# FACTORS INFLUENCING THE ACCEPTANCE OF SOLAR ENERGY IN SOUTH HUVADHOO ATOLL, MALDIVES.

# *By Rukshana fathimath , Master in rural development management, Graduate school of Khon Kaen University*

# *Advisor: Associate Prof. Nongluck Suphanchaimat.*

# Abstract

Energy has become an essential part of our livelihood but the sources we are using are depleting and non-renewable. To procure a better future the need for cleaner and reliable resources for energy is essential. In case of Maldives, the energy is not cheap, due to non-availability of energy resources and needs for imported fossil fuel. The characteristics of atoll islands require each island to have a power plant using fossil fuel and the fuel storage availability is limited, making the electricity in these islands unstable and costly. To overcome this problem, the government has introduced solar energy. Despite the high government subsidy and the effort by government, the usage of solar energy is uncommon. The study aimed to study the factors influencing acceptance of the solar energy. From South Huvadhoo atoll, 119 samples were collected vie an electronic survey. The data obtained from the questionnaires were analyzed using SPSS 21st version program. From the data obtained the respondents can be classified as young at age37 years, mostly educated with a certificate level and over 39.5 percent were government officers. The result displayed that majority of respondents knew about the benefits and gains of solar energy (83.72%), but unaware of the promotion activities done by the government and other parties (16.27%). Furthermore, 88.2% of respondents are ready to accept solar energy but unaware of the market prices of solar energy system, and they are not ready to invest at the moment. They would prefer to see the result before investing in the solar energy (33. 6%).The presumptions for policymakers are to increase the knowledge and awareness of the people to elevate a positive attitude and involve the private sector to increase competition and utility in the field.

Keywords: Solar energy, South Huvadhoo Atoll, Maldives, Electrification.

# Introduction

Maldives is a coral island country consists of 1,190 islands which are scattered around an area of 298 km² separated by the sea. The country does not have any conventional energy sources and a main source of energy is petroleum. The power systems rely on imported fossil fuel. Maldives electricity supply is inefficient and unreliable. The limited capacity of oil storage facilities interferes with the bulk purchasing of oil when the price is low. The country spends almost 30% of its GDP on the import of petroleum. The share of petroleum products in total imports rose to 29% in 2014, from only 16% in 1990. The country spent $572 million for imported fuel 33% of the country’s GDP in 2014(Bank, 2015). In order to make electricity affordable to all, the government has to give subsidies. However, subsidies are increasing year by year and it has become a big burden to the Government budget. The total cost of subsidies in 2010, was around US$ 5 million and in 2015, the government spent US$46 million on subsidies (MEE, 2014) Maldives is among the highest cost of electricity generation in South Asia- 30-40 US$ cents per kWh in large islands, and even higher in the remote small islands. (ADB, 2014) There is an increase in the energy consumption (MWh) of the greater male and other atolls from the year 2010, 2011 to 2012. It shows an increase in growth rate of specific electricity consumption (kwh/capital) in greater male regions from 4.13% in 2011 to 6.09% in 2012. In addition, there is an increase in the estimated electricity consumption in other atolls during 2010 to 2012. Annual growth rate of consumption of electricity is 21%. (Maldives energy authority, n.d.)

Using renewable energy in Maldives is just not the matter of protecting the environment but also for physical and economic conditions of the country. It is essential that the country have stable electricity without totally depending on other countries. According to Government policy 2015, the country gives important on providing reliable and sustainable electricity service and it aims to achieve 30 percent of daytime peak load of electricity in all inhabited islands from renewable energy sources by 2020. In order to achieve these targets, the country is implementing different solar energy projects in different islands. Under different projects, 7 islands have installed a solar Photovoltaic system. They are DH Kudahuvadhoo, G DH Thiandhoo, villi male’, Hulhumale, V Rakeedhoo and A DH Dhidhoo. In addition to this, resorts named Gas finolhu is a 100% clean energy resort and there are other resorts that produce some percentage electricity using clean energy. The resorts are revolving in to clean energy sources for its production. Being a tropical country, out of all RE resources solar energy is easily applicable. Solar energy means Energy created by using the sun radiation. Solar electricity / power is produced by converting sunlight into electricity directly or indirectly using photovoltaics (PV) and concentrated solar power ( CSP). The solar power helps reduce the global warming, saving the world from the heat crises. It saves billions of dollars of the society and of the individual. The society benefits form the reduction of the cost of import of fossil fuel and this saved money can be used to the countries development. The individual saves or earns by putting a PV panel on the roof, generating own energy or by connecting to the grid and selling it to the utility companies. Solar energy is a reliable energy source, because rising and setting of the sun is constant, and is reliable. (Shahan, 2013). Moreover, its gives energy security and energy independence. No longer, people have to depend on the grid connection and the country electric providers. Beside all these, if it is produced in business scale rather than individual scale it creates jobs to the community.

