved in the sale of solar energy installations to industrial, commercial, and residential customers further highlighted importance of culture and national identity for advancing energy transition. One executive noted that some of the market issues (discussed in a later section) could be overcome appealing to the national identity themes of being green and sustainable (B1). Meanwhile, one solar engineer shared that he uses the sense of

[8] It is likely that A2 is referring to the Mercedes-Benz G 63 AMG. Sheikh Mohammed purchased three of the 2013 model and has given each an exclusive license plate number (1, 5, and 11). In the UAE, license plate numbers are often viewed as a sign of status and wealth (lower numbers being at a premium) with several plates auctioning for millions of dollars. Adorning the G 63 AMG with low plate numbers, particularly 1, further cemented the status of this car as symbol within the country.

nationalism and culture to sell solar installations arguing that an appeal to being part of government vision – in addition to the financial benefits – is particularly effective (A2).

6.3.2 The solar megaproject

A theme that emerged during the qualitative portion of the research was the extension of the UAE's national identity through the production of solar energy at a massive scale commensurate with the UAE's reputation for large infrastructure. The UAE has deployed its vast wealth to create megaprojects designed to attract businesses and tourists and to obtain global media attention. Dubai, in particular, has gained notoriety for its megaprojects. As of 2018, the city is home to 12 of the 60 tallest buildings (including the Burj Khalifa), Dubai Mall (2^{nd} largest by land area), Mall of the Emirates (home of the indoor ski slope, Ski Dubai), man-made archipelagos (the Palms Jebel Ali and Jumeirah and the yet-to-be completed World), and will host the 2020 World Expo. One-fourth of interview respondents noted that the UAE has adapted its predilection for megaprojects to the production of solar power. The Head of Renewable Energy at one firm argued that the country's approach to solar is an extension of this legacy:

> It is a statement. We have the biggest building, we have the best hotel, we have the biggest solar field. Everything is about the biggest and the best, especially in Dubai. The roll out of solar energy in Mohammed bin Rashid Al Maktoum park, etc., is a means of staying in the spotlight and staying with the narrative that we have the biggest and best (D1).

Contributing the "biggest," "best," and "tallest" megaprojects was a popular refrain of many experts (A2, K2); whereas other key informants more broadly defined these megaprojects as part of the country's desire to "show off" (B1, M2) and be the global center of solar energy (J2, K2, O1, S1, Y1). These claims are further reflected in pro-government news media which often touts government plans for the "largest" (*The National* 2017) and "lowest cost" (Mammoser 2018) – a record set in 2016 and then broken again in 2017 (Sadaqat 2017). The increased news coverage has not gone unnoticed with the local experts. One CEO noted that, "In the last three years or so there has been a large media buy to promote solar. Every few days or weeks, there was a news article touting the developments of the industry as a means to convince locals to invest in and adopt solar" (J2). In the context of Dubai, specifically, the focus on constructing solar megaprojects designed to capture global headlines fits within the so-called "Brand Dubai," whereby the emirate is portrayed as modern and marked by consumption and displays of wealth (Govers and Go 2005; Coombe and Melki 2011).

The perceived focus on headlines as part of the country's larger image created a divide within the respondents. For several respondents, the fixation on solar energy stems from the technology currently being *en vogue* as part of larger global discourses on the reduction of carbon emissions and the transition to sustainable energy. Respondent S1, for example, argued that the global popularity of solar has largely influenced the country's interest:

> Right now, I liken solar and renewable energy to being in-style. Like fashion, it is a trendy topic and countries and companies are increasingly paying attention to it. In some sense, being "green" or sustainable is something companies can use to promote themselves… This renewable/solar energy moment is both corporate social responsibility as well as good press.

The self-identified conservationists within the interview sample argued that framing interest in solar energy as the "hot topic" provided a means of generating interest in solar investment. For these individuals, the rationale a company used to invest in solar did not matter; what matters is that the company invests (M1). However, other respondents noted their general unease with the use of solar to generate headlines. One respondent argued that like fashion, solar could eventually go "out-of-style":

> There is a certain fear that the industry is narrative driven and the news and headlines need to stay good. What happens when there is an epic failure? Renewable and solar energy is all the rage right now, so the thought is can we be a part of it? If something goes wrong or a project is a disaster, does the UAE just move on to the next big thing? Do they say, ok, we are going to be the world leader in medicine and then invest in hospitals and doctors? If so, there is real risk in solar (D1).

For this respondent, headlines and world records represent a key impetus for solar development, yet they may also be a contributing factor to the industry's eventual decline. D1 argued that the fixation on headlines cuts both ways: positive headlines reinforce the industry and negative headlines destabilize it. Headlines that have thus far propped up the emerging solar industry could also contribute to its uncertain future if global trends shift away from solar energy or if negative headlines concerning the state of the industry arise.

6.4 The political dimensions of solar energy investment and transition

Based on the coding protocol, the last theme concerning the UAE's interest and investment in solar energy concerns the political and security dimensions of energy transition. Throughout the course of the qualitative research, eleven of the key informants highlighted energy transition rationales relating to energy independence and security. Although there was widespread support for the country's adoption of solar energy as a means of establishing broader energy security, several respondents also highlighted the importance of solar energy as a political statement for domestic energy security. For these individuals, solar energy is not only an attempt to diversify away from oil dependence as a country, but an effort on behalf of the other six emirates to gain a degree of energy independence from oil-rich Abu Dhabi.

In addition to security and political dimensions, respondents highlighted the present and future state-wide benefits of solar energy investment. Informants argued that the UAE's growing economy, in the short-term, necessitates greater future energy production. Although the UAE currently has the capacity to meet such demand, the incorporation of solar into the energy mix decreases the burden on the current system. Moreover, respondents argued that the current electrical generation system – largely predicated on oil and gas derived electricity – represents a poor short- and long-term economic strategy. Despite an abundance of low-cost hydrocarbons, many argued that domestic consumption represents a suboptimal outcome as these resources could be sold on the global market at a premium. Domestic consumption, then, represents an opportunity cost that solar has the potential to reduce by allowing the country to pursue the optimal strategy while still providing for domestic needs. In this way, solar investment is viewed as a means of consolidating and augmenting oil and gas exports. Lastly, key informants shed light on the UAE's desire to be a solar energy first mover. As one of the earliest large-scale adopters of solar energy, respondents posited that the UAE could leverage its legacy as an energy exporter to become a net-solar exporter. Although in its early stages, the proposed EU-GCC Clean Energy Network could provide an avenue for the country to transition to the post-oil age.

6.4.1 Oil (in)dependence

As a classic rentier state (Beblawi 1987), the UAE derives a significant portion of revenue from the extraction and sale of crude oil. Regionally, the oil dependence remains high, with the commodity representing between 48% (Qatar) and 77.8% (Bahrain) of government revenues (First Abu Dhabi Bank 2018). In the UAE, the geography of oil is highly varied with Abu Dhabi containing approximately 94% of the country's estimated 97.8 billion barrels (UAE Embassy 2018). Despite this, oil exports comprise almost 50% of total government revenue; thereby ensuring the commodity remains an integral component of the economy (First Abu Dhabi Bank 2018). The country's efforts to diversify the economy beyond oil have been well documented (see Wilson 2013; Cherif et al. 2016; Baldwin-Edwards 2011; Ewers 2016; Mohammad and Sidaway 2012) and the UAE has further codified its intent to become less dependent on oil in its national development agenda, Vision 2021. Despite these efforts, six of the key informants highlighted the country's intimate relationship with oil as a key factor driving the growth of solar energy. For example, respondent M4 succinctly compared the UAE's need to diversify as similar to that of other countries: "every country wants to have solar today. No one wants to depend on one source of energy. Even in oil rich countries, they don't want to depend 100% on one source." For these individuals, the UAE's investment in sustainable energy is part of a larger state strategy to diversify the energy mix and become less reliant on oil.

Part of the argument for decreasing oil dependence stems from market volatility. Figure 6.4 displays the OPEC Basket Price of oil, which contains Abu Dhabi's Murban oil, against the country's fiscal breakeven point – the price per barrel needed to balance the budget. During the early 2000s, budget surpluses filled government coffers, allowing the country to invest heavily in infrastructure and grow the size of its sovereign wealth fund, the Abu Dhabi Investment Authority. Beginning with the Great Recession (2007-2009), however, budget surpluses largely dried up – in some cases leading to budget deficits. While the UAE, and broader GCC, can sustain short term budget deficits, the region's future outlook remains unclear with the EIA projecting oil prices to remain in the low seventy-dollar per barrel range through 2019 (EIA 2019). Current projections estimate the fiscal breakeven point for the UAE to decrease to $64.75 for 2019 (Table 6.3), representing a larger regional shift towards decreasing spending in light of lower oil prices. Continued reliance on hydrocarbons, increasingly disperse geographies of oil production due to the rise of hydraulic fracturing, and increased fuel efficiency, shifts towards more sustainable feedstocks amid climate concerns present existential threats to state income (Luomi 2009, Reich 2010, Sultan 2013; McGlade and Ekins 2015).

Figure 6.4 Fiscal break even price for the UAE. Graph created with data contained in IMF (2018) and OPEC (2018)

Table 6.3 Fiscal break even prices for select GCC countries. Adapted from IMF (2018)

Country	2014	2015	2016	2017	2018	2019*	% Change
Saudi Arabia	$106.20	$94.24	$96.55	$82.63	$87.90	$77.90	-26.65%
Kuwait	$54.31	$47.67	$42.98	$46.91	$48.12	$48.11	-11.42%
Qatar	$56.31	$52.43	$52.86	$48.28	$47.10	$44.47	-21.04%
Oman	$94.04	$101.89	$101.74	$80.55	$77.08	$71.74	-23.72%
UAE	$90.99	$64.71	$54.41	$62.44	$71.52	$64.75	-28.84%

*Projected

Source: IMF (2018)

The impact of broader diversification efforts on solar emerged during the interview process. For some, investment in solar is an acknowledgement that the oil era, and by extension oil rents, will one day come to an end. Although a minority of respondents (such as A5) argued that the UAE is reluctant to acknowledge the potential end of an oil era, others argued that the distant threat has necessitated bold action in the present. Respondent S1 shared his belief that the current solar investment is part of a larger forward-thinking vision for the country:

> The UAE leaders are very intelligent and capable managers…Oil will eventually run out and the leaders know it. Right now, you have two primary uses for oil here: transportation and electricity generation. Decrease in global demand for oil for either of these uses is a large threat. The electric car or other electricity generation methods could cause a lot of problems. These technological innovations force you to think beyond oil.

Changing global energy contexts potentially necessitate changes in government strategy. While there is little evidence of decreased global demand (IEA 2018), the continued spectre of a shift has increased the drive for a more diversified economy. Although its contribution to the economy remains small, several of the respondents argued that the development of a solar energy industry was part of larger efforts to diversify the economy (A3, A5, K2) and provide increased energy security (M1, M2, M4).

