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Feasibility Study for Replacement of Renewable Sources of Energy, in Selected Segments Fars Province

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Abstract: Iran has a vast supply of renewable energy resources, but, due to high reliance on fossil sources of energy, less attention was paid to utilization of renewable energy till now. Fortunately today the importance of renewable energy alternatives are understood, therefore many projects are implemented by scientists supported by the private or public sector, to make renewable energy useful for households and industries. This study established to show the feasibility for replacement of the conventional energy sources, in Fars province, located in south part of Iran. To do so, a questionnaire was prepared in accordance to ASABE S612 to audit the households' energy utilization; evaluation of the forms should answer the following questions:

- Which are the most energy consumer activities in rural life?
- How rural households use energy?
- Which renewable based technologies can be used & is feasible for the villagers?

In regard to impact of thermal needs in energy consumption, three thermal region segments were considered. By using cluster sampling method, 3-4 villages and in each one, 4-5 families were selected to fill out the questionnaires, in each segment. Analysis of the forms showed that the highest share of energy consumption belongs to electricity appliances. In the second step the renewables potential in the region, was evaluated by using the official data; and at the end, by using VENSIM software and the present data and the collected data, during the research, a model was evaluated to show the forecasts' for energy consumption status of Fars, if the current trend, would continues.

Key words: Renewable Energy · Energy Consumption Trend · Rural Sector · Energy Auditing · Modeling

INTRODUCTION

Due to growing demands of energy and the global consensus in 1978 on the implementation of policies based on production sustainability, more than 190 countries accepted the terms and definitions for sustainable production in 1992 and 1997, in Rio de Janeiro and Kyoto congresses [1].

Oil crisis in the 70s, technological progress and the environmental effects of conventional fossil fuels, caused the governments and scientists to look for new sources of energy [2].

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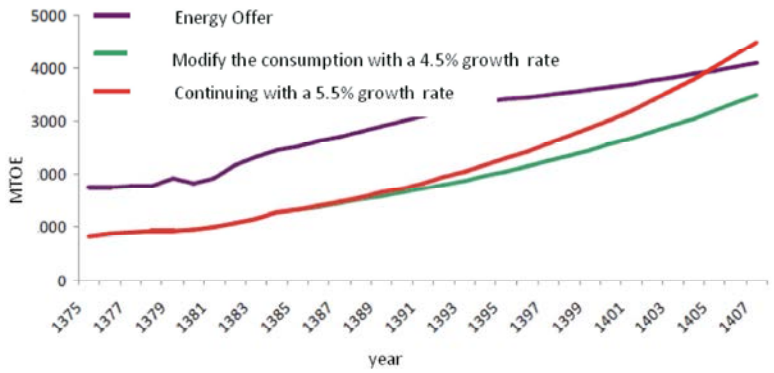

Fig. 1: Changing Iran Status from an Exporter to an Importer of energy if the present trend of energy consumption continues (Iran Energy facts and figures, 2009)

Statistical data show that in 1997 world energy consumption was about 8610 MTOE, in 2010 this amount had a 10% increase and world energy outlook predicts that world energy demand would have an increasing amount of 57% in 2020. Iran Energy Consumption data also show increasing energy demand and consumption amount in the past years [3, 4].

In Iran, due to high reliance on the vast fossil sources of energy, less attention was paid to renewable energy utilization till now. Fortunately today the importance of renewable energy alternatives are understood, therefore many projects are implemented by scientists supported by the private or public sector, to make renewable energy useful for households and industries [4, 5].

It should be noted that if current energy consumption trends continues in Iran, in the fore coming years it would no longer be a major exporter of energy. Figure 1, shows that what would happen to Iran, with the current energy consumption trend, forecasts indicates that in 1405, Iran, would become an importer of energy, if the current trend continues [3, 5].

According to the Millennium Development Goals, governments agreed to implement different policies, to eliminate the present problems of human kind, all over the world [6].

Beside the environmental impacts and the restrictions of using common energy sources, some social, political or economical aspects, would influence the utilization of renewable energies [7]. Studies of macro-planning center of ministry of Energy (in Iran), showed that, energy costs have a greater effect on low income families, than high income ones. In 2006, share of energy costs for an urban family was about 2.5% of its total voucher, but at the time it was almost 4% for a rural family [5]. 20% of Iran's GDP, 25% of none-Oil exports, 25% of employment, production of more than 75-80% of countries food requirements and having 25-30% of industrial products gross value, indicates the importance of Agricultural sector in Iran's Economy and social situation [8].

