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Impacts of Human Factors on Willingness to Use Renewable Energy Sources in Iran and Morocco

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Abstract

Currently Iran and Morocco are going through an energy transition. Ambitious plans exist at international, regional and national governance levels to deploy renewable energy sources (RES), such as concentrated solar power (CSP) and photovoltaic (PV) solar power. These plans foresee deployment of RES to cover local growing energy needs, to diversify energy supply and to benefit from electricity trade. Even though the majority of MENA countries have favorable geographic conditions, namely, the level of solar irradiance, for deployment of solar projects, they are very diverse in terms of availability of fossil fuels, which might hinder deployment of RES projects. For instance, Morocco is covering almost 95% of its energy needs by imports at the same time as Iran is not only benefiting from availability of fossil fuels for local consumption but are also exporting fossil fuels to the global markets. The first question of this paper is trying to answer is how availability of fossil fuels for domestic consumption might impact the willingness of people in Iran and Morocco to use RES. And secondly how public acceptance of RES in general, and solar projects in particular effects the development of RES projects in this region. The methodological basis of this paper is formed by the case study method of two countries. It also includes different methods of elicitation of opinions and views to understand public acceptance and willingness to use renewable energy. By comparing Iran and Morocco we aim to understand to which extent availability of non-renewable energy sources in in these two countries influence perceptions of its inhabitants regarding RES energy.

Keywords: Concentrated solar power, Willingness to use renewable energy sources, Human factors of energy transition, Energy policy in Iran and Morocco

Introduction

Policy and scientific communities speak about the need to reduce the current level of green house gas (GHG) emissions to avoid further rise of temperature, which can make adaptation of humankind to climate change impacts difficult. By far, the highest share of GHG emissions come from energy generation based on fossil fuels. Deployment of renewable energy sources (RES) can be one of the possible options to satisfy the growing globally energy demand with low carbon energy and to diversify energy supply (IPCC, 2014). RES are continuing to grow and in 2012 contributed to 19% of global final energy consumption. Currently RES are facing

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two tendencies. At one side, in 2013 public support for RES was declining (UNEP, 2013). At another side, technological advances, falling prices and innovations in financing made RES increasingly affordable for a broader range of consumers worldwide (REN21, 2014).

The potentials of solar energy among other RES are almost unlimited (Cho, 2010). The year 2013 experienced return of profitability of solar, mainly PV, projects. This was the first year, when the world added more solar than wind capacity. More than 39 GW of capacity were added, which made the total solar capacity equal to 139 GW. The growth rate of solar PV made almost 55% at average per year for the last five years and 98% of all existing PV capacity was added after 2004. The volumes of CSP capacity grew up by 36% in 2013 and increased from 0.9 GW to 3.4 GW, with US and Spain remaining the market leaders but also with a significant share of capacity shifting to the Middle East and North African (MENA) region, India and China (REN 21, 2014). Several countries of MENA region now have solar energy in their energy plans. The major drivers for the deployment of solar capacity in the region are rapid increase in energy demand, diversification of energy supply to free up more crude oil for export and high solar insolation rates. Besides PV capacities, currently three countries of the region are hosting CSP projects, Algeria (25MW), Egypt (20MW) and Morocco (20MW). Large volumes of CSP capacities are currently under construction in Morocco (160 MW) and in Egypt (100 MW) (Komendantova and Patt, 2014).

Several scientific works exist on the topics of economic and technical feasibility of RES. However, deployment of new technology, such as solar for energy generation, cannot be driven by availability of technical and economic capacities alone. Stakeholders, who are implementing the technology and the consumers of the generated energy, are driving energy transition. Therefore, there is a need to understand human factors and triggering behavior of different stakeholders towards low carbon energy systems. These human factors include public acceptance towards energy generation and transmission capacities being constructed in the vicinity, willingness to use RES and, finally, willingness to pay for different energy generation options. Evidence on policy mechanisms also suggests that for successful implementation, energy policy has to have three components and the exclusion of one of them might result in less successful outcomes. These elements are: portfolio standards mandating minimum levels of renewable energy use, energy support programs and human factors, such as public acceptance and consumers voluntary renewable energy purchases (Wiser et al., 1998).

