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Investigating the Effect of Buffer Tank Type on Technical and Environmental Performance of Solar Heating Systems in Iran

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Abstract

The amount of solar radiation in Iran has been higher than the global average and this has made Iran one of the most desirable countries in terms of solar energy use compared to other parts of the world. On the other hand, providing the right temperature in the living space has been one of the needs of human beings today, and therefore the use of different types of cooling and heating systems in buildings has become common. By replacing the energy from fossil fuels with heating and cooling systems with renewable energy, there will be significant effects on optimizing energy consumption, reducing the growing trend of global temperatures, reducing air pollution, and reducing fossil fuel consumption. In this paper, the technical-environmental performance of solar heating systems in Iran and the effect of buffer tank type on their performance using Valentin T*SOL software in 3 different configurations and in climatic conditions of 3 cities of Tabriz, Tehran and Shiraz have been studied. Is. The studies showed that in the first arrangement (using a hot water tank) in Shiraz had the greatest savings in natural gas consumption and the greatest reduction in CO2 emissions. In the second arrangement (using two hot water tanks) in Tabriz, the highest savings in natural gas consumption have the greatest reduction in CO2 emissions and the amount of energy produced, and in the third arrangement (thermosiphon system) in Shiraz with the greatest savings in natural gas consumption and Reduced CO2 emissions have been associated. The results of the present work show the need to study different systems for stations located in different climates to find the most suitable system for each station.

Keywords: solar heating, buffer tank, heating and cooling systems, solar radiation, thermosiphon
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1. Introduction

Today, the energy consumed by humans in the use of various types of cooling and heating systems, accounts for a large part of the total energy consumption in the world [1-4]. The use of renewable energy can have a significant impact on optimizing energy consumption, reducing the growing trend of global temperatures, reducing air pollution and also reducing the consumption of fossil fuels [5-8].

One of the most common ways to use solar energy is to heat water for use in a building or industry. In this regard, developed countries have taken great and effective steps to control environmental pollution in the energy sector by investing in renewable energy and improving energy efficiency, but this issue still faces serious challenges in developing countries [9-13].

Solar heating systems are considered as one of the most effective plans for general and easy use of solar energy to supply hot water for consumption in domestic and industrial sectors, so that the surface temperature of solar absorber collectors up to about 2 °C and the temperature of hot water produced [14,15]. In high efficiency models, water increases up to the boiling point. The use of solar heating systems can provide about 3% of the energy needed to heat water annually. The use of buffer tanks or buffer tanks can also have a significant impact on the performance of solar heating systems, which work for maximum efficiency of the boiler with an electric heat generator [16,17].

The energy, environmental and economic assessments of integrated solar heating systems in zero-energy-optimized smart buildings is described in [18]. The energy, environmental and economic assessments of integrated solar heating systems in zero-energy optimized smart buildings are mentioned. The results show that building optimization leads to a significant reduction in fuel consumption and carbon dioxide emissions. Also, the addition of the solar thermal scenario has increased the thermal efficiency of the system to 47%.

The environmental, technical and financial feasibility of home solar water heating system in India has been studied in [19]. The results show that all sites have more than 60% solar sections and the gross greenhouse gas emission reduction for the 25-year project life is 739000 Kg of CO2. The repayment period obtained for seven people for a typical family is between 7 and 10 years except in two cities. They have also shown that at least 50% of government incentives must be considered to make such an installation possible.

In previous studies, the technical and economic performance of these systems has been studied, but to achieve the desired results, factors such as natural gas consumption, reduced CO2 emissions, efficiency, stored energy and energy consumption in solar heating systems are needed. In this paper, the technical and environmental performance of solar heating systems in Iran and the effect of buffer tank type on their performance using Valentin T * SOL software in three different configurations and in the climatic conditions of Tabriz, Tehran and Shiraz are studied. Is located.

2. Research and analysis methods

In this study, to investigate the effect of buffer tank type on technical and environmental performance of solar heating systems in Iran, including the cities of Tabriz, Tehran and Shiraz with different arrangements have been selected. The three items under consideration are:

A. Use of a solar collector and an indirect coiled hot water storage tank with a gas boiler (Fig. 1).

B- Using a solar collector and 2 indirect hot water storage tanks with gas burner (Fig. 2).

C- Using a thermos phonic solar heating system (Fig. 3).