On the other hand, this sector usually uses conventional methods and equipments in production chain, which ends in high energy consumption rates. Also it should be mentioned that villagers are (the) low-income section of Iran's population, so increasing or decreasing of energy costs, may make a big deal in their family economy [9, 7].

We should note that, Iran, has done many projects to use clean sources of energy, such as solar electrification of off-grid villages, development projects of wind farms, construction of new Dams and hydro-power plants and so many other projects, which resulted in supplying more than 3.6% of electricity use in Iran, from renewable sources, till 2010. These makes, solar panels, solar water heaters, or even wind turbines, as familiar scenes around the country [4, 5, 7, 10].

But why Fars was chosen as the target zone of this research? Fars is the 5th greatest province of Iran, which is more an agricultural basis province, than an industrial one. It includes 7.5% of total Iran's lands and 6.4% of its population. Rural population of this region is almost 38% of the total province population, which in comparison with the whole country is some how the same (rural population of Iran is about 32% of total country's population). Fars residents consumed 6.6% of gasoline, 4.1 of kerosene, 6.2% of gas oil and 2.1% of fuel oil, of which was consumed in whole country, in 2006. In the same year, agricultural sector of Fars, consumed 29% of total consumed gas oil in province, which made this sector the second consumer of this energy input [3, 5]. This is almost the same as the rate of energy consumption in the whole country.

By determining the high energy consumer appliances and evaluation of ready to use renewable sources of energy, it was possible to make a model to forecast the status of energy demand and consumption in Fars province; and as it mentioned before because of the similarity in energy consumption trends of this region and the whole country, any results gained here, could be assumed for the whole country [3]; Many works and researches were done all over the world to replace the common energy sources, or to maintain reliable energy for the poor, off grid parts of countries, in under development and developing countries. As examples of these, the following could be mentioned:

UK international development program, which is established to study the effect of accessibility to sustainable energy resources on economical, social, environmental issues; such as poverty reduction, access to clean water, reduce in starvation and improvement of sanitary indexes, sexual equality and environmental sustainability [6, 7] REEP (Renewables and Energy Efficiency Programs); which includes many National research programs in different countries; such as China, India, Maldives, Philippines, Brazil, Ghana, South Africa & …; Electrification of off-grid parts of Ghana by wind electric generators, financing by government and International assistance; Installing Photovoltaic generators for electricity, in Zambia; Rural electrification in brazil, financing by national and international sector; Island of energy (Denmark's wind power generation project); and so Many other different projects in China, using renewables to make power are placed in this category [6 4, 1]. In Iran also, there were so many projects done to make renewables useful for community. Mandjil Wind power plant, Persian Gulf solar power plant, Hydrogen and Biofuels production projects in research centers and universities, development of solar baths and subsidized distribution of solar water heaters by government in rural parts and mostly in poor areas of the country, are some of these activities [10]. Also there are some other projects in progress in the Renewable Energy Organization of Iran; preparing the Wind Atlas of the country, which is almost finished; making the Potential Atlas of Solar Radiation in Iran and Study and Evaluation of Geothermal Energy feasibility in North West of Iran, are some of these projects. Because of these projects, Iran is now the leading country in using hydro and wind power in the Middle East [4]. Studies show that there exist a great potential for renewables especially, solar energy in Iran. In long term development program around 1000 MW Solar thermal power plant is to be installed [11]. Due to recent advancements in wind energy, many investors in the country have become interested in investing in this type of energy. At the moment, projects assuming 130 MW of wind power plants are underway, of which, 25 MW is operational [12]. There has been also several projects established to investigate the interactions of public and the private sector in providing energy demands from the different sources. The results showed that there should be more privatization in this sector to have sustainable electricity generation from renewable energy resources economically competitive [13].

MATERIALS AND METHODS

3 steps completed to do this research; which are briefly describe as follows:

- Study of energy consumption and determining of energy consuming equipments and their energy demands.
- Evaluation of the available energy sources, from the farmers point of view and the reality.
- Designing a model to forecast energy sources' status if the present consuming trends continues and if the trends changed.

Study and Determination of Energy Consuming Equipments and Their Energy Demand: Statistics demonstrates that the most energy demand for each household is for their thermal needs [14]. Climate and the mean temperature would be the most effectual factors in energy demands. So we decided to classify the province to several segments based on the temperature. As a matter of fact there is a classification in Fars, which made the province to three distinguished temperature regions, warm, cold and moderate. The first zone has a mean temperature of 19-23°C, the second zone has a mean temperature of 14-17°C and the third has a mean temperature of 17-19°C [15].

