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EARLY VIEW

Barriers to the adoption of energy efficiency measures in Mostaganem, Algeria

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Abstract

The residential sector of Algeria consumes 29 % of the total energy consumption. In order to reduce and address this consumption along with the challenges of climate change, the Algerian public policy considers energy Energy Efficiency Investment Measures (EEIMs) in the residential sector as a key factor. However, despite the recommendations and incitement measures from the government, the adoption of EEIMs of Algerian homeowners is too low. In 2018, EEIMs have been implemented in 4000 houses. This number represents only 4% of the government's target which is the implementation of EEIMs in 100.000 houses per year. The present paper, accordingly, attempts to explore the barriers to the adoption of energy efficiency investment measures. To this effect, a questionnaire survey with 150 randomly selected Algerian single-family homeowners in Mostaganem area was used for the study. It was found that the five greatest barriers to the adoption of EEIMs were: (1) the lack of subsidies and rebates on energy efficient equipment, (2) the high initial prices of energy efficient equipment, (3) the lack of techniques

and tools for the estimation of saved energy, (4) the unwillingness to borrow money, (5) the difficulty of identifying, procuring, installing, operating, and maintaining energy efficiency measures. The Principal Component Analysis (PCA) categorised 16 barriers around four components: (1) "Financial" barriers, (2) "Technological" barriers, (3) "Lack of time and knowledge" barriers, (4) "Attitude towards energy efficiency improvements" barriers.

Finally, the Multivariate Analysis of Variance (MANOVA) analysis has shown that the perception of barriers to the adoption of EEIMs also differs in accordance with certain personal characteristics of the homeowner.

Keywords: barriers, energy efficiency investment measures; homeowners, questionnaire survey, Algeria

INTRODUCTION

The residential sector of Algeria consumes a lot of energy and is responsible for a high level of CO2 emissions (Denker, 2014). An effective way to reduce household energy consumption is the implementation of Energy Efficiency Investment Measures (EEIMs) which use less energy while offering the same level of service (Prete et al., 2017). In 2016, the Algerian government has launched a program to foster the adoption of energy efficiency investment measures. This program aims at insulating 100.000 houses per year and installing 100 000 solar water heater per year (APRUE, 2016). Nevertheless, with the low prices of energy due to various subsidies, Algerian households were not conscious of their energy consumption, and the government could not meet this objective yet. Currently, due to the economic crisis, the Algerian

government is no longer able to maintain its financial support to the energy sector. Consequently, the price of energy has increased by 20 percent and Algerian households are now more conscious of their energy consumption (Seddiki, 2016). By adopting EEIMs, Algerian households can significantly reduce their energy consumption. Several municipalities in Algeria provide various incentives in the form of zero-interest loans, tax exemption or tax reduction to stimulate the implementation of EEIMs. The climate in different parts of Algeria varies greatly due to its vast geographical expanse. Therefore, for more consistency, this paper focuses on Mostaganem area, which is located in Northern Algeria (see Figure 1). Mostaganem area has been granted funds by the Algerian government and is considered as a pilot area for the adoption of EEIMs (Denker, 2014).

However, despite the high prices of energy and a favourable policy context, the adoption of EEIMs of Algerian homeowners is too low. Indeed, for 2018, the national agency for the promotion and the rationalization of the energy use (APRUE) has announced that EEIMs have been implemented in 4000 houses. This number represents only 4% of the government target which is the implementation of EEIMs in 100.000 houses per year (Mokhtar, 2018). This indicates that the main drivers and barriers to the adoption of EEIMs are not well understood and not correctly handled by current policymakers. To the best knowledge of the authors, no empirical studies on homeowners' adoption of EEIMs have been conducted in Algeria. To help close this gap, the objectives of the study outlined in this paper are: (1) to identify and rank the critical barriers that hinder the adoption of EEIMs of Algerian single-family

homeowners, (2) to investigate the underlying relationships between these barriers, (3) to investigate the differences in the perception of the barriers to the adoption of EEIMs of the different groups segmented according to personal and contextual variables. For the conduction of this research study, we rely on data from a questionnaire survey with 150 randomly selected Algerian single-family house owners in Mostaganem area to analyse the barriers to the adoption of EEIMs.

INSERT FIGURE 1 AROUND HERE

LITERATURE REVIEW

This section will review studies of drivers, barriers, and factors influencing the adoption of Energy Efficiency Investment Measures (EEIMs) of homeowners within the broader context. Several researchers have investigated the adoption of EEIMs of homeowners focusing on different streams of research (Prete et al., 2017). A stream of research has analysed factors that influence the adoption of energy efficiency investment measures of homeowners. According to Nair et al. (2010), these factors can be categorized within two groups; contextual factors (e.g. homeownership, the age of the house, etc.) and personal factors (e.g. education, age, income, etc.). An early study by Cameron (1985) using individual household data from the U.S indicated that the adoption of EEIMs is strongly influenced by retrofit costs, relative energy prices, and income. The researcher focused on discrete energy conservation retrofits such as insulation and storm windows. Achtnicht and Madlener (2014) studied the key drivers and barriers to the adoption of energy retrofit actions

in Germany. A survey of more than 400 owner- occupiers of single-family detached, semi-detached, and row houses that were conducted as a computer-assisted personal interview (CAPI). The respondents also faced a choice experiment involving different energy retrofit measures. The results indicate that the income, energy cost savings, payback period, and favourable opportunities (e.g. heating system that needs replacement) strongly influence the adoption of energy retrofit actions in Germany. Prete et al. (2017) examined the determinants of Southern Italian households' intention to adopt energy efficiency measures in residential buildings. Open-ended questionnaires were administered to 128 Apulian households. The particularity of the research carried out by Prete et al. (2017) is to demonstrate that attitude is the main determinant of households' intention and willingness to adopt energy efficiency measures.

