Analysis of the social acceptance of PV and BIPV technologies in Mediterranean cities

Abstract

This paper provides an analysis of six Mediterranean countries as regards the attitudes and preferences on solar technologies. It analyses the social acceptance of PV technologies both in the private dimension (i.e. willingness to install a specific PV system) and in the public dimension (i.e. acceptability of specific BIPV applications in the urban context where the individual resides). We designed an original experiment, using simulations of BIPV applications in residential buildings representative of each city, in order to elicit preferences for different technological and aesthetic solutions, conditional on different levels of information on the cost effectiveness of each option. Results show the positive influence of awareness of benefits, subsidies, "neutral" information and peer effect on the potential adopter of PV technologies; a positive attitude and attachment toward the city also plays an important role. Similar results are found when we examine the social acceptability of different PV applications on residential buildings in the urban context. A comparative analysis across countries reveals that Italian, Tunisian and Jordanian respondents seem the most interested in PV technologies, while Spanish respondents focus on negative aspects associated with a PV investment. Lebanese and Egyptian respondents are in between the two positions.

1. Introduction

The total demand of primary energy in the Mediterranean countries is steadily increasing, with an estimated growth rate of about 2.8% per year since 1970. This trend has a significant impact on the fossil fuel consumption in the region, raising concerns of import dependency, pollution, and climate change issues, which can be addressed by orienting energy policies more decidedly toward renewable energy sources. Southern European countries, in accordance with the Climate-Energy Package – the so-called "20-20-20" package, have undertaken this path, and are on average close to the 20% target of renewable energy in gross energy consumption, to be reached by 2020 (EEA, 2014). By contrast, the MENA countries rely for over 95% of their energy needs on oil and natural gas (Fattouh and El-Katiri, 2013): this seem unfortunate, considering that the region is abundantly endowed with renewable energy sources. In particular, solar technologies have a special relevance in the Mediterranean basin, which is considered to be one of the best locations for solar energy, although its enormous potential is still unexpressed, especially for what concerns the adoption of photovoltaic technologies in the residential sector (Foster in Med, 2014). The investments in renewables in the Mediterranean region have been mainly directed to large power plants (see, Tsikalakis et al., 2011; Griffiths, 2013; and Hawila et al., 2014) rather than to micro-generation at a domestic level.

"Fostering Solar Technologies in the Mediterranean area" is the title of a European funded project (ENPI CBC MED – FOSTEr in MED) aimed at the design of strategies for the promotion of innovative Photovoltaic (PV) technologies in the Mediterranean area, with a specific focus on the residential sector. The research involved six partner countries (Spain, Italy, Tunisia, Egypt, Jordan and Lebanon) in a multidisciplinary framework. The last part of the work, still in progress, entailed a pilot project of a Building Integrated Photovoltaic (BIPV) application in five cities, one for each partner country (except for Spain). As a preliminary step before the pilot projects activities, a survey was administered in each city, with the aim of providing information on the level of awareness that residents in different cities/countries have with respect to innovative PV technologies, and on the social acceptance of BIPV applications in these different urban environments. The present paper reports on the results of the survey.

With respect to previous literature our research presents some innovative aspects: first, it presents a comparative analysis of Southern European and Middle East and North Africa (MENA) countries as regards the attitudes, opinions, and preferences on energy, energy efficiency, and solar technologies; second, it analyses the social acceptance of PV technologies both in the private dimension (i.e. willingness to adopt a specific PV system) and in the public dimension (i.e. acceptability of specific BIPV applications in the urban context where the individual resides). A third innovative aspect is related to the fact that we designed an original experiment, using simulations of BIPV applications in residential buildings representative of each city, in order to elicit preferences for different technological and aesthetic solutions, conditional on different information on the cost effectiveness of each option.

The paper is structured as follows: the second section presents a review of the literature and a description of the main fact about renewable energy policies in the involved countries; afterwards there is a description of the survey administration and the questionnaire; the fourth section is devoted to the econometric analysis description and the following presents the result of the estimation. Finally, a conclusion highlights main results and policy indications.

2. Review of literature

In a review of the energy policies focused on MENA countries, Fattouh and El-Katiri (2013) identified some causes that lead to an excess of demand of fossil fuels, and to difficulties in matching national electricity needs in this area. In particular, the high level of subsidization of fossil fuels, though constituting an important social safety net for the poor and achieving some economic goals such as promoting industrialization, has produced many unintended adverse consequences such as: a rise in the energy intensity of GDP and low energy efficiency rates; a rapid growth in the consumption of the various primary fuels and electricity: all MENA countries' demand for both primary fuels and electric energy has been far above the world trend; underinvestment in the energy sector where subsidies are poorly implemented: caps on government subsidies to be paid to produces or flat payment subsidies may often not fully compensate the investments and the result is often the provision of low quality services to end users. Indeed, irregulars services with recurring power outages have characterised electricity provision throughout wide parts of MENA countries; an increase in greenhouse gases emission and in an exacerbation of the local air pollution, and a discouragement in the development of alternative energies.

As a consequence, also in these countries there is a growing necessity to increase the share of renewables in order to relax the dependence from fossil fuels. As highlighted by Griffiths (2013) PV has become cost competitive against conventional power generation in MENA for three primary reasons: Dramatic cost reduction in solar equipment costs, with further reduction forecasts; the good fit of solar power generation with demand patterns, particularly in the countries where air-conditioning drives electricity demand; gas shortages in some MENA countries, with increasing reliance on expensive imported LNG and/or oil-based fuels for power generation.

However, the public perception in MENA countries is that renewable energy is too expensive, especially in relation to the low price of electricity provided by national grids, and feasible only for rural areas not connected to the national grid (Kinab and Elkhoury, 2012). As reported by Fattouh and El-Katiri (2013) and Hawila et al., (2014), different subsidy programs have been designed to promote the transition to renewables; however, the implementation of the policies has often been unsatisfactory and the communication of the existing policies and subsidies has also been defective.

