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Adoption of renewable energy technologies in oil-rich countries: Explaining policy variation in the Gulf Cooperation Council states

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ABSTRACT

While the member states of the Gulf Cooperation Council have economically and politically been dominated by the exploitation of fossil fuels, recent years have seen an increasing adoption of renewable energy technologies, the reasons of which are not yet sufficiently understood. This paper argues that the recent adoption of renewable energy technologies in the Gulf and its striking variation can be explained by theories of policy transfer. In addition, we find some support for the alternative hypothesis of endogenous policy development regarding political leadership. Yet there is no support for the alternative hypothesis of a strong direct influence of the international climate regime. Furthermore, the policy transfer hypothesis and political leadership stand as coexisting influences on renewable energy adoption, rather than competing ones. Based on an extensive study of primary and secondary sources, local reports and country analyses of international organizations, and personal interviews with key experts, this paper lays out in detail how transfers of renewable energy policies take place in the Gulf; their drivers; and their impacts. We also discuss the factors that lead countries to lag behind, which can be helpful for prospective research on a more extensive utilization of renewable energy in the region and beyond.

1. Introduction

It is often assumed that the states of the Arab Gulf are strong laggards when it comes to the development of renewable energy. Having vast oil resources, these countries are expected to strongly oppose the phase-out of fossil fuels and the worldwide development of renewable energy such as wind energy or solar power, which would reduce their export profits. Gulf Cooperation Council states are also widely seen as typical examples of the "rentier state," that is, countries that are characterized in their political and economic systems by the exploitation and export of abundant natural resources. Indeed, these member states still lead the international rankings of climate-polluters: In a global ranking of countries according to their 2009 carbon dioxide emissions (metric tons per capita), Qatar ranked first, Kuwait third, the United Arab Emirates fifth, Bahrain seventh, Saudi Arabia eleventh, and Oman thirteenth, among a total of 214 countries [62]. The United Arab Emirates also has the dubious distinction of being the country with the largest per-capita ecological footprint globally [37].

And yet, these statistics hide numerous important trends in this region. Several Arab Gulf states have begun to diversify their energy economy by investing in renewable energy technologies. Revenues from the export of fossil fuels have enabled these countries to invest in newly emerging technology-intensive sectors. For instance, the Emirate of Abu Dhabi established the "Masdar Initiative" to develop breakthrough projects in renewable energy and sustainable solutions, such as residential architecture and public transport. Also, Saudi Arabia has invested in solar technologies for both domestic use and larger scale energy production, such as desalination plants [18]. Likewise, the Emirate of Dubai initiated a Green Building code that is compatible with the U.S. Green Building Council's LEED certification system [58]. Moreover, all Gulf countries have signed or ratified the International Renewable Energy Statute for increasing the share of renewables in their energy grids [28]. These initiatives promise numerous benefits for these states: For example, when fewer fossil fuels are used domestically, more oil and natural gas can be exported. Importantly, such initiatives prepare the Gulf Cooperation Council countries for the post-oil age, and help them to contribute to combating climate change and hence improving their international

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reputation. Gulf Cooperation Council countries could also assist their less developed neighbors in climate protection policies [55].

However, there is also a strong variation in the adoption of renewable energy technologies in the Arab Gulf. While some countries have begun to seriously engage in the development of renewable energy, other – seemingly similar – countries are lacking behind and remain stuck in the traditional fossil-fuel economic model. So far, not much research is available to explain this variation. Why do some oil-rich Gulf countries slowly begin to embark on a post–fossil future, while others stay behind? What are the determinants of the development and deployment of renewable energy technologies in the Arab Gulf countries? These are the questions at the center of this article that seeks to explain the variation in the adoption of renewable energy in these countries.

Theoretically, three main hypotheses could explain the emergence of renewable energy development in some oil-rich countries in the Arab Gulf area.

- First, it can be hypothesized that the adoption of renewable energy technologies is the result of horizontal policy transfers from other countries, both within the region (intraregional policy transfer) and from outside the region (international policy transfer) (*policy transfer hypothesis*).
- Second, it can be hypothesized that the adoption of renewable energy technologies is the result of endogenous developments within the countries themselves, for example due to specific political-economic circumstances, political leadership or driven by domestic environmental movements or problems that stem from the dominance of fossil resources (*endogenous policy hypothesis*).
- Third, it can be hypothesized that the adoption of renewable energy technologies is a consequence of the implementation of international regimes, such as the United Nations Framework Convention on Climate Change (*international regime hypothesis*).

We chose the Gulf Cooperation Council states as our empirical domain because of their similar political systems that allow for a focused comparison; their vast resource revenues and high dependencies on oil, making them interesting cases; and their potentially leading function within the larger group of Arab and Middle Eastern countries. Although there are slight differences among these countries, such as their organization of government and administration, electoral rules, and the degree of participation of women and minorities, they are not significant for our research question. The fact that all these states strongly rely on resource rents and practise rentierism makes them comparable in our analysis of renewable energy technology adoption.