Another stream of research has examined households' willingness to pay (WTP) for EEIMs of different types of technologies. Scarpa and Willis (2010) applied a choice experiment approach to investigate households' WTP for renewable energy technologies in the UK. The results indicate that households considered the capital cost of renewable energy technologies as too high. Štreimikienė and Baležentis (2015) studied the main drivers of WTP for renewable electricity of Lithuanian households. The researchers used the focus group approach with 100 participants. The results indicate that the lack of information and environmental awareness play a crucial role in the WTP for renewables in Lithuanian households. Tampakis et al. (2017) studied citizens' views on electricity savings and production from renewable energy sources

(RES) on a Greek island. A survey was conducted using a structured questionnaire and face-to-face interviews with 385 respondents. The results show that insufficient information regarding RES systems that can be used in households are considered by the citizens as being a major barrier.

Another stream of research has focused only on the barriers that influence the adoption of EEIMs of homeowners. Different types of barriers have been identified in the literature such as low energy prices, priority to comfort and other non-energy aspects, lack of attractive products and services (Risholt and Berker, 2013), incentives and regulations (Palm and Tengvard, 2011), the helpless (Reddy, 1991), technical parameters and general housing activities (Jakob, 2007), limited knowledge about new technologies (Häkkinen and Belloni, 2011), lack of expertise of the executive board (Nair et al., 2011), high initial prices of energy efficient equipment (Dianshu et al., 2010), lack of personal involvement (Stieß and Dunkelberg, 2013). Jakob (2007) investigated drivers and barriers to energy efficiency in renovation decisions of single-family homeowners using survey data. The findings indicate that energy-efficient renovations are affected by technical parameters (e.g. lifetime of a roof), and general housing activities (e.g. building extensions). Ravetz (2008) affirms that energy efficiency refurbishments are not considered as a high priority for UK homeowners when updating their homes. The findings indicate that the perceived hassle of installation, upfront costs, uncertainties over lower fuel bills, and a lack of knowledge over payback periods are considered as major barriers. Mortensen et al. (2011) presented a literature review of the barriers for energy renovations in private households found in

Denmark. The findings indicate that the lack of knowledge and interest in the topic, the uncertainty about both investment size and savings, lack of examples and unbiased information represent the main barriers.

Häkkinen and Belloni (2011) studied barriers and drivers for sustainable building in Finland using literature review, inquiries, and interviews. The results show that the main barriers for households' to adopt EEIMs is the limited knowledge about new technologies and their prices. Nair et al. (2011) investigated the barriers to the implementation of EEIMs in Swedish co-operative apartment buildings. The researchers sent a questionnaire to chairmen of 3000 co-operative housing association across Sweden. The findings indicate that the lack of expertise of the executive board was considered as a strong barrier to energy efficiency investments. Dianshu et al. (2010) investigated the barriers to energy efficiency in the residential sector within one province in China. A survey questionnaire of more than 600 households was conducted. The high initial prices of energy efficient equipment, the low prices of energy in China, the lack of subsidies and rebates on energy efficient equipment represent the main barriers to energy efficiency. Stieß and Dunkelberg (2013) investigated the objectives and barriers of German homeowners to energy-efficient refurbishment. The practicality of this study compare to the previous ones is to consider two groups an energy group who informed themselves comprehensively and a standard group. The main barriers for both groups were the lack of personal involvement, satisfaction with the existing thermal performance, the lack of financial resources, and unwillingness to borrow money.

The research presented in this paper is related to this specific stream of research where only the barriers that influence the adoption of EEIMs of homeowners are considered by the authors. To the best knowledge of the authors, no empirical studies on homeowners' adoption of EEIMs have been conducted in Algeria. This study tries to fill this gap, the main objective of our empirical study are: (1) to identify and rank the critical barriers that hinder the adoption of EEIMs of Algerian single-family homeowners, (2) to investigate the underlying relationships between these barriers, (3) to investigate the differences in the perception of the barriers to the adoption of EEIMs of the different groups segmented according to personal and contextual variables.

METHODOLOGY

Questionnaire development and implementation

In order to collect data on the barriers hindering the adoption of Energy Efficiency Investment Measures (EEIM) of Algerian single-family homeowners in Mostaganem area, an empirical survey was carried out on a random sample of 180 owners of single-family houses in Mostaganem (Algeria). As a result of inappropriate completion and non-recovery of about thirty questionnaires, a total of 150 owners of single-family houses were used for the study. The sample size in this survey was considered as appropriate since each dependent variable (16 dependent variables have been considered in the survey) had practically 10 participants as indicated in Hair et al. (2010). Furthermore, the sample size was considered acceptable compared with the sample size of 128 respondents for the survey on factors influencing Southern Italian

households' intention to adopt energy efficiency measures conducted by Prete et al. (2017). Respondents who had the responsibility to decide the adoption of EEMs were considered as the target population of the study. The survey was carried out using a self-administered questionnaire in the winter of 2018.