Italy and Spain, the Southern European partners of the project, introduced a generous system of incentives (feed-in tariffs) to promote the diffusion of PV technologies (see Campoccia et al., 2014, for a review of subsidies in some European countries). These economic incentives helped to achieve the required EU targets: currently, solar energy accounts for 7% of electricity produced in Spain and 6% in Italy. However, in the last two years, Italian and Spanish Governments decided to cut the feed-in tariffs due to the difficulties to manage the financial requirements (see, Antonelli and Desideri, 2014 for the Italian situation and Del Rio and Mir-Artigues, 2012 for Spain).

The protracted economic crisis could be an obstacle to further PV deployment if policies and strategies are focused only to economic drivers. However, increasing awareness regarding PV economic benefits (grid parity induced by the decreasing cost of PV modules, and the increase in electricity bills), could drive PV demand in Italy and Spain even with reduced or no subsidies. It is therefore important to understand what factors, besides the economic drivers, could influence the adoption decision. Unfortunately the literature on the social acceptability of technologies for production of renewable energy, while extensive for large plants, is somewhat lacking for technology adoption at household level. The remaining of this section presents a short overview of studies in this area of research.

Jager (2006) and Faiers and Neame (2006) analyse the elements that could influence the choice of adopting a PV technology. They found that the financial aspect is only one of a variety of important elements: the perception of technical, operational and bureaucratic barriers as well as aesthetic concerns, which can be smoothed by providing information and support. Jager (2006) indicates the important role of social networks and the influence of people who have already installed a PV system to induce people to adopt the technology. The so-called peer or network effect is an important psychological factor in explaining innovative technology adoption. Bolligher and Gilligham (2012) find strong evidence for causal peer effects in their studies on PV adoption in California cities: an extra installation in a zip code increases the probability of an adoption in the zip code areas. The rate of adoption is positively associated with the size of installations in the zip code area; furthermore, there is an especially strong neighbour effect. The results suggest how the peer effect works: on one side the strong effect of the visibility of the panels and on the other side the social interactions lead to further adoption.

Scarpa and Willis (2010) adopt a choice experiment approach to investigate the determinants of the adoption of micro-generation technologies by households in the UK; and their WTP for these renewable energy technologies. The micro-generation technologies comprise, among others, solar photovoltaic and solar thermal. The respondents traded-off 5 attributes: the type of technology (solar power, solar water, wind turbine); capital cost of the new system; maintenance cost; the source of the recommendation (none, friend, plumber, friend & plumber); and the energy bill savings. They found that the consumers' choice of the consumer is influenced by the advice of friends and technicians; but the average WTP estimated is not enough to cover initial capital cost for most of the technologies, including PV panels. Claudy et al., (2010) analyse the determinants of the awareness of the micro-generation in the Republic of Ireland. They found that the level of awareness differs across technologies, with nearly 80% of the population having some knowledge of the PV technology. Gender, age, professional status and social class (a proxy for education and income) influence the knowledge level.

Claudy et al. (2011) estimate the WTP for different micro-generation technologies, such as PV panels and identify the determinants of WTP. They adopt a Contingent Valuation with a double bound dichotomous choice methodology. Using a Likert scale they measured the perceived product characteristics: environmental friendliness, energy saving costs, independence from conventional sources, compatibility with habits and routines, the difficulty to understand and the complexity of a new technology, compatibility to the house characteristics, the performance and related costs. The respondents expressed higher valuations for micro wind and PV technologies. The positive determinants of the PV panel WTP are the independence from conventional sources, the level of education (medium and high educated people are more willing to pay than other people) and to live in an rural area, while living in a new (built after 1990) and larger dwelling have a negative effect. As far as we know, only few studies have been conducted to assess individuals' attitudes and preferences toward renewable energy in the residential sector in MENA countries. One example is Zyadin et al. (2012, 2014) who study the perceptions of Jordan secondary school students and teachers, finding a general positive attitude, and a need to enhance education regarding these technologies.

As affirmed by Azadian and Radzi (2013) "success or failure in BIPV projects totally depends on civilians' cooperation": it is very important to understand the aesthetic preferences of residents in a city in order to predict the success of some policy intervention aimed at the diffusion of BIPV. Cronemberger et al. (2014) study the aesthetical effect of the BIPV technologies on new buildings in a European context; while Radmehr et al. (2014) analyse the acceptability of BIPV installations in residential housing design in Cyprus through a Contingent Valuation methodology.

3. Survey administration and the questionnaire

In order to analyse the social acceptability of PV technologies, a survey was administered to citizens from the partner countries of the FOSTEr in MED project. The survey was aimed at examining the attitudes, opinions, and preferences that households may have with respect to issues related to energy, energy efficiency, and renewables, with a particular interest on the attitudes to-ward photovoltaic technologies, including some integrated PV. This is finalized to understand which characteristics influence the respondent choices and behaviours.

Given the exploratory purpose of the study, and due to budget and time constraints, a convenience sampling method was employed: 100 individuals were sampled in each partner country, for a total amount of 600 respondents. The survey was administered in the period July – August 2014, in the cities of Tunis (Tunisia), Alexandria (Egypt), Haddath (Lebanon), Barcelona (Spain), Cagliari (Italy). People were sampled randomly in streets, public venues, parks. A preliminary question was posed to select home proprietors only, as it may be more difficult for households on rent to decide installation of solar panels in the house. Different contingent conditions have influenced the actual sampling in each country (for example, the choice of locations where to intercept potential interviewees was severely conditioned in Lebanon and Egypt by the turbulent socio-political conditions occurring in that period). The resulting sample precludes a generalization of the results to the population of the cities (or even less of the countries) where the interviews have been taken: for example, the share of high educated people in the selected samples is certainly higher than what observed in the corresponding populations. Notwithstanding this, we believe that the present analysis is useful to shed some light on awareness, attitudes, and preferences regarding the photovoltaic technology, among a class of people who can be a potential PV market target in our partner countries.