The need to address perceptions and human behavior towards new technology as an essential element for climate change policy was also stressed in the recent report of the International Panel of Climate Change (Kunreuther et al., 2014). This need gives one of the major roles to social sciences to address human and behavioral factors regarding energy and climate policy (Sovacool, 2014). The need to understand human factors as an essential element of energy policy is also caused by the fact that development and acceptance of any innovation is not a purely rational process. This process is also often settled in a top-down manner by policy-makers through advice of scientists and then communicated to stakeholders. This process involves conflicting values, different beliefs and views as well as perceptions and social interactions (Wheeler, 2008).

Current understanding of human factors and their impact on energy transition is limited. Also, It is often assumed in the energy technology policies that stakeholders will passively be adapting to technological innovations. In practice, nowadays, the attitude of stakeholders towards technological development has been changed since fifty years ago, for example, when technology deployment was perceived as being a driver for socio-economic progress. Today, inhabitants want to participate in decision-making regarding infrastructure projects. Public attitudes may include active protests and conflicts around newly developed renewable energy power plants, lack of willingness to use this technology in everyday life from the side of

inhabitants or lack of willingness to invest into projects which involves newly developed technologies from the side of investors.

In light of the discussion above on human factors, the goal of this paper is to understand impacts from availability of non-renewable energy sources on the willingness to use RES, such as concentrated or photovoltaic power. We conducted our analysis based on available evidence from two case countries in the Middle East and North African (MENA) region, Iran and Morocco.

Background

The MENA region is currently experiencing a major shift in its energy policy as governments of several MENA countries are facing the challenges of growing population's demand for electricity and limited investment into new electricity generation projects. The power demand is projected to grow at around 7% per year over the next 10 years, caused mainly by population growth and economic development. According to the World Energy Outlook, the share of RES in the MENA region is planned to increase from 2% by 2010 to 12% by 2035 (IEA, 2011). Currently only 4% of the MENA primary energy consumption is covered by RES, which is much below an average of 17% for the rest of the world. The current level of energy consumption from RES also stands in strong contrast with availability of resources. According to the World Bank estimations, the MENA region receives between 22% and 26% of all solar energy striking the earth. In additional to solar energy, MENA also has wind resources. But solar energy is considered to have by far the largest potential. The biggest volumes of solar capacity are currently being deployed in the North of the Mediterranean region however the South Mediterranean region has much higher direct solar irradiance.

Concentrated solar power (CSP) and photovoltaic (PV) are two major technologies, which converts sunlight into electricity (Quaschning, 2004). CSP uses mirrors and lenses to concentrate sunlight onto a small area. There are different types of CSP technologies, such as parabolic, enclosed trough, Fresnel reflectors, solar power towers, and dish stirling. In the Mediterranean region, for example, a connected CSP system could provide 70-80% of current electricity demand at no extra cost compared to gas-fired power plants (Pfenninger et al., 2014). Due to thermal storage systems of CSP this technology is projected to become more and more profitable. PV is another technology of converting solar energy into electricity. It uses the semiconducting materials to create a photovoltaic effect. The energy generation system uses solar panels, which are composed of a number of solar sells, and can be suitable not only for centralized but also for small scale decentralized energy generation plant. Currently this technology is one of the most widely used RES.

Despite key relevance between human factors for energy and climate policy (Kunreuther et al., 2014; Sovacool, 2014) the drivers of willingness to use RES are investigated less often than economic and technological barriers. The majority of existing studies in this area has the focus on RES in Europe. These studies investigate questions such as public acceptance of wind energy, frequently. Indeed, public acceptance is a key issue for deployment of RES (Wüstenhagen et al., 2007) and scientific evidence exists that public acceptance can be a barrier not only for deployment of energy generation capacities, including different kinds of energy generation, such as waste to energy (Achillas et al., 2011), wind- energy or micro-generation (Sauter and Watson, 2007), but also for energy transmission infrastructure (Battaglini et al., 2012). Public acceptance is a first step for deployment of RES technology, but the willingness to use RES goes beyond passively accepting transmission and generation capacities. It requires active will from stakeholders and their active participation in energy transition.