In regard to this classification, in each zone 4 villages selected randomly from the list of villages. The list was obtained from the county governor and the publications of ministry of Iran Interior affairs. In each of these villages some households were selected randomly and the questionnaire forms were handed to them. The forms were designed due to energy auditing standards, like ASABE/S612 and the data we need to find the interest of villagers about various energy sources. To achieve the goals of the research, following questions should be answered [16]:

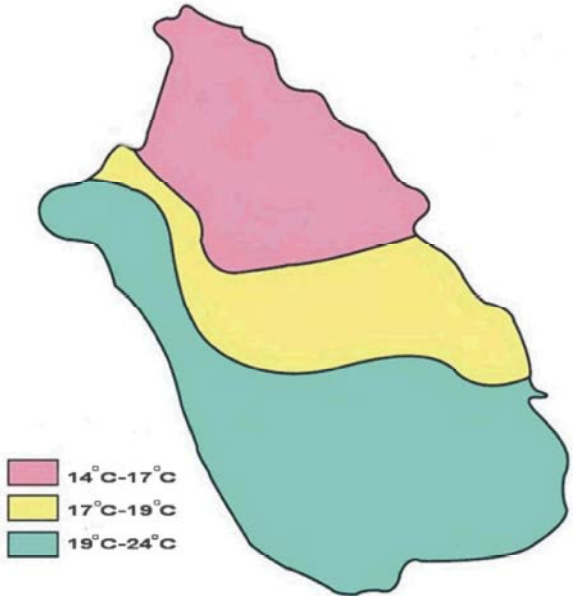

Fig. 2: Fars province temperature regions used in this research

SITE/HOUSEHOLD ASSESSMENT INFORMATION FORM

Assessor Name:	**Appointment Time & Date**:	**Season**: warm□ cold□
Audited 's Name: Age: Gender: Education:	**Audit region**: warm□ temperate□ cold□	
Site Address & Tel:	**Major activity**: Irrigated farming□ Dry farming□ Gardening □ Animal husbandry□ Green house cultivation□	
Household information: Residents: Mean Age:	**Education level of family**:	
Lodging information: Area : Windows orientation: No. of Floors: Wall & Floor Insulation type: Piping Insulation type:		

Client Renewable Energy Interest

❒ Environmental ❒ Save Energy ❒ Reduce Energy Bills ❒ Energy Independence ❒ Reliability
❒ Other _____

Energy Sources Used

Electricity □ Natural Gas (grid) □ Natural Gas (compressed) □ Kerosene □ Gas Oil□ Gasoline □ Wood□

Major Consumptions of Energy:

	electricity	Natural Gas (grid)	Natural Gas (compressed)	Kerosene	Gas Oil	Gasoline	Wood
Lighting							
Heating							
Triggering house equipments							
Triggering husbandry equipments							
Triggering farm equipments							
Other							
Monthly Consumption Rates							

Major Consumers Data:

	Consumer	No.	Nominal Consumption Rate	Total Consumption
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Fig. 3a: Audit questionnaire energy sources used and the appliances data for households

Hot Water & Air Heating System:

- Piping type : Above ground□ Under ground□
- Are the pipes Insulated? Yes □ No□
- Water heater type : Gas Operated Water Heater □ Electrical Water Heater □ Kerosene Operated Water Heater□
- Hot Water Tank Insulated: Yes □ No□
- How to warm residential environment:

Windows Information:
Area of Windows:

Site and Equipment Sketch
Site Plan, Roof Plan, Key Dimensions

Fig. 3b: Audit questionnaire Site sketch data, hot water system data

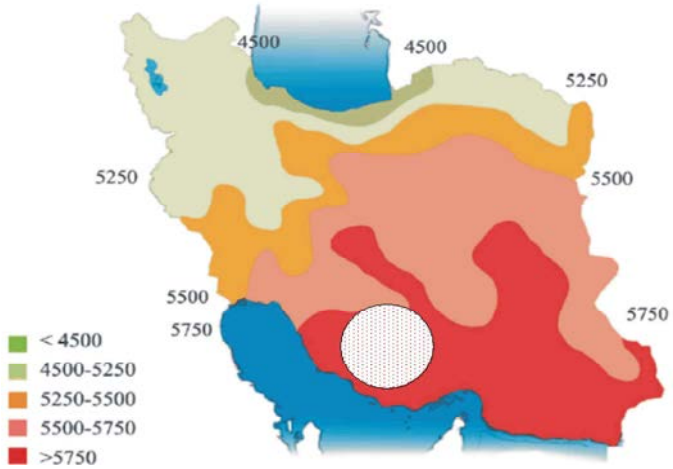

Fig. 4: Solar radiation Potential of Iran, Circle shows Fars Province on the map (figures in w.h/m^{2}day)

- Which energy sources are used in the village, in houses and in agricultural activities?
- How do consumers obtain fuel and energy? (e.g. gas fuel obtained as LPG capsules, Kerosene sold by mobile tankers and …)
- Which equipments and appliances are used in the field and houses and how much is the energy demand?
- What is the renewable potential in the region and do villagers like to use them as their source of energy?