Acceptance typically means that to take or receive what is offered. It can be defined as an act of approval of what is offered and act on it. Besides that, the concept of acceptance of innovation is analyzed in 3 different phases. The study was done by RoseK.Gold and Max Ralis on factors relating to influence acceptance of innovation in Bang Chan states that the first phase of acceptance is the initial adoption by one or more members of the group. The second phase would be a continuous use of the innovation and phase can be express as the individual physiological acceptance of the innovation when it is fully incorporated in the way of life in the society.

However, to become more independent in SE for electricity production, the country needs the full participation of the population. It is essential to adopt solar energy at the household level. The government has launched a Net Metering regulation where privately produced electricity or renewable energy can be connected to the utility power grids. In addition to this, the Maldives Bank introduces Green Fund for clean energy initiatives.

#  Despite the high cost, high government subsidy and the effort by government, the households are reluctant to adopt. The government has introduced the solar energy to the country, there is no clear understanding of how many people have known and accepted solar energy in the country. Therefore, this study focus on demographic characters, external factors including attitude and knowledge of respondents to identify the factors that influence the acceptance of the solar energy in Maldives. In the past, no similar research has been conducted in Maldives. After the introduction of certain system or technology to the society, it is essential to know that the concerned people know and accept the technology.

# Measurements and Methodology

# This research survey was done using questionnaire to get the primary data from households in the islands. The measurement method was numerical scale. The survey consists of Four types of questions: Open and close ended questions with dichotomous and Likert scale type questions. The dichotomous type of question was where respondents have only two choices (Yes or No) to determine whether they agree or disagree on certain statement (Opeyemi Akinwale, Olalekan Ogundari, Eniola Illevbare, & Oluwaseun Adepoju, 2014). Other questions were formulated as three Likert scale questions. In this question, the scaling frame was adopted from Halder et al. (2010) in which (0) corresponds to disagree, (1) neutral and, (2) corresponds for agree (Halder, Pietarinen, & Havu-nuutinen, 2013).

This study was conducted in south Huvadhoo atoll, where there are 9 islands with a population of 11,587 and Number of households are 21866. The questionnaire was constructed in a way to discover four different aspects of respondents. First part aims to discover socio-geographical characteristics of the respondents. As well as the preferences of respondent and respondent’s electricity condition of the household were also assessed. Second part concentrated in the knowledge level of the respondents on solar energy. Third part aims to aimed to analyze the respondent’s attitude towards solar energy. Forth part concentrated on knowing the respondent's decision on solar energy.

The questionnaire was constructed in google form and was distributed to the islands through the internet. The data was collected through interview and an online survey in a period of 2 months. As a result, there were 119 respondents participated in the electronic survey.

The knowledge of solar energy is tested by using 26 questions. The score computed by adding all the “yes” answers given by the respondents. The sample was categorized in to two classes named high level of knowledge and low level of knowledge. The respondents, who scored more than 13 (13/26)) was categorized as having a high level of knowledge and vise verse.

As for the question on attitude evaluation, the answers were scaled with 3 scales; agree, neutral and disagree. If respondent agrees with the matter, the score is given (2) and (0), for disagree or (1), for neutral. A Score of each question was computed by adding for all 7 questions of each respondent. The highest score can be obtained is 14 from 7questions. The respondents that scored more than 7 are classified as having a high level of attitude and vise versa.

# Result

# *Demographic Characteristics:*

There were 119 people participated in the online questionnaire survey from 9 islands with 52.1% of the respondents being women. The Average age of the respondents is 37.11 years (median: 34, min: 20 max: 76). Regarding the family size of the respondents, in this study, the family size was calculated based on the dependents of the respondent. On an average, they had 4.48 ± 2.7 individual in the family. Majority of the respondents held Certificate or Diploma (32.8%). As for occupation, 39.5% of the respondents were government officers. Regarding the income, 26.1% of respondents get a salary higher than USD 800 followed by 25.2% of respondents earn income between USD401-USD600. On an average income earned by respondents was USD575.5 per month. As per the question of whether the respondent is environment concern person or not 60.5% of people stated that they are concerned about the environment (Table 1).

