Identifying the effective factors for implementing solar water heaters (SWH) for Yazd, Iran

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Abstract

Solar Water Heating (SWH) refers to the process of providing hot water with the help of solar energy. There is a strong potential for implementing of solar water heaters in Iran. Yazd is a province in Iran which has a great potential for solar energy. The purpose of this research is to identify and prioritize the factors associated with the use of SWH systems in Yazd province. The required data is collected using questionnaire which is then processed with SPSS software and confirmatory factor analysis method. The suitability of data for factor analysis is investigated with KMO and Bartlett's sphericity tests and then components (factors) and subcomponents (items) are obtained with the help of Scree test. The results of analyses on the factors associated with the construction and operation of solar water heaters indicate that environmental issues have direct effect on the use of solar water heater and the effects of other factors are indirect. Also, according to the results, financial support of the government has the biggest effect on implementation of SWH.

Keywords
Solar water heating; factor analysis; arid regions; risk factors.

1. Introduction

While being economic and easy to use, traditional energy sources such as oil, coal and natural gas have well-known adverse effects on environment and human being. Fossil fuels produce pollutants such as sulfur dioxide (SO2), nitrogen oxide (NOx), carbon monoxide (CO), hazardous chemicals, and more importantly carbon dioxide, which has direct environmental consequences such as global warming (Ghobadian et al., 2009). The root cause of increasing greenhouse gas emissions is the steady growth of economic and industrial development without adequate means and motivation to offset the consequent environmental effects. It is estimated that continuation of current trends will lead to 2-4°C increase in the earth's temperature and 30-60 cm rise of sea level in the coming century (Kalogirou, 2004). Iran is an energy-rich country with ample reserves of fossil fuels such as oil and gas, but it also has a great potential for solar and geothermal and wind energy (Mohammadi et al., 2014; Shamshirband et al., 2015). Several research have been done to evaluate performance of passive techniques and find the reliability and viability of renewable energies in different location and climate of Iran. Goudarzi and Mostafaeipour (2017) carried

out a research about performance of four different passive techniques in hot and dry region of Iran. Alavi et al. (2016) studied on potential of electricity generation by wind turbine in Kerman city. Mostafaeipour et al. (2014) evaluated the impact of wind catcher and underground building on energy reduction of warehouse in Yazd city. Saljoughinejad and Sharifabad (2015) reviewed passive techniques in vernacular houses in Iran. Abbaspour Fard et al. (2011) carried out an experimental study to evaluate cooling potential of EAHE in Mashhad city.
Iran is an energy-rich country with ample reserves of fossil fuels such as oil and gas, but it also has a great potential for harvesting solar, wind, and geothermal energy. This country is located between 25 and 40 degrees north latitude in an area with the highest potential in terms of solar energy. Iran's solar irradiation is estimated to be between 1800 and 2200 kWh/m2, which is higher than the global average (Chang et al., 2009). It is also estimated that in 80% of Iran' geographical domain, average daily irradiation on horizontal surface is about 4.5-5.4 kWh/m2 and the annual count of sunny days reaches to 240 to 250 days; estimations that highlight the great solar energy potentials of the country (Janjai et al., 2009). Tsoutsos et al. (2005) reviewed environmental impacts of solar energy system, including photovoltaics, solar thermal and solar power. Rezaei-Shouroki et al. (2017) investigated a study to use renewable wind energy for Fars province which is located in Southwest of Yazd Province. But wind energy is not suitable for Yazd since there are not enough wind power potential for installing commercial turbines. Many researchers investigated use of different renewable energies in Iran which their findings show that it is possible to invest in many parts of Iran (Alavi et al., 2016a; Alavi et al., 2016b; Alavi et al., 2016c; Ezzabadi et al., 2015; Fereidooni et al., 2018; Goudarzi and Mostafaeipour, 2017; Minaeian et al., 2017; Mostafaeipour and Abessi, 2010; Mostafaeipour et al., 2016a; Mostafaeipour et al., 2016b; Mostafaeipour et al., 2014; Mostafaeipour et al., 2017; Mohammadi et al., 2016a; Mohammadi et al., 2016b; Qolipour et al., 2016; Qolipour et al., 2017; Ramezankhani et al, 2016; Sedaghat et al., 2017; Zarezade and Mostafaeipour, 2016).Although Yazd gains high intensity of solar radiation and there is an appropriate potential to employ and develop various types of renewable energies, such as solar water heaters, based on solar radiation, there is no study about most important factors for installation and implementation of solar water heaters(SWH) in this city. For the first time, this paper identifies and prioritizes the most important factors for installation and implementation of SWH in city of Yazd using the factor analysis methodology. Clearly, the main objective of this study is to identify and prioritize the factors associated with the use of SWH systems in Yazd province. The rest of this paper is organized as follow: literature review on solar water heaters is reviewed in Section 1.1. The method and material is discussed in Section 2. Results and discussion is presented in Section 3. And the conclusion is drawn in Section 4.