Attitudes towards innovation, in general, are influenced by perceived costs, risks and benefits of these innovations (Huijts et al., 2012). Attitudes towards technological innovations, which are foreseen by climate change and energy security policies, are influenced by the level of knowledge and awareness about climate change and energy security issues (Joireman et al., 2010). Speaking about willingness to use RES, the existing studies investigate preferences of private households. For instance, there is evidence about the impacts of moral obligations to reduce energy consumption, prioritization of collective interests over self-interests and awareness about environmental problems caused by energy use on willingness to use RES in Europe (van der Werff and Steg, 2015). But only few studies investigate willingness to use RES and human factors in energy transition in the MENA region. The majority of existing studies, for instance in Morocco, are focusing on the governance structure at international and national levels and how the goals settled by energy policy could be implemented via a top-down approach (Fritzsche et al., 2011).

Method

This research is based on the case study methodology, which is frequently used in social sciences as a research method of in-depth examination of a subject of study and its related contextual conditions. The case can be defined as follow, "case studies are analyses of people events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more methods. The case that is the subject of the inquiry will be an instance of a class of phenomena that provides an analytical frame — an object — within which the study is conducted and which the case illuminates and explicates" (Thomas, 2011). One of the most famous examples of application of case study method is the Galilei's rejection of the Aristotle's law of gravity. The rejection was based on a case study selected by information-oriented sampling and not by random sampling (Flyvbjerg, 2006).

As opposed to random sampling, which is also often used in social sciences, cases are selected based on information-oriented sampling and often includes the extremes, including this research. In this research a country that does not only have rich fossil fuel reserves for local consumption but It is also one of the largest exporters of fossil fuel energy, and a country, which does not have such reserves neither for export nor for local consumption and is covering its energy demands by imports, are chosen. The majority of existing studies on public acceptance and willingness to pay or use renewable energy apply quantitative methods of research, using random sampling and large-scale surveys of public opinion. The research methods included the hedonic analysis of actual price premiums charged for green electricity in deregulated markets (Roe et al., 2001), the elicitation method to develop survey design (Bollino and Polinori, 2007), contingent valuation and double bound dichotonomous choice format to collect people's elicitations (Zografakis et al., 2010) and other methods based on large-scale surveys of stakeholders opinions and views. The case study approach can create additional benefits through detailed and more in-depth evaluation of the case.

The majority of existing studies focus on either public acceptance of renewable energies or willingness to pay for renewable energies. The Willingness to Pay (WTP) is a method to identify the price for goods, when the market does not exist. With the help of quantitative methods, such as large-scale surveys, researchers are trying to determine the price that people will be willing to pay for goods. The method was most frequently used to evaluate environmental benefits in financial terms when markets for environmental quality do not exist. Often WTP is a more economic indicator, which calculates a number but it does not include all nuances of individual decision-making and factors, which influence this decision- making. Even though, WTP can be easily quantified by collecting preferences of stakeholders on how

much they will be willing to pay for deployment of RES, the willingness to use RES is much more difficult to quantify as it includes qualitative evaluations and views.

The MENA region is one of the most suitable regions in the world for deployment of solar power capacities due to abundance of this renewable energy source (Fritzsche et al., 2011). We are choosing two countries of the MENA region, Iran and Morocco, as they do not only have similar environments, which is mostly arid or semi-arid, but also share to a large extent the same religion and history (Yazdanpanah et al., 2013). Both countries are rich with RES, such as solar and wind. In Iran solar is considered as an important energy source in the future energy mix (Hosseini et al., 2013), but the entire process of deployment of RES in the country is at the preliminary stage and the share of RES in energy mix is not significant (Fadai et al., 2011). Morocco is often viewed as a front-runner for deployment of RES and its political will, at the same time the country is highly dependent on energy imports (Schinke and Klawitter, 2010).