Household electricity situation shows that 46.2 % of household are sharing the electricity bill, but the average household electricity condition is one house having more than one meter in the house. In terms of electricity bill, 38.7 % of household have bills were below USD50. Average of respondent household is USD90.6 (median: $67, min: $ 3, max: $1000). While 71.4 % respondents state that their electricity is stable and 84.9% of respondents are not satisfied with the electricity prices. Out of 119 respondents, 95% people prefer to have renewable source of energy for electrification. (Table 2)

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| **Table 1: The General characteristics of the sample.** |
| **General characters** | **Mean** |
| Age | 37.11 years |
| Sex | Female |
| Family Size | 4.48 members |
| Education | Certificate / diploma |
| Occupation | Government Officers |
| Income | US$ 575.5 |
| Status of marriage | Married |

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| **Table 2: The General characteristics of the sample.** |
| **Detail** | **Mean**  |
| Person concern of Environment | An environment concern person |
| Electricity Conditions | 2 or more meters in one house |
| Electricity bill | US$90.6 |
| Electricity stability | Stable |
| Satisfaction of ELCT Price | Not Satisfied |
| Prefer renewable source of energy | Prefer |

***The knowledge on solar energy***

A set of questions to examine the level of knowledge was included in the questionnaire. The question was categorized into five sections testing on the environment, the economic benefit of the solar energy, promotion carried out by the government, household gain and national level benefits of solar energy. The questions were asked in dichotomous scale (yes /no). Computing up all answers given by respondents and a total score was created. This indicated that the average score of the respondents is 16.5 (median:17, min:6, max:26) (table 3). Furthermore, respondents who have scored more than 13 are categorized as High level of knowledge and others low level of knowledge, based on this classification, 68.1% of respondents have high knowledge about the solar energy.

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| **Table 3: Status of knowledge** |
| **Statement**  | **Count** | **%** | **Statement** | **Count** | **%** |
| It is a renewable energy source | 111 | 93 | It adds value to the house | 72 | 61 |
| Cost saving through reduction in electricity bill | 110 | 92 | Gain energy reliability  | 72 | 61 |
| It reduce pollution | 99 | 83 | It guarantees performances  | 71 | 60 |
| The electricity generated from the sun more feasible compared to fossil fuel electricity. | 97 | 82 | Gain energy security  | 70 | 59 |
| It is sustainable | 94 | 79 | It is an affordable technology | 69 | 58 |
| It helps to reduce carbon emission | 94 | 79 | With right storage system solar energy can be used in whole day | 69 | 58 |
| Its more economical compared to fossil fuel | 91 | 76 | Maldives government promote solar energy | 69 | 58 |
| It helps to slow global warming | 90 | 76 | Clean and maintenance need to be done regularly | 66 | 55 |
| Gain energy independency | 88 | 74 | Introduction of green fund for green energy | 53 | 45 |
| Implement solar panels in government building | 82 | 69 | If there is excess energy storage, one can sell to the power grid | 48 | 40 |
| It is a secured investment  | 81 | 68 | Duty exemption of solar energy related products imported to country | 43 | 36 |
| Reduction of oil import | 79 | 66 | Net metering regulation allows you to sell the energy produced from renewable energy to the grid | 37 | 31 |
| It creates job opportunity  | 75 | 63 | Implementation of net metering regulation | 36 | 30 |
| Low level of Knowledge  | 38 | 31.9 | High level of knowledge  | 81 | 68.1 |
| Mean of the Total Knowledge Score = 16.5 |

The table 3, demonstrates that a huge number of respondents know about solar energy and benefits or gains from it. 93% of respondents know that solar renewable energy resource. Besides that, 92% of respondents believe that they will gain cost savings through a reduction in electricity bills. On the other hand, it was found out that respondents are unaware of the promotion programs done by the government and other parties. Around 70%, 64% and 56% of respondents stated that they do not know about duty exemption for import of renewable energy product, Net metering regulation, and green fund respectively.