Much of the justification for investments in solar energy examines the global context surrounding energy transition. In the UAE, the academic literature predominately focuses on state-wide assessments for the investment in renewable and sustainable energies (Ferrouki et al. 2016; Abdullah et al. 2015). During the interview process, however, several domestic considerations for solar energy transition emerged. Subnational tariff variation was widely cited as a factor underpinning solar investment (see 6.2.1. Increasing Efficiency, Decreasing Costs and Electricity Tariffs). Yet many of the key informants argued that subnational resource allocation also plays a significant role in facilitating solar investment. According to the UAE government, the country has proven oil reserves in excess of 97 billion barrels; however, the distribution of oil is highly uneven with only 6% of the reserves located outside of Abu Dhabi – Dubai (4%), Sharjah (1.5%), and Ras al Khaimah (0.5%) (UAE Embassy 2018).

According to local experts, the variation in oil endowment produces two rationales for solar investment. First, the comparative lack of oil in the six smaller emirates grants a powerful incentive to shift the energy mix. Respondents argued that smaller oil endowments necessitate larger oil imports to meet demand (S1). Therefore, investing in solar is a means of decreasing imports and increasing energy security (S3). This analysis fits within Griffith (2013), who argues that solar PV's attractiveness in the Middle East largely breaks down among four groups: i) net hydrocarbon imports; ii) net hydrocarbon exports; iii) short-term development planners; and iv) countries where solar is not economically viable. As net hydrocarbon importers, the appeal of solar for Dubai and the Northern Emirates concerns the ability to substitute solar electricity for oil (Northern Emirates) and gas (Dubai) imports. Second, the shift towards solar investment in

Dubai potentially represents a larger political statement. When queried about the emirate's interest in solar, the CEO of a solar investment firm argued:

> There are shades of political dimensions as to why the UAE is investing in solar. When you look at the country, the large majority of the energy – mainly oil – is concentrated in Abu Dhabi. They are the "haves" while the other emirates are the "have nots" in terms of oil endowment. Part of the shift towards solar energy is to avoid energy dependence on Abu Dhabi. Although there is a unified federal government, the Emirates act more as independent states. I think there is a larger push to create solar as a means of declaring energy and political independence from Abu Dhabi (J2).

Energy independence within the UAE was a prominent theme during the interview process with respondents often discussing how the country functions like a series of separate states despite a central federal government (A3, A4, A5, B1, D1, J2). In this way, solar investment represents not only a means to create energy security for the state, but also inter-emirate dependence, however, this claim needs further investigation.

6.4.2 Oil and Beyond

The final aspect of solar energy transition concerns the present and future status of capitalism's "lifeblood" (Huber 2013). While "peak oil" arguments for solar energy transition were prevalent within a fifth of responses, far more respondents highlighted current and future advantages to solar transition. In particular, respondents noted the current opportunity costs of oil consumption, increased energy consumption, and the potential to become a renewable energy exporter as contributing factors to the country's unprecedented level of investment.

Over the past two decades, the UAE has experienced massive growth in both population and the economic realms. Rapid growth population, as a result of oil-driven development, as well as an expanding economy has augmented energy consumption and stimulated demand (Al-Faris and Soto 2002). The Ministry of Energy estimates that the UAE will need to augment its energy production as domestic consumption is expected to increase 9% annually (Asif and Muneer 2007). This phenomenon is symptomatic of the larger the unambiguous positive relationship between GDP growth and energy consumption (Asafu-Adjaye 2000). Both Abu Dhabi (99.7%) and Dubai (73%) rely heavily on natural gas to meet growing energy demands (Hasan et al. 2019; United Nations 2014). Although both emirates are capable of meeting these energy demands (D1, K2), domestic consumption potentially hinders external rents. Respondent M1 described the shift towards solar as a means of creating more oil revenue for the state:

> There is plenty of sun available in the UAE and in the whole GCC. If you take this amount of sun and turn it into solar energy it is equivalent to a lot of the things being burned - diesel, coal, other things - which are being burn to generate power. Rather than using domestic oil and gas, you can use solar to meet needs. This offsets pollution for the country and lets the country sell the extra oil abroad for foreign currencies. The additional money can help build up the budgets for future years.

Other respondents (B1, D1, K1, M1, M2, S3, W1) agreed with this assessment, arguing that the solar investment can offset oil consumption. For net importers (Griffith 2013), solar investment is an import substitution cost-saving measure. For net exporters, such as Abu Dhabi, solar investment decreases domestic hydrocarbon consumption, allowing for greater quantities to be sold for profit on the global market (S3, W1). These potential savings are significant as domestic consumption of oil accounts for between 8.5 and 15.6% (Abdullah et al. 2015). In both net importing and exporting polities, the transition to solar generated electricity provides economic benefits.

Lastly, respondents highlighted the future potential of solar energy and the country's legacy as an energy exporter a rationale for largescale energy transition. For these individuals, solar investment is happening because of the rationale that "if you can export oil now, you can maybe export solar energy later" (M1). Around 25% of respondents argued that part of the local appeal for solar energy is the potential to eventually export solar energy abroad. In particular, key informants argued that the creation of an intraregional grid could provide a lucrative future opportunity for the UAE, with one informant stating:

> Whenever there is excess power, [the UAE] can pass it on or sell it elsewhere on the grid. The country could export the energy to many other areas provided that the grid is connected. That could be a great source of income for the future. The UAE is always looking for diversity of income and a shift away from dependence on oil - at least in the long term. The amount of land and the efficiency of solar technology, which is always getting better, provides the UAE with a chance to develop another source of income (M1).

During our discussion the respondent discussed the now defunct Desertec project[9], arguing that a revival of such efforts in the GCC countries could be lucrative if the power grids become connected. Respondents argued that the ability to sell electricity through a larger interconnected

[9] The Desertec project is a since-discontinued initiative to install solar capacity in the Middle East and North Africa – particularly, in the Sahara Desert – and export clean electricity to meet demand in Europe. The vast empty space and solar potential would avoid many of the social issues associated with renewable energy development in populated spaces (see Pasqualletti 2000; Walker et al. 2014; Bell et al. 2005, 2013; Wolsink 2007; Brannstrom et al. 2011).

grid could spur local solar investment because the electricity would be sold in states with a more favorable electricity tariff (S3).

Despite the optimism and implications for solar of a potential intraregional grid, several respondents shared hesitations. Two respondents, in particular, were skeptical that the region would follow through on plans to become interconnected (M2, S6). Moreover, dependency on the Middle East as a clean energy exporter may create the potential of a "new energy weapon" (Pearce 2009); however, the efficacy of a "new energy weapon" is dubious (Lilliestam and Ellenbeck 2011). Although the concept of an intraregional grid was touted as a means of exporting solar abroad, and thereby increasing the incentive for solar investment, the Solar Director of one firm shared his concern that it may have the opposite effect:

> the low electricity tariff is hurting solar. While the tariff might go away, the development of a regional grid means that prices may stay lower, longer. If cheap electricity starts flowing into the country, it could hurt the long-term outlook for solar as it would not be cost effective (K2).

From a domestic perspective, removing the electricity tariff would bring the cost of electricity in line with the cost of production. As outlined in Section 6.2.1, such a move would increase demand for solar because the technology could offer cost-saving solutions. On one hand, the move towards a regionally integrated grid system would allow the UAE to export excess power. On the other hand, low-cost subsidized and unsubsidized energy would also flow into the country, potentially lowering electricity costs, thereby, making solar less financially enticing.

6.5 Conclusion

Respondents offered a number of key insights into the rationales underpinning the growth and development of the UAE's solar energy industry. In particular, respondents highlighted rationales concerning the immense solar potential of the region, favorable economic and locational considerations, the construction and perpetuation of national identity narratives, and the future status of hydrocarbons in the global economy. Although iterations of each argument exist in the academic literature, the findings underscore the interconnectedness and importance of these rationales to the creation of the UAE's solar industry. As a region, broader Gulf has high solar energy potential due to favorable incoming solar radiation. The dry climate and population distribution have created massive amounts of open space and flat rooftops primed for solar installations. Moreover, the overlap of peak electricity demand and solar power potential positions both CSP and PV technologies as favorable energy alternatives for the country.

Although the immense solar potential and climate considerations highlight the favorability of the region, they do little to highlight the individual success of the UAE – especially when compared with neighboring states. Respondents highlighted the importance of tariff reform, favorable business and political climates, and the country's strategic location to other markets as primary factors underpinning the growth and development of the local market. The respondents additionally pointed to the extension of the UAE's preference for massive construction marvels – the Burj Khalifa, the Emirates Palace, etc. – as a key explanation for solar development. The respondents argued that this preference, merged with a national identity centered on the "green legacy" of Sheikh Zayed, have produced a powerful local narrative about the forward-thinking, sustainable image of the monarchy, which seeks to alter the global perception of the region. Lastly, the respondents highlighted broader energy security and geopolitical contexts which favor solar energy development locally. These respondents argued that the uncertain future of hydrocarbons amidst climate concerns necessitates future planning from the government. In this context, solar energy investment represents a way for the government to invest present hydrocarbon rents in a renewable energy future. This investment, favorable solar potential, and open spaces sets the UAE on a course to become a net renewable energy exporter into the future.

7 DISCUSSION AND CONCLUSION

This research analyzed the structure and key actors of the emergent solar industry, the labor requirements and skill demands necessary for solar energy production, and the complex, multilayered rationales underpinning renewable energy transition in a the United Arab Emirates, a hydrocarbon super power. This section summarizes the findings and places these findings within literatures, showing how the research contributed to knowledge on large-scale energy transition, mapping industry actors, and labor demands. Lastly, this section reviews the limitations of the research and proposes avenues of future inquiry.

7.1 Summary of Core Findings

The following section reviews the core findings from the dissertation. These include insights from the GPN analysis, human capital and labor market assessment and firm perspectives on renewable energy transition in the UAE.

7.1.1 GPN Analysis

The GPN analysis (Section 4) of the UAE's emerging solar industry highlighted a number of key actors and organizations central to industry through evaluations of power, value, and embeddedness. Whereas GPN analysis has been applied to the renewable energy sector (Mulvaney 2016), the novel application to a single case study provided a number of insights. Research identified the industry's central actors and how these actors exercise power throughout the broader GPN. Despite energy transition narratives highlighting the country's solar potential and economic considerations (Section 6), the GPN underscores the state as the primary industry actor in terms of both corporate and institutional power. This assertion requires further differentiation between the federal government and the local emirate governments.

From the local government perspective, the local utility authorities (ADWEA, DEWA, SEWA, and FEWA) exercise considerable power through their ability to manipulate tariffs, fund utility scale projects, credential private firms, and create commercial solar providers. The variation between emirates endows local utility providers with considerable power through their ability to alter slab tariff schedules to spur investment in solar energy. Within the various emirates, both slab tariff costs and net metering programs significantly foster investment in solar energy. Amongst the two leading emirates (Abu Dhabi and Dubai), Dubai's comparatively higher tariff schedule (32 to 38 fils/kWh; \$0.087 to \$0.10 USD/kWh) at medium to high consumption (>4000 kWh) provides favorable economic conditions for the implementation of solar technologies. Moreover, the emirate's early adoption of net metering – a system whereby customers are billed based on the difference between their electricity production by solar panels and consumption – has further spurred development. Taken together, the power to alter tariff schedules and legislate net metering has the willingness to alter the tariff schedule and implement net metering programs has facilitated development in Dubai; whereas, Abu Dhabi (low tariff schedule), the Northern Emirates (no net metering program), and Sharjah (no interest in solar energy) lag behind.