The questionnaire (in French) was divided into two parts (please see Appendix [online supplemental data] for the English translation of the full survey). The first part included the overarching aims of the research study and covered questions to identify contextual factors (e.g. homeownership, the age of the house, etc.) and personal factors (e.g. education, age, income, etc.). The second part detailed 16 possible barriers for the adoption of EEIMs of Algerian single-family homeowners in Mostaganem area. The barriers in our questionnaire were all identified after a comprehensive review of the literature (Häkkinen and Belloni, 2011) (Ravetz, 2008) (Nair et al., 2011) (Mortensen et al., 2011) (Risholt and Berker, 2013) (Friedman et al., 2018). The respondents were asked to evaluate every single barrier using a five-point Likert scale, where 1 meant that the barrier was not important while 5 meant that the barrier was very important. In order to identify potential practical problems as well as problems with the survey design, a pilot study with 20 questionnaires preceded the main survey. The results of the pilot survey helped to improve the questionnaire.

Analytical procedure

The analysis of the collected data were conducted as follows: Reliability analysis, Ranking analysis, Principal Component Analysis (PCA), Multivariate Analysis of Variance (MANOVA)

Reliability analysis

The Cronbach's alpha coefficient was calculated to examine the internal consistency among the barriers in order to test the reliability of the five-point scale (Kim et al., 2016) (Chileshe et al., 2016).

Ranking analysis

In order to identify and rank the critical barriers to the adoption of EEIMs of Algerian single-family homeowners, the ranking analysis as indicated in Chileshe et al. (2015) was implemented. The relative importance of the critical barriers was defined through the examination of descriptive statistics (mean score values, standard deviation). The relative importance of each barrier is represented by the mean score while the degree of compromise between participants is characterised by the standard deviation (Kim et al., 2016). The selection of the variable with the lowest standard deviation was performed for the rank differentiation where two or more barriers had the same mean values (Doloi et al., 2012).

Principal Component Analysis (PCA)

The principal component analysis was conducted mainly to examine the multivariate interrelationships within the barriers and derive a reduced set of

hindrance factors that can be readily used in practice as indicated in Michelsen and Madlener (2013).

Multivariate Analysis of Variance (MANOVA)

The personal and contextual variables were used for separating the participants into groups. In order to investigate the differences in the perception of the barriers to the adoption of EEIMs of the different groups segmented according to personal and contextual variables, MANOVA was conducted as indicated in Chileshe et al. (2016). When an overall difference was found between any groups of homeowners as a result of MANOVA, univariate ANOVA tests were applied to find the source of differences as indicated in Yuksel et al.(2000).

ANALYSIS AND FINDINGS

This section presents the outcomes of the analysis of the collected data and discusses the results, including characteristics of the sample, the reliability analysis, the ranking of hindrance factors, the principal component analysis of hindrance factors, and the multivariate analysis of variance.

Characteristics of the sample:

A summary of personal and contextual characteristics of the respondents are presented in Table 1. The respondents were mainly men (62.7 %). 89 % of the respondents ranged from 30 to more than 60 years. 90 % of the respondents possessed a Bachelor's degree or higher. The majority of the respondents' (60 %) have a household's monthly net income more than 300 us dollar (which

represents the average salary in Algeria). Most of the sampled houses (69.3 %) were constructed between 1991-2018. The area of the sampled houses ranged from less than 100 m2 to More than 250 m2.

INSERT TABLE 1 AROUND HERE

Reliability analysis:

In order to test the reliability of the five-point scale, the Cronbach's alpha coefficient was calculated to examine the internal consistency among the barriers as indicated in Kim et al. (2016)and Chileshe et al. (2016). The five-point scale has been found reliable as the 16 barriers presented a Cronbach's alpha of 0.821, which was greater than the acceptable lower limit for the Cronbach's alpha (0.7).

Ranking analysis:

This analysis ranked the hindrance factors based on the value of their means and standard deviations. Table 2 presents the statistical means, standard deviations, and ranks of these factors.

INSERT TABLE 2 AROUND HERE

The respondents ranked the lack of subsidies and rebates on energy efficient equipment as the primary hindrance to the adoption of energy efficiency investment measures. Similarly, Dianshu et al. (2010) have indicated that the lack of subsidies and rebates on energy efficient equipment represents a major barrier for the implementation of energy efficiency measure in China. Although there is an Algerian public policy that provides financial incentives in

the form of tax credits, loans, and rebates (Bouamama, 2013), the results indicate that this policy is not sufficient and need to be improved in order to encourage homeowners to invest in energy efficient measures.

The respondents ranked the high initial prices of energy efficient equipment as the second hindrance. This result is in agreement with the findings of Yang and Zhao (2015). The high initial prices of energy efficient equipment are mainly due to the lack of local production in Algeria. Algerian suppliers import energy efficient equipment from abroad which generates high initial prices for homeowners. Therefore, it is crucial to develop local production capacity in order to reduce the prices of energy efficient equipment.

It is surprising to note that the respondents ranked the lack of techniques and tools for estimation of saved energy as the third hindrance. This is in agreement with Du et al. (2014) findings that the lack of techniques and tools for estimation of saved energy is one of the major barriers to the adoption of energy-saving technologies in the building sector in China. It is crucial that the potential saved energy could be accurately estimated by installers and architects in order to reassure homeowners about their investment.

The unwillingness to borrow money was ranked as the fourth hindrance by the respondents. This could be because existing financing instruments in Algeria are not sufficient or are inappropriate for homeowners. In order to finance the adoption of energy efficient measures, it is very important for homeowners to access attractive and long-term financing that is adapted to their needs, investment capacity and ability to pay off a debt. The unwillingness to borrow

money was also identified as important barriers in Stieß and Dunkelberg (2013) and Zundel and Stieß (2011).