Results

The results of this paper are based on analysis of existing empirical data collected by different research projects, which are currently on-going with the focus on the MENA region. First, the framework conditions for energy policy in the region are discussed. And following to this, the patters of public acceptance and willingness to use renewable energies in two countries.

Energy availability, consumption and policy

Morocco and Iran have major differences in terms of availability of fossil fuel resources. Iran has the second largest oil reserve in the world, holds 10% of the world's total proven oil reserves and is the third largest oil exporter (BP, 20123). It also has the world's largest reserves of natural gas, which makes 18% of the total reserves. Natural gas is mainly exploited for domestic use (Hosseini et al., 2013). Iran has a lower level of solar irradiance then Morocco. However, with 300 clear sunny days per year and the level of solar irradiance of about 2,200 kWh per square meter, Iran has high potentials for solar energy. Also 90% of the territory of Iran would be suitable to generate solar power (Alamdari, 2013).

Morocco is covering almost all its energy needs from import of energy sources for domestic generation of electricity. Most of imported energy is from fossil fuels, for instance, over 80% of electricity produced domestically in Morocco is generated from coal, oil and gas and the rest is generated from domestic renewable energy sources, such as wind and hydro. Rural households are using firewood, which results in disappearing of almost 50,000 ha of forest every year (Zejli and Bennouna, 2009). The country could diversify its primary energy supply significantly as its geography is characterized by intensive solar radiation, which is above 2,200 kWh (Benkhadra, 2009).

Energy consumption in Iran is significantly higher than international standards and continues to grow. Its per capita energy consumption is 15 times higher than of Japan and 10 times higher than of European Union. In the last years the oil consumption decreased due to an increased consumption of natural gas and electricity. Only in the year 2012 electricity consumption increased by 5.6% comparatively to the previous year. Iran has the third highest level of consumption of natural gas in the world and its domestic consumption is projected to grow by making Iran the largest natural gas consumer in the world (BP, 2013). Domestic consumption of natural gas is expected to increase at about 7% per year in the following decade. Energy consumption in Morocco is rapidly increasing due to population growth and an increase in quality of life and changes in the life style. Currently Morocco has around 30 million people and its population is becoming increasingly urban. The national demand for electricity in 2015

will be around 40,000 GWh or even higher. Industry remains the largest electricity consumer (38%). Electricity consumption per capita makes 474 kWh and the Morocco's government is expecting that this consumption will be growing annually by 7.5% (IEA, 2011).

Both countries, Iran and Morocco, settled ambitious energy policies for deployment of RES projects. In November 2009 Morocco announced the "Moroccan Solar Plan" for installing 2GW of solar electricity generating projects by 2020. Morocco is also participating in the Mediterranean Solar Plan, which foresees deployment of 20GW of RES projects by 2020. The country also launched the "National Energy Strategy of Morocco" and the "National Priority Action Plan", which sets a target to meet 12% of primary energy demand with RES by 2020 and 20% by 2030 (MEMEE, 2009). In the year 2010 hydro and wind capacity already existed in Iran and the government has a target to deploy 2GW of additional RES capacity by the year 2015. In the year 2012 Iran allocated 500 million Euros to the National Development Fund for renewable energy projects and established a state-sponsored Renewable Energy Organization of Iran (SUNA).

Level of awareness and knowledge about RES

According scientific evidence about factors influencing willingness to use renewable energy, such as solar, and public acceptance. The two groups of factors for Morocco and Iran, such as energy frameworks and human factors, were identified. These factors are level of information and awareness and perceptions about risks, costs and benefits of technology. Regarding the level of information and awareness, it is more likely for people to take actions to mitigate climate change if they are aware that climate change is happening (Joireman et al., 2010). Therefore, awareness about impacts and causes of climate change is crucial for implementation of climate and energy policies. The variables on perceptions of risks, costs and benefits of the renewable energy projects were selected as according to scientific literature perceptions of economic risks and benefits of the renewable energy projects are often regarded as a driver for public acceptance (Petrova, 2013).