The centrality of local governments to the emergence of the solar energy industry provides the basis for the collective power of private firms. Although the governments of Abu Dhabi and Dubai possess controlling interest in several quasi-governmental solar energy firms (Masdar, Environmena, and Etihad ESCO), the majority of solar energy installations are carried out by private firms with local firms predominately focused on solar rooftop installations and foreign firms predominately focused on large utility-scale projects. Whereas the government is able to tender new projects and develop legislation aimed at encouraging solar energy investment, it is these firms which carry out the design, construction, and integration of new installations. Individually, these firms are central to the growth, development, and expansion of the solar energy industry in the UAE. Collectively, through industry association groups they are able to lobby for the adaptation of standard practices and the implementation of new legislation able to foster further industry growth. In this way, transnational industry organizations (MESIA and World Green Building Council) and their members are able to exercise collective power and become central actors in the emergence and evolution of the local solar energy industry.

From a federal government perspective, the state remains a prominent actor through its ability to successfully create and reproduce national narratives concerning sustainability as a means of rationalizing energy transition through global rebranding as a "green" energy advocate. Much of the firm narrative (public and private as well as foreign and local) concerned the "green legacy" of H.H. Sheikh Zayed (see 6.3.1 National Image and Solar Narratives). Firm respondents routinely reproduced the "green legacy" narrative while discussing the country's motives for energy transition. When combined with the UAE's propensity for megaprojects, the state has had some success shifting the national narrative from climate antagonist to pro-sustainable energy and climate protagonist (Michaelowa and Luomi 2012).

Despite the centrality of the government (federal and local) and the power it exerts throughout the solar GPN, the analysis shed light on the limitations of state power. In particular, the GPN shed light on the various dimensions of value within the emerging solar industry with attention to how it is created, enhanced, and captured. The government successfully creates value through its ability to legislate local and national trade policies which allow (or restrict) the use of various product inputs. These exclusionary policies, which are often prohibitively expensive to overcome, represent licensing barriers to trade which favor those firms whose products are already approved. Additionally, the government creates value through its preference for certain products with specific national origins. As a consumer, the state demonstrates preferences for product brands, particularly those from Europe, which increases local consumer confidence in these firms. In both instances, the firms, rather than the state, captures this value, however, the state occupies a key role in creating value through its credentialing apparatus and preferences as a consumer.

The GPN analysis also revealed areas where the government has thus far been unable to create and capture value. Relational rents highlight the ability of actors to create value through the leveraging of their relationships. A central theme of the research proposal concerned the ability of the UAE to leverage its advanced hydrocarbon energy sector to create and sustain a renewable energy industry. Yet analysis of the GPN, survey findings, and key informant interviews highlight the surprising absence of the oil industry – ADNOC and ENOC – in the emerging solar energy industry. This contrary finding suggest that firm strategies do not include establishing relationships with existing energy entities in oil related fields, nor do they value sourcing human capital from such fields. Moreover, these findings suggest more nuanced understandings of energy transition from hydrocarbon to renewable as this transition is largely independent of the existing energy regime.

A further limitation outlined in the GPN analysis concerns how the state's institutional power produces unintended incentives which may limit the adoption of solar rooftop technologies. Although electricity slab tariffs in the UAE have increased over the last decade, the majority share of the increase concerns the consumption tariff for expatriates. Abu Dhabi, in particular, has altered its tariff schedule for expatriates. In 2014, the expatriate tariff was 15 fils/kWh ($0.041 USD/kWh). In 2016, the government increased the tariff to 21 fils/kWh ($0.057 USD/kWh) for ideal use (<200 kWh for villas; <20 kWh for apartments) and 21 fils/kWh for non-ideal use (Dajani 2016). In 2017, the government increased the ideal use tariff for expats to 26.8 fils/kWh ($0.073 USD/kWh), yet decreased the non-ideal consumption rate to 30.5 fils/kWh ($0.083 USD/kWh). From 2014 to 2017, the expatriate electricity tariff increased 78.7%. In comparison, the electricity slab tariff price for nationals increased 34% over the same time period to 6.7 fils/kWh ($0.018 USD/kWh) for ideal use (<400 kWh for villas; <30 kWh for apartments) (Dajani 2016). Although the electricity slab tariff increased for all residents, the comparatively low cost for nationals and the temporary residential status of expatriates creates a mismatch of incentives and leads to questions as to who (the tenant or the landlord) is capturing value. This unintended outcome, perhaps, grants insight into subnational variation of residential rooftop installations as an outcome of institutional power. Despite importing the knowledge necessary for domestic solar energy production and relying on foreign firms for utility scale installations, the UAE is increasingly exporting renewable energy expertise to places around the world. Analysis of the solar GPN reveals an outward-facing industry able to mobilize expertise and knowledge to its global projects.

7.1.2 Preference seeking, hiring practices, and labor agency

The assessment of the local solar labor market produced a number of key insights which reaffirm observations in the existing literature, yet add to our understanding of labor agency and migration in the UAE. The analysis (Section 5) details the complex rationales, preferences (both individual and firm), and decision-making which produces labor market outcomes. While local firm preferences and practices are found in the academic literature, the research found that skilled labor strategically relocates to the UAE to further career development. Solar energy firms in the UAE, both local and foreign, demonstrated clear preferences for hiring skilled labor abroad for a variety of reasons. First, and perhaps most importantly, the survey found that over 70% of firms agree that there are widespread experience and knowledge gaps in the UAE's local solar labor market. As a result, the majority of firms (92%) must provide on-the-job or on-site training to properly prepare new hires for projects.

Both foreign and local firms faulted the local university system for failing to produce the skilled labor necessary to support the growing industry. Despite aims to become a global leader in renewable energy production (Alrawi 2018), only 15 local universities offer a combined 56 courses in renewable energy – of which only 32% explicitly focus on solar energy (Al Kaaki et al. 2015). More than half of respondents argued that the current education system did not meet the demands of the growing industry, with several respondents highly critical of the focus of the coursework (S6). Labor market analysis in the UAE has highlighted the issues surrounding the informal disincentives for knowledge transfer as workers are concerned about training their replacements (Ewers 2013). Yet, the country's emerging solar energy industry provides early evidence that these disincentives for knowledge transfer are notably weaker. Several respondents shared their experiences training young solar energy professionals both on-the-job and in university settings, with one individual arguing that the responsibility to help train the labor force is on the private sector (G1).

Whether this departure from traditional Gulf knowledge transfer disincentives is particular to this industry remains to be seen. It appears more likely that outcome is a product of a young, emergent industry with astronomical demand and limited supply. Regardless, the locally trained labor force has continued to grow. The University of Sharjah's Department of Sustainable and Renewable Energy Engineering (SREE) was highly touted by the interview respondents, is accredited by the Accreditation Board for Engineering and Technology (ABET), and now enrolls over 500 students. With a 275% change in incoming class size since 2011, the private sector has started to see the impact of this training. Around half of the respondents who were critical of the local universities' ability to provide the skills and labor necessary for solar energy development, noted that the quality of new market entrants is increasing. This, perhaps, represents a departure from traditional labor market analysis in the Gulf, which predominately supports the attraction of global labor and skill, and towards an endogenous production of knowledge. Yet, in the present, the limited supply of local skilled labor forces firms to look abroad to fill local knowledge and skill needs.

Solar energy firms operating in the UAE also face challenges concerning profit and consumer expectations, which further condition the hiring practices of firms and labor market outcomes. The low electricity slab tariffs for nationals, expatriates, commercial properties, and industry limit the profitability of foreign and local solar energy firms (Section 4) and impact hiring decisions and sources. Respondents noted that firms are often "squeezed" and forced to make decisions between hiring the best available talent – likely expensive – and maintaining profit margins. This tradeoff produces labor outcomes which largely reproduce the existing migrant division of labor through several key considerations. First, respondents highlighted the salary premium associated with local hiring. To incentivize highly skilled individuals to change occupations, firms must often pay a salary premium to encourage prospective hires to forfeit their current fringe benefits and incur the costs of job change (Mitchell 1983). The global skill availability ensures that solar energy firms are not restricted to the local labor market. Given the low profit margins and salary premiums for local hire, firms often look abroad to find comparable skill for partial costs. Second, in an effort to cut cost structures, foreign and local solar energy firms are increasingly seeking individuals with multiple areas of expertise (e.g. – solar energy develop and solar energy finance) to reduce the number of employees and payroll burdens. Although these highly skilled individuals are in demand, the limited supply of talent with these particular skill sets means that firms must source internationally. Lastly, solar energy consumer preferences in the UAE often correlate national origin with product and installation quality. In an effort to meet these expectations, firms hire various (European) nationalities to certain positions, often at a cost, and cut costs by hiring other skilled labor from cheaper locations (south and southeast Asia). The sorting of certain nationalities to particular positions is common in Gulf labor markets (Ewers and Dicce 2016). These findings affirm that the practice has reproduced within the emerging solar industry.

Firm perceptions of the local labor market, perceived lack of available endogenous human capital capable of meeting project demands, consumer preferences, and cost considerations amidst small profit margins ensures that both foreign and local firms operating in the UAE's emerging solar industry maintain a preference for hiring abroad. Rather than a new economic trajectory and the establishment of new labor market dynamics, the solar energy industry has largely reproduced the labor market divisions through a combination of incentives which conspire to produce local outcomes. These outcomes include the global, rather than local, sourcing of talent and a purposeful division of labor by skill and national origin.

Despite their importance to reproducing local labor market outcomes, firms only represent one actor of knowledge mobility. From the key informant interviews, labor – through its preference seeking – is an important element which factors into knowledge mobility and produces labor market outcomes through the differential decision-making of individuals. The analysis of individual preferences includes both the amenity-based pull factors which attract labor to the UAE and how labor leverages the unique industry context of the country's emerging solar energy industry to further career development.

Labor recruitment to the UAE is not an exception. Rather, key informants highlighted the importance of quality of life and amenities for attracting human capital to the emirate capitals of Abu Dhabi and Dubai. As the country's profile has increased, skilled labor is attracted to these locations similarly to how it is attracted to global cities like New York, London, and Tokyo. Given the broader regional insecurity, the UAE remains a comparatively safe. Abu Dhabi, in particular, rates highly in terms of digital security (28th), health security (33rd), infrastructure security (16th), personal security (29th), and overall safety (28th) (The Economist Intelligence Unit 2017). Both Abu Dhabi (77th) and Dubai (74th) rate highly for quality of life (Mercer 2018) and both cities have favorable livability (Abu Dhabi 71st, Dubai 69th) (The Economist Intelligence Unit 2018). Moreover, salaries in the UAE are often above market rate (Singh and Sharma 2015). Given these dimensions, the labor recruitment specialist argued that it is unsurprising that he receives daily emails from talent around the world seeking to relocate to the UAE's growing solar energy sector.

Yet, labor exercises considerable agency beyond amenity-seeking. The interview respondents noted how skilled labor is not only used by the UAE to build and sustain a growing solar energy system, but how skilled labor is also using the UAE to advance careers. In particular, interview respondents noted three means through which highly skilled migrants leverage the emerging industry to further their careers while contributing to the growth and development of the local solar industry. First, respondents highlighted the importance of installed capacity as the key line on a perspective employee's resume. Both labor recruitment providers and industry CEOs argued that the rapid pace of growth and development within the UAE's solar energy industry provides a means to quickly inflate the total installed MW capacity through both utility and rooftop scale installations. Rooftop, in particular, provides ample opportunity as recent legislation – namely, Dubai's Shams program – has increased demand for solar. Skilled labor relocating to the UAE is able to quickly gain experience vis-à-vis installed capacity; thereby becoming more favorable future job candidates.