The difficulty of identifying, procuring, installing, operating, and maintaining energy efficiency measures was ranked as the fifth most important hindrance. In fact, some homeowners have knowledge about energy efficiency measures and their benefits and could pay for the energy efficiency measures. However, they are completely helpless in the face of all the problems that must be tackled in identifying, procuring, installing, operating and, maintaining energy efficiency measures (Reddy, 1991).

The low energy prices of energy was not evaluated as a barrier that considerably affects the adoption of energy efficiency investment measures and therefore was ranked last. This is because the energy bills become an increasingly heavy burden for Algerian households. In fact, due to the economic crisis, the Algerian government is no longer able to maintain its financial support to the energy sector, which use to assure in the past decade very low energy prices. Consequently, the price of energy has increased by 20 percent and the Algerian households are now more attentive about the energy consumption (Seddiki, 2016).

Principal component analysis: categorizing the barriers:

In order to define the underlying structure of the barriers to the adoption of EEIMs of single-family homeowners, a principal component analysis (PCA) with varimax rotation was used (see Table 3). A Kaiser–Meyer–Olkin (KMO) test, as well as Bartlett tests were performed in order to evaluate the factorability of

the data. The KMO statistic is at 0.882, and the p-value of the Bartlett test was (<.001). Both of them showed that the items in the scale were suitable for factor analysis. The PCA groups the 16 variables around four components: (1) "Financial" barriers, (2) "Technological" barriers, (3) "Lack of time and knowledge" barriers, (4) "Attitude towards energy efficiency improvements" barriers.

INSERT TABLE 3 AROUND HERE

Component 1: "Financial" barriers

The first of the four components includes five barriers to the adoption of EEIMs, namely, the lack of financial resources, the uncertainty about economic future, the high initial prices of energy efficient equipment, the lack of subsidies and rebates on energy efficient equipment, the unwillingness to borrow money. This component accounts for the highest variance (16.9%) of all the components and represents the major "Financial" barriers hampering the adoption of EEIMs.

Component 2: "Technological" barriers

The second component accounts for 15.2 per cent of the total variance and includes four important barriers that hinder the adoption of EEIMs, namely: the lack of knowledge of architects and installers, the lack of techniques and tools for estimation of saved energy, the difficulty of identifying, procuring, installing, operating, and maintaining energy efficiency measures, the lack of attractive products. Component 2 represents the major "Technological" barriers hampering the adoption of energy efficiency measures.

Component 3: "Lack of time and knowledge" barriers

This component explains 12.6 per cent of the total variance of the data. The component includes four barriers, namely, the limited knowledge about energy efficiency measures and their benefits, the lack of knowledge over the payback periods, the lack of time to collect necessary information, the lack of examples. This component could be described as "Lack of time and knowledge" barriers. The barriers included in component 3 were considered by homeowners as less important as the barriers of component 1 and component 2.

The limited knowledge about energy efficiency measures and their benefits leads homeowners to not invest in EEIMs or to invest in unsuitable products. Therefore, it is of crucial importance to effectively disseminate information about EEIMs and their benefits (Nair et al., 2011).

Uncertain economic benefits may also lead homeowners to avoid EEIMs. However, the result indicates that the respondents ranked this hindrance fourteenth. This disagrees with Zundel and Stieß (2011) findings that uncertain economic benefits represent a major barrier.

The respondents ranked the lack of time to collect necessary information as the eighth hindrance. This could be explained by the fact that the different sources of information in Algeria are not well organised. Consequently, it is extremely time-consuming for a homeowner to find the right information. As stated before, it very important to provide for homeowners easy access to

information about EEIMs. The lack of time to collect necessary information was also identified as important barriers in Golove and Eto (1996).

The lack of examples of homeowners that have invested in energy efficiency measures was not perceived by the respondents as a strong barrier and was ranked thirteenth. This indicates that the decision of homeowners to invest in energy efficiency measures is not influenced by neighbours, friends, colleagues, or anyone who has invested in such measures. This disagrees with Mortensen et al. (2011) findings that indicate the lack of example represents a strong barrier for energy renovation of Danish single-family houses.

Component 4: "Attitude towards energy efficiency improvements" barriers

The last component includes the flowing barriers: the low energy prices, the investments in energy efficiency measures are a low priority compared to other measures and the perceived hassle of installation. These barriers were ranked respectively 16, 15, and 11. This final factor accounts for 10 per cent of the total variance. This component could be described as "Attitude towards energy efficiency improvements" barriers. The barriers included in this component were considered by homeowners among the least important hindrances for the adoption of EEIMs. These results are in agreement with the findings of Nair et al. (2011) who also indicate that "Attitude towards energy efficiency improvements" barriers such as" Investments in energy efficiency measures are a low priority compared to other measures "are not a serious hindrance. However, the results are in disagreement with the findings of Friedman et al. (2018) and Stieß and Dunkelberg (2013) that "Attitude towards

energy efficiency improvements" barriers such as" lack of interested in energy efficiency "are fairly important. The fact that homeowners have considered "Attitude towards energy efficiency improvements" barriers as not significant hindrances might be because, for these homeowners, their energy costs are high enough to motivate them to invest in energy efficiency measure.