***Attitudes of the respondents***

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| **Table 4: Attitude of respondents** |
| Scale  | 2 | 1 | 0 |
| Statements  | count  | % | count  | % | count  | % |
| It is good to produce electricity by solar energy | 91 | 76.5 | 26 | 21.8 | 2 | 1.7 |
| Maldives can go for solar energy to produce electricity | 64 | 53.8 | 35 | 29.4 | 20 | 16.8 |
| Social / moral support for going for solar power | 49 | 41.2 | 25 | 21.0 | 45 | 37.8 |
| Maldives government is promoting solar energy | 42 | 35.3 | 38 | 31.9 | 39 | 32.8 |
| The government can achieve its goal of 30% of energy from renewable energy. | 39 | 32.8 | 49 | 41.2 | 31 | 26.1 |
| Availability of solar energy technical support | 13 | 10.9 | 29 | 24.4 | 77 | 64.7 |
| Availability of Investment funds /loan in solar energy in Maldives | 11 | 9.2 | 32 | 26.9 | 76 | 63.9 |
| Low level of attitude  | 58% | High level of attitude  | 42% |

The attitude section of the questionnaire mostly dealt with Government goals, Solar for electricity, government promotion and financial, technical and social difficulties. Based on the 3 scales, a sum-up score was calculated, which indicated that the average score of the respondent was 7.16 (median: 7, min: 2, max: 14). In addition to this, 58% and 42% are classified as low and level of attitude respondents respectively (Table4). Most of the respondents had a low level of attitude.

# Out of 119 respondents, 49 respondents were neutral about government being able to achieve 30% of the energy used from renewable energy but 64 respondents think that Maldives can go for solar energy to produce electricity. Respondents (nearly 77%) strongly believe that it is good to produce electricity using solar energy. An enormous number of respondents believe that it is difficult to get technical and financial support for solar energy, 77 (65%) and 76 (64%) respectively (Table 4).

***Acceptance of solar energy***

From the data obtained it shows that most of the respondents (88.2%) were ready to accept the solar energy and 11.8% were not interested in solar energy.High percentage of people representing the South Huvadhoo atoll in the study specifies that they accepted solar energy (Table 5)

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| **Table 5: Frequency of the decision to use solar energy.** |
| **Will you use solar energy?** | **Frequency** | **Percent** |
| No | 14 | 11.8 |
| Yes | 105 | 88.2 |
| Total | 119 | 100.0 |

***Type of solar energy system the respondents prefer***

 There were 105 out 119 respondents, indicated their preferences towards the solar energy. The Table 6 data presented that over half of the respondents 57.1% wanted to have communal solar energy system. Other 42.9% would go for individual solar energy system.

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| **Table 6: Type of solar energy system Respondents prefer**  |
| **Type of solar energy**  | **Frequency** | **Valid Percent** |
| Communal | 60 | 57.1 |
| Individual | 45 | 42.9 |
| Total | 105 | 100.0 |

***Time of investment***

Given the respondents’ acceptance, a question was asked for the readiness to invest. Out of 119 respondents, 116 gave a time, they would prefer on investing. As stated in table 7, 34.5% of respondents would invest in later time and 31.9% was ready to invest in current time.

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| **Table 7: Time of investment choose by the respondents**  |  |
| Time to invest in SE | Frequency | Valid Percent |
| Valid | Now | 37 | 31.9 |
| After neighborhood adopt | 39 | 33.6 |
| Later | 40 | 34.5 |
| Total | 116 | 100.0 |
| Missing | System | 3 |  |
| Total | 119 |  |

***Expected amount of SE investment***

Table 4.26 shows that the amount of money respondents were ready to invest solar energy, on an average were US$ 8038.3. Out of 119 respondents, 61 respondents had an idea of how much they would like to spend on solar energy installment. However, over 72% of the interested respondent indicated an extremely low amount of investment of less than USD 1,000. This indicated their lack of information on SE, cost of installment.

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| **Table 8: Amount of Investment** |
| Amount in US dollar  | Frequency | Percent |
| 0-$1000 | 44 | 72.1 |
| $1001-$5000 | 9 | 14.8 |
| $5001-$10000 | 5 | 8.2 |
| More than $10000 | 3 | 4.9 |
| Total | 61 | 100.0 |
| Mean (S.D) = $ 8,038.39 (43,238.6) |

Concern over SE of the respondents

Respondents had clarified the issues raising for the adoption of solar energy and the reasons why they would like to adopt solar energy. Table 4.27 shows that out of 119 respondents 59 mentioned about the concern they had on investing in solar energy. Based on the information provided by 59 respondents, the highest concern they had was the initial cost of the investment (27%) followed by the getting a good installation partner/supplier 22%. The least concern was on the maintenance of SE (15%), the rest of 15%was an obtaining correct and reliable information