Second, compared with European and North American solar industries, the UAE's solar energy sector is still in infancy. For skilled labor hailing from these regions, the UAE provides a distinct advantage. In areas where the solar energy market has slowed down, such as Spain, the UAE provides an opportunity for gainful employment in a growing solar economy. More than just lateral employment, however, the comparative infancy of the UAE's solar sector provides opportunity for skilled labor to relocate in search of positions that might otherwise not be available in sending countries. Several respondents (S5, A1, A6, M1, W1) noted that the ability to occupy key positions, or create meaningful industry impacts factored heavily into their individual decisions to relocate. The labor recruitment specialist (S5), for example, highlighted the opportunity to work intensively with the key climate change and regulatory agencies in the UAE to effectuate change – an opportunity that was not available to him in his home country. In this way, skilled labor migration in the UAE's solar industry represents an opportunity for self-actualization through meaningful and fulfilling employment. Third, labor is leveraging the unique development context of the local solar market to advance its post-UAE career trajectories. Although gaining experience – and installed capacity – has a positive impact on career development, respondents also shared insights concerning how skilled labor uses local development as a springboard for careers after the UAE. For these respondents, expatriation is a strategic individual decision aimed at increasing long-term career opportunities.

When combining firm perceptions of labor, hiring practices, and individual preferences, several trends emerge from the data. First, firm demands for foreign labor coupled with a vast supply of qualified labor willing to relocate, ensures that the emerging sector will be largely shaped and staffed by skilled international labor. Second, labor migration to the Gulf States has largely focused on state and firm-level explanations of labor market outcomes. Such analysis often positions labor as being deployed by firms to create and sustain local industries. Yet, evidence from the UAE's solar industry sector suggests that labor, through its individual decision-making and preference seeking, utilizes expatriation as a career advancement tool. In this way, the relationship between skilled labor, firm hiring practices, and state aspirations is more symbiotic.

7.1.3 Assessing the rationales for transition

The key informant interviews revealed considerable insight into firm perspectives of renewable energy transition in the UAE (Section 6). These informant understandings of solar energy transition largely broke down along three broad narratives: solar potential, economic, and national identity. Transition theories concerning solar potential (Alnaser and Alnaser 2009; Islam et al. 2009) and economic considerations (MESIA 2016; Sultan 2013) are found in the literature, few researchers have examined the role of national identity in producing solar transition outcomes (Luomi 2016 is a notable exception). Yet, the literature largely examines energy transition in Western context with marginal attention to transition elsewhere (Coenen et al.

2012). The qualitative portion of the dissertation research adds depth to our understandings of energy transition while examining the complex rationales and understandings underpinning solar energy development in a hydrocarbon superpower.

Respondents argued that solar energy development represents a natural course of action for the UAE given the solar potential, climate considerations, and population centers of the country. The so-called Sunbelt – a loosely defined region ranging in latitudes from 35N to 35S – receives high amounts of solar irradiation each year. As a country within this area, the UAE receives both DNI (important for CSP) and GHI (important for PV) far above the global averages, making the Emirates one of the most desirable locations for solar energy development (Alnaser and Alnaser 2009). Moreover, the climate is extremely predictable with temperatures ranging between 18 and 34 degrees Celsius and precipitation ranging between 8mm and 19mm (Climate Change Knowledge Portal 2018). While the extreme heat of the summer months decreases the efficiency of solar panels up to 25% (King et al. 1997), the relatively stable climate provides ideal solar conditions for electricity generation.

A second argument for transition due to solar potential concerns the suitability of solar to the energy demand dynamics of the UAE. According to local utility providers, the peak demand for electricity ranges between noon and 6pm (DEWA 2018). The overlap of peak electricity demand and peak solar energy electricity supply make solar well suited to meet the local grid demands. Additionally, respondents highlighted how the comparatively dry climate and resulting flat rooftops provide vast amounts of space for solar energy installations, which in turn support the creation of a distributed solar electricity generation network. This, coupled with a population largely centered in urban areas near the coasts, means that the UAE has an abundance of space for solar energy installations in areas which avoid potential issues traditionally associated with the "social gap" (Bell et al. 2013).

Although the immense solar potential of the region explains the recent development of solar energy in the UAE, it does not explain why investment lagged behind less suitable regions (Europe and North America) or why the country is now a regional leader despite better solar potential in surrounding areas (notably Yemen, Ethiopia, Chad, Sudan, and Somalia). To answer questions concerning the delay in adopting solar energy technologies, respondents pointed towards economic arguments for solar energy transition. Unlike more developed markets, the UAE's electricity tariff price controls (Section 4) limit the profitability of solar installations. In the United States, for example, the American Southwest's average electricity price is $0.111/kWh (EIA 2011). Meanwhile the cost of electricity in the UAE ranges between $0.018/kWh for nationals and $0.010/kWh for non-ideal use amongst expats and commercial properties. The comparatively low costs have largely restricted the profitability of solar until recently as the price of components has decreased dramatically. The declining costs of solar installations and new net-metering legislation in Dubai and Abu Dhabi have created an economic environment which encourages solar energy investment as a cost-savings tool.

Respondents also elucidated rationales as to why the UAE, rather than other high solar potential locations, has witnessed dramatic industry growth and development. The consensus amongst respondents is that the UAE benefits from its comparative safety, business climate, and access to regional markets. The UAE has successfully leveraged its location to create and sustain an emerging solar energy industry through comparative advantage. From a business climate standpoint, the UAE rates favorably in terms of ease of doing business (1st regionally; 21st globally), ease of starting a business (3rd regionally; 51st globally), issuing construction permits

(1st regionally; 2nd globally), accessing credit (1st regionally; 90th globally), protecting minority investors (tied 1st regionally; tied 10th globally), low taxes (1st regionally; 1st globally), and enforcing contracts (1st regionally; 12th globally) (World Bank 2018). Moreover, the country is noted for world class institutions, public trust in leadership, and maintenance of law and order (Schwab 2018). These metrics position the country and its leading cities of Abu Dhabi and Dubai as key favorable business locations within the region. Given the broader instability of the region, the UAE's political stability and security increases firm confidence while mitigating the micro – firm or industry specific – and macro – geopolitical or regime-based – risks associated with location selection (Alon and Herbert 2009; Robock 1971).

Respondents also highlighted state-produced rationales for solar energy transition. These explanations consisted of national identity narratives as well as strategic state decisions in terms of resources management and allocation. One element of the national identity narrative concerns the linkage of the "green legacy" of H.H. Sheikh Zayed al-Nahyan with the current push for clean energy within the country. Both foreign and local respondents highlighted this legacy as a primary reason underpinning the UAE's transition to green energy in the form of solar. For its part, the state has largely embraced the "green legacy" and solar energy nexus and dedicated official portions of government websites to solidify this link. This includes touting the UAE as one of the first hydrocarbon superpowers to ratify the Kyoto Protocol, the successful campaign to locate IRENA's headquarters on Masdar's campus, and various global environmental awards obtained by the late leader, including the World Wildlife Foundation's Golden Panda and UNEP's Champion of Earth (Ministry of Presidential Affairs 2018). Since 2008, the government has awarded the Zayed Future Energy Prize (now the Zayed Sustainability Prize) as a tribute to the founder's legacy and to highlight sustainable contributions in health, food, energy, water, and education (Zayed Sustainability Prize 2019).

Although the respondent reproduction of this narrative underlines the government's success at shifting the perception of the country from one of the highest per capita carbon emitters in the world (World Bank 2018b) to a progressive, environmentally conscious climate activist and clean energy leader, questions remain as to whether this shift is purely a public relations pivot or if it effectuates actual change. Analysis of the CO_2 emissions per capita reveals considerable insight. From 1990 to 2010, the country's CO_2 per capita emissions decreased from 30.39 tons to 20.70 tons; yet, from 2010 to 2016, per capita emissions have increased an average of 2.25% to 23.60 tons (EDGAR 2017). The increase in emissions despite a massive increase in solar energy investment appears to undermine the "green legacy shift". Beyond a shift toward green energy, respondents noted that the UAE is using solar energy to reproduce its megaproject driven development strategies. In other instances, the UAE has utilized the construction of the tallest buildings, largest islands, and most luxurious hotels to draw global headlines to the country and put Dubai and Abu Dhabi firmly on the map of global cities (Global and World Cities Research Group 2018). Despite the headline-grabbing success of this strategy and the subsequent pull factor for skilled labor, respondents shared concerns about the long-term sustainability of the strategy as the UAE looks to grab global attention with the next trendy industry.

The success of the solar megaproject and the ineffectiveness of the "green legacy" national identity in decreasing carbon emissions, perhaps, points to a different rationale for the country's energy transition. As the Business Development Manager of a local firm pondered, "I fear that installing these plants makes people think 'we are already doing something, why should we do more?' It promotes or continues the electricity consumption habits but doesn't change them" (B1). In this way, solar energy transition may be less about constructing a national identity narrative around sustainable energy and more about a socioecological fix for capitalism, which perpetuates consumption through shifting the production; thereby allowing accumulation (and consumption) to continue without addressing the underlying cause (McCarthy 2015). Moreover, respondents noted that a shift towards renewable energy decreases domestic consumption of hydrocarbons. With energy consumption predicted to increase 9% annually (Asif and Muneer 2007) and domestic oil consumption estimates ranging between 8.2 and 15.6% (Abdullah et al. 2015), a shift to renewable energy allows the government to profit from additional oil exports in the near future, and potentially allows the country to export clean energy in the future.

Although solar and similar renewable energy technologies are often classified as post-oil or post-hydrocarbon (Sultan 2013; Reiche 2010), the relationship between the two energy sources in the UAE requires more nuanced explanations. Rather than post-oil, the UAE's investment in solar energy is, perhaps, better described as "co-oil." The phrase "energy transition" implies a distinct shift from one source of energy to the adoption of a different form. In parts of the developing world, energy transition may signify the shift from biomass fuels to electrical grids (Bradshaw 2010), whereas transition in more developed countries involves a shift towards low-carbon energy sources (Bridge et al. 2013). While "energy transition" in the context of a country with a mature oil industry may imply a shift from oil to low carbon renewable energy, the development of solar in the UAE suggests a more co-constructive relationship.

Although the development of solar energy is often framed as happening *despite* the UAE's vast quantities of oil, the presence of such reserves, in part, is *why* this investment is possible. Oil, through rents derived on the global market, provides the necessary seed capital for solar energy development. The estimated $600 billion AED in planned solar energy investments will likely come in large part through oil revenue. Beyond the capital necessary for investment, the growth and development, and predilection for megaprojects, which serve as a key means of skilled labor recruitment (see 6.3.2 The solar megaproject), are legacies of oil-driven development. Yet, the emerging solar energy sector facilitates the continuation of the incumbent energy industries through feedstock substitution. This substitution of solar generated electricity for hydrocarbon-derived electricity allows the oil industry to sell excess supply on the global market for additional revenue. Additionally, the creation of solar megaprojects – funded by oil rents – provides a "green" and "sustainable" cover for the hydrocarbon industry; thereby, curtailing climate change-based criticisms of hydrocarbon superpowers.