Multivariate Analysis of Variance (MANOVA)

In order to investigate the differences in the perception of the components of the different groups segmented according to personal and contextual variables, we have implemented a one way MANOVA. According to Chileshe et al. (2016), the most common multivariate test is Wilks' Lambda. Table 4 displays significant MANOVA (i.e., p- value under 0.05). Then, if an overall difference is found between any groups of homeowners as a result of MANOVA, univariate tests ANOVA are applied to find the source of difference as indicated in Yuksel et al. (2000).

INSERT TABLE 4 AROUND HERE

Component 1: "Financial" barriers

Table 4 indicates significant effects of the gender (P 0.01) as well as the household's monthly net income (P 0.002) on the respondents' perceptions of the financial barriers hindering the adoption of EEIMs.

In order to find the source of difference, univariate tests ANOVA are applied. The results of the univariate tests indicate that there is a statistically significant difference in the perception of the barrier "lack of financial resources" (P 0.001) between groups of homeowners segmented according to gender (see Table 5).

INSERT TABLE 5 AROUND HERE

INSERT TABLE 6 AROUND HERE

Table 6 indicates that respondents who were female were more likely to consider the lack of financial resources as a very important barrier to the adoption of energy efficiency measures than respondents who were men. This is in disagreement with Nair et al. (2010) findings that homeowners' gender does not influence their preference for energy efficiency.

The disparities in financial resources between women and men could be explained by the facts that in Algeria, men generally earn more money than women do, and that majority of women do not benefit from employment stability (Missous-Kadry, 2014).

Furthermore, the results of the univariate tests indicate that there are statistically significant differences in the perception of the barriers "the lack of financial resources" ($P < .001$) and "the uncertainty about economic future" ($P < .001$) between groups of homeowners segmented according to household's monthly net income (see Table 7).

INSERT TABLE 7 AROUND HERE

INSERT TABLE 8 AROUND HERE

Table 8 indicates that homeowners in the income group (605 - 760 $) and the income group (760 $ and more) were more likely to find the financial resources in order to invest in energy efficiency compared to other income groups. While homeowners who had an annual income less than 150 were the least likely to find the financial resources in order to invest in energy efficiency. This is agreement with Herring et al. (2007) findings that homeowners' income affects the investment in energy efficiency. Furthermore, homeowners in the income group (Less than 150 $) were more likely to consider the uncertainty of the economic future as a very important barrier compared to other income groups. Due to the precarious financial situation of the income group (Less than 150 $), energy efficiency loans would

not be the right option. Therefore, funding in the form of subsidies and tax reduction would be more appropriate.

Component 2: "Technological" barriers

For the "Technological" barriers, we find no statistically significant differences between any groups of homeowners. Therefore, the perception of the "Technological" barriers hindering the adoption of energy efficiency measures seems to be similar for all groups of homeowners in our simple.

Component 3: "Lack of time and knowledge" barriers

The results of the MONOVA analysis indicate that the gender has a significant effect (P 0.01) on the respondents' perceptions of the "Lack of time and knowledge" barriers hindering the adoption of energy efficiency measures (see Table 4).

More precisely, the results of the univariate tests (see Table 9) indicate that there are statistically significant differences in the perception of the barriers "Limited knowledge about energy efficiency measures and their benefits" (P 0.014) and "Lack of time to collect necessary information" (P 0.008) between groups of homeowners segmented according to gender.

INSERT TABLE 9 AROUND HERE

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Table 10 indicates that respondents who were women were more likely to consider the "Limited knowledge about energy efficiency measures and their benefits" as an important barrier to the adoption of energy efficiency measures than respondents who were men. This could be explained by the fact that women do not access equally with men to the information about energy efficiency measures (Clancy et al., 2004). However, this is in disagreement with other studies that have reported no statistical relationship between respondents' gender and their perception of energy efficiency (Sardianou, 2007).

Furthermore, respondents who were women were more likely to consider the "Lack of time to collect necessary information" as an important barrier to the adoption of energy efficiency measures than respondents who were men (see Table 10). This could be explained by the fact that many Algerian women juggle family obligations, domestic tasks and paid work, and don't find time to collect necessary information about energy efficiency measures (Clancy et al., 2004).

Component 4: "Attitude towards energy efficiency improvements" barriers

For the "Attitude towards energy efficiency improvements" barriers, we find no statistically significant differences between any groups of homeowners. Therefore, the perception of the "Attitude towards energy efficiency improvements" barriers hindering the adoption of energy efficiency seems to be similar for all groups of homeowners in our simple.

CONCLUSIONS, POLICY IMPLICATIONS AND RECOMMENDATIONS

Conclusions

This paper extends current knowledge by conducting an empirical study on homeowners' adoption of Energy Efficiency Investment Measures (EEIMs) in Algeria. The main purposes of this paper are: (1) to identify and rank the critical barriers that hinder the adoption of EEIMs of Algerian single-family house owners, (2) to investigate the underlying relationships between these factors, (3) to investigate the differences in the perception of the barriers to the adoption of EEIMs of the different groups segmented according personal and contextual variables.

Sixteen barriers have been identified in this paper. Through the ranking analysis, it was found that the five greatest barriers to the adoption of EEIMs were: (1) the lack of subsidies and rebates on energy efficient equipment, (2) the high initial prices of energy efficient equipment, (3) the lack of techniques and tools for estimation of saved energy, (4) the unwillingness to borrow money, (5) the difficulty of identifying, procuring, installing, operating, and maintaining energy efficiency measures.

The principal component analysis was implemented in order to explore the relationships among the 16 barriers. The PCA categorised the 16 barriers around four components: (1) "Financial" barriers, (2) "Technological" barriers, (3) "Lack of time and knowledge" barriers, (4) "Attitude towards energy efficiency improvements" barriers.