The survey instrument has been designed on the basis of the results of the previous stages worked out in the Context Analysis, i.e. the desk analysis and the in-depth interview phase. The first section was devoted to analyse how each respondent relates to the city where s/he lives. The aim is to understand what people feel about the aesthetic and social characteristics of the city, their relationship with other residents and the perceived environmental quality of the neighbourhood where they live. We inserted three Likert scales with psychometric items in the questionnaire. The respondents were requested to indicate the extent of the agreement or disagreement with respect to some statements concerning the city and the neighbourhood where they live, and their opinion of neighbours.

In the second section we gather information on opinions and attitudes toward energy and renewables. The first question asked which sources in electricity production are considered the most suitable or desirable to be adopted in the national energy mix and which sources are currently used. The respondents were required to select three energy sources in both questions. Afterwards, we asked respondents to indicate which technologies they would install in their house if they had to choose among solar thermal, roof and wall insulation, double and triple glazing, PV panels and PV panels plus storage, and which had been al-ready installed in their houses. We then focus specifically on the PV technology. We first asked respondents to indicate which PV technology they would install in their houses. They had to rank three proposed options: to install a PV technology in the rooftop, or in windows and balconies or in the façade of the building. Subsequently we used a psychometric scale: people had to indicate the extent of their agreement or disagreement toward some statements about PV costs, PV aesthetical aspect, bureaucracy, technology etc. The third question dealt with the peer effect: we asked people to indicate how much their choices to invest in PV could be influenced by an analogous decision taken by relatives and friends and by neighbours. In addition, we asked people to indicate how much they could consider the Public Administration choice as an example that could drive their decisions: we have not found this element in the previous studies but it has been indicated as very important in our qualitative analysis.

The following questions are related to governmental subsidies to promote the diffusion of the PV technologies. The first question verifies if people are aware about the existence of public subsidies and the second question asks to rank in order of preference four types of subsidies: a tax allowance, more favourable credit conditions, a feed-in tariff system and a net metering system.

Afterwards, respondents were asked to indicate which source of information they would seek if they needed information on PV, providing a rank of the first three choices.

Finally, we proposed a choice exercise, where the respondents had to express their preferences on different PV applications. We presented four pictures to the respondents: the first picture showing a residential building in the city where the interview took place; the other three were modifications of the first picture, each with a different PV technology applied to the building. The respondents were requested to rank the alternative options; and in a follow up, we asked the respondents to repeat the exercise after providing some information on costs and benefits of the alternative options. Some examples of the pictures proposed are inserted in the Appendix.

After the choice experiment we enquired about the probability that in the near future the individual would install a PV system on the rooftop, on windows and balconies or in the façade of the house.

The final section of the questionnaire deals with demographic and socioeconomic characteristics, house and heating system characteristics, questions related to the diffusion of air conditioner systems in houses and workplaces, electricity management habits and the amount of electric and energy bills.

4. The econometric analysis

The econometric analysis has been based on univariate and bivariate probit models and rank ordered logit models.

The univariate probit models the choice between two discrete alternatives. Given a latent variable y* representing the behavioral intention to install a PV technology in the future, conditional on covariates x:

$$\boldsymbol{y}^{*} = \boldsymbol{\beta}'\boldsymbol{x} + \boldsymbol{\varepsilon}$$

We observe the answer Yes=1 or No=0:

$$y = \begin{cases} 1 \; if \; y^* > 0 \\ 0 \; if \; y^* \leq 0 \end{cases}$$

and model the probability through a Probit model.

$$P(y = 1|\mathrm{x}) = 1 - \Phi(\mathrm{x}, \beta)$$
$$P(y = 0|\mathrm{x}) = \Phi(\mathrm{x}, \beta)$$

The bivariate probit model is a joint model for two binary outcomes (Greene, 2003). These outcomes may be correlated, with correlation ρ. The unobserved latent variables are presented as:

$$y_1^* = \beta_1' x_1 + \varepsilon_1$$
$$y_2^* = \beta_2' x_2 + \varepsilon_2$$

The bivariate probit model specifies the outcomes as:

$$y_1 = \begin{cases} 1 \; if \; y_1^* > 0 \\ 0 \; if \; y_1^* \leq 0 \end{cases}$$

$$y_2 = \begin{cases} 1 \; if \; y_2^* > 0 \\ 0 \; if \; y_2^* \leq 0 \end{cases}$$

The related function is:

$$logL = \sum_{i=1}^{n} \log \Phi_2 \begin{cases} (2y_{i1} - 1)\beta_1' x_{i1} \\ (2y_{i2} - 1)\beta_2' x_{i2} \\ (2y_{i1} - 1)(2y_{i2} - 1)\rho \end{cases}$$

For the analysis of the ranked data we apply a rank ordered logit model (ROL). The ROL model can be seen as a series of Multinomial Logit (MNL) models (Fok et al., 2012): an MNL for the most preferred item; another MNL for the second-ranked item to be preferred over all items except the one with rank 1, and so forth:

$$\Pr[r_i; \; \beta] = \Pr\left[U_{ir_{i1}} > U_{ir_{i2}} > \cdots > U_{ir_{iJ}}\right] = \prod_{j=1}^{J-1} \frac{\exp\left(V_{ir_{ij}}\right)}{\sum_{l=j}^{J} \exp\left(V_{ir_{il}}\right)}$$

The information obtained through the Likert scales is used in the econometric analysis after being processed with a Principle Component Analysis (PCA). The Principal Component Analysis (PCA) is a statistical technique used to reduce data dimensions, while finding meaningful patterns in the data (see Johnson, 2010).