Our research is largely qualitative and provides new empirical knowledge on the most prominent scientific and technological developments in this region and the conditions which explain these developments and their variation. We used primary sources in English and Arabic, such as institutional databases and statements of influential policy-makers; secondary sources, such as journal and newspaper articles and conference papers; along with quantitative data sets such as renewable energy performance indicators, energy capacity, and generation and consumption data.

The paper is structured as follows: Section 2 presents the variation in renewable energy technology adoption in the Arab Gulf Area on the basis of three quantitative indicators: (a) intensity of renewable energy as percentage of total energy mix, (b) installed renewable energy capacity, and (c) installed renewable energy capacity per capita. Section 3 explains variation relying primarily on the policy transfer hypothesis, specifically through international research cooperation with prestigious research institutes, and technological knowledge-based public-private partnerships with major corporations. This section also examines the endogenous policy and international regime hypotheses as alternative explanations for the variation observed in the Arab Gulf region regarding renewable energy technology adoption. Section 4 concludes the paper by reflecting on the potential for similar developments in the remaining laggard countries in the region.

2. Variation in the adoption of renewable energy technologies in the Arab Gulf area

This section outlines the deployment of renewable energy in Gulf Cooperation Council states and it highlights the variation among the six countries, that is, between ‘leaders’ and ‘laggards’ in the field of renewable energy adoption. The countries in the Arab Gulf region are prominently rich in various sorts of renewable energy, particularly solar. These states have significant resource potentials that remain yet to be fully utilized. Accordingly, for instance, less than 0.2% of the Saudi land area has to be covered with solar photovoltaic cells to provide for all the energy needs of the country [7]; (p. 2300). As for Oman, despite its wind potential particularly during the summer monsoon between April and September, no utility-scale wind turbines have yet been connected to the grid [4]; (p. 1585) as of 2009. Only in Fall 2014 it has been announced that the Masdar Initiative of Abu Dhabi will build the first large-scale wind farm in Oman, with 50 Megawatts capacity [42].

Importantly, despite largely similar political and economic systems, as well as vast potentials, there is a sizeable variation in the adoption of renewable energy technologies in the Gulf Cooperation Council area. We use three indicators to distinguish “laggards” from “leaders”:

Our first indicator is the intensity of renewable energy as percentage of total energy mix. Intensity is calculated by dividing total energy capacity by total installed renewable energy capacity, which is the sum of photovoltaics, concentrated solar power, wind, biomass and waste energy in megawatts (MW). This is the most important indicator because it shows the accurate comparison among the GCC states in terms of the level of energy sector diversification with renewable resources. Their energy sectors are not the same size, yet these intensive values outline the current proportions, making them comparable regardless of their differences in sector size.

Our second indicator is the absolute amount of installed renewable energy capacities of GCC states. Total capacities also need to be examined, as they also reflect the state's willingness to expand the share of renewables within the energy mix, even though the current renewable energy intensity is at a negligible level.

Our third indicator is installed renewable energy per capita. Even though GCC states share numerous common characteristics, demography-wise there is a substantial differentiation among them. While, it is important to see the total amount of installed renewable energy capacity and its intensity within total energy mix, it is also crucial to see how much each citizen can benefit from the total adoption. Even though these figures are still incremental and these states still have some time before they fully utilize their renewable energy potential, especially in highly populated countries, the current level of adoption per person can be a positive indicator of what can be expected from that country in the future.

On the basis of these three indicators we observe the following:

Regarding intensity values, we see that United Arab Emirates and Qatar have the highest share of renewable energy adoption within the total energy mix, hence the highest renewable energy intensities. Even though none of the GCC States have substantial levels of renewable energy utilization yet, current intensities in the

two leaders are much closer to 1% with an average of 0.55%, while the highest level of intensity among the laggards is only 0.14% of Bahrain.

As for the total amount of renewable energy that was generated through concentrated solar power (CSP), photovoltaic (PV), wind, and other resources, we see that United Arab Emirates is the leader with 134 MW, followed by Qatar with 41.2 MW. Other four GCC states lag behind regarding this indicator. While Saudi Arabia seems to stand closer to leaders in terms of total installed renewable energy capacity, it falls substantially behind in terms of renewable energy intensity within the energy mix and installed renewable energy capacity per capita, and it is thus not included among leaders.

Finally regarding installed renewable energy per capita, United Arab Emirates and Qatar are again the two leaders, with more than 14 and 18 Watts per citizen respectively. Despite its substantial potential for solar energy, Saudi Arabia lags again behind in terms of total installed renewable energy capacity. While Saudi Arabia experiences more than 2.0 MWH/m^2 solar radiation per year [54]; (p. 1847), as of 2013, it has 19 MW of installed solar photovoltaic capacity [29]; (p. 29). Hence, it still has some significant way before it fully utilizes its potential. Nevertheless, some important initiatives have evolved in this direction in recent years.

In these calculations the most recent data of total installed renewable energy capacity refers to different years for each GCC state. While for United Arab Emirates and Saudi Arabia, the newest data belonged to 2013, it was 2012 for Qatar, Bahrain and Oman, while that of Kuwait was 2010. We do not believe that this is a major problem. Hence, in order to reach an estimated per capita amount, 2013 population level data are used for all states. Table 1 shows the variation based on three indicators, for each GCC member state.