The MANOVA and ANOVA analysis have indicated that there are differences in our sample regarding the perception of the barriers to the adoption of EEIMs. Especially, evidence for differences between groups that were segmented according to gender as well as the household's monthly net income have been found. The results indicate that gender as well as the household's monthly net income significantly affect the respondents' perceptions of the component "Financial" barriers. It was also found that gender has a significant impact on the respondents' perceptions of the component "The lack of time and knowledge" barriers. It should be noted that for the components "Technological" barriers and the "Attitude towards energy efficiency improvements" barriers" barriers no statistically significant differences between any groups of homeowners have been found.

Policy implications and recommendations

The reduction of energy consumption in the residential sector is among the top priorities of the Algerian government. By adopting Energy Efficiency Investment Measures (EEIMs), Algerian households can significantly contribute to reducing the residential energy demand. In spite of the many barriers hindering Algerian homeowners from implementing EEIMs the trend to promote the adoption of EEIMs is the only way forward. In light of the above analysis, we suggest the following policy recommendations to improve the efficiency of government interventions and diminish these barriers.

Firstly, different financial incentives and subsidy policies should be correctly targeted and be made adequate in order to encourage Algerian homeowners to adopt EEIMs. In our survey, financial barriers have been

considered by homeowners as the major barriers hampering the adoption of energy efficiency measures.

The government could reduce the expense of purchasing energy-efficiency systems by offering tax credit. For instance, the government could implement tax incentives for home insulation, heat systems, energy –efficient-equipment such as A + refrigerator and air conditioning systems. Also, rebate programs could be implemented by the government. It would give consumers price reduction to purchase new energy efficient appliances when they replaced used appliances. Although subsidized low or zero interest loans seems a good strategy for motivating energy efficient investment, our survey has indicated that homeowners are unwilling to borrow money; therefore, incentives in the form of rebate and tax reduction would be more appropriate. Furthermore, the Algerian government should propose tax incentives in order to attract investors and boost the development of a local production of energy efficiency equipment. A local production, as well as a competition among local producers, would induce lower initial prices and encourage the adoption of energy efficiency measures.

Secondly, our empirical study showed that technological barriers were considered by homeowners as very important. Therefore, different strategies should be adopted by the government in order to overcome these barriers. The lack of techniques and tools for estimation of saved energy, and the lack of knowledge of architects and installers can be addressed together through the development of specialized training programmes in the field of energy efficiency, which would be adapted for each category of trainees (students, architects, engineers, installers, and so on). The program should train participants on reliable energy simulation tools in buildings and facilitate access to such tools. In order to address the barrier of the difficulty of identifying, procuring, installing, operating, and maintaining EEIMs, an organisation dedicated specifically to the adoption of EEIMs could be set up for homeowners. The organisation would be composed of partners from the public, private and research spheres. It would provide support and advice

during all the phases of the energy project, followed by proper monitoring of the results in terms of savings after project implementation ends.

Thirdly, the government should implement information instruments to motivate homeowners to adopt EEIMs. Energy performance certificates and labels seem to be good solutions. Such instruments have not been implemented in the residential sector of Algeria yet. They provide homeowners reliable information about the real energy performance of their home and they classify that level of performance. Energy performance certificates are also practical to inform and educate homeowners about energy efficiency measures and their benefits. Another solution to provide homeowners real time information on how energy is being used in their homes is to require from the energy suppliers to install smart meters or home electrical monitoring systems for their customers. Such devices would help homeowners to manage and reduce their energy use. In addition, the distribution of energy efficiency guides by homeowner associations or energy suppliers companies could be an effective way to disseminate information. Traditional media, social media, and information-sharing portals also represent good opportunities to facilitate access to the latest policy, technical, and energy related developments in the sector.

Fourthly, our empirical study showed that respondents who were female were more likely to consider the barriers "Limited knowledge about energy efficiency measures and their benefits" as well as "the lack of financial resources" as a very important barrier to the adoption of energy efficiency measures than respondents who were men. Therefore, it is of crucial importance that the government implements financial incentives and information instruments that adequately address women's requirements. For instance, the creation of energy efficiency groups and mentor programs that focussed on women could support the provision of awareness raising and the training of women about the energy efficiency measures and their benefits (Clancy et al., 2004). Besides, the government could boost women's direct access to financial incentives through technical innovation and changes in

financial services' design to better tailor products to women's preferences and constraints (Fletschner and Kenney, 2014). Furthermore, in order to improve women's access to financial resources in general, it is essential to guarantee women an equal pay with men as well as job stability through measures such as paid maternity leave, paid childcare, and childcare subsidies.

Finally, some limitations are worth mentioning. Since the study was conducted in the area of Mostaganem in Algeria, the findings may not be generalised to other geographical locations. Other studies in countries with similar context such as Tunisia and Morocco could put our findings into a broader perspective. Also, the survey focused mainly on the barriers to adoption to the adoption of EEIMs. Similar studies that focus on other dimensions such as motivations of Algerian homeowners for the adoption of EEIMs and their perceptions on different incentives could be an interesting direction in future research.