Let X be a vector of n data values with corresponding population variance–covariance matrix Σ. By the Spectral Decomposition theorem, Σ can be written as follows:

$$\sum \; = \sum_{i=1}^{n} \lambda_i e_i e_i'$$

where $\boldsymbol{\lambda_i}$ are the eigenvalues and $\boldsymbol{e_i}$ are the corresponding eigenvectors. The principal components are defined as the following linear combinations:

$$\begin{gathered}\boldsymbol{Y_1 = e_{11}x_1 + e_{12}x_2 + \cdots + e_{1n}x_n} \\ \boldsymbol{Y_2 = e_{21}x_1 + e_{22}x_2 + \cdots + e_{2n}x_n} \\ \cdots \\ \boldsymbol{Y_n = e_{n1}x_1 + e_{n2}x_2 + \cdots + e_{nn}x_n}\end{gathered}$$

If all the *n* components are taken, there will be no amount of variance unexplained, but also no data reduction; however, if the *X* variables are correlated, a good proportion of variance can be explained with only $k<n$ components, and data dimensionality can be reduced.

In order to find the principal components the eigenvectors are selected so that Var(Y_i) is maximized, subject to two constraints: the sum of squared eigenvectors must add to 1 and the covariance between the component Y_i and all the previously defined components must be equal to zero, so that the components are unrelated.

The selection of components is based on statistical criteria: eigenvalues greater than a certain threshold, additional variance explained by an extra component (the amount of variance explained is decreasing in the number of principal components).

5. Results

The respondents were requested to evaluate the probability of making an investment in a PV system in the near future. The Likert scale range from 1: sure not to invest, to 5: sure to invest. In the next analysis we characterize the profile of people who stated to be sure to make this investment. We construct a dummy variable that takes value 1 for those people who indicated they are certain to install a PV system in the near future, and 0 for all other options. The table below reports the econometric results.

Tab. 1- Probit model

Probit estimation – Dependent Variable: people who are sure to install a PV technology in the future YES= 144 NO= 445		
	Coefficients	**Standard Errors[§]**
Living in the city centre	0.382	0.246
Living in a detached building	0.595***	0.168
Using electric boilers	0.464***	0.175
Using electric saving bulbs	0.228	0.209
City attachment	0.393***	0.102
PV-Pros	0.393***	0.144
Peer effect	0.532***	0.116
Subsidies awareness	0.442***	0.057
Info: people who have already installed	-0.182	0.130
Info: NGOs	0.576***	0.129
Info: local institutions	-0.438	0.280
Constant	-2.807***	0.331
N° observations: 589		
Pseudo Log Likelihood: -238.016		
Pseudo R2= 0.273		

[§] Robust Standard Errors Clustered by country; Level of significance: *** at 1%; ** at 5%; * at 10%

People who have a positive attitude and attachment toward the city where they live are more interested to invest in PV systems. As expected, living in a detached house positively influence the stated probability of investment; and conversely, living in a condominium – the common condition in the cities involved in the project – will be a hinder: people living in an independent house have to face less stringent rules (and, as emerged in the in-depth interviews, they do not have to ask permissions to other tenants). The “adopters” are well informed of the existing subsidies to promote these technologies. They would be further pushed by seeing PV systems installed in friends/relatives/neighbours households, or in public buildings. They would prefer to gather information from NGOs: a possible interpretation is that these organizations are seen as not having a direct economic interest in selling or installing PV, like installers or engineers/architects, or other interests in the diffusion of PV such as local institutions. NGOs may be seen as providing a more “neutral” source of information. A more direct source of information would be seeing how the PV system works in other households or in public buildings; on the other hand these innovators would not base their decision on the information coming from people who have already installed the technology: as it will be discussed below, this is due to the fact that in this group of innovators there are people who would like to install new technologies, such as PV in façade or in windows and balconies, which could hardly be found when the survey took place. It is noticeable that both the specialised press and the Internet are not considered as a useful form of information by this group of respondents (the variables are not included as they were steadily not significant): this result contrasts with the findings in the in-depth interviews stage of the research, where many stakeholders indicated the Internet as the most important source of information for people interested in this technology. It may be argued that the Internet could provide a first stage, general information while people really interested in buying a PV system will seek further information from the aforementioned sources.

In the following model we analyse the common traits and the differences between stated preference for the traditional PV technology (PV installed in rooftops) and the innovative technologies installed in the windows/balconies and in the façade. The dependent variables are dummies constructed, as before, assigning the value 1 to those individuals who stated their intention to invest in the specific technology for sure, and 0 otherwise. The estimated model is a bivariate probit, which allows for correlation between the two choices.

Tab. 2 – Bivariate probit model

Bivariate probit estimation – Dependent Variable: people who are sure to install a PV technology in the rooftop in the future YES= 116 NO=473		
	Coefficients	**Standard Errors§**
Living in the city centre	0.439**	0.183
Living in a detached building	0.489***	0.147
Using electric boilers	0.334*	0.184
Using electric saving bulbs	0.130	0.258
City attachment	0.323***	0.056
PV positive	0.388**	0.172
Peer effect	0.471***	0.145
Subsidies awareness	0.360**	0.175
Info: people who have already installed	-0.145	0.186
Info: NGOs	0.518***	0.128
Info: local institutions	-0.309	0.260
Constant	-2.694***	0.448
Bivariate probit estimation – Dependent Variable: people who are sure to install a window/balcony or façade PV technology in the future YES= 73 NO= 516		
Living in the city centre	0.406**	0.183
Living in a detached building	0.307**	0.141
Using electric boilers	0.443**	0.180
Using electric saving bulbs	0.476***	0.078
City attachment	0.361***	0.135
PV positive	0.398***	0.092
Peer effect	0.481***	0.019
Subsidies awareness	0.300	0.305
Info: people who have already installed	-0.452***	0.109
Info: NGOs	0.444**	0.200
Info: local institutions	-0.532**	0.206
Constant	-3.232***	0.262
N° observations: 589 Log Likelihood: -377.513 Rho= 0.389**		

§ Robust Standard Errors Clustered by country; Level of significance: *** at 1%; ** at 5%; * at 10%

Both choices are related to a positive attitude toward the city and PV technology; examples by peers and institutions can influence both choices; the use of electric boilers in the household seems also a push to invest in both PV technologies. The main differences are in the source of information, since individuals who select the more innovative technologies are less likely to seek information from people who have already installed, and from local installers. It is confirmed the important role of NGOs in providing reliable information to this category of "innovators".