In sum, United Arab Emirates and Qatar are clear leaders in terms of all three indicators. In the following parts, we try to explain the underlying reasons for this variation in the region.

3. Explaining variation in the Gulf Cooperation Council states

The previous analysis has indicated that regarding the installed renewable energy capacity, its intensity within the energy mix and per capita energy generated from renewables, two of the Gulf Cooperation Council states are leaders, while others lag behind. How can this variation be explained?

Our analysis indicates that the adoption of renewable energy technologies in the pioneering countries can best be explained by theories of policy transfer. We also find some support for the endogenous policy hypothesis; however we find no support for the international regime hypothesis.

3.1. Policy transfer hypothesis

The key rationale behind the policy transfer hypothesis is that global developments subject countries to similar pressures and expand the amount of information available for policy makers. This allows policy makers to search for alternative policy solutions that are successful in other countries [16]. In other words, the set of global problems cause more or less similar concerns for all countries, but the ways in which each country reacts to these common problems vary. Some succeed, some do not. Those who fail to cope with these problems study the more successful political systems in order to improve their own systems.

Policy transfer can thus been seen as a set of “processes where nations learn from or imitate policies implemented elsewhere through bilateral communication and direct interaction or exchange of experiences” [14]; (p. 92). Accordingly, policy transfer is linked to policy learning, a horizontal mechanism of influence occurring among nations voluntarily rather than by means of imposition [43]; (p. 72). Policy transfer and policy learning occur mostly bilaterally, such as state-to-state, international institution-to-state, or think tank-to-state. More specifically, “governments may imitate what peer countries do simply because they are peers, or governments may imitate what apparently successful countries do simply because they are high status countries that are considered to know best” [43]; (p. 73). This distinguishes policy transfer from vertical mechanisms of influence, such as pressures from international regimes [34]; (p. 2). As a result of policy transfer, a new policy paradigm may occur [13]; (p. 149), which will likely result in a new set of rules, norms, regulations, and other policy trends in a region.

There are different explanations about how policy transfers occur, the agents of transfer, and the levels of analysis. Building on Wolman’s [61] earlier work, Evans and Davies develop the “prerequisites for modeling policy transfer” [24]; (p. 367). They argue that this should focus on policy processes rather than solely measuring outcomes. Moreover, attention should be paid particularly to factors external to the country or organization where the transfer takes place. Specifically, networks play an important role in policy transfers: countries with higher international connectivity are likely to be more successful in learning [32]; (p. 186).

In this paper, we operationalize policy transfer as the causal link between a policy development in one country and policy developments in another country, without pressure of international institutions and agencies. Hence, we use the policy transfer concept as analysis channel through which renewable energy policy and technology knowledge are disseminated. We aim to understand the policy variation among the Gulf States with the hypothetical role of voluntary policy transfer. In niche areas like the adoption of renewable energy technologies in fossil resource-rich states, policy transfer can indeed be helpful in understanding the motives and processes behind similar policy decisions. Parallel levels of renewable energy technologies adoption can be the results of other causal mechanisms like emulation and/or competition. However, from the larger perspective, directly or indirectly imitating other countries' success stories involves policy transfer. That is, in order

Table 1
Variation in renewable energy adoption of Gulf Cooperation Council states as per three indicators.

	Leaders		Laggards			
	United Arab Emirates	Qatar	Saudi Arabia	Bahrain	Kuwait	Oman
Intensity of renewable energy as percentage of total energy mix (%)[a,b]	0.57	0.52	0.01	0.14	0.12	0.01
Installed renewable energy capacity (MW) (data's year)[b]	134 (2013)	41.2 (2012)	19 (2013)	5.5 (2012)	1.8 (2010)	0.7 (2012)
Installed renewable energy per capita (Watts/person)[b,c]	14.41	18.73	0.63	5	0.51	0.18

Source:
[a] Total installed electricity capacity (GWe in 2013): [20].
[b] Total installed renewable energy capacity (MW): [29]; (p. 29).
[c] [47].

for emulation or competition to result in similar policies, certain channels of transfer exist. The approach we embrace in this paper towards policy transfer is the rational learning process. In this context, we identify two main avenues of policy transfer in the Arab Gulf countries.

The first channel of transfer is international and/or interregional institutionalized research collaboration within specific research areas. Through specialized research cooperation, technological know-how in the field of renewable energy is being taken up in the pioneering Gulf countries. Currently, Gulf Cooperation Council states lack the *modus operandi* regarding the national production of cutting-edge technologies and their incorporation into their economy. Setting up research collaboration with an exclusive focus on renewable energy technology development will enable them to develop specialized knowledge in this area.