The answers could be gained from the questionnaire forms, mentioned before (Figure 3).

Renewables Potential in Fars Region: Studies done by government organizations, such as Renewable Energy Organization of Iran and other organizations, showed that there is a great potential of solar energy in almost all parts of Iran, especially in Fars. Fars also has a good background of using this energy, so it seems that in short and medium term plans, solar energy would be the best choice to replace the fossil fuels, for maintaining thermal needs [5] (Figure 4).

Data Analysis: Collected data were examined by experts and the AHP analysis was done by Expert Choice software, version 11.0.0. Different sources of energy like wind, solar, gas oil, kerosene, gasoline and some others were compared with each other. The sources were compared according to six following factors [17, 18]:

- Availability
- Generation cost
- Emission of CO_2
- Storability
- Safety
- Investment cost.

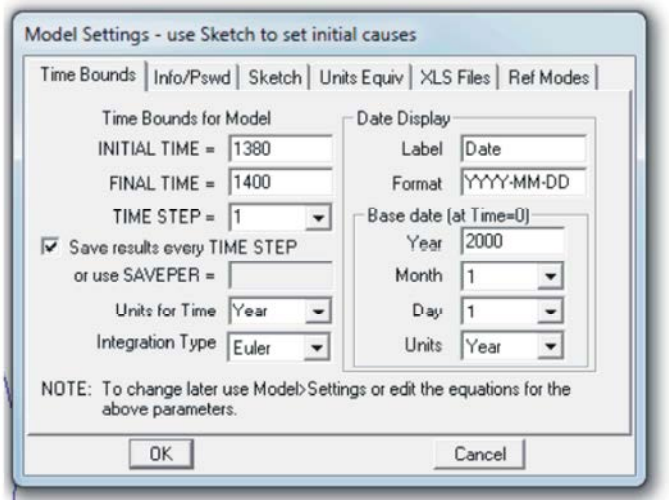

Fig. 5: Modeling settings in VENSIM software

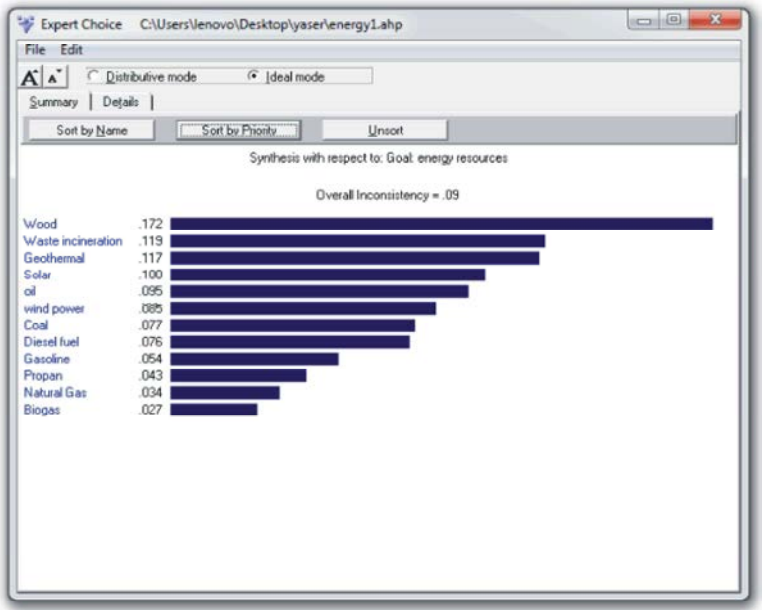

Fig. 6: Results of AHP analysis by Expert Choice 11.0.0

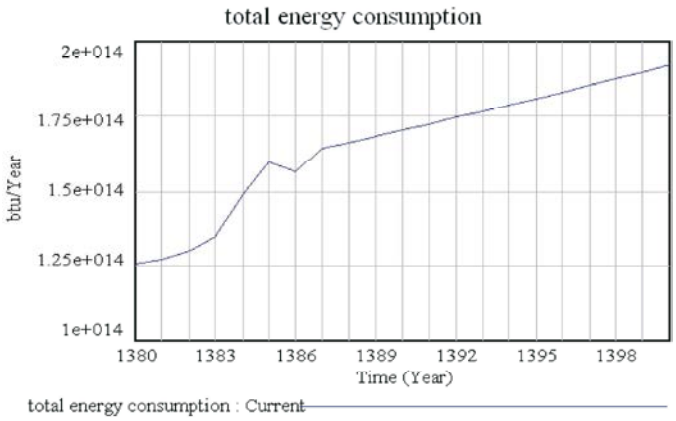

Fig. 7: Total energy consumption trend, due to evaluated model (from 2002-2022)