The assumption that knowledge about causes and impacts of climate change influenced willingness to use RES, such as solar, was formulated in the recent research, which focuses on perceptions of renewable energy among students in Iran. This research found that there is a significant relationship between willingness to use RES and the level of awareness about benefits of the technology. From another side, perceived barriers for RES have no significant influence on intention to use RES (Yazdanpanah et al., 2015). Another identified factor is self-efficacy, which refers to stakeholder's self-confidence in the ability to be able to use RES (Bandura, 1977). It can strongly influence intension to use RES in case if individuals consider that such behavior can be performed successfully. The results of research among students in Iran show that self-efficacy, which is connected with the level of knowledge and information about the technology, has a key component in stakeholders' intension to use RES (Yazdanpanah et al., 2015). Field research conducted around the large-scale planned concentrated solar power (CSP) installation Noor-I in Morocco showed that the level of awareness among population about this project was relatively low and more than half of all stakeholders themselves, felt badly informed about details of the project. They were aware about the project because the Royal family was at its opening. Also results of regression analysis showed that there is a correlation between the level of awareness and public acceptance of the project (Hanger at el., 2016).

These results correlate with available data from studies with focus on other regions and countries that the level of awareness about RES has an impact on public acceptance and willingness to use RES. The study focusing on US energy consumers found out that consumers favor electricity produced from renewable energy sources, with solar and wind being the most

popular options. Although consumers knew little about it. The US energy consumers' study shows that commercial customers are slightly more aware of electricity from renewable energies than residential customers. Solar and wind are the most known technologies and although 84% of respondents heard about products such as solar panels, the lack of knowledge is commonly cited as a reason for not installing them. The percentage of people willing to use RES might increase with educational and awareness raising programs about available options (Farhar, 1999). The study with the focus on US consumers recommends further research on current environmental concerns of electricity consumers and the level of awareness about renewable energy sources. The study conducted among households in Greece finds out that people, who are aware about renewable energies, have also positive attitudes towards further implementation of RES (Zografakis et al., 2010). The results on self-efficacy are also in correlation with findings of Zografakis et al., (2010) who identified that people who know how to produce, install and use RES are more willing to use it.

Perceptions of risks, costs and benefits

Perceptions of benefits of RES technology can be connected with such benefits as mitigation of risks for own health and future generations, which might arise from climate change as well as mitigation of risks for environment, connected with non-sustainable energy consumption (Bang et al., 2000). Perceptions of benefits can be also associated with an individual's belief towards the relative effectiveness of a risk mitigation action, such as mitigation of climate change impacts (Ng et al., 2009). Perceptions of barriers also have significant influence on behavior, in general, (Janz and Becker, 1984) and regarding energy choices, in particular (Vassallo et al., 2009).

The study with the focus on willingness to use RES among future project managers in Iran identified that moral norm had the strongest impact on the willingness to use RES. This factor is influencing perceptions of benefits from technology, such as contribution to own moral principles. It was strongly connected with the positive feeling of doing the right thing for development of society (Yazdanpanah et al., 2015). These results also correlate with findings from behavioral economics, which show that own moral principles have strong influence on individual intentions (Arvola et al., 2009). This leads to a conclusion that willingness to use RES is also a moral action and the measures to address it should be reflected in energy policies. The study conducted among students in Iran identified that beliefs about effectiveness of using RES for protection of human health and environment from climate change is perceived as a benefit from implementation of RES (Yazdanpanah et al., 2015). The results also show that perceived costs and risks connected with technology have much less influence on intension to use RES.

Another identifying factor, which impacts the willingness to use RES among project managers in Iran, is the evaluation of own ability to accomplish a specific action. This factor is connected with perceptions of the costs of technology such as the need to change daily routing or accomplish extensive learning process to be able to manage the technology. The evaluation is closely connected with perceived difficulty to use RES. If a technology is perceived as being complex, which would require significant learning and a significant change in daily routine, it is less probably that stakeholders would be willing to use it (Yazdanpanah et al., 2015).