Next we analyse the responses obtained from the ranking exercise on the BIPV.
In the first set we present 4 pictures of a large building and 4 pictures of a small building; both buildings are representative of the actual built environment in each town were the survey has been administered. The first picture is: 1) the "status quo" option; the next three are renderings with a modification in the façade due to the installation of 2) monocrystalline PV panels plus some coloured polycrystalline glasses in the balconies; 3) coloured polycrystalline glasses in the façade and in the balconies or windows; 4) in this last case, we proposed different solutions depending on the building: in some cases, coloured polycrystalline glass in the balconies and a solar shading PV technology in the windows, in other cases a coloured amorphous glass in the façade. We refer to these options as 2): "monocrystalline", 3): "polycrystalline" and 4): "special case". In this first exercise set we provided information on the type of technology shown, but no other information was added on the production or costs of each installation. The respondents were asked to rank the status quo and the alternative options just based on their aesthetic preferences.
The aim of this exercise is to analyse how the respondents evaluate the application of PV modules in the façade of a building: it is important to stress (and this was done after the exercises) that these pictures do not represent real cases or real architectural projects and are not be taken as a real nor a desirable example of BIPV.
The second exercise proposed the same large and small building pictures but we included some information about the percentage of an average household electric consumption covered by the PV installation proposed and the cost of purchasing the technology (without installing cost). The numbers provided were roughly indicative of the different cost/efficiency ratio of the different technologies, but could not be taken as an example of real costs and production level (and again this was recalled after the exercise). The aim of the exercise is to understand if information on the economic aspects pertaining to the proposed technologies could have an effect on their social acceptability.
The econometric results of the ranked ordered logit models are reported in the Tables below. It should be noted that the cases are less than 600 in the estimations because some individuals did not complete the exercises (11 and 12 respondents for, respectively, the exercises with the Large and the Small buildings).

As regards the large building, the results show that:

- Italian, Tunisian and Jordanian respondents prefer all PV solutions to the status quo. In particular, Italians like best the special case (a solar shading technology), while this is the least preferred application in all other countries. Egyptian and Lebanese respondents prefer the status quo; while for Spanish respondents the status quo is not significantly different from the monocrystalline and the polycrystalline, but they are all preferred to the special case.
- After economic information has been provided, the rank of preferences changes: in the Italian sample, now the monocrystalline is the best, followed by polycrystalline, special case, and the status quo the least preferred. Also for Jordanian and Lebanese respondents there is a switch in the position of the mono and polycrystalline applications; the latter is now the preferred option for Jordanians, while for Lebanese the status quo remains the best. In Egypt individuals are now undecided between the status quo and all other options; conversely, in Spain the order is now more clear, with the monocrystalline and the polycrystalline preferred to the special case, and the status quo ranked worst.

Tab. 3 – Rank Ordered Logit Model (large building – country comparison)

Rank Ordered Logit – Dependent Variable: picture ranking
Large building
BASE: each country*status quo

		no economic information		with economic information	
		Coefficients	Standard Errors	Coefficients	Standard Errors
Monocrystalline	Italy	2.013***	0.254	3.744***	0.35
	Tunisia	2.132***	0.238	3.282***	0.3
	Jordan	1.54***	0.217	3.501***	0.302
	Egypt	-0.939***	0.201	0.149	0.187
	Lebanon	-0.49***	0.179	-0.403**	0.187
	Spain	-0.194	0.183	1.332***	0.202
Coloured polycrystalline	Italy	1.805***	0.247	2.861***	0.331
	Tunisia	2.01***	0.234	2.890***	0.287
	Jordan	1.649***	0.221	2.408***	0.277
	Egypt	-1.138***	0.207	-0.149	0.195
	Lebanon	-0.479***	0.182	-0.568***	0.186
	Spain	-0.12	0.178	1.25***	0.201
Special case	Italy	2.121***	0.253	2.357***	0.32
	Tunisia	0.905***	0.215	1.567***	0.254
	Jordan	1.196***	0.22	1.625***	0.253
	Egypt	-1.473***	0.225	-0.283	0.21
	Lebanon	-1.682***	0.213	-3.346***	0.361
	Spain	-1.119***	0.197	0.644***	0.197
Number of observations		2356		2356	
Number of cases		589		589	
Log Likelihood		-1606.081		-1387.288	
Pseudo R2		0.140		0.257	

Level of significance: *** at 1%; ** at 5%; * at 10%

For what concerns the small building exercises, we found that:

- Also in the small building exercise Italian, Tunisian and Jordanian respondents prefer the options with an installation, while the respondents from other countries prefer the status quo. The special case is again the less appreciated technology in all countries but Italy, where it ranks second.
- When information on electricity production and investment costs is added, the preferences change. Tunisian and Jordanian respondents now prefer the monocrystalline to the polycrystalline; the monocrystalline and special case switch positions for Italians. More importantly, in the other countries there is not any more a clear preference for the status quo option: Lebanese respondents now rank the same the status quo and the monocrystalline, while the other technologies are still less preferred. The preferences stated by Spanish and Egyptian respondents change a lot: Spanish respondents now prefer the monocrystalline PV application, followed by the polycrystalline which is preferred to both the status quo and the special case; while for Egyptian respondents, all options now are ranked the same.