1.1. **Solar water heating**

Solar water heating (SWH) is one of the popular passive systems for providing hot water for small-scale applications. The main components of a SWH are the collector, heat transfer pipes, pump, fan and fluid (Sadhishkumar et al., 2014). This system has a potential to reduce 60-80% of thermal energy to provide heated water over a year (Sabiha et al., 2014). In general, there are two types of SWH. The first type is the Active System, or the forced flow system, where pump and taps force a flow between the collector and storage tank. This system can be classified into two types of direct flow (open loop) and indirect flow (closed loop) (Seveda, 2013). The second type of SWH is the Passive System, which utilizes natural convection due to density differences. This system is based on a simple mechanism, where the heated fluid loses density and becomes lighter, and thus flows up toward the collector and then into the storage tank, while the cold fluid flows down toward the tank floor and enters the collector. There are also several types of passive systems, including: thermo syphon, integrated system with storage, etc (Raisul Islam et al., 2013). In fact; various studies about solar water heating (SWH) have been done. Mehmet and Hikmat Esen (2005) conducted an experimental study on two phase closed thermo syphon solar water heater. Kalogirau et al. [5] reviewed various types of solar thermal collectors including flat-plate, compound parabolic, evacuated tube, parabolic trough, Fresnel lens, parabolic dish, and heliostat field collectors. Prasad et al. (2010) conducted an experimental research to compare performance of fixed flat plate water heater with that of heater with tracking. Results showed that heater with tracking, improves 21% performance of the water system and 4○C in the outlet temperature. Camargo Nogueira et al. (2016) developed an algorithm to predict technical and economical solutions for the solar water heating system in MATLAB software. Shrivastava et al. (2017) employed TRNSYS software to evaluate and predict performance of SWH under different conditions. The results showed error ranging from 5% to 10% between simulation data and reviewed experimental data. Also, the same studies have been conducted in different countries previously.

2. Method and materials

Factor analysis is a well-known method for taking a mass of data to shrink them to a smaller data set in order to be more understandable and manageable. It is a method for finding hidden patterns, and shows how the patterns overlap and what characteristics are visible in multiple patterns. Factor analysis is being used for creating a set of variables for similar items in the set (the variable sets are called dimensions). This is a common method for complex sets of data in different fields such as psychology, socioeconomic, and other related issues. A "factor" is a set of observed variables that have similar response patterns, because they are associated with a variable that isn't directly measured. Factor analysis is a statistical method that is used to describe variability among observed variables in terms of a potentially lower number of unobserved variables called factors (Grover et al., 2017). For example, it is possible that variations in six observed variables mainly reflect the variations in two unobserved (underlying) variables The observed variables are modeled as linear combinations of the factors plus ''error'' terms (Scheid et al., 2017). The information obtained about the interdependencies among the variables can be used later to reduce the set of variables in a dataset (Turner et al., 2017). With factor analysis, one can produce a small number of factors from a large number of variables; these factors are in turn capable of explaining the observed variance in the larger number of variables.