The heat load required to supply hot water to a one-story building with a population of 3 people has been determined according to the standard of hot water consumption in Iran. According to this standard, the daily consumption of hot water per person is equal to 2 liters, so for a family of three, the volume of hot water consumed will be about 2 liters per day.

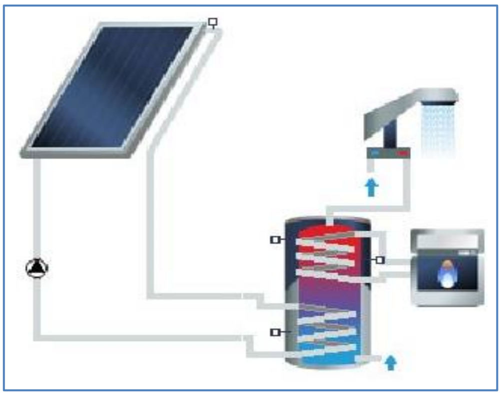


Fig. 1. Structure consisting of a solar collector and an indirect coiled hot water storage tank with a gas boiler (Scenario 1)

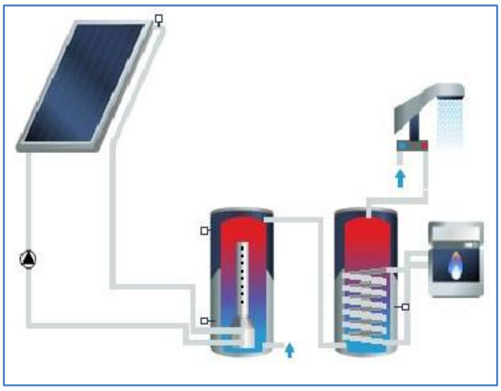


Fig. 2. Structure consisting of solar collector and indirect hot water storage tank with coil, gas boiler and 2 water storage tanks (second scenario)

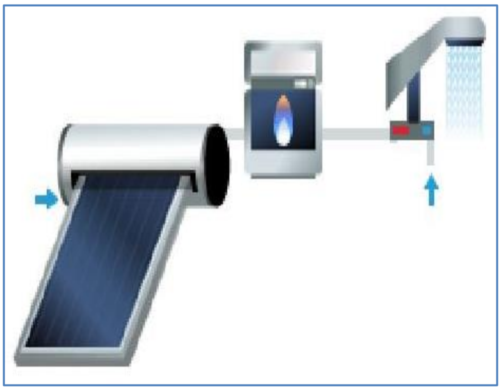


Fig. 3. Structure consisting of thermosyphon solar heating system (third scenario)

The amount of heat required to supply this volume of hot water is determined from (1) [20,21]:

$$Q = mC_p(T_1 - T_2) \quad (1)$$

where m is the actual amount of hot water consumed per day in liters, CP is the specific gravity of water at constant pressure in KJ/Kg-K, and T_1 and T_2 are the water inlet and outlet temperatures of the solar heating system in degrees Celsius, respectively. The values of the parameters for determining the required amount of heat are given in Table 1.

Table.1.
Data to calculate the amount of heat required to supply hot water

Parameter	***Value***
CP	4.18 KJ/Kg.K
M	180 liters per day
T1	20 °C
T2	55 °C

Therefore, according to (1), the amount of thermal energy required by the building during one year is equal to 67.2 MWh. Geographical characteristics and climatic conditions of the studied cities are given in Table 2.

Table.2.
Geographical characteristics and climatic conditions of the studied cities

City / Parameter	Shiraz	Tabriz	Tehran
Latitude (N°)	29.6	38.1	35.7
Longitude (E°)	52.6	46.3	51.2
Average ambient temperature (C °)	19.0	13.3	18.5
Average wind speed (m/s)	2.21	1.88	1.81

Valentin T*SOL software also uses calculations of functions such as the collector's solar contribution to simulate systems. The share of solar is the ratio of two similar amounts of energy, in general, the share of solar is the ratio of the amount of energy absorbed by the sun to the total energy consumed for heating water or the environment. The share of solar (SF) is equal to:

$$SF = \frac{Q_s}{Q_s + Q_{aux}} \times 100 \quad (2)$$

where Q_S is the amount of solar thermal energy absorbed (kwh) and Q_{aux} is the amount of thermal energy consumed by the auxiliary system (kwh). By simulating the proposed arrangements for the solar heating system in Valentin T*SOL software and by considering a 4-watt gas boiler as a support system, the results are obtained for all 3 arrangements in the studied cities. The solar collector used in all three configurations is a standard flat plate collector.

3. Simulation results and discussion