- **Tab. 4 – Rank Ordered Logit Model (small building – country comparison)**

Rank ordered logit – Dependent Variable: picture ranking Small building BASE: each country*status quo					
		no economic information		**with economic information**	
		Coefficients	**Standard Errors**	**Coefficients**	**Standard Errors**
Monocrystalline	**Italy**	0.693***	0.207	1.998***	0.242
	Tunisia	2.31***	0.261	3.67***	0.327
	Jordan	1.401***	0.212	3.59***	0.3
	Egypt	-0.48**	0.193	0.181	0.187
	Lebanon	-0.457**	0.179	-0.093	0.187
	Spain	-0.249	0.179	1.684***	0.214
Coloured polycrystalline	**Italy**	1.789***	0.216	2.196***	0.238
	Tunisia	2.312***	0.262	3.311***	0.316
	Jordan	1.709***	0.217	2.435***	0.264
	Egypt	-0.953***	0.207	0.000	0.199
	Lebanon	-1.043***	0.19	-1.109***	0.201
	Spain	-0.073	0.187	1.677***	0.216
Special case	**Italy**	1.356***	0.209	1.228***	0.219
	Tunisia	1.708***	0.251	1.559***	0.26
	Jordan	1.124***	0.212	1.215***	0.229
	Egypt	-1.297***	0.218	-0.098	0.205
	Lebanon	-1.735***	0.212	-3.473***	0.355
	Spain	-1.344***	0.21	-0.038	0.198
Number of observations		2356		2356	
Number of cases		589		589	
Log Likelihood		-1606.081		-1387.288	
Pseudo R2		0.140		0.268	

Level of significance: *** at 1%; ** at 5%; * at 10%

Finally, we analyze the experimental data applying a specification with individual characteristics covariates.

Results from large building experiments indicate that:

- Individuals well informed of the governmental subsidies for investments in energy efficiency prefer all PV solutions to the status quo, while individuals who see the positive elements of the PV technology propend for the polycrystalline and special case technologies. This result is hardly a surprise, since these individuals are evidently especially interested in technical innovations, and particularly in PV, that enhance the energy performance of the buildings. Somehow more unexpected is the strong positive effect of the variable related to the positive feelings that individuals have toward their environs: it seems that this class of people is particularly attracted by renovation in the façade of the buildings that involves application of PV modules. The ranking of the three applications varies with covariates: for example, PV-pros is associated with a preference for the "special case" application, while environ is associated with a preference for the monocrystalline application. It is interesting to see how people who would seek information on PV systems on the Internet or from people who have already installed clearly propend for the status quo option.

- After that economic information has been provided, the number of respondents who prefer the PV applications to the status quo increases. The variable pertaining to people who would seek information from installers now becomes significant (these individuals are now more interested in the PV applications), while loses significance the variable relative to information from people who have already installed (these individuals are now less negative towards the innovative PV applications). The rank of preferences changes for PV-Pros people: they now rank the monocrystalline (which is generally the most cost-efficient technology) as their favourite application, and the special case is now the least preferred of the technical solutions.

- **Tab. 5 – Rank Ordered Logit Model (large building – socioeconomic covariates)**

Rank ordered logit – Dependent Variable: picture ranking
Large building
BASE: each country*status quo

		no economic information		with economic information	
		Coefficients	Standard Errors	Coefficients	Standard Errors§
Monocrystalline	Environs	0.971***	0.233	1.568***	0.455
	PV pros	0.434	0.290	1.166*	0.604
	Peer effect	0.289	0.236	0.16	0.310
	Subsidies	0.919***	0.295	0.982***	0.203
	Info: people who have already installed	-0.245	0.163	0.334	0.251
	Info: installers	0.144	0.174	0.437	0.384
	Info: the Internet	-0.339	0.211	-0.377***	0.112
Coloured polycrystalline	Environs	0.953***	0.251	1.289***	0.342
	PV pros	0.608***	0.200	0.822**	0.370
	Peer effect	0.316*	0.163	0.277	0.174
	Subsidies	0.947***	0.216	1.011***	0.220
	Info: people who have already installed	-0.394**	0.174	0.140	0.204
	Info: installers	0.256	0.189	0.51**	0.256
	Info: the Internet	-0.555**	0.290	-0.727***	0.240
Special case	Environs	0.948***	0.345	1.167**	0.568
	PV pros	0.677**	0.399	0.699*	0.421
	Peer effect	-0.033	0.147	0.073	0.158
	Subsidies	0.837**	0.351	0.824***	0.240
	Info: people	-0.758***	0.229	-0.200	0.324

who have already installed				
Info: installers	0.075	0.205	0.399*	0.224
Info: the Internet	-0.446	0.377	-1.15**	0.575
Number of observations	2356		2356	
Number of cases	589		589	
Log Likelihood	-1726.456		-1560.641	
Pseudo R2	0.075		0.162	

§ Robust Standard Errors Clustered by country; Level of significance: *** at 1%; ** at 5%; * at 10%

As regards the small building exercises, we found that:

- Also in the small building exercise the covariates PV-Pros, environs, subsides and examples are associated with a preference for the PV applications; the "special case" application seems attractive (especially for PV-Pros people, and individuals informed of subsidies, while the residents satisfied with their environs prefer polycrystalline). The variables relative to information on the internet and information from people who have already installed are associated with preference for the status quo.
- When economic information is provided, again the interest toward the PV applications increases, and the preferences shift toward the more productive technologies, i.e. monocrystalline and polycrystalline, while the less productive solution, i.e. the "special case", is generally ranked last among the technological options.