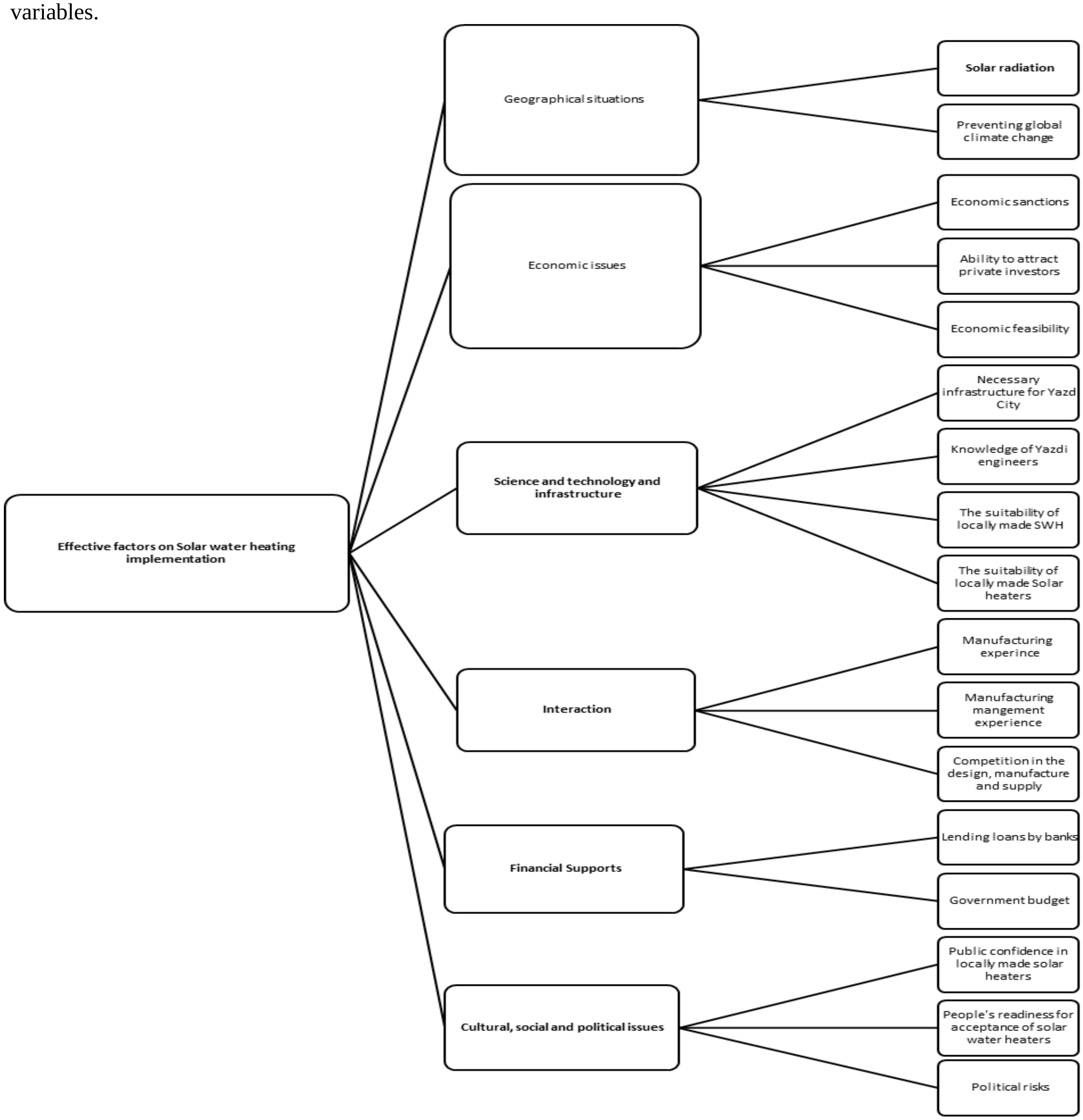

Figure 1. Configuration of effective items on solar water heating in Yazd City.

Four stages of factor analysis are shown as following (Nunes, 2002):

- Data are gathered then a correlation matrix is set for the variables.
- Factors that are related to the correlation coefficients of the variables are extracted from the correlation matrix.
- Factors are rotated in order to maximize the relationship between the variables and some of the factors.
- Factors are scored in order to observe the positions of the variables.

In this study, required data was collected by questionnaire. In this process, first the demographic characteristics (age, sex, education) were acquired. Next, the primary factors associated with the design, construction, and operation of SWH systems were identified. The identified factors included geographical location and environmental issues; economic issues; level of science, technology and infrastructure; collaborations; financial support; and cultural, social, and political issue. Figure 1 illustrates a summary of factors associated with the construction and operation of solar water heaters in Yazd. This part of questionnaire was designed based on the 5-point Likert scale (strongly agree, agree, no opinion, disagree, and strongly disagree). In addition, the importance of each of the mentioned factors was enquired based on the 5-point Likert scale (very low, low, medium, high and very high).

This study also examined some of the risks that are associated with the construction and operation of SWH system and may undermine the success of such effort. In this study, financial issues such as exchange rate, interest rate, price, budget, and administrative risks were considered as the "financial risks" associated with the success of effort; the risks associated with deviation of construction from the design, health, safety and environment, and project delivery were studied under the term of "manufacturing risks"; and the factors such as economic environment, laws and regulations, political risk, and demand risk were considered under the label of "external risks". Figure 2 presents a summary of the risks examined in this study. Inquiries about these risks were also made by the questions devised based on the 5-point Likert scale (very low, low, medium, high and very high).