International research cooperation in the field of renewable energy has already existed at the academic level in the Gulf for the last decade in branch university campuses like Georgetown University School of Foreign Service in Qatar, Paris-Sorbonne University in Abu Dhabi, Middlesex University Dubai and Qatar Campus of Cornell University. This trend has intensified recently, particularly at the private sector-level in the pioneering countries of the United Arab Emirates and Qatar. There are also regional initiatives which aim to build a bridge between Gulf Cooperation Council and western developed countries. The EU-Gulf Cooperation Council Clean Energy Network is a prominent example. This network aims to improve and strengthen energy relations between the European Union (EU) and the Gulf Cooperation Council by supporting the exchange of experience and know-how, coordinating and promoting joint actions between the EU and Gulf Cooperation Council stakeholders, and facilitating joint research. Providing policy support to promote actions in areas such as renewable energy sources, energy demand side management and energy efficiency, clean natural gas and related clean technologies are also among its objectives [21]. The network has many types of participants, such as independent research centers (Gulf Research Center, The Centre for European Policy Studies, National Renewable Energy Centre), academic research centers (Masdar Institute, Energy Delta Institute, Fraunhofer Institute), think tanks and associations [22]. The network also periodically arranges calls for tenders regarding the joint projects [23].

The second channel of policy transfer is international multi-sector business partnerships for the promotion of renewable energy technologies. Generally, these do not merely involve governments, but rather non-state actors and specifically corporations. This is important because even though the Gulf region has sufficient funds to support technology-intensive projects, it lacks the necessary know-how at the corporate level. In this context, transfer agents are the corporations that are involved in these partnerships, transferring renewable energy project know-how.

Following up on the idea that policy transfer leads to further renewable energy technology adoption over time, country-specific motives are not emphasized per se. Nevertheless, one noteworthy aspect of the policy transfer debate with regards to renewable energy in the GCC is that these countries face numerous similar challenges. These can also act as common grounds for regional cooperation [8] and they can even lead to spillovers to other countries with similar geographic characteristics in the region. When facing similar challenges, these countries would have to consider their own limitations, as well as their comparative advantages vis-à-vis their neighbors. Indeed, in a niche area like renewable energy technologies each betterment would make a significant difference and lead the way to success. Moreover, in order for policy transfer to take place, there needs to be a common ground on which these countries are situated. There needs to be a collective understanding, for instance, that the matter at hand is of significant importance. In that sense, the alarming problems of Gulf Cooperation Council states, such as the increasing energy need for the growing population, combating climate change, reducing per capita carbon emissions, enabling access to electricity in off-grid areas, etc., lead to a continuously growing awareness of the need to consolidate renewable energy technologies as soon as possible. Despite these common problems, there exists a variation among these states. At this point, the two channels of policy transfer themselves can be seen as independent variables that will eventually lead to the consolidation of renewable energy technologies.

We now discuss these channels of policy transfer in more detail with a focus on the two leading countries, in order to see a correlation between renewable energy adoption and existence of policy transfer channels. Our research indicates that the development of renewable energy in the United Arab Emirates and Qatar can be largely explained by policy transfers and policy learning, notably by international research collaboration and international business partnerships.

3.1.1. Leaders

3.1.1.1. United Arab Emirates. The leading GCC State in renewable energy adoption is United Arab Emirates, which stands out with its ambitious renewable energy projects. Firstly, the flagship initiative of United Arab Emirates, Masdar Institute, is a clear example of international research collaboration. The policy of establishing a specialized research institution for the development of renewable energy technologies has been transferred from the Massachusetts Institute of Technology (MIT) within the framework of the renewable energy strategy of the Emirate of Abu Dhabi. According to a cooperation agreement signed in February 2007 between MIT and Abu Dhabi Future Energy Company, MIT's Technology Development Program would help develop the Masdar Institute. MIT Chancellor Phillip Clay explained the nature of the cooperation as follows: “MIT faculty and staff will provide advice, scholarly assessment and assistance in connection with the establishment of the Masdar Institute. This includes working with ADFEC [Abu Dhabi Future Energy Company] to develop collaborative research and create indigenous academic programs, to create a strategy for commercializing Masdar Institute's research results and to build the institute's organizational and administrative capabilities” [46].

Masdar's research and institutional structure mirrors that of an important body of MIT, the MIT Energy Initiative, a specialized research hub, which aims at developing breakthrough energy technologies in order to provide a more sustainable future at the global level. This Initiative, established in 2006, has four main research foci: *transformations* (advanced solar technologies, offshore and onshore wind, biofuels, geothermal, wave, and tidal energy, etc.); *global systems* (science and policy of global change, buildings and urban systems, vehicles and transportation systems, etc.); *innovations* (carbon capture and sequestration, power electronics, heat management, etc.); and *tools* (nanotechnology, multi-electron chemistry, intelligent robotics) [45]. Likewise, the Masdar Institute fosters multidisciplinary research with similar research foci divisions. Just like the MIT Energy Initiative, Masdar has preferential research areas that include water, environment and health, future energy systems, and microsystems and advanced materials [41]. These domains focus on both specific and general issues, thereby covering various technology development areas with regards to renewable energy.