Tab. 6 – Rank Ordered Logit Model (small building – socioeconomic covariates)

Rank ordered logit – Dependent Variable: picture ranking Small building BASE: each country*status quo					
		no economic information		with economic information	
		Coefficients	Standard Errors	Coefficients	Standard Errors[§]
Monocrystalline	Environs	0.515*	0.284	1.211***	0.467
	PV pros	0.396	0.320	0.962**	0.470
	Peer effect	0.477**	0.198	0.738***	0.129
	Subsidies	0.212	0.313	0.431*	0.247
	Info: people who have already installed	-0.342	0.247	0.075	0.324
	Info: installers	0.362	0.242	0.652**	0.304
	Info: the Internet	-0.207	0.225	-0.406*	0.231
Coloured polycrystalline	Environs	0.929**	0.377	1.259***	0.432
	PV pros	0.576**	0.274	0.767*	0.406
	Peer effect	0.359**	0.180	0.517***	0.137
	Subsidies	0.417**	0.168	0.575**	0.225
	Info: people who have already installed	-0.521*	0.291	-0.028	0.270
	Info: installers	0.695***	0.211	0.581	0.372
	Info: the Internet	-0.598**	0.248	-0.674**	0.334
Special case	Environs	0.867**	0.380	1.011**	0.452
	PV pros	0.628*	0.340	0.709**	0.355
	Peer effect	0.099	0.193	0.234**	0.118
	Subsidies	0.601***	0.193	0.544***	0.094
	Info: people who have already installed	-0.768***	0.281	-0.512**	0.292
	Info: installers	0.228	0.151	0.143	0.245
	Info: the Internet	-0.515	0.348	-0.839	0.583
Number of observations		2352		2352	
Number of cases		588		588	
Log Likelihood		-1736.221		-1556.999	
Pseudo R2		0.062		0.159	

[§] Robust Standard Errors Clustered by country; Level of significance: *** at 1%; ** at 5%; * at 10%

6. Conclusions

As mentioned before, the results of our research cannot be used to make inference on the population of the cities where the survey was administered: the samples are not representative of the populations. However, we gain some interesting insights on the characteristics of the individuals who may generate a potential demand for innovative PV technologies, and on drivers or hinders to the adoption of PV systems in the residential sector.

Our results show the importance of attitudes in influencing the social acceptance in PV and BIPV: for example, how citizens relate with their city and their neighbourhoods, the role of awareness and information, the importance of demonstrative projects that can raise such awareness, especially regarding the economic and productive aspects of the technology.

We find that potential "adopters" (i.e. those individuals who said that they are certain to install a PV system in their house in the near future) are well informed of the existing subsidies to promote these technologies, and would be further pushed toward the investment if they could see PV systems at work in friends/relatives/neighbors households, or in public buildings.

As expected, space constraints may be a hinder to the decision to install a PV system: innovative PV modules that do not require permissions (by authorities or by other tenants in the condominium), such as windows glazing, would enhance the probability of adoption.

Another relevant issue is how the information is conveyed. Although in the in-depth interviews the Internet was often identified as a good source of information that would help the diffusion of PV technologies, our results show that it is important that other sources are available for those who are seriously interested in the investment; and that this information should be perceived as "neutral", i.e. not coming from professionals or organizations that hold a private interest in the investment. Finally, it is interesting to note that the potential "adopters" are characterized by a positive attitude and attachment toward the city where they live.

Similar results are found when we examine the social acceptability of different PV applications on residential buildings in the urban context. The respondents had to rank in order of preference 4 technological options (including the status quo) for BIPV applications in two different buildings of their city (a large and a small building). In the first exercise the respondents did not have any information on the cost effectiveness of each application; in the second exercise this information was provided and the interviewees were required to rank again the technological options.

Individuals characterized by positive feelings toward the environmental qualities of their neighborhood are especially keen on the BIPV applications, which are strongly preferred to the status quo solution (with no PV modules installed). This is an interesting result, since it is often claimed (and this was also the case in some of our in-depth interviews) that a higher identification and attachment to a place generates higher opposition toward changes in the landscape produced by the installation of renewable energy technologies.

Specific information, awareness of the pros of the PV technology, and of governmental subsidies are also positively associated to this kind of preference; this is clearly confirmed in the experiments, since when technical and economic information on the cost effectiveness of each option is provided, the preferences for the most beneficial technologies increase significantly.

Finally a comparative analysis across partner countries reveals that Italian, Tunisian and Jordanian respondents seem the most interested in PV technologies, either when considering a possible investment for their household, and when evaluating PV applications in the buildings presented in the experimental scenarios. The Spanish respondents are those who especially see the problems and risks associated with a PV investment (here the recent problems related to the termination of the feed in tariff system, and the retroactivity of some effects may have played a role); and would be more interested in other types of energy efficiency investments. Also in the experimental scenarios they propend for the status quo, and switch preference only in front of clear economic advantages. Lebanese and Egyptian respondents are in between the two positions: it seems that much more work should be required to raise awareness of the benefits of PV applications in the residential sector especially in the latter three countries.