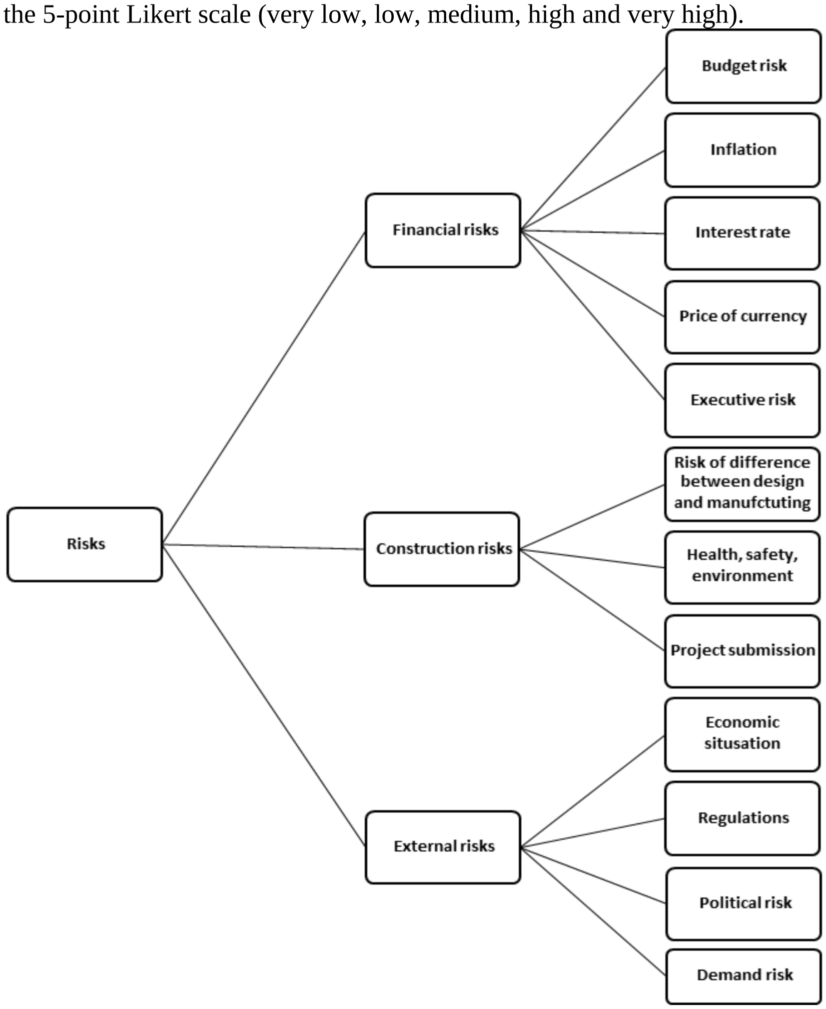

Figure 2. The effective risks on the solar water heating systems implementation.

At the end of the questionnaire, respondents were asked to provide any suggestions about improving the design, construction and operation of solar water heaters.

3. Results and discussion

3.1. Reliability and validity of the questionnaire

Reliability of a measuring tool refers to reliability, consistency and accuracy of the results. A test can be called reliable if it yields the same results when repeated in the same condition. To determine the reliability of the questionnaire, it was distributed among 30 people, and the results provided in 26 questionnaires, which met the acceptance criteria, were analyzed with the software SPSS. In this software, the questioned factors q_n (n = 1,2,3, ..., 20), the importance of factors I_n (n = 1,2,3, ... 20), the risks R_n (n = 1 2,3, ..., 12), and the response parameter (the likelihood of the use of SWH systems in Yazd) were introduced as variables. There are two types of validity, content validity and construct validity. Content validity refers to the ability of the questionnaire to cover all aspects and components of the subject that it is made to measure. In this study, content validity of the questionnaire was approved by the experts. The city of Yazd has a population of about 660,000 people, so sample size was determined using the Cochran's formula (Eq. (1) and (2)).

$$n = \frac{n_0}{1+\frac{n_0-1}{N}} \qquad (1)$$

$$n_0 = \frac{Z_{\frac{\alpha}{2}}^2 p(1-p)}{E^2} \qquad (2)$$

Where:
n = sample size;
N = population size;
Z = acceptable standard error in confidence level;
p = proportion of the population having the targeted trait (e.g. people who respond);
q = proportion of the population lacking the targeted trait (e.g. people who do not respond);
E = confidence level with desired potential accuracy.

In this study, α was considered to be 8% and both p and q were considered to be 0.5; in other words, it was assumed that 50% of people would properly fill the questionnaire. Parameter E was considered to be 0.05. Using the Cochran's formula, proper sample size was estimated to 144 people. To offset the error in filling the questionnaires, a total of 150 questionnaires were distributed among the population (people of Yazd) and eventually 145 properly filled questionnaires were collected.