7.2 Connecting research on the UAE's solar energy industry to the literature

This section places the findings from the dissertation research within the broader academic literature. The research contributes to calls for social science and interdisciplinary research in energy geographies (Calvert 2015; Sovacool 2014; Sovacool et al. 2015) by determining underlying reasons for a paradoxical investment in PV and CSP in an oil-rich state. In particular, the findings reinforce, expand, and add nuance to literatures on energy transition, human capital mobility in the Gulf region, and global production network creation and assessment.

7.2.1 The UAE's solar GPN construction and analysis

Global production network analysis is largely concerned with the analysis of industry actors, their territoriality, and interactions across space (Coe and Yeung 2015). Traditional GPN analysis (see Henderson et al. 2002; Coe et al. 2008) rely heavily on theory with little attempt at constructing conceptual industry models (Bridge 2008 is a notable exception). This research offered a novel contribution by providing a conceptual model of an emerging industry through publicly available data, industry reports, and government white papers. The academic literature on GPNs has centered primarily on advanced producer services (APS) with marginal attention to energy industries, their emergence, and development. Broadly, GPN analysis focuses on examinations of power, value, and embeddedness with particular attention to the state, transnational corporations, civil society organizations, consumers, and labor (Dicken 2015). Yet the literature on GPN analysis, remains focused on lead firms and financialization.

The dissertation GPN (Section 4) advances the literature in several ways. First, the literature contributes to an underdeveloped, yet growing focus on GPNs of renewable energy (Mulvaney 2016; Baker and Sovacool 2017; Curran 2015). Moreover, the case study of the United Arab Emirates contributes to calls for energy transition research in non-Western contexts (Coenen et al. 2012; Sovacool 2014). Second, the research strengthens GPN analysis through the identification and study of dominant firms in the emerging solar energy sector (Coe and Yeung 2015). Although transnational firms represent important actors in the UAE's solar energy industry, the state remains the dominant industry actor through its various positions in the GPN. Third, the dissertation's focus on the various iterations of power, value, and embeddedness within the solar energy GPN contribute to calls for assessing the "complex bargaining process" (Coe et al. 2004, 476) between multiscalar actors which conditions GPN form and function. Fourth, the incorporation of labor into the analysis strengthens an under researched segment of GPNs. Importantly, the inclusion of labor analysis contributes to research on renewable energy labor dynamics (IRENA 2013; Sooriyaarachchi et al. 2015) and labor analysis in GPNs (Baker and Sovacool 2017; Curran 2015). Last, the examination of value capture contributes to understandings of how local contexts influence individual renewable energy investment. The research found that the varying tariff schedule for expats and nationals, combined with the permanent temporary status of expats provides a mismatch of incentives for solar energy investment, which potentially stifles further distributed electricity generation investment.

Recently, academics have revisited GPN theorizations and reoriented analysis around strategic actor-level choices, dubbed "GPN 2.0" (Yeung and Coe 2015). In particular, these theorizations highlight intrafirm coordination and control, interfirm partnerships, and extrafirm bargaining as key elements of competitiveness for the GPN. The construction and analysis of the UAE's solar GPN, however, revises this assessment in several ways. Yeung and Coe (2015) argue that intrafirm coordination examines how firms reorganize internal structures to optimize cost-competency of firms, develop markets, and mitigate risk. While firm hiring practices in the UAE consider strategic cost-based decision-making in terms of employment, the reliance on economic assessments only partially explains broader firm hiring practices.

Yet, the findings suggest the need for more nuanced understandings of intrafirm coordination dynamics. GPN 2.0 theorizations argue that firms capture value through increasing capabilities while decreasing costs. However, labor and GPN analysis in the UAE's solar energy industry highlights two challenges. First, firms must contend with local consumer expectations and preferences. In the UAE, this includes hiring certain nationalities to various positions (see 5.3.2 Local outcomes of firm decisions). Second, firms highlighted the need to hire various forms of knowledge (technical and business) to remain competitive. The adaptation of global solar knowledge and capability to local projects represents a deterritorialization of knowledge and fits within capitalist logics of cost and production (Bridge and Wood 2005). However, the need for territorialized knowledge in the form of navigating local institutions runs counter to capitalist understandings of competitiveness. Counter Yeung and Coe's (2015) cost-capability assessment of intrafirm coordination, the firms operating in the UAE's solar energy industry are increasing costs while maintaining neutral capability; yet, becoming more competitive. This finding underscores the importance of local context in understanding and assessing lead firm decisions in GPN.

7.2.2 Preference seeking, hiring practices, and labor agency

The labor market research in the dissertation largely affirms the findings present in the academic literature. In particular, the dissertation research found that local labor market outcomes are conditioned by firm hiring preferences, local and foreign labor preference seeking and local solar market contexts. The use of human capital and knowledge variables to assess the underlying rationale for investment in renewable power represents a new approach to studying energy transition and adds to literature that estimates the solar potential as the key determining factor. Taken together, the research confirms the complex incentives, rationales, and business decisions underpinning the attraction and retention of the skilled labor necessary for solar energy transition.

The research contributes to existing inquiries in several ways. From a local labor perspective, the research reaffirms the public-private sector divide between nationals and expatriates (Randeree 2009). While several respondents reiterated concerns about hiring nationals and their preparedness for private sector work (see Forstenlechner et al. 2012), others provided more nuanced understandings of the labor market divide. For these individuals, the solar energy labor market division is a reproduction of mismatched incentives which produce divergent preferences for firms and nationals (Forstenlechner and Rutledge 2010), furthered by institutional inertia; whereby, the natural inclusion of national labor in an emerging sector is through existing positions within the public sector – namely as regulators.

From a firm perspective, distortions in the labor market – skill gaps, salary premiums for local hires and nationals – combined with local market contexts – tariff schedules and low profit margins – provide incentive to search globally for skilled labor. The research contributes to regional firm hiring preferences and practices through its analysis of hiring sources, local labor market perceptions, and skill requirements. Through these preferences and practices, the emerging solar energy industry reproduces existing divisions of labor in the broader UAE labor market. These include a hiring of certain nationalities to certain positions to meet both consumer expectations and salary cost considerations. While consumer expectations, small profit margins, and salary considerations are found elsewhere in the literature (Ewers and Dicce 2016), the research also identified the global sourcing of knowledge as an explicit strategy to merge several costly positions into one highly skilled position. Firms increasingly favor skilled individuals capable of performing several job functions, yet the specialized nature of this knowledge necessitates a broader global talent search.

Additionally, the research contributes to individual preference seeking approaches to skilled labor migration. The quality of life indicators largely reaffirms the attractiveness of cities to highly-skilled labor (Ewers and Dicce 2017). Despite the tendency of globalization to act as a centrifugal force through space- and time-shrinking technologies, highly skilled labor remains centered in the "spikes" (Florida 2012) of the global economy. As a result, cities compete in a global "war for talent" to attract flows of highly skilled migrants in an effort to create and sustain industries (Michaels et al. 2001). The academic literature has gone to great lengths to catalogue the amenity driven perspectives on labor migration (Clark et al. 2002; Florida 2009; Glaeser et al. 2004; Glaeser and Gottlieb 2009). The key informant explanations of individual preference seeking and the “glitz and glamour” of the UAE fit within these conceptualizations of highly skilled labor mobility. The higher average salaries, comfortable standard of living, and comparatively safe and secure environment makes the UAE an attractive destination for skilled labor in solar energy.

Lastly, the research’s use of mixed methods contributes to similar research in renewable energy geographies (Walker et al. 2014) and highly skilled labor mobility (Al Ariss et al. 2012; Ewers 2017), with a particular attention to individual level qualitative data to better situate individual agency in larger processes (Watson and Beaverstock 2014). Expatriation as a career advancement strategy has been well documented in the literatures (Shaffer et al. 2012), with both expatriates and repatriates viewing the practice as highly beneficial for career development (Benson and Pattie 2009). Respondents in the UAE’s solar energy sector largely agreed with this assertion, yet also add nuance to our understanding. S5 argued that the benefits of expatriation largely depend on the next destination market. For skilled labor from less developed markets – South and Southeast Asia – the benefits of expatriation include the opportunity to work with leading international firms, learn best practices and industry standards, and gain experience. The expatriation logic is that these individuals will be highly competitive upon repatriation to less developed solar markets. For skilled labor from more developed markets – Europe and North America – the ability to increase installed capacity and learn best practices is less appealing. Rather, the expatriation logic concerns the opportunity to obtain key positions on large solar megaprojects, the size of which are found few other places. Attention to skilled labor mobility in the emerging solar energy industry contributes previous calls for increased attention to knowledge mobility in energy sectors (Bridge and Wood 2005; Böttcher 2010).

Future research on this topic should investigate whether labor is able to use expatriation to further post-UAE careers as the literature on the benefits of repatriation remain unclear (Benson and Pattie 2009). Additionally, researchers should examine whether skilled labor in other sectors, particularly advanced producer services, display similar preferences and career development aspirations.

7.2.3 Assessing the rationales for energy transition

Data gleaned from the key informant interviews highlights the importance of a multidisciplinary approach to assessing renewable energy transition. In line with calls for research at the "academic borderlands" between various subdisciplines (Calvert 2015), this research underscores the importance of assessing energy transition through a multidisciplinary geographic lens. Utilizing semi structured interviews with key informants, the research elicited a number of rationales underpinning solar energy transition in a hydrocarbon superpower. The qualitative portion of the research makes several contributions to the literature. First, it contributes to political economy approaches to state-level renewable energy transition (Rignall 2015; Power et al. 2016; Baker et al. 2014; Kern and Smith 2008). Second, it contributes to economic and technical arguments (MESIA 2016) for solar energy transition, as well as solar potential understandings for solar energy development (Griffiths 2013; Islam et al. 2009; Alnaser and Alnaser 2004). Third, the research highlights climate-based narratives for resource conservation (McGlade and Ekins 2015) and solar energy transition (Bardi et al. 2016).

Yet, economic, solar potential, and climate narratives alone do not capture the full complexity of rationales and understandings underpinning the creation of an emerging solar energy industry in a hydrocarbon superpower. Instead, the question of energy transition is best understood through the complex overlap of multiscalar political, business, economic, cultural, and physical geographies found in a particular area. In this way, the dissertation research contributes to academic discourse concerning energy transitions through its attention to both space and place (Huber 2015). Future work on energy transition must incorporate the wide range of actor rationales which condition or hinder the incentives for adopting post-hydrocarbon energy sources.

The linkage of national identity and energy politics features heavily in the academic literature, yet the focus predominately encompasses non-renewable resources. For example, the linkage between oil and Russian super power identity (Bouzarovski and Bassin 2011) or nationalism and mineral extraction in Bolivia (Kohl and Farthing 2012) represent the sociopolitical co-construction of national identity and resource narratives. The government's positioning of solar energy development as part of the national identity and legacy of the country's founder, perhaps represents a new instance of the identity-energy nexus. Although this nexus has been examined at the local level (Brannstrom et al. 2011), the literature has yet to examine state-level iterations. The dissertation research advances the literature through a broad incorporation of the various rationales – economic, climate, solar potential, technical, and national identity – to more fully understand how and why energy transition takes place in certain areas.