International business partnerships can also be identified, particularly regarding investment in technology and know-how. Masdar would not have been possible without the participation of major corporations such as Siemens AG, Credit Suisse, Japan Bank for International Cooperation, Nippon Oil Corporation, and others

[40]. Masdar also collaborates with prominent clean energy companies. For instance, the Spanish engineering group Sener Grupo Ingenieria S.A. and Masdar together established Torresol Energy for the construction of solar power plants in a number of sun-drenched countries [9]. Furthermore, Abu Dhabi is also pursuing certain initiatives in the field of inter-regional financial aid. The Abu Dhabi Fund for Development is distributing 183 million dirham-worth soft loans to developing countries for a period of seven years for renewable energy development projects [1]. This is another sign of willingness in renewable energy consolidation in the country and beyond.

3.1.1.2. Qatar. Similar to United Arab Emirates, Qatar also possesses channels of policy transfer which pave the way for significant renewable energy adoption in both short-run and long-run. In terms of research environment that is focused on sustainable technology development, Qatar Foundation's Education City highly resembles Masdar City, including branch university campuses of widely acclaimed Western universities like Texas A&M University, Georgetown University and Carnegie Mellon University. Furthermore, again just like in Masdar City, Qatar's Education City hosts Qatar Science and Technology Park, which is home to numerous foreign and national energy companies like Shell, General Electric, and Green Gulf [49,50]. Another commonality is that, just like Masdar City, Qatar Science and Technology Park is a free zone with zero taxes and opportunities like 100% foreign ownership [50]. Hence, it is designed to attract foreign investors which would invest in technology development projects. Aside from the above mentioned companies, its current members include Microsoft, Cisco and Siemens [49]. Also, again under the auspices of Qatar Foundation, Qatar Environment and Energy Research Institute was launched in 2011, operating in research areas like solar photovoltaics, energy storage technologies and grid integration, in cooperation with partners like Qatar Solar Technologies, Pacific Northwest National Laboratory, Oak Ridge National Laboratory, and University of California Los Angeles [53].

As for the second indicator of policy transfer, that is the presence of project development and private sector-academia partnerships, Qatar Solar Technologies acts like a bridge, bringing together companies like Philips and General Electric with research and development activities of foreign branch university campuses. Such research collaborations take place especially in the field of solar energy technologies [52]. Qatar Solar Technologies is an investment of Qatar Solar, 100% owned holding company of Qatar Foundation. Another important investment of Qatar Solar is the acquisition of 29% equity holding in German SolarWorld AG [51], which took place in 2014. Furthermore, in 2008, Qatar established a US$ 400 million joint clean energy investment fund with the United Kingdom in order to attract additional foreign investments in technology development projects in clean energy [59]. These can be regarded as the leading joint ventures of Qatar in the renewable energy sector.

3.1.2. Laggards

3.1.2.1. Saudi Arabia. Saudi Arabia can be regarded as a laggard regarding the two indicators of policy transfer hypothesis. With respect to the first channel of policy transfer hypothesis, even though it has specific research areas for the development of renewable energy technologies at the King Abdullah University of Science and Technology, like solar and alternative energy engineering center, red sea, clean combustion, and water desalination and reuse [35], so far there has not been a concrete output in terms of substantial renewable energy generation. Even though, there exists a subject-specific research institute, Solar and Photovoltaics Engineering Research Center [36], it only includes research laboratories and has not carried out any large scale renewable energy utilization project yet. Although such initiatives are promising for future achievements, considering current conditions they have not resulted in striking renewable energy adoption levels as in United Arab Emirates and Qatar.

As for the second indicator of the policy transfer hypothesis, Saudi Arabia had an experimental joint venture case in 1975, when the US Department of Energy and the Saudi Arabian National Center for Science and Technology (SANCST) formed the Solar Energy Research American Saudi (SOLERAS), under the responsibility of the Solar Energy Research Institute (SERI) which is located in Golden, Colorado. Both parties committed US$50 million each. Before its conclusion in 1997, the project supplied electricity generated from solar resources to two villages that were disconnected from the national electricity grid [15]; (p. 20). At the time of installment, SOLERAS was considered as one of the largest PV systems worldwide, with 350 kW capacity. Its main concern was the supply of energy in remote areas, focusing on principles like “decentralized usage and non-dependence on grids” [60]; (p. 15). Total investment cost of SOLERAS was quite remarkable, such that the funding exceeded all expenditures by Saudi Arabia's total solar energy investments and the overall international solar research engagements of the United States [48]; (p. 5). However, solar-powered water desalination project of SOLERAS was eventually shut down for technical and economic reasons [3]; (p. 62), which can be an indicator of problems regarding the recovering of investment costs. Saudi Arabia currently lacks mass-scale joint ventures which would enable the utilization of renewable energy resources, like the two leading countries. For instance, although one joint venture regarding solar energy installation was announced in early 2012 between Saudi Aramco and Solar Frontier K. K., a subsidiary of Showa Shell Sekiyu K. K. of Japan [57] as of 2015 this project has still not been materialized. Similarly, French Soitec and Khaled Juffali Co. of Saudi Arabia have signed a memorandum of understanding to create a joint venture, which will be responsible for the marketing and selling of concentrator photovoltaic systems (CPV) systems in Saudi Arabia [56], however, this project has only recently been announced and remains yet to provide actual solar energy output. Despite such planned or recently tendered projects, no significant evidence was found regarding current actual renewable energy project development through joint ventures and foreign direct investments, unlike the examples of Masdar Initiative or Qatar's Education City.