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Table 1. Personal and contextual characteristics of the respondents

Variable	Classification	N	Frequency (%)
Gender	Male	94	62.7
	Female	56	37.3
Age	20-30	16	10.6
	31-40	36	24
	41-50	42	28
	51-60	32	21.3
	More than 60	24	16
Education	No secondary school qualification	3	2
	Lower secondary school qualification	2	1.3
	Intermediate secondary school qualification	2	1.3
	Higher secondary school qualification	7	4.7
	Bachelor degree	15	10
	Master degree	62	41.3
	PhD degree	59	39.3
Job	Farmer	3	2
	Artisan	1	0.7
	Merchant	12	8
	Industrial	3	2
	Employee	32	21.3
	Student	11	7.3
	Middle-management	19	12.7
	Senior executive	15	10
	Professional	28	18.7
	Retired	10	6.7
	Jobless	3	2
	Other	13	8.6
Household's monthly net income (converted in this paper to US dollar)	Less than 150 $	10	6.7
	150 - 300 $	13	8.7
	300 - 455 $	27	18
	455 - 605 $	29	19.3
	605 - 760 $	15	10
	760 $ and more	28	18.7
	Not stated	28	18.7
Year of construction	Before 1945	6	4
	1945-1962	7	4.7
	1963-1990	16	10.7
	1991-2000	47	31.3
	2001-2010	33	22

	2011-2018	24	16
	No stated	17	11.3
Size of the home	Less than 100 m^2	27	18
	100-150 m^2	37	24.7
	150-200 m^2	22	14.7
	200-250 m^2	15	10
	More than 250 m^2	38	25.3
	No stated	11	7.3

Table 2. Ranking of the barriers to the adoption of energy efficiency investment measures

Barriers	Mean	Standard Deviation	Rank
The lack of subsidies and rebates on energy efficient equipment	4.21	1.02	1
The high initial prices of energy efficient equipment	4.09	1.17	2
The lack of techniques and tools for estimation of saved energy	3.97	1.21	3
The unwillingness to borrow money	3.97	1.32	4
The difficulty of identifying, procuring, installing, operating and maintaining energy efficiency measures	3.92	1.14	5
The lack of financial resources	3.87	1.19	6
The lack of attractive products	3.73	1.18	7
The lack of time to collect necessary information	3.65	1.24	8
The lack of knowledge of architects and installers	3.60	1.42	9
The limited knowledge about energy efficiency measures and their benefits	3.51	1.33	10
The perceived hassle of	3.40	1.33	11

installation doesn't motivate them to implement the efficiency improvement			
The uncertainty about economic future	3.35	1.42	12
The lack of examples	3.32	1.53	13
The lack of knowledge over the payback periods	3.20	1.35	14
The investments in energy efficiency measures are low priority compared to other measures	3.07	1.36	15
The low energy prices don't motivate to implement the efficiency improvement	2.84	1.38	16

Table 3. Component Matrix After Varimax Rotation

	Component				Variance explained (%)
	1	2	3	4	
The limited knowledge about energy efficiency measures and their benefits			0.806		12.6
The lack of knowledge over the payback periods			0.583		
The lack of time to collect necessary information			0.574		
The lack of examples			0.597		
The lack of attractive products		0.689			
The lack of techniques and tools for estimation of saved energy		0.742			
The lack of knowledge of architects and installers		0.755			15.2
The difficulty of identifying, procuring, installing, operating and maintaining energy efficiency measures		0.689			
The high initial prices of energy efficient equipment	0.781				
The lack of subsidies and rebates on energy efficient equipment	0.556				16.9
The lack of financial resources	0.825				

Uncertainty about economic future	0.788			
The unwillingness to borrow money	0.425			
The Investments in energy efficiency measures are low priority compared to other measures			0.629	10
The perceived hassle of installation doesn't motivate them to implement the efficiency improvement			0.553	
The low energy prices don't motivate to implement the efficiency improvement			0.709	

Note. 'varimax' rotation was used

Table 4. Wilks' Lambda Result (MANOVA Tests)

Variable	Component 1: "Financial" barriers	Component 2: "Technological" barriers	Component 3: "Lack of time and knowledge" barriers	Component 4: "Attitude towards energy efficiency improvements" barriers
Gender	**P 0.01 Lambda 0.904**	No significant differences	**P 0.01 Lambda 0.915**	No significant differences
Age	No significant differences	No significant differences	No significant differences	No significant differences
Education	No significant differences	No significant differences	No significant differences	No significant differences
Household's monthly net income	**P 0.002 Lambda 0.666**	No significant differences	No significant differences	No significant differences
Year of construction	No significant differences	No significant differences	No significant differences	No significant differences
Size of the home	No significant differences	No significant differences	No significant differences	No significant differences

Table 5. Univariate tests with gender as an independent variable and the five financial barriers as the dependent variables

	Dependent Variable	Sum of Squares	df	Mean Square	F	p
Gender	The high initial prices of energy efficient equipment	3.541	1	3.541	2.616	0.108
	The lack of subsidies and rebates on energy efficient equipment	0.596	1	0.596	0.573	0.450
	The lack of financial resources	14.383	1	14.383	10.919	0.001
	The uncertainty about economic future	5.757	1	5.757	2.893	0.091
	The unwillingness to borrow money	2.240	1	2.240	1.292	0.257

Table 6. Characteristics of respondents' gender and relationships with the lack of financial resources

	Gender	N	Mean	SD	SE
The lack of financial resources	Female	56	4.27	1.05	0.141
	Male	94	3.63	1.20	0.124

Table 7. Univariate tests with household's monthly net income as an independent variable and the five financial barriers as dependent variables