In a broader sense, understanding energy transition in the UAE highlights the socio-political nature of resource construction and utilization. Bridge (2009) adapts Erich Zimmerman's conceptualizations of how resources "become" to better explain how the properties of a potential resource conspire with the socio-technical needs of society to satisfy a need. The dissertation findings similarly highlight how changing socio-political contexts have positioned solar as an emerging resource and facilitated the country's energy transition. Solar potential and power density arguments for the UAE's transition ignore the social, economic and political dimensions which fostered transition. After all, the UAE has long possessed favorable solar potential and the country's urbanization dynamics have ensured that power density concerns remain minimal.

Rather, advances in technology marked by increasing efficiency and decreasing cost made the adaptation of solar energy feasible. Further, shifting geopolitical conditions altered local contexts in ways that allowed solar energy to solve energy issues associated with growing energy demand. Jim Krane (2018), for example, argues that 2014-2015 oil bust, 2010-2011 Arab Spring, and the 2015 Paris climate agreement provided economic, political, and environmental cover for the Gulf states to reform energy subsidies under the guise of state preservation. Previous studies have suggested that framing subsidy reform as a sacrifice for the promotion of national interests is a powerful tool for garnering social acceptance (Krane 2015). The shifting socio-political context, which has resulted in electricity subsidy reform, has greatly contributed to ongoing energy transition in the UAE. Theorizing energy transition, then, necessitates an understanding of how the physical (solar potential and power density), economic and technical (increased efficiency and decreasing costs), and socio-political (subsidy reform in light of declining oil prices and security and climate considerations) contexts condition the adoption of new energy resources, and in turn, grant greater understanding about the societies in which transition occurs (Bridge 2009).

7.3 Limitations and Future Research

Although the research provides insight into the growth and development of the solar energy industry in the UAE, there are a number of limitations to this study. The rapid growth and development of the local solar industry ensures that the dissertation provides valuable insight, but also a temporary snapshot of the industry. Since the beginning of the study in 2017, the number of firms, actors, and interested parties involved in solar production in the UAE has increased. This has several implications for this study. First, while the survey results are representative of the solar energy industry from November 2017 to September 2018, the increasing number of firms necessitates further examination to determine if the findings hold true or change as the industry grows. Second, the vast majority of solar energy growth and development during the fieldwork portion of the research occurred in Abu Dhabi and Dubai. All of the survey results and all but two of the respondents represent the perspectives and understandings of solar energy professionals living and working in Abu Dhabi and Dubai. This is an important limitation as Ras Al Khaimah and Umm al Quwain have respectively announced plans for 1200MW (Parnell 2019) and 200MW (Bellini 2019) of solar energy installations. During the interview portion of the research, I spoke with two individuals working in the Northern Emirates (S2 and A3). Although both interviews were productive, they were largely characterized by respondent frustrations at the slow pace of development. Given these announcements and the subsequent development that will take place, future research should examine the development of solar in spaces other than Abu Dhabi and Dubai.

Another limitation of this study is the reliance on firm perspectives on solar energy development and the broader solar energy transition in the country. While the firm respondents provided insight into the growth, change, and rationales underpinning the development of solar energy, government and local citizen perspectives and explanations are notably absent. This is particularly limiting in terms of the discussions of national identity and solar energy development as I have used firm perspectives to speak for the whole. During the fieldwork portion of the research, I attempted to contact key members of the local utility authorities and the UAE's Ministry of Climate Change, but was unsuccessful in securing an interview. Although public declarations from the government are widely available, future research should seek to interview government representatives to better assess their motives and local citizens to assess whether these narratives are reproduced and accepted.

Lastly, Coe et al. (2008) presciently note that the "lone researcher" approach likely cannot capture the multiactor complexity of GPNs. The evolution of this dissertation's GPN is a testament to the difficulties associated with such an approach. Yet, the process of constructing, assessing, altering, and augmenting the GPN in conjunction with industry actors potentially helps overcome some of these shortcomings. For this research project, this approach identified new actors, outlined new inter-actor relationships, and increased the complexity of solar energy production within the UAE. Future research on GPNs could benefit from these more grounded approaches to understanding production networks.

7.4 Conclusion

In conclusion, the dissertation research on renewable energy transition in the UAE produced a number of insights into the growth and development of a new industry. The GPN analysis identified the key actors involved with the creation, financing, development, and construction of the solar energy industry. In particular, the research identified the state as the key industry actor through its status as a financier (through various national banks), as a regulator and offtaker (through ADWEA, DEWA, FEWA, and SEWA), as a research and training entity through (Khalifa University, University of Sharjah, etc.), and as a developer (through Masdar, Etihad ESCO, Environmena, etc.). The analysis identified areas where the UAE can still capture, create, and enhance value within the solar GPN. Importantly, the absence of substantive linkages with the mature oil industry means that the emerging solar sector represents a new energy development trajectory rather than an evolution of the existing industry.

The labor market analysis of the emerging solar energy industry reinforced existing labor market divisions between nationals and expatriates. Yet, survey results and interview respondents highlighted labor market considerations – skill and experience needs, salary premiums for nationals and local hires, and specialized knowledge – and local market contexts – price controls and small profit margins – as important factors underpinning the hiring preferences and practices of foreign and local firms. While the UAE benefits from sourcing skill globally, skilled labor also benefits from the unique local development of the UAE. The research found that the large number of projects provides opportunity for rapid career advancement and the infancy of the industry allows skilled labor with considerable solar experience to obtain more impactful positions. Together, firm demand for foreign skilled labor and a large supply of skilled labor ready and willing to relocate to the UAE in search of career advancement ensures that the country will continue to import the knowledge necessary for solar energy development and transition.

Last, the dissertation highlighted the complex, overlapping, and mutually reinforcing rationales which favor solar energy transition in a hydrocarbon superpower. Although technical and solar potential arguments remain important elements of energy transition, they do little to explain why the UAE has aggressively pursued solar energy development while countries with comparable solar potential have not. The research found that energy transition in the UAE is best explained through these arguments, in addition to rationales concerning favorable power density and population spatial dynamics, national image and cultural identity considerations, and climate concerns and future government revenue opportunities. Rather than a singular, or even dominant, rationale, energy transition in a hydrocarbon superpower is a complex assemblage of various national and global considerations, embedded in place to condition the development of a new energy sector.

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APPENDIX A

RESPONDENT CODES

Code	Position	Style
A1	Senior Project Engineer	Phone
A2	Solar Energy Manager	In person
A3	Renewable Energy Manager	Phone
A4	Business Development Manager	In person
A5	Production Director	Phone
B1	Business Development Manager	In person
D1	Head of Renewables	In person
G1	Head of Solar Projects	In person
J1	Associate Director of Solar	Phone
J2	CEO	In person
K1	Business Development Manager	In person
K2	Head of Solar Division	In person
M1	CEO	Phone
M2	Energy Services Manager	Phone
M3	CEO	N/A
M4	Solar Project Development Manager	Phone
O1	Chief Solar Engineer	Phone
S1	Partner	In person
S2	Senior Project Manager	Email
S3	CEO	In person
S4	N/A	In person
S5	CEO	Phone
S6	COO	In person
T1	Solar Design Manager	Phone
W1	Head of Solar Division	In person
Y1	CEO	In person

APPENDIX B

SURVEY INSTRUMENTS

TEXAS A&M UNIVERSITY

Validation/Background/Control Block

Approximately how many years has this firm been involved in solar energy?

- This firm is not involved in solar energy
- 1 to 3 years
- 3 to 6 years
- 6 to 9 years
- 9 to 12 years
- More than 12 years

Which of the following best describe your firm?

- Locally owned private company
- Locally owned public company
- Mixed public-private company
- Joint venture
- Affiliate of a foreign multinational company
- Other (Please explain)

Approximately what percent of the firm is owned by the UAE government?

	Percentage
	0 10 20 30 40 50 60 70 80 90 100
Percentage owned by the UAE government	

In which city is your firm's headquarters located?

Is this firm located in any kind of special economic zone (free trade zone, export processing zone, industrial park, etc.)?

- ◯ Yes
- ◯ No

What type of special economic zone is this firm located in? (Please explain)

Evolutionary Economic Geography Block

How important are the following activities to your firm?

	Very Important	Important	Neither Important nor Unimportant	Unimportant	Very Unimportant
Solar Energy	◯	◯	◯	◯	◯
Other Renewable Energy	◯	◯	◯	◯	◯
Other Energy (non-renewable)	◯	◯	◯	◯	◯
Product Design and Development	◯	◯	◯	◯	◯
Consultation	◯	◯	◯	◯	◯
Construction	◯	◯	◯	◯	◯

In five years time, how important will the following activities be to your firm?

	Very Important	Important	Neither Important nor Unimportant	Unimportant	Very Unimportant
Solar Energy	◯	◯	◯	◯	◯
Other Renewable Energy	◯	◯	◯	◯	◯
Other Energy (non-renewable)	◯	◯	◯	◯	◯
Product Design and Development	◯	◯	◯	◯	◯
Consultation	◯	◯	◯	◯	◯
Construction	◯	◯	◯	◯	◯

Human Capital Block

Approximately how many employees at this firm are employed in the UAE?

Approximately what percentage of your employees are nationals (Emiratis)?

Percentage

	0	10	20	30	40	50	60	70	80	90	100
Percent of employees who are Emirati											

Approximately what percentage of your employees specialize in photovoltaic (PV) or concentrated solar power (CSP) solar energy?

Percentage

	0	10	20	30	40	50	60	70	80	90	100
Percentage of employees specializing in PV or CSP											

How likely are employees specializing in PV or CSP to have the following degrees?

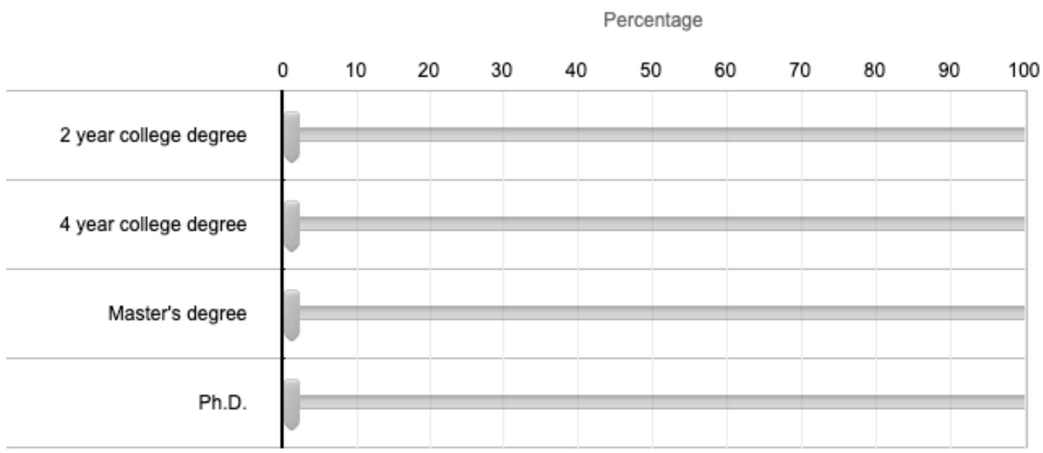
	Not at all likely	Unlikely	Likely	Very Likely
2 year college degree	○	○	○	○
4 year college degree	○	○	○	○
Master's degree	○	○	○	○
Ph.D.	○	○	○	○

Among employees specializing in PV or CSP who hold the following degrees, approximately what percentage obtained their qualifications abroad?