3.1.2.2. Oman. Oman is the second laggard country in renewable adoption. As for the first indicator of policy transfer, it has no specialized research institute focusing on renewable energy technology development. It lacks substantial research networks in order to develop the necessary data to appeal for investments in wind technologies [2]; (p. 324) [17]; (p. 338). Moreover, regarding the second indicator of policy transfer, unlike the examples in United Arab Emirates and Qatar, the scope of joint ventures and foreign direct investments in the renewable energy sector have been negligible so far. Importantly, in March 2014, Terra Nex Financial Engineering AG Switzerland and Middle East Best Select Group of Funds announced their intention to start up a $2 billion project in Oman with the aim of generating around 400 MW of solar power [64]. At the moment, however, this intention has not materialized, making Oman a laggard in present day conditions.

3.1.2.3. Kuwait. Even though Kuwait is the country with most of the conditions present for large-scale sustainable energy projects, it has no significant developments or deployments [25]; (p. 38), making it a laggard in renewable energy adoption. With the world's sixth largest oil reserves and as the tenth largest exporter of oil

products [19], Kuwait currently stands as a latecomer country in developing renewable energy technologies. Regarding the first indicator of policy transfer, The Kuwait Institute for Scientific Research carries out some research activities in fields like design and installation of solar energy applications for power generation, desalination and air conditioning [18], (p. 3723). Yet, Kuwait lacks large-scale research projects and specialized research on renewable energy technology development, different from both the Masdar Institute and Qatar's Education City [38]. Kuwait also lacks a financing mechanism to support its research-and-development projects in the field of renewables. Similarly, no significant evidence was found regarding the second indicator, in terms of joint ventures and foreign investments in the renewable energy sector.

3.1.2.4. Bahrain. Bahrain is another laggard, where neither of the two indicators of policy transfer, research institutes with specialized renewable energy research foci, nor convincing renewable energy-related joint ventures and or foreign direct investments exist. Bahrain has not yet utilized its solar potential either and shown no significant efforts in that direction. In principle, also Bahrain has abundant solar potential, even though the mixture of dust and humidity can make solar cells less efficient [5]; (p. 26), which requires more advanced solar photovoltaic technologies. Regarding Bahrain's prospects for wind energy, the available wind potential seems insufficient for export, although it can be used for low power domestic consumption [6]; (p. 254). Yet again, there have been no noteworthy developments in that respect.

To sum up, clear evidence of strong international research cooperation with prestigious research institutes, along with numerous ongoing business partnerships with major corporations, support the policy transfer hypothesis in the two leading countries. These indicators lead to policy transfer, which enables and further initiates the adoption and consolidation of renewable energy adoption.

3.2. Endogenous policy hypothesis

This hypothesis suggests that the development or not of renewable energy technologies is the result of country characteristics rather than external factors. We consider the following characteristics as important: (a) dependence on oil for revenues and domestic energy consumption; (b) political leadership and presence of strong environmental institutions; and (c) pressure by domestic civil society actors.

As for our first variable, the relationship between oil dependence and the need for further diversification in the energy sector could provide support for the endogenous policy hypothesis. That is, the more a state is dependent on oil export revenues, the more willing it would be to promote renewable energy, as the opportunity costs of investing in such a niche sector will be higher later on. To a large extent, all Gulf Cooperation Council States are “rentier states” defined as “a state that lives from externally generated rents rather than from the surplus production of the population” [33]; (p. 661). Abundance of fossil resources does not only shape these economies, but it also defines their political economy, social structure, public–private relationships, and even demographic characteristics. Decades-long reliance on hydrocarbon revenues acted as an obstacle in front of economic diversification, since these states had little or no motives for investing in sectors other than oil, natural gas and/or petrochemical products. However, as Fig. 1 illustrates, the two leaders – the United Arab Emirates and Qatar – are at two different levels of oil dependency: While the United Arab Emirates is the least oil-dependent state within the Gulf Cooperation Council, Qatar is one of the most dependent. Yet both are pioneers in the development of renewable energies.

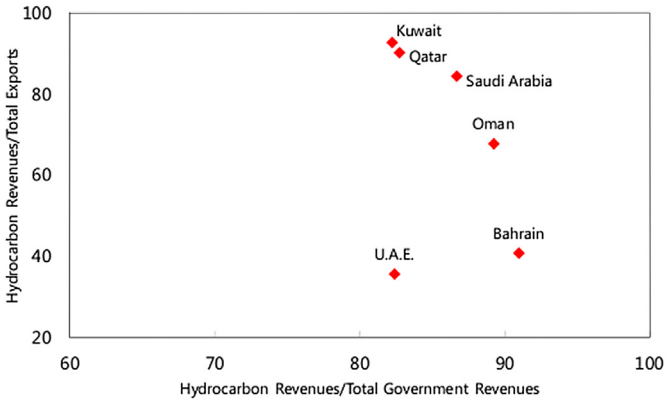

Fig. 1. Reliance on Hydrocarbon Export Revenues in percentage, 2011 (Source: [26]; October 12).