**Table 9: Issues concerned by the respondents**

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| Statements  | Count | % |
| Initial cost | 48 | 27 |
| Finding a good instillation partner / supplier | 38 | 22 |
| Finding a proper technician | 32 | 18 |
| Obtaining the correct and reliable information | 31 | 18 |
| Uncertainty in maintenance | 27 | 15 |
| Total Answer  | 176 | 100 |

 Even though there were problems, the respondent anticipated when adopting solar energy they gave a reason for adopting the solar energy. Revealed below were the summary of respondents view about why they would like to have solar energy.

- Save money and world environment.

- Socially everyone will be benefited by improving the living standards.

- An economic model for both individuals and nation as a whole.

- Expected healthier life.

# Discussion and conclusion

# Based on the survey, the results showed that respondents have a clear understanding of the environment-economic benefits and other gains to the country if solar energy were adapted in Maldives. On the other hand, they were rather weak in knowledge about the solar energy promotion activities done in Maldives. As a result, around 64% of respondents were unaware of the duty exemption on imported renewable energy product. Although these exemptions had been practiced for more than 2 years. Likewise, at the end of 2015 net metering regulation was introduced by the government. The green fund for renewable energy was also introduced in collaboration with the Bank of Maldives. Despite these initiatives, around 70% of respondents were with no knowledge of these promotions.

# The attitude score was calculated through the series of questions. If the respondent felt that, the government of Maldives would achieve the 30% of energy from renewable energy goal by 2020 and solar energy could be used to produce electricity, people were more likely to accept the solar energy. On the contrary, if the respondent does not feel that government was promoting solar energy and it was not suitable to produce electricity, he /she would more likely not accept solar energy. Likewise, if the respondent felt it was difficult to get financial, technical and social support to invest in solar energy, the attitude towards solar energy usage would be negative. He or She was more likely to reject solar energy.

# Furthermore, among those who accept solar energy, they were more comfortable with going for the communal solar system instead of individual SE system. This could be due to the practice they had in the past, where the government or the island community provide electricity services to the Islanders. The other 25% of the respondents would like to go for more independent and stable service of electrification by going for individual SE system. However, half of the respondents did not have an idea how much they like to spend and an individual are more likely to spend less than US$1000 on SE. Even though, a system of 3 to 4wk cost approximately US$5000 in today’s market in Maldives. This indicates that the respondents were lacking the knowledge about the cost of SE system. The result implicated that most of the individual is not ready to spend on solar energy right now. They would rather wait for their neighbors to adopt SE or they would spend on it on a later date. The concerns respondents had on adapting to SE were the initial cost, finding a good installation partner or supplier, obtaining the correct information, concern about the maintenance and finding a proper technical support in Maldives.

According to the respondents, if they adapt to solar energy, it would save money and world. The money saving would give them the opportunity to spend on medical purpose or save it for future. In addition to this, the respondents stated that financially their cost would be reduced and socially everyone will be benefited by improving the living standards, so they can spend more time with family. In the long run, it is an economic model for both individuals and nation as a whole. Everybody can live a happier and healthier life. The study was done in Italy(Cucchiella & D’Adamo, 2015) showed that that reduction in the investment costs and tax deduction can confirm the profitability of investment and consumers can obtain greater profitability, the PV manufacturers can continue posting positive financial results, and the country will continue achieving the status of the energy-independent nation.

**Recommendation**

Based on the finding; of the research, the following recommendations are made:

* 1. If it is possible for the small islands to convert in to solar energy according to their demand forecast, making an island producing electricity as 100% using solar energy and advertising that as a Model island where other islanders can come and visit and learn or experience SE.
	2. There is a need to include solar energy lessons to the public Medias and school curriculum to increase the knowledge about the solar energy and the government promotions done in Maldives. In addition to this, more promotion activities have to be done on the public, in order to increase the people’s awareness on the subject.
	3. Training and human development is needed in the solar energy sector, this would give the residents that the needed technical and maintenance support is available in the country.
	4. Initiation and participation from the private sector and the general public are important especially, on investment scheme and maintenance system. Which intern increase the competition in the sector and residents should be made available to get the correct information about the market prices of solar energy related equipment’s.
	5. Introduce a group investment scheme on SE for the islander, where they can make a group and borrow money and invest on SE.

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