Percentage

	0	10	20	30	40	50	60	70	80	90	100
2 year college degree											
4 year college degree											
Master's degree											
Ph.D.											

Approximately what percent of all employees at your firm specializing in PV or CSP with a university degree (2 year, four year, Master's, or Ph.D) are foreign nationals?



For PV and CSP professionals with university degrees, what subjects are these degrees in? (Select all that apply)

- ☐ Sustainable Critical Infrastructure
- ☐ Mechanical Engineering
- ☐ Chemical Engineering
- ☐ Engineering Systems and Management
- ☐ Water and Environmental Engineering
- ☐ Microsystems Engineering
- ☐ Space Systems and Technology
- ☐ Materials Science and Engineering
- ☐ Petroleum Engineering
- ☐ Electrical Engineering
- ☐ Computing and Information Science
- ☐ Other (Please Specify)

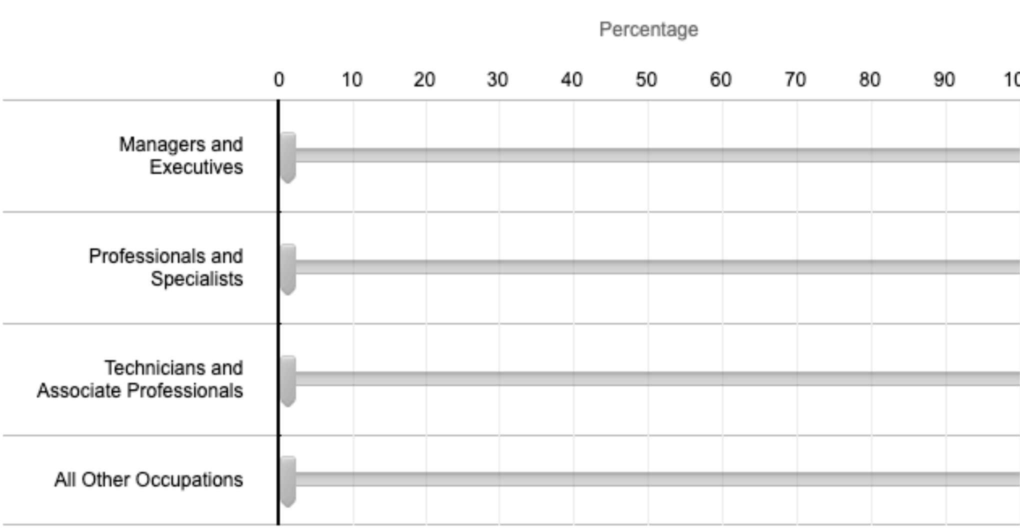
Which of the following ways are employees with university degrees primarily trained within your company? (Select all that apply)

- ☐ On-the-job or on-site training
- ☐ Off-site training within the Gulf (GCC)
- ☐ Training internationally (outside the GCC) at a different firm
- ☐ Training internationally (outside of the GCC) at another branch of your firm
- ☐ Courses at local universities
- ☐ Courses outside of the GCC at foreign universities

Which of the following skills are important when you are hiring for PV or CSP specialists?

	Extremely Important	Important	Neither important nor unimportant	Unimportant	Not at all important
Leadership skills					
Analysis/Synthesis skills					
Arabic fluency					
Written/Verbal communication					
Multilingual					
Research and development					
Marketing					
Managerial/supervisory					
English fluency					
Mathematics/Statistics					
Programming skills					
Teamwork					
Problem solving					
Critical/analytical thinking					
Presentation skills					
Technical skills					
Computer skills					
Product design					

Approximately what percentage of employees at your firm hold the following positions?



Labor Force and Hiring Preference Questions

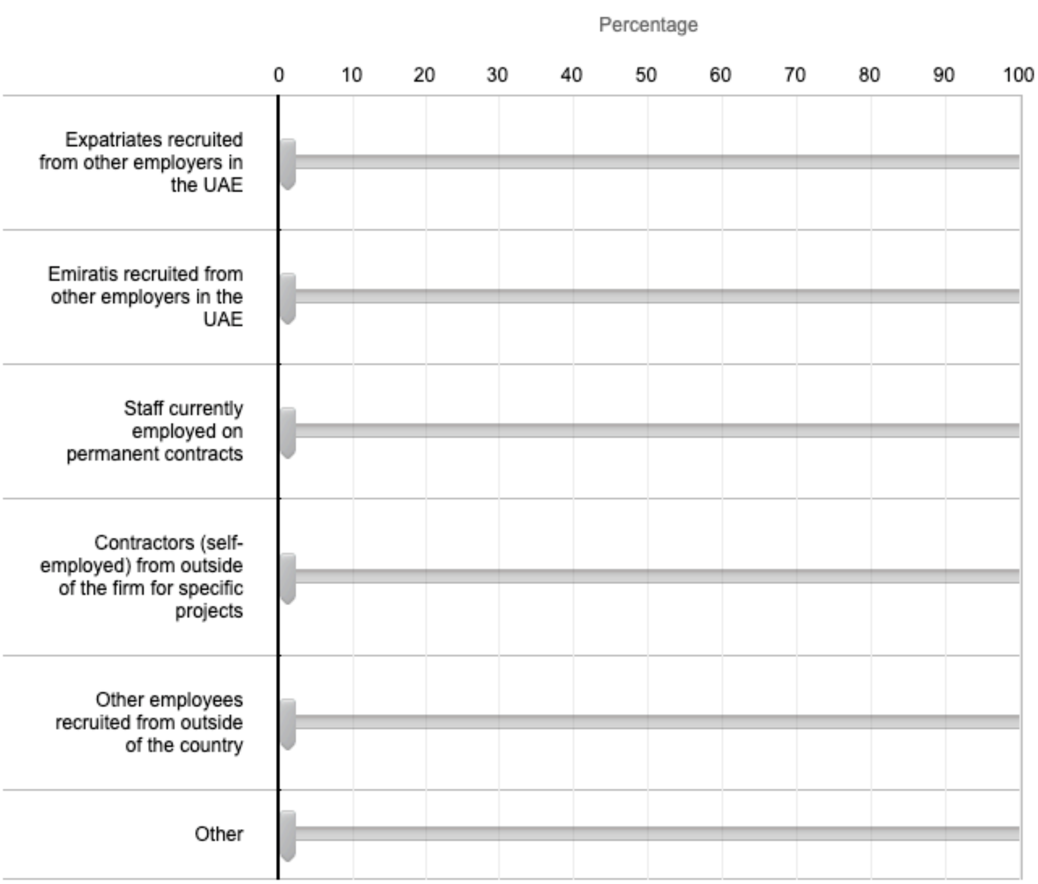
How long has the average PV or CSP specialist been...

	Less than 6 months	6 months to 1 year	1 to 2 years	2 to 5 years	Greater than 5 years
with this firm in the UAE?	○	○	○	○	○
employed in the Middle East?	○	○	○	○	○

For solar energy hires, which of the following positions do you almost always search INTERNATIONALLY, LOCALLY, or BOTH? (Select all that apply)

	Internationally	Locally	Both	N/A
Project construction	☐	☐	☐	☐
Solar plant operations	☐	☐	☐	☐
Manufacturing	☐	☐	☐	☐
Solar consultancy	☐	☐	☐	☐
Solar panel installation and maintenance	☐	☐	☐	☐
Executives and managers	☐	☐	☐	☐
Solar panel research and design	☐	☐	☐	☐

Approximately what percentage of the total number of those recruited for solar energy positions are from each of the following employee groups or pools?



The following is a list of statements about the current labor force in solar PV/CSP. Please select the degree to which you agree with the following statements.

	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
There are shortages of potential employees with engineering knowledge in solar technologies.	○	○	○	○	○
New hires that lack formal solar training will learn the appropriate skills with on-the-job training.	○	○	○	○	○
Before hiring, few of our solar engineering workforce had specific solar energy training.	○	○	○	○	○

How important is the following coursework for prospective solar energy professionals?

	Very high importance	High important	Average importance	Low importance	Not important
Solar application: industrial	○	○	○	○	○
Power electrics (AC/DC power conversion, etc)	○	○	○	○	○
Solar energy supply chain and logistics	○	○	○	○	○
Solar energy finance	○	○	○	○	○
Semiconductor theory	○	○	○	○	○
Solar engineering principles (PV and CSP basics)	○	○	○	○	○
Solar energy and sustainability	○	○	○	○	○
Solar energy policy	○	○	○	○	○
Solar energy and society	○	○	○	○	○
Solar thermal power systems	○	○	○	○	○

The following is a list of statements about future labor force needs in solar PV/CSP. Please select the degree to which you agree with the following statements.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
New hires must be able to design solar projects of any scale.	○	○	○	○	○
New hires must be able to apply business practices along with engineering skills.	○	○	○	○	○
New hires must demonstrate project management expertise.	○	○	○	○	○
New hires must demonstrate effective written communication skills.	○	○	○	○	○
New hires must be able to solve problems in a multidisciplinary context.	○	○	○	○	○
New hires must demonstrate effective teaming skills.	○	○	○	○	○
New hires must demonstrate effective oral communication skills.	○	○	○	○	○

What is your main source of recruitment for solar energy-specific hires? (Select all that apply)

- ☐ Local UAE universities
- ☐ Universities in the Middle East (outside UAE)
- ☐ Universities in North America or Europe
- ☐ Universities in South or Southeast Asia
- ☐ Local government organizations
- ☐ Oil companies
- ☐ Other solar energy firms in the UAE
- ☐ Other solar energy firms in the Middle East (outside of UAE)
- ☐ Other solar energy firms outside of the Middle East
- ☐ Energy (non-solar) companies in the UAE
- ☐ Energy (non-solar) companies in the Middle East (outside UAE)
- ☐ Energy (non-solar) companies outside of the Middle East
- ☐ Recruitment firms
- ☐ Other source (Please specify) ______

Which of the following factors are important considerations in determining whom you hire for solar energy positions?

	Not important at all	Unimportant	Neither important nor unimportant	Important	Very important
Applicant has experience working in solar energy in Europe or North America	○	○	○	○	○
Applicant has experience working in solar energy in the UAE	○	○	○	○	○
Applicant has a degree or higher in engineering (any type)	○	○	○	○	○
Applicant has a foreign university degree or higher	○	○	○	○	○
Applicant has experience working in solar energy in South or Southeast Asia	○	○	○	○	○
Applicant has experience working in solar energy in the Middle East (outside of UAE)	○	○	○	○	○
Applicant is a UAE national	○	○	○	○	○
Applicant is located in the UAE (non-national)	○	○	○	○	○
Applicant has experience working in the oil industry	○	○	○	○	○

Locational Decisions

How important are the following factors in influencing your decision to locate key solar energy activities in a city or country?

	Very important	Important	Slightly important	Not important
Availability of skilled employees in solar energy	○	○	○	○
Government support for R&D	○	○	○	○
Presence of feed-in tariffs for solar energy	○	○	○	○
Intellectual property protections	○	○	○	○
Proximity to reputable research universities	○	○	○	○
Proximity to other solar energy firms	○	○	○	○
Government support for solar energy development	○	○	○	○
Availability of skilled employees in general	○	○	○	○

How would you rate the level of collaboration between your firm and the following organizations?