3.2. Factor analysis

The suitability of confirmatory factor analysis for identifying the factors affecting the applicability of SWH system in Yazd was measured using the Kaiser-Meyer-Olkin (KMO) test. This test determines whether the variance of research variables is affected by the variance of observed and latent factors. The value of this statistic varies between 0 and 1, and this range is divided into three intervals:
KMO<0.49: factor analysis is not recommended and significant modifications are needed before data would be suitable for such analysis.
0.5<KMO<0.69: factor analysis is a relatively suitable strategy.
0.7<KMO: Factor analysis is completely suitable and highly recommended.
The result of KMO and Bartlett's test for each studied factor are presented and analyzed in the following. Table 1 shows the factor loadings and component coefficient of the factors involved with the use of SWH system.
The values for factor loading items for geographic location and environmental issues are both equal to 0.771 (Table 1), It can be concluded that both items are suitable these components. Geographic location and environmental issues have only two items which their component coefficients are equal to 0.648. This shows that the impact of the items in the components are relatively good.

Table 1. Factor loadings and component coefficients of geographic location and environmental issues.

Item	Items	Factor loading	Component coefficient
1	Suitable solar radiation is the advantage of manufacturing of SWH in Yazd.	0.771	0.648
2	The use of solar water heaters instead of conventional water heaters can be a solution to climate change.	0.771	0.648

The values for factor loading items for economic problems are equal to 0.767, 0.546, and 0.762 (Table 2), it can be concluded that three items are suitable for these components. Economic problems have only three items which their component coefficients are almost 0.6. This shows that the impact of the items in the components are relatively good.

Table 2. Factor loadings and component coefficients of economic problems.

Item	Items	Factor loading	Component coefficient
3	It is possible to attract private investors to build solar water heaters in there Yazd.	0.767	0.686
4	Economic sanctions on Iran is the main obstacle to making solar water heater installations.	0.546	0.632
5	The use of solar water heaters in Yazd is economically feasible.	0.762	0.651

The values for factor loading items for financial support are both equal to 0.836, (Table 3), it can be concluded that two items are suitable for these components. Financial support have only two items which their component coefficients are 0.598. This shows that the impact of the items in the components are relatively good.

Table 3. Factor loadings and component coefficients of financial support.

Item	Items	Factor loading	Component coefficient
6	The main issue is that banks refuses to allocate loan for project of Solar water heating.	0.836	0.598
7	The Government do not budget for projects of Solar water heating.	0.836	0.598

The values for factor loading items for infrastructures, technology, and knowledge are all more than 0.6 (Table 4), it can be concluded that four items are suitable for these components. Infrastructures, technology, and knowledge have only four items which their component coefficients are almost 0.3. This shows that the impact of the items in the components are relatively same and good.

Table 4. Factor loadings and component coefficients of infrastructures, technology, and knowledge.

Item	Items	Factor loading	Component coefficient
8	Yazd has necessary infrastructure such as knowledge, facilities and so on.	0.680	0.330
9	Local engineers in Yazd have enough knowledge and facilities to design Solar water heater properly.	0.678	0.329
10	Iran made Solar water heaters are appropriate for industrial of solar energy.	0.786	0.381
11	Yazd has a bright future by implementation of Solar water heating system.	0.721	0.350

The values for factor loading items for interaction are all more than 0.7 (Table 5), it can be concluded that three items are suitable for these components. Interaction has only three items which their component coefficients are almost 0.4. This shows that the impact of the items in the components are relatively good. The effect of items 1, 3, and 2 are decreasing respectively.

Table 5. Factor loadings and component coefficients of interaction.

Item	Items	Factor loading	Component coefficient
1	There is lack of enough experience about solar water heater in city of Yazd.	0.701	0.416
2	There is no experience about construction management of solar water heater.	0.789	0.468
3	Lack of competitive markets to produce solar water heater in Yazd.	0.756	0.449

The values for factor loading items for culture, society, and politics are all acceptable except items no. 2 and 3 (Table 6), it can be concluded that people in Yazd do not have enough knowledge about advantageous and disadvantageous of solar water heater, but are ready to accept using solar water heater.

Table 6. Factor loadings and component coefficients of culture, society, and politics.

Item	Items	Factor loading	Component coefficient
1	People in Yazd do not have enough knowledge about advantageous and disadvantageous of solar water heater.	0.507	-0.394
2	People has more confidence in imported solar water heaters rather than Iranian productions.	0.298	0.231
3	There are various types of risks in Iran including investment risk for foreign investors in Iran	-0.0540	-0.419
4	People in Yazd ready to accept using solar water heater.	0.870	0.626

The values for factor loading items for financial risks are all more than 0.495, except construction risk with value of 0.192 (Table 7), it can be concluded that four items are suitable for these components, but construction risk is not suitable. Financial risks have five items which only two of them have component coefficient of less than 0.3 This shows that the impact of the items in the remaining components are relatively good.

Table 7. Factor loadings and component coefficients for financial risks.