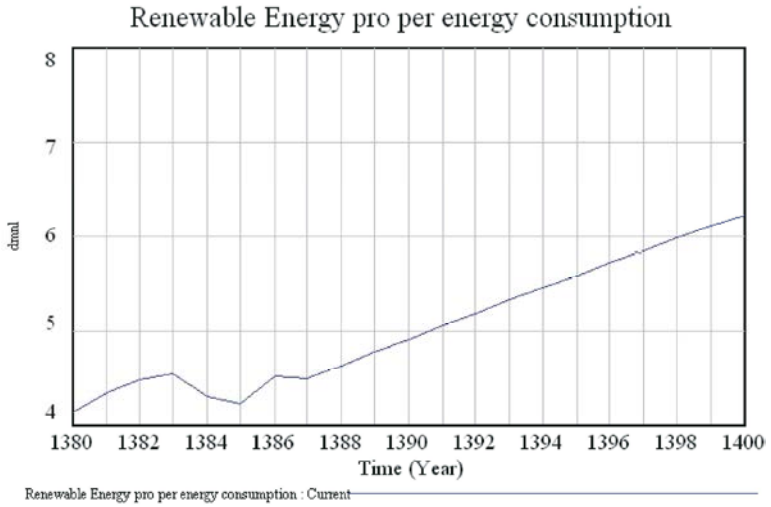

Fig. 8: Energy production from renewable resources due to evaluated model (from 2002-2022)

Finally the collected data and the official statistics from department of energy and the ministry of Oil, were used to establish a model to forecast the status of energy resources in Iran. VENSIM was used as the modeling software and to simulate the model, the Euler Integration method was used. Year 2002, was chosen as starting year and 2022 as the final year of simulation.

The model and the simulation trend of using energy in province are shown in figures.

RESULTS

As it was mentioned before, the first step was doing an energy audit in selected villages. Results of this step indicated the total energy need of the selected rural household, where as the data can be used in determining the most energy consuming activities or facilities, in the home or on the fields. Also by processing the questionnaire forms, the opinion of the villagers about using sources of energy other than the conventional ones, could be obtained [16].

Results showed that, as the same as the other segments of community, highest utilization of gas oil and gasoline, related to transportation and operating the heavy duty field machines. The other sources of energy like electricity, wood, kerosene, LPG and the others are mainly used for lighting, space heating or cooling and cooking [19, 17].

According to AHP analysis results, regarding to six comparison factors mentioned above, wood would be the best choice as an energy resource, but due to actual state of environment restrictions, it won't be recommended. Due to actual status, Solar and Wind energy would be the best choices to maintain energy needs of rural community. Although Solar electricity is still expensive, but regarding to limitation of fossil resources and the high investment and production cost of them and also their environment pollutant capability and the government's plan to eliminate the subsides of energy in the country, it would be more admissible. The other reasons we can add to the above ones to propose solar energy as the alternative energy for fossil fuels, is that this source has no monthly and high service and maintenance costs form the energy providers [19, 18, 1].

CONCLUSION

Any proposal for decreasing fossil energy consumption needs to consider the exact amount of energy demand, but it should also be considered that the first step in energy management is to increase energy efficiency, which in turn, at first, must replace conventional methods with more efficient ones and then decide to replace high energy demand equipments with lower energy demanding appliances. To do so, we shall have the information on how energy is being used in the region, which is gained by analyzing the audit forms; but it should be considered that changing the present technology is a hard thing to do. Changing the energy consumer technologies like diesel machines and heavy duty ones which consume high amounts of refined fossil fuels, is very difficult; because:

- There should be a large amount of investment to change the current technology [9].

- There should be a training plan to train the villagers, on how they can use new equipments [9]
- If the current technology wanted to be changed, then there should be a wide attorney network to support the new equipments and offer the services to the customers, which would not be practicable in short or even medium term plans [9].

So it would be more executable to change the common facilities, like water heaters or lightings which won't need to have a training program, in the first step and then in further steps try to change some higher energy consumer equipments like water pumps and others.

Due to high potential of solar energy in Iran and especially in Fars, it seems that the most in hand energy source which can be easily supersede for conventional fuels, would be this source and wind, or other resources, would take the next places.

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