References

Antonelli M., Desideri U. (2014). *The doping effect of Italian feed-in tariffs on the PV market*. Energy Policy 67, 583-594

Bolligher B., Gillingham K. (2012). *Peer Effects in the Diffusion of Solar Photovoltaic Panels*. Marketing Science 31(6), 900-912

Bonaiuto M., Fornara F., Bonnes M. (2003). *Indexes of perceived residential environmental quality and neighbourhood attachment in urban environments: a confirmation study on the city of Rome*. Landscape and Urban Planning 65(1-2), 41-52

Campoccia A., Dusonchet L., Telaretti E., Zizzo G. (2014). *An analysis of feed-in tariffs for solar PV in six representative countries of the European Union*. Solar Energy, 107, 530-542

Claudy M.C., Michelsen C., O' Driscoll A., Mullen M.R. (2010). *Consumer awareness in the adoption of microgeneration technologies: an empirical investigation in the Republic of Ireland*. Renewable and Sustainable Energy Reviews, 14(7), 2154-2160

Claudy M.C., Michelsen C., O' Driscoll A. (2011). *The diffusion of microgeneration technologies – assessing the influence of perceived product characteristics on home owners' willingness to pay*. Energy Policy, 39(3), 1459-1469

Cronemberger J., Corpas M.A., Ceron I., Caamano-Martin e., Vega Sanches S. (2014). *BIPV technology application: highlighting advances, tendencies and solutions through Solar Decathlon Europe houses*. Energy and Building, 83, 44-56

Del Rio P., Mir-Artigues P. (2012). *Support for solar PV deployment in Spain: some policy lessons*. Renewable and Sustainable Energy Reviews, 16(8), 5557-5566

EEA (2014). Share of renewable energy in final energy consumption. Available at: http://www.eea.europa.eu/data-and-maps/indicators/renewable-gross-final-energy-consumption-3#tab-latest-figures-and-vizualizations

Fawcett W., Ellingham I., Platt S. (2008). *Reconciling the architectural preferences of architects and the public: the ordered preference model*. Environment & Behavior 40(5), pp. 599-618

Fok D., Paap R., Van Dijk B. (2012). *A rank-ordered logit model with unobserved heterogeneity in ranking capabilities*. Journal of Applied Econometrics, 27, 831-846.

FOSTEr in MED (2014). FOSTEr in MED Informative Materials. Available at: http://www.fosterinmed.eu/index.php/news-and-events/informative-material

Griffiths s. (2013). *Strategic considerations for deployment of solar photovoltaics in the Middle East and North Africa*. Energy Strategy Reviews 2, 125-131

Faiers A., Neame C. (2006). *Consumer attitudes towards domestic solar power systems*. Energy Policy, 34(14), 1797-1806

Fattouh B., El-Katiri L. (2013). *Energy subsidies in the Middle East and North Africa*. Energy Strategy Reviews 2(x), 108-115

Greene W. H. (2003). Econometric Analysis. Prentice Hall.

Hawila D., et al. (2014). *Renewable energy readiness assessment for North African countries*. Renewable and Sustainable Energy Reviews, 33, 128-140

Kinab E., Elkoury M. (2012). *Renewable energy use in Lebanon: Barriers and solutions*. Renewable and Sustainable Energy Reviews, 16, 4422-4431

Jager W. (2006). *Stimulating the diffusion of photovoltaic system: a behavioural perspective*. Energy Policy, 34, 1935-1943

Johnson G. (2010). Lectures Notes. Pennsylvania State University. Available at: https://onlinecourses.science.psu.edu/stat505/

Scarpa R., Willis K. (2010). *Willingness-to-pay for renewable energy: Primary and discretionary choice of British households' for micro-generation technologies*. Energy Economics, 32(1), 129-136

Tsikalakis et al, (2011). *Review of best practices of solar electricity resources applications in selected Middle East and North Africa (MENA) countrie*s. Renewable and Sustainable Energy Reviews, 15, 2838-2849

White E.V., Gatersleben B. (2011). *Greenery on residential buildings: Does it affect preferences and perceptions of beauty?*. Journal of Environmental Psychology 31, pp. 89-98

Zyadin A., Puhakka A., Ahponen P., Cronberg T., Pelkonen P. (2012). *School students' knowledge, perceptions, and attitudes toward renewable energy in Jordan*. Renewable Energy 45, pp. 78-85

Zyadin A., Puhakka A., Ahponen P., Pelkonen P. (2014). *Secondary school teachers' knowledge, perceptions, and attitudes toward renewable energy in Jordan*. Renewable Energy 62, pp. 341-348

Acknowledgement

This research has been made under the FOSTEr in MED project with the financial assistance of the European Union under the ENPI CBC *Mediterranean Sea Basin Programme*.

Appendix 2. Choice experiment: pictures and economic information

<table>
<tr><td colspan="2">Large Building (Italy, City of Cagliari)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>(A) Status quo</td><td>(B) Monocrystalline panels + coloured polycrystalline glasses in balconies</td></tr>
<tr><td></td><td></td></tr>
<tr><td>(C) Coloured polycrystalline glasses in the façade and in balconies</td><td>(D) Coloured polycrystalline glasses in balconies and a solar shading PV technology</td></tr>
</table>

Small Building (Tunisia, City of Tunis)	
	
(A) Status quo	(B) Monocrystalline panels + coloured polycrystalline glasses in balconies
	
(C) Coloured polycrystalline glasses in the façade and in balconies	(D) Coloured amorphous PV technology in façade

Large Building (Lebanon, City of Haddath)	
	
(A) Status quo	(B) Monocrystalline panels + coloured polycrystalline glasses in balconies
	
(C) Coloured polycrystalline glasses in the façade and in balconies	(D) Coloured polycrystalline glasses in balconies and a solar shading PV technology

Small Building (Jordan, City of Aqaba)

(A) Status quo

(B) Monocrystalline panels + coloured polycrystalline glasses in balconies

(C) Coloured polycrystalline glasses in the façade and in balconies

(D) Coloured amorphous PV technology in façade

Large Building (Egypt, City of Alexandria)	
	
(A) Status quo	(B) Monocristallyne panels + coloured polycrystalline glasses in balconies
	
(C) Coloured polycrystalline glasses in the façade and in balconies	(D) Coloured polycrystalline glasses in balconies and a solar shading PV technology

Large Building (Spain, City of Barcelona)	
	
(A) Status quo	(B) Monocristallyne panels + coloured polycrystalline glasses in balconies
	
(C) Coloured polycrystalline glasses in the façade and in balconies	(D) Coloured polycrystalline glasses in balconies and a solar shading PV technology