Item	Items	Factor loading	Component coefficient
1	Inflation	0.495	0.316
2	Currency price	0.748	0.477
3	Interest rate	0.718	0.458
4	Price and budget risk	0.495	0.293
5	Constructional risk	0.192	0.123

The values for factor loading items for infrastructure risks are all more than 0.6 (Table 8), it can be concluded that three items are suitable for these components. Infrastructure risks have only three items which their component coefficients are almost 0.4645, 0.645, and 0.697 respectively which shows decrease of their effectiveness impacts respectively.

Table 8. Factor loadings and component coefficients of infrastructure risks.

Item	Items	Factor loading	Component coefficient
24	Risk difference between design and manufacturing	0.776	0.464
25	Health, Safety and Environment	0.694	0.645
26	Project submission	0.751	0.697

Table 9 shows that four items are suitable for these components. External risks component coefficients are not almost equal. It shows that regulations risks have more effects than others.

Table 9. Factor loadings and component coefficients of external risks.

Item	Items	Factor loading	Component coefficient
27	Economic situation	0.405	0.265
28	Regulations	0.842	0.551
29	Demanding risk	0.701	0.458
30	Political risk	0.405	0.265

Based on the factor analysis described in Tables 1 to 9, it was found that the factors affecting the use of SWH system in Yazd can be classified into 6 primary categories listed in Table 10.

Table 10. Factors affecting the use of SWH system in Yazd.

Components	**Factor**
Geographical location and environmental issues	Solar radiation.
	Preventing global climate change.
Economic issues	Attract private sector to invest.
	Economic benefits.
	Economic sanction.
Financial support	Allocation of Bank's loan.
	Governmental budget.
Science, technology and infrastructure	Enough knowledge, information and facilities to proper design.
	Necessary infrastructures
	Appropriation of Iran made Solar water heaters for industrial of solar energy.
	Appropriation of production of Solar water heater
Interactions	Lack of enough experience to produce Solar water heater.
	There is no experience about construction management of Solar water heater.
Cultural, social and political	People in Yazd has not enough knowledge about advantageous and disadvantageous of Solar water heater.
	People has more confidence in imported Solar water heaters rather than Iranian productions.
	People in Yazd ready to accept using Solar water heater.
	Political risks
	People in Yazd has not enough knowledge about advantageous and disadvantageous of Solar water heater.

Based on the factor analysis described in Tables 1 to 9, it was found that there are three main risks associating with SWH manufacturing in Yazd. The risks and factors are presented in Table 12.

Table 12. Final risks and factors related to SWH manufacturing in Yazd.

Risks	**Factors**
Financial risk	Inflation
	Currency price
	Interest rate
	Price and budget risk
Manufacturing risk	Risk difference between design and manufacturing
	Health, Safety and Environment
	Project submission
External risk	Economic situation
	Regulations
	Demanding risk
	Political risk

4. Conclusion

The goal of this study was to identify and prioritize the factors affecting the use of solar water heaters in Yazd using the factor analysis methodology. This is the first study that uses factor analysis for investigating the factors affecting the use of solar water heaters; so its results can contribute to the progress and success of programs associated with further use of solar water heating systems. The factors affecting the design, construction and operation of solar water heaters and the risks that may undermine this process were identified by preliminary studies on solar energy and then solar water heaters, their components, functions of each component, and different types of these heaters. The most important results of this study are as follows:

- In areas where there is a great potential for exploitation of solar energy, the people's tendency toward the efficient use of solar energy and solar-based techniques and appliances increases with their awareness about available solar options and applications.
- Finally, 74.62% of the participants expressed a positive view on the prospect of using solar water heaters in Yazd. The risks associated with the implementation of such project can be divided into three major categories: financial risks, construction risks, and external risks.
- Classification of factors affecting implementation of solar water heater in Yazd indicates that there are six components which can be considered like: Geographic location and environmental issues; economic problems; financial support; infrastructures, technology, and knowledge; interaction; culture, society, and politics.
- There are three main risks in implementing solar water heaters which can be divided into the following three categories: internal; external; and manufacturing risks.
- Based on the results and the model obtained in this study, all factors affecting the design, construction, and implementation of solar water heating systems in Yazd were identified and prioritized. According to the results, to develop and promote the use of solar water heating systems in Yazd, government should focus on the economic issues, financial support, and infrastructure associated with this effort. Boosting the level of local engineering knowledge and technology related to manufacture and maintenance of solar water heaters and promoting the design and manufacturing techniques required for such efforts will allow the solar-based systems to be utilized with greater efficiency.

References

Abbaspour-Fard, MH., Gholami, A., and Khojastehpour, M., Evaluation of an earth-to-air heat exchanger for the north-east of Iran with semi-arid climate, Internatinal Journal of Green Energy, vol. 8, pp. 499-510, 2011.

Alavi O., Sedaghat A., Mostafaeipour A., Sensitivity analysis of different wind speed distribution models with actual and truncated wind data: a case study for Kerman, Iran, Energy Conversion and Management, vol. 120, pp. 51-61, 2016a.