Furthermore, another measurement of oil dependencies of GCC states, which take into account the total proven oil reserves, total consumption, and estimated petroleum net exports reveals different results. Looking at the share of daily petroleum consumption summed up by estimated daily petroleum exports within the total proven oil reserves, we see that Kuwait is the most dependent country on oil, United Arab Emirates is the 2nd most dependent, while Qatar is the 4th most dependent (Table 2). Therefore, even though United Arab Emirates and Qatar have substantially high shares of oil revenues within governmental income as seen in Fig. 1, taking into account other indicators, it is obvious that their levels of dependency on oil are not causal factors that lead the way to total renewable energy deployment, as there does not exist a causal relation.

Likewise, while Gulf States face numerous common challenges resulting from the dominance of fossil resources, they have responded differently. Specifically, all Gulf States need to address high and growing demand for cooling, water and transport, industrial development strategies based on hydrocarbon inputs and peak electricity demand issues [39]; (p. 9). Although there are variations between United Arab Emirates and Qatar in terms of population growth rates[1] high population density in the urban areas of the region leads to demand-based problems in the urban sphere.

In addition, international energy price fluctuations and fluctuations in international money markets (since most GCC currencies are highly in interaction with US dollar) [27]; (p. 13) point to the fact that diversification of energy resources would be a common benefit for these states, rather than only some of them.

Our second variable, political leadership and presence of strong environmental institutions, played a significant role in the development towards renewable energy technology adoption in the United Arab Emirates and Qatar. This is demonstrated by the Emirates' strategic decision to design Masdar City as a free trade zone, with the right of full foreign ownership and no import tariffs and taxes, all in order to attract foreign direct investments, as well as Qatar's Education City and Qatar Science and Technology Park. According to one IRENA Official, in the absence of strong governmental institutions and effective ministries that are able to shape and manage renewable energy policy, substantial project initiatives are mostly the reflections of the will of the political ruler, or actors in the private sector [30]. Thus, it is not surprising that Mubadala Development Company, which is the owner of Masdar, is the investment tool of Government of Abu Dhabi. Similarly, Qatar

[1] Between 2009 and 2013, population growth rate increased from 1.6% to 1.9% in Saudi Arabia, while it decreased from 12.7% to 3.1% in United Arab Emirates [63].

Table 2
Oil dependence of GCC states 2013.

	United Arab Emirates	Qatar	Saudi Arabia	Bahrain	Kuwait	Oman
Total proven oil reserves (billion barrels)	97.80	25.24	268.29	0.12	104.00	5.15
Total consumption (thousand barrels per day)	698.00	220.00	2968.29	49.00	467.00	153.84
Estimated petroleum net exports (thousand barrels per day)	2742.59	1847.30	8733.22	12.16	2344.84	791.29
Oil dependence	28,425.36	12,209.16	22,927.81	1962.07	36,986.46	5448.99

As calculated by dividing the total proven oil reserve quantity by the ratio of estimated petroleum net exports to total consumption.
Source [20].

Foundation, which manages many projects including Qatar Solar Technologies and Qatar Science and Technology Park, is partially funded by the Qatari government. These outstanding initiatives of United Arab Emirates and Qatar, therefore, are results of political leadership. Regarding the achievements of United Arab Emirates, for instance, it has been highlighted that Sheikh Zayed bin Sultan Al Nahyan's visionary leadership played pivotal role [31]. Hence, the variable of political leadership as an endogenous factor has also been effective in renewable energy adoption of leader states.

Our third and last indicator for the endogenous policy hypothesis is pressure by domestic civil society actors. Lack of a strong civil society in general, and on environmental policy in particular, speaks against this hypothesis. Among the six Gulf Cooperation Council countries, only Bahrain and Kuwait have organized civil societies. Interestingly, these are the two countries that still lack concrete comprehensive plans for sustainable development. This shows "the irrelevance of societal input in the decision-making process on sustainability policies" in the member states of the Gulf Cooperation Council [25]; (p. 41).

In sum, except for the role of political leadership, endogenous policy hypothesis is not entirely fulfilled. Two leaders share the common characteristic of strong political leadership, while other endogenous variables exist in all Gulf states. Accordingly, as for this hypothesis, we can only attribute the observed variation to the strong political leadership in United Arab Emirates and Qatar. Furthermore, political leadership also explains the initiation of policy transfer, since the establishment of policy transfer channels have been possible with the rulers' determination and fostering. Thus, even though we did not find support for the whole endogenous policy hypothesis, still we argue that the policy transfer hypothesis does not stand in competition with the endogenous policy hypothesis, as political leadership acts like a bridge between the two. In fact, combination of policy transfer hypothesis and political leadership has been the explanatory reason behind the renewable energy achievements of the two leaders.