In the case of Morocco, respondents expected "somewhat more positive impacts than negative" (44%) and as many positive impacts as negative impacts (30%). Most of expectations on benefits were at the global scale, such as positive impacts on environment, or at the local scale, such as job creation processes and impacts on community (Hanger et al., 2016).

Conclusion

Our study allows us to make two conclusions. The first one is that human factors, such as the level of awareness about RES, and perceived benefits from their use, have an impact on public acceptance and willingness to use RES. The second one is that these factors are equally present in economies, which have extensive fossil fuel resources as well as in economies, which are dependent on energy imports and do not have fossil fuel reserves. Thus, these results show that such factors as the level of awareness about RES and perceptions of costs benefits impacts the willingness to use RES and public acceptance independently from countries framing conditions, such as availability of fossil fuels. However, further research is necessary to measure the strength and extent of impacts from human factors. It would be interesting to research further, if there are correlations between the strength of impact and the availability of fossil fuel reserves.

Table 1. Energy framework and human factors addressing deployment of renewable energy projects

Energy framework	**Iran**	**Morocco**
Energy availability	Second largest oil reserves in the world and largest reserves of natural gas. Good availability of solar resources.	Primary energy demand is covered mainly by energy imports. High availability of solar resources.
Energy consumption	High level of consumption, continues to grow	Low level of consumption but is rapidly growing
Energy policy	2GW of additional renewable energy capacity by 2015	RES share of 20% in primary energy demand by 2030, mainly solar and wind
Human factors		
Level of awareness and knowledge	Confidence in ability to use renewable energies impacts willingness to use RES	Not well informed about concrete solar projects but relatively well informed about renewable energies, in general
Perceptions of risks, costs and benefits	Global: protection of human health and environment from climate change	Global: expectations of positive impacts on environment Local: expectations of positive impacts in terms of jobs availability and impacts on community

Our study shows that there is a need for energy policy to settle different instruments and strategies to increase the level of knowledge and to raise awareness about RES among all groups of stakeholders. Even though the level of awareness about solar and wind is the highest comparatively to other RES, measures are needed to raise awareness about other sources of RES. There are also significant information gaps and misleading perceptions regarding RES from the side of general public and specific groups of population, such as project developers or managers. The efficient energy policy has to take seriously existing public perceptions, awareness attitudes, behavior and acceptability in regards to deployment of RES.

The study shows that besides such “hard facts” framing the energy policy as the availability of non-renewable energy sources or patters of domestic energy consumption, so-called “soft factors” or human factors, such as the level of awareness about renewable energy, in general, and solar energy projects, in particular, play a significant role by raising public acceptance and willingness to use renewable energies.

The case studies allow two additional conclusions. The first one shows that the level of awareness could be increased in both cases. Surprisingly, in the country such as Morocco which is considered to be a leader in deployment of RES to avoid dependency on energy imports, the level of knowledge and awareness about renewable energies was, in general, low. The second one tells that the level of awareness and knowledge, itself, can be a significant driver for further deployment of renewable energies, public acceptance and willingness to use them.

Regarding the perceptions on risks and benefits from renewable energies we could also make two conclusions. First one is that deployment of renewable energies is perceived in both countries, even in Iran, which has extensive non-renewable energy reserves, with more benefits rather than with costs or risks. The second conclusion is that global impacts, such as positive impacts on environment but also on human health, are perceived as being a benefit from renewable energy projects in both cases. In the case of Morocco, benefits at local level were also identified, mainly because the research was conducted around the power station, which is already in construction, and targeted inhabitants of communities around the station.

However, further research is necessary on how additional information not only on benefits of RES and their impacts of climate change but also on information facilitating the use of RES and increasing self-efficacy feeling of stakeholders can help to convert a passive consumer, who might be accepting or not energy generation or transmission infrastructure, into a responsible and active citizen, who will through decisions and actions choices participate in shaping of energy landscape.

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