Alavi O., Mohammadi K., Mostafaeipour A., Evaluating the suitability of wind speed probability distribution models: A case of study of east and southeast parts of Iran, Energy Conversion and Management, vol. 119, pp.101-108, 2016b.

Alavi, O., Mostafaeipour, A., and Qolipour, M., Analysis of hydrogen production from wind energy in the southeast of Iran. International Journal of Hydrogen Energy, vol. 41, no.34, pp. 15158–15171, 2016c.

Chang, K.C., Lin, W.M., Lee, T.S., and Chung, K.M., Local market of solar water heaters in Taiwan: Review and perspectives, Renewable and Sustainable Energy Reviews, vol. 13, pp. 2605-2612, 2009.

Camargo Nogueira, C.E., Vidotto, M.L., Toniazzo, F., and Debastiani, G., Software for designing solar water heating systems, Renewable and Sustainable Energy Reviews, vol. 58, pp. 361-375, 2016.

Ghobadian, B., Najafi, G., Rahimi, H., and Yusaf, T., Future of renewable energies in Iran, Renewable and Sustainable Energy Reviews, vol. 13, pp. 689-695, 2009.

Grover, S., Sahoo, S., Du, D., Chakrabarti, S., and Avasthi, A., Scales for assessment of depression in schizophrenia: Factor analysis of calgary depression rating scale and hamilton depression rating scale, Psychiatry Research, vol. 252, pp. 333–339, 2017.

Goudarzi, H., and Mostafaeipour, A., Energy saving evaluation of passive systems for residential buildings in hot and dry regions, Renewable and Sustainable Energy Reviews, vol. 68, Part 1, pp. 432-446, 2017.

Esen, M., and Esen, H., Experimental investigation of a two-phase closed thermosyphon solar water heater, Solar

Energy, vol. 79, pp. 459-468, 2005.

Ezzabadi J.H., Saryazdi M.D., Mostafaeipour A., Implementing Fuzzy Logic and AHP into the EFQM model for performance improvement: A case study, Applied Soft Computing, Vol. 36, pp.165-76, 2015.

Fereidooni M., Mostafaeipour A., Kalantar V., Goudarzi H., A comprehensive evaluation of hydrogen production from photovoltaic power station. Renewable and Sustainable Energy Reviews. vol. 82, pp.415-423, 2018.

Goudarzi H., Mostafaeipour A., Energy saving evaluation of passive systems for residential buildings in hot and dry regions, Renewable and Sustainable Energy Reviews, vol. 68, pp. 432-446, 2017.

Janjai, S., Pankaew, P., and Laksanaboonsong, J., A model for calculating hourly global solar radiation from satellite data in the tropics, Applied Energy, vol. 86, pp. 1450-1457, 2009.

Kalogirou, S.A., Solar thermal collectors and applications, Program Energy Computer Science, vol. 30, pp. 231-295, 2004.

Minaeian A., Sedaghat A., Mostafaeipour A., Alemrajabi A.A., Exploring economy of small communities and households by investing on harnessing wind energy in the province of Sistan-Baluchestan in Iran,, Renewable and Sustainable Energy Reviews, vol. 74, pp. 835-847, 2017.

Mohammadi, K., Mostafaeipour, A., Dinpashoh, Y., and Pouya, N., Electricity generation and energy cost estimation of large-scale wind turbines in Jarandagh, Iran, Journal of Energy, 2014.

Mohammadi K., Alavi O., Mostafaeipour A., Goudarzi N., Jalilvand M., Assessing different parameters estimation methods of Weibull distribution to compute wind power density, Energy Conversion and Management, vol. 108, pp. 322-335, 2016a.

Mohammadi, K., Alavi, O., Mostafaeipour, A., Goudarzi, N., Jalilvand, M., Assessing different parameters estimation methods of Weibull distribution to compute wind power density, Energy Conversion and Management, vol. 108, pp. 322-335, 2016b.

Mostafaeipour A., Abesi S., Wind turbine productivity and development in Iran. Biosciences (BIOSCIENCESWORLD), 2010 international conference on, 112-118

Mostafaeipour A., Qolipour M., Mohammadi K., Evaluation of installing photovoltaic plants using a hybrid approach for Khuzestan province, Iran, Renewable and Sustainable Energy Reviews, vol. 60: pp. 60-74, 2016a.

Mostafaeipour A., Khayyami M., Sedaghat A., Mohammadi K., Shamshirband S., Sehati M.A., Gorakifard, E., Evaluating the wind energy potential for hydrogen production: A case study, International Journal of Hydrogen Energy, vol. 41, issue 15, pp. 6200-6210, 2016b.