	Do not collaborate	Collaborate with infrequently	Collaborate with moderately	Collaborate with intensely
Other UAE Universities	○	○	○	○
UAE Ministry of Energy	○	○	○	○
International Petroleum Investment Company	○	○	○	○
Abu Dhabi National Oil Company (ADNOC)	○	○	○	○
UAE University	○	○	○	○
Dubai Electric and Water Authority (DEWA)	○	○	○	○
Abu Dhabi Investment Authority	○	○	○	○
Mubadala Development Company	○	○	○	○
Emirates National Oil Company (ENOC)	○	○	○	○
Petroleum Institute	○	○	○	○
Dubai Supreme Council of Energy (DSCE)	○	○	○	○
Other UAE solar energy firms	○	○	○	○
Masdar Institute	○	○	○	○
Abu Dhabi Water and Electric Authority (ADWEA)	○	○	○	○
International Renewable Energy Agency (IRENA)	○	○	○	○

APPENDIX C

SEMI STRUCTURED INTERVIEW QUESTIONS

1. Why is the UAE pursuing a solar energy future?

2. What is the future of solar energy in the UAE?

3. What are the competitive advantages of solar energy development in the UAE?

4. What role does the government play in fostering solar energy?

5. How does the creation of a regional energy grid (GCCIA) impact renewable energy development?

6. What crossovers or collaboration exist between solar energy and the existing energy sector (oil and gas, for example)?

7. What role do national oil companies/subsidiaries play in renewable energy development?

8. What are the key decisions for locating firm operations in the UAE?

9. Does your firm predominately hire locally or internationally? For which positions? Why?

10. What is the nature of your downstream linkages? Who are the key downstream links?

11. What is the nature of your upstream linkages in the production process? Are they more locally oriented or more globally oriented?

12. What is the importance of local linkages (upstream and downstream) to your firm?

13. What legislative changes or additions would further renewable energy development in the UAE?

14. What solar energy skills are most abundant locally? What solar energy skills still need further local development?

APPENDIX D

IRB INFORMED CONSENT DOCUMENTS

D-1: Informed Consent Document (Interviews)

Title of Research Project: *Doctoral Dissertation Research: Explaining Renewable Energy Transition through Human Capital Analysis in the United Arab Emirates.*

You are invited to take part in a research project conducted by Ryan Dicce through Texas A&M University and under the supervision of Dr. Christian Brannstrom. As part of the preliminary proceedings of the project, you are asked to read this letter providing you with information about the project so that you may make an informed decision about your potential participation. In the event that you decide NOT to participate in this project, or decide to terminate your participation at any time, there will be no penalty or loss of benefits normally afforded to you.

The following letter will explain the project so please read it carefully. Questions about both the project and your involvement are highly encouraged.

PURPOSE: You are invited to participate in a research project seeking to better understand the development of renewable energy in the United Arab Emirates (UAE).

PROCEDURES: About 30 mid-level, executive, and upper management employees at renewable energy firms in the UAE will be asked for an interview. The interview will either be conducted face to face or electronically depending on convenience. This process should take less than an hour to complete. You are free not to answer any questions. You may withdraw from the study at any time.

CONFIDENTIALITY: The researcher, Ryan Dicce, will ensure that all participants in this project maintain confidentiality. All proper names will be replaced by pseudonyms/codes. The only connection between your participation in this study and the study itself will be the code sheet, but there will be no association between your identity and the information you provide. All interview notes and codes will be destroyed within 3 years of the completion of the interview.

RISKS: At this time, the only known risk of participating in this project is the accidental disclosure of a participant's identity. This risk is minimized by the procedures used for collecting and rendering all data anonymous. Participants are free to withdraw at any time and to refuse to answer particular questions.

BENEFITS: There are no anticipated benefits to you for participating in this study.

COMPENSATION: There is no compensation provided for participation in this study.

PRIVACY: The records of this study will be kept private and any identifiers linking you to the research will be removed. Records will be stored securely on an encrypted hard drive accessible only by Ryan Dicce and Dr. Brannstrom. Representatives of regulatory agencies such as the

Office of Human Research Protections (OHRP) and entities such as the Texas A&M University Human Subjects Protection Program may access your records to make sure the study is being run correctly and that information is collected properly.

FOR QUESTIONS ABOUT THIS RESEARCH, CONTACT:
This project is being conducted by Ryan Dicce under the supervision of Dr. Christian Brannstrom. Questions, comments, and concerns about this project can be directed to Ryan Dicce via his email (rdicce@tamu.edu) or office phone (+971.2.628.4268). Additionally, Dr. Brannstrom may be reached at his email address (brannst@geos.tamu.edu).

D-2: Informed Consent Document (Survey)

Title of Research Project: *Doctoral Dissertation Research: Explaining Renewable Energy Transition through Human Capital Analysis in the United Arab Emirates.*

You are invited to take part in a research project conducted by Ryan Dicce through Texas A&M University and under the supervision of Dr. Christian Brannstrom. As part of the preliminary proceedings of the project, you are asked to read this letter providing you with information about the project so that you may make an informed decision about your potential participation. In the event that you decide NOT to participate in this project, or decide to terminate your participation at any time, there will be no penalty or loss of benefits normally afforded to you.

The following letter will explain the project so please read it carefully. Questions about both the project and your involvement are highly encouraged.

PURPOSE: You are invited to participate in a research project seeking to better understand the development of renewable energy in the United Arab Emirates (UAE).

PROCEDURES: About 170 mid-level, executive, and upper management employees at renewable energy firms in the UAE will be asked to complete a survey. This process should take less half an hour to complete. You are free not to answer any questions. You may withdraw from the study at any time. Upon completing the survey, you have the option to either submit it through the SurveyMonkey portal, email it to Ryan Dicce (rdicce@tamu.edu), or mail it to Ryan Dicce, Department of Geography, Texas A&M University, Room 810, Eller O&M Building, College Station, Texas 77843-3147.

CONFIDENTIALITY: The researcher, Ryan Dicce, will ensure that all participants in this project maintain confidentiality. Survey results will be cleaned and all personal identification information will be removed. There will be no association between your identity and the information you provide. All personal data will be destroyed within 3 years of the completion of the survey.

RISKS: At this time, the only known risk of participating in this project is the accidental disclosure of a participant’s identity. This risk is minimized by the procedures used for collecting and rendering all data anonymous. Participants are free to withdraw at any time and to refuse to answer particular questions.

BENEFITS: There are no anticipated benefits to you for participating in this study.

COMPENSATION: There is no compensation provided for participation in this study.

PRIVACY: The records of this study will be kept private and any identifiers linking you to the research will be removed. Records will be stored securely on an encrypted hard drive accessible only by Ryan Dicce and Dr. Brannstrom. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) or (if FDA regulated) the Food and Drug Administration (FDA) and entities such as the Texas A&M University Human Subjects

Protection Program may access your records to make sure the study is being run correctly and that information is collected properly.

FOR QUESTIONS ABOUT THIS RESEARCH, CONTACT:
This project is being conducted by Ryan Dicce under the supervision of Dr. Christian Brannstrom. Questions, comments, and concerns about this project can be directed to either Ryan Dicce at his email (rdicce@tamu.edu), on his cell phone (01.610.513.3698). Additionally, Dr. Brannstrom may be reached at his email address (brannst@geos.tamu.edu).

APPENDIX E

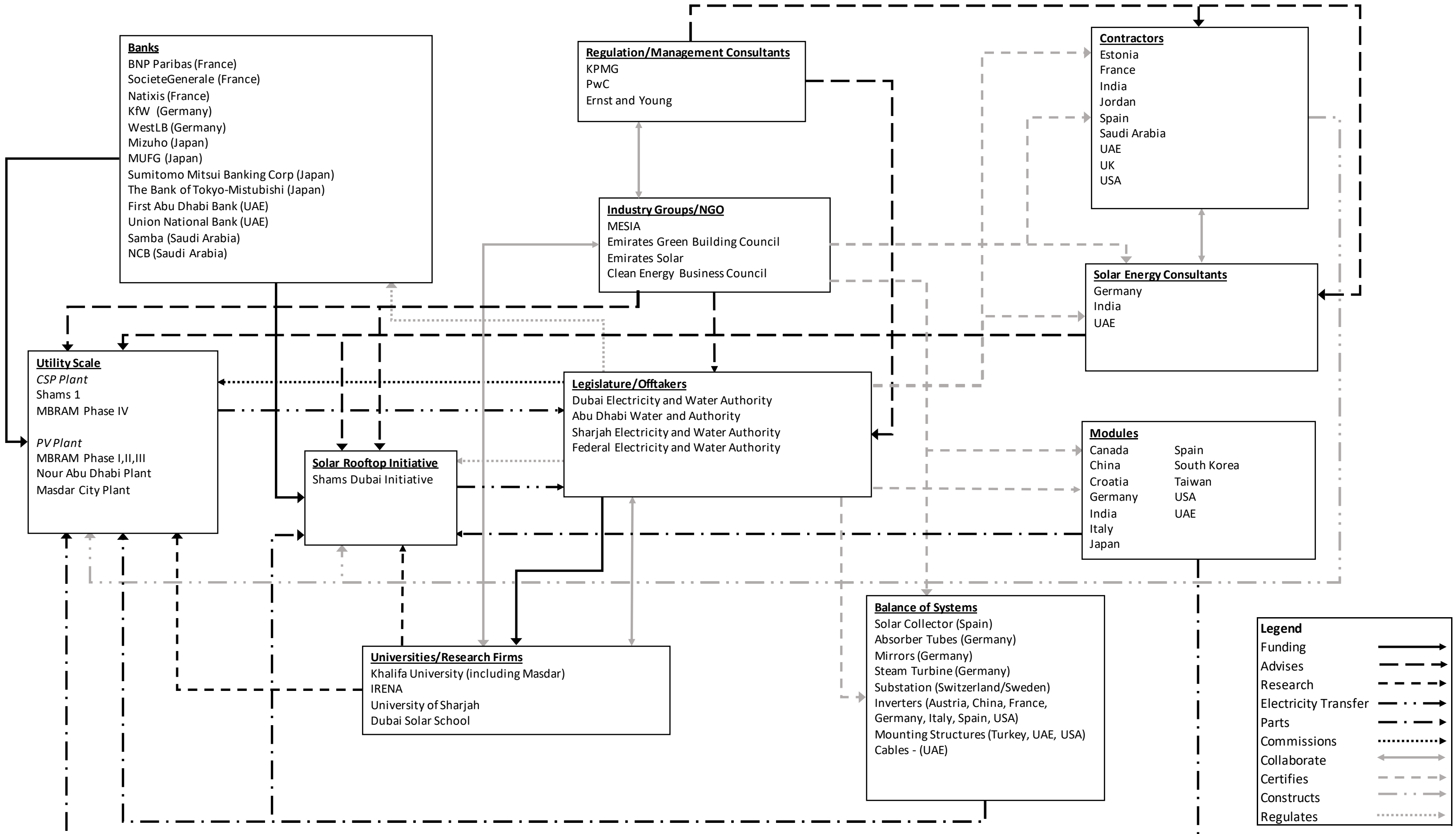


Figure E.1 The UAE's Solar GPN