	Dependent Variable	Sum of Squares	df	Mean Square	F	p
Household's monthly net income	The high initial prices of energy efficient equipment	15.57	6	2.595	1.971	0.074
	The lack of subsidies and rebates on energy efficient equipment	9.62	6	1.604	1.582	0.157
	The lack of financial resources	30.54	6	5.090	4.071	< .001
	The uncertainty about	44.79	6	7.465	4.178	< .001

	economic future					
	The unwillingness to borrow money	2.77	6	0.461	0.258	0.956

Table 8. Characteristics of respondents' monthly net income and relationships with the lack of financial resources as well as the uncertainty about economic future

	Household's monthly net income	N	Mean	SD	SE
The lack of financial resources	150 - 300 $	13	4.08	1.320	0.366
	300 - 455 $	27	4.37	0.967	0.186
	455 - 605 $	29	4.07	1.033	0.192
	605 - 760 $	15	3.93	0.799	0.206
	Not stated	28	3.71	1.243	0.235
	Less than 150 $	10	4.30	0.949	0.300
	760 $ and more	28	3.04	1.290	0.244
The uncertainty about economic future	150 - 300 $	13	3.46	1.561	0.433
	300 - 455 $	27	3.96	1.160	0.223
	455 - 605 $	29	3.07	1.462	0.272
	605 - 760 $	15	3.60	1.298	0.335
	Not stated	28	3.36	1.224	0.231
	Less than 150 $	10	4.40	0.966	0.306
	760 $ and more	28	2.50	1.478	0.279

Table 9. Univariate tests with gender as an independent variable and the four lack of time and knowledge barriers as dependent variables

	Dependent Variable	Sum of Squares	df	Mean Square	F	p
Gender	Limited knowledge about energy efficiency measures and their benefits	10.563	1	10.563	6.181	0.014
	Lack of knowledge over the payback periods	0.223	1	0.223	0.123	0.727
	Lack of time to collect necessary information	10.739	1	10.739	7.317	0.008
	Lack of examples	1.82e-4	1	1.82e-4	7.79e-5	0.993

Table 10. Characteristics of respondents' gender and relationships with the barriers the limited knowledge about energy efficiency measures and their benefits as well as the lack of time to collect necessary information

	Gender	N	Mean	SD	SE
Limited knowledge about energy efficiency measures and their benefits	Female	56	3.86	1.26	0.168
	Male	94	3.31	1.34	0.138
Lack of time to collect necessary information	Female	56	4.00	1.04	0.140
	Male	94	3.45	1.30	0.134

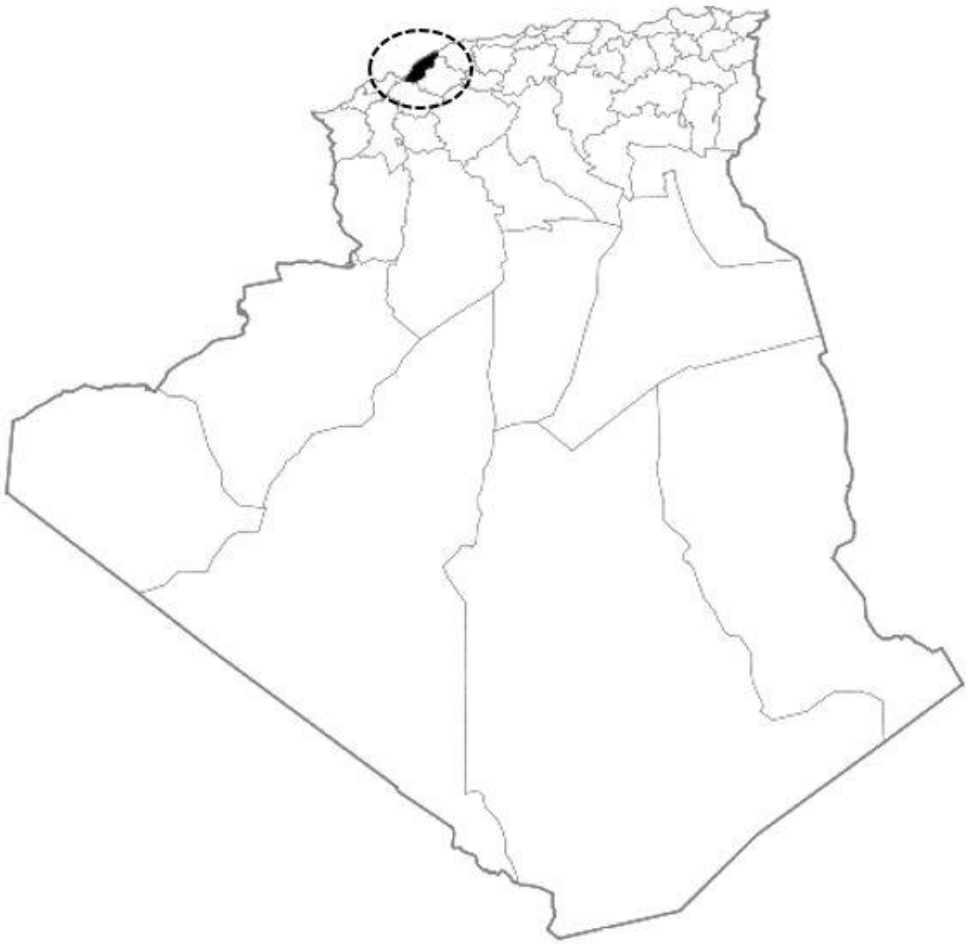

Figure1. Location of Mostaganem area in Northern Algeria