Mostafaeipour A., Bardel B., Mohammadi K., Sedaghat A., Dinpashoh Y., Economic evaluation for cooling and ventilation of medicine storage warehouses utilizing wind catchers, Renewable and Sustainable Energy Reviews, vol. 38: pp. 12-19, 2014.

Mostafaeipour A., Zarezade M., Goudarzi H., Rezaei-Shouroki M., Qolipour M., Investigating the factors on using the solar water heaters for dry arid regions: A case study, Renewable and Sustainable Energy Reviews, vol. 78, pp. 157-166, 2017.

Nunes, P., Using factor analysis to identify consumer preferences for the protection of a natural area in Portugal, European Journal of Operational Research, vol. 140, pp. 499–516, 2002.

Qolipour M., Mostafaeipour A., Shamshirband S., Alavi O., Goudarzi H., Petković D., Evaluation of wind power generation potential using a three hybrid approach for households in Ardebil Province, Iran, Energy Conversion and Management, vol. 118, pp. 295-305, 2016.

Qolipour M., Mostafaeipour A., Tousi O.M., Techno-economic feasibility of a photovoltaic-wind power plant construction for electric and hydrogen production: A case study, Renewable and Sustainable Energy Reviews, vol. 78, pp.113-123, 2017.

Ramazankhani M.E., Mostafaeipour A., Hosseininasab H., Fakhrzad M.B., Feasibility of geothermal power assisted hydrogen production in Iran, International Journal of Hydrogen Energy, vol. 41, issue 41, pp.18351-18369, 2016.

Rhushi Prasad, P., Byregowda, H., and Gangavati, P., Experiment analysis of flat plate collector and comparison of performance with tracking collector, European Journal of Science and Research, vol. 40, pp. 144-155, 2010.

Raisul Islam, M., Sumathy, K., and Ullah Khan, S., Solar water heating systems and their market trends, Renewable and Sustainable Energy Reviews, vol. 17, pp. 1-25, 2013.

Rezaei-Shouroki, M., Mostafaeipour, A., and Qolipour, M., Prioritizing of wind farm locations for hydrogen production: A case study, International Journal of Hydrogen Energy, 2017. http://dx.doi.org/10.1016/j.ijhydene.2017.02.072

Sedaghat A., Hassanzadeh A., Jamali J., Mostafaeipour A., Chen W.H., Determination of rated wind speed for maximum annual energy production of variable speed wind turbines, Applied Energy, vol. 205, pp. 781-789, 2017.

Seveda, M.S., Performance analysis of solar water heater in NEH region of India, International journal of renewable and sustainable Energy, vol. 2, pp. 93-98, 2013.

Sadhishkumar, S., and Balusamy, T., Performance improvement in solar water heating systems: A review, Renewable and Sustainable Energy Reviews, vol. 37, pp. 191-198, 2014.

Saljoughinejad, S., and Rashidi Sharifabad, S., Classification of climatic strategies, used in Iranian vernacular residences based on spatial constituent elements, Building Environmental, vol. 92, pp. 475-493, 2015.

Shamshirband, S., Mohammadi, K., Yee, P.L., Petkovic, D., and Mostafaeipour, A., A comparative evaluation for identifying the suitability of extreme learning machine to predict horizontal global solar radiation, Renewable and Sustainable Energy Reviews, vol. 52, pp. 1031-1042, 2015.

Sabiha, M., Saidur, R., Mekhilef, S., and Mahian, O., Progress and latest developments of evacuated tube solar collectors, Renewable and Sustainable Energy Reviews, vol. 51, pp. 1038-1054, 2015.

Shrivastava, R.L., Vinod, K., and Untawale, S.P., Modeling and simulation of solar water heater: A TRNSYS perspective, Renewable and Sustainable Energy Reviews, vol. 67, pp. 126-143, 2017.

Scheid, V., Tuffrey, V., and Bovey, M., Chinese herbal medicine for treating menopausal symptoms in London women: developing a good practice protocol via the factor analysis of prescribing patterns in a clinical study, Complementary Therapies in Medicine, vol. 32, pp. 33-40, 2017.

Tsoutsos, T., Frantzeskaki, N., and Gekas, V., Enviromental impacts from the solar eneergy technolgies, Energy Policy, vol. 33, p. 8, 2005.

Turner, B.M., Wang, T., and Merkle, E.C., Factor analysis linking functions for simultaneously modeling neural and behavioral data, NeuroImage, vol. 153, pp. 28–48, 2017.

Zarezade M., Mostafaeipour A., Identifying the effective factors on implementing the solar dryers for Yazd province, Iran, Renewable and Sustainable Energy Reviews, vol. 57, pp. 765-775, 2016.

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