3.3. *International regime hypothesis*

International environmental regimes, the norms, rules and decision-making procedures around which actors' expectations converge on environmental issues, can play pivotal roles in states' adoption of clean and sustainable policies. Once states are committed to an international environmental regime it is hypothesized that they will change their behavior and policies to meet the expectations of the particular regime. We investigate this hypothesis by examining the Gulf states' commitments under the most prominent international environmental regime relevant for renewable energy development, the United Nations Framework Convention on Climate Change and its Kyoto Protocol.

As the world's leading per-capita emitters of carbon dioxide, the relevance of the climate change regime for Arab Gulf cannot be underestimated. Importantly, all Gulf States have acceded to the Kyoto Protocol and so, no noteworthy variation in their obligations can be identified. Saudi Arabia seems to be most reluctant when it comes to further negotiations under the climate convention. Bahrain, Kuwait and Oman appear to have sided with the Saudis over economic concerns. All these countries agree that the processes under the climate convention might disadvantage them if their oil revenues are reduced by the emissions reduction initiatives [12].

However, we also find that the United Arab Emirates and Qatar have been more active in the climate regime in relation to the other four Gulf Cooperation Council countries. The Emirates have "clearly stated its environmental actions, commitments, and limitations, and has asked what others will do in return; " whereas Qatar "has played a constructive role behind the scenes" [12]; (p. 2). Qatar has even hosted the 18th conference of the parties to the climate convention in 2012. Hence, even though current literature's emphasis on these two leader countries is noteworthy, they are still not active and assiduous enough to be positively influenced by the norms and regulations of the international environmental regime.

4. Conclusion

This study showed that significant variation exists in the adoption of renewable energy technologies in the Arab Gulf countries. While some countries, notably the United Arab Emirates and Qatar, are leaders in this area, others such as Saudi Arabia, Bahrain, Oman and Kuwait lag behind. We explained this variation largely on the basis of the policy transfer hypothesis. Specifically, we identified two major channels of policy transfer in the leading countries, (i) international and interregional research collaboration with prestigious institutes, and (ii) business partnerships with the involvement of large corporations. In contrast, our study found less support for the endogenous policy, except for the significance of political leadership, and no satisfying support for the international regime hypothesis. This suggests that any developments towards that direction in the future are more likely to stem from international and intraregional policy and knowledge transfers, supported by political leadership, rather than external pressures. Especially during the initial design of renewable energy policies, presence of farsighted leaders plays a crucial role, as it paves the way for more determined steps in the following implementation phases where policy transfer channels kick in. Accordingly, policy makers wishing to see a change in that region would best focus their attention on enabling such transfers rather than employ other, possibly ineffective, tactics.

The region of the Gulf Cooperation Council is rather unique inasmuch as its countries are not only crucial parts of the global fossil-fuel-based economic system, but also notorious blockers in international environmental negotiations. Indeed, the solution of the global climate change problem cannot be achieved without including these states. As our research suggests, there have been notable developments in these countries in terms of renewable energy policies. While some countries do better than others, one thing is certain: all have abundant potential for renewable energy sources.

One question regarding the region remains yet unanswered. How could the international community put pressure on the Gulf countries to actively support renewable energy deployment and a more meaningful role in global climate policy? First, we need to understand and address the reasons for that resistance. To date resource-rich states have been hesitant and unwilling to comply by the rules of international environmental negotiations, primarily because they want to keep oil prices high and they are alarmed by the need to reduce greenhouse gas emissions from the burning of oil [11]; (p. 1). However, scholars argue that their ability to influence oil prices will not necessarily be diminished by the Kyoto Protocol [10]; (p. 2085) or similar agreements. On the contrary, many resource-rich states face the risk of experiencing more serious economic losses due to climate change than those that might be experienced as a result of response measures [10]; (p. 2087). Therefore, one indirect way of putting pressure on these states would be promoting and supporting more research related to economic modeling of potential vulnerabilities of these states due to climate change. In this context, the International Renewable Energy Agency could play a pivotal role in solving the gridlock that was experienced during the recent United Nations Framework Convention on Climate Change (UNFCCC) negotiations, by framing renewable energy towards these countries as a pro-business enterprise, creating a knowledge base for renewable energy in the region, and limiting the "downside risk of hurting cooperation efforts in other energy institutions", while focusing on "more modest and achievable goals" [44]; (p. 347). This issue can be further tackled by future research, and more solid explanations of this phenomenon can be found from the perspectives of political science, economics, and/or sociology.

To sum up, contrary to a common perception our research has shown that some countries in the Arab Gulf region have experienced unprecedented initiatives in the renewable energy sector. Based on three indicators (intensity of renewable energy within the energy mix, total installed renewable energy capacity, and per capita installed renewable energy capacity), we have shown that the United Arab Emirates and Qatar are two prominent leaders, while Saudi Arabia, Bahrain, Oman and Kuwait are laggards with little renewable energy deployment. Following the analysis of three hypotheses, our research has concluded that achievements in the renewable energy adoption in the two leaders can be explained by the combination of policy transfer analysis and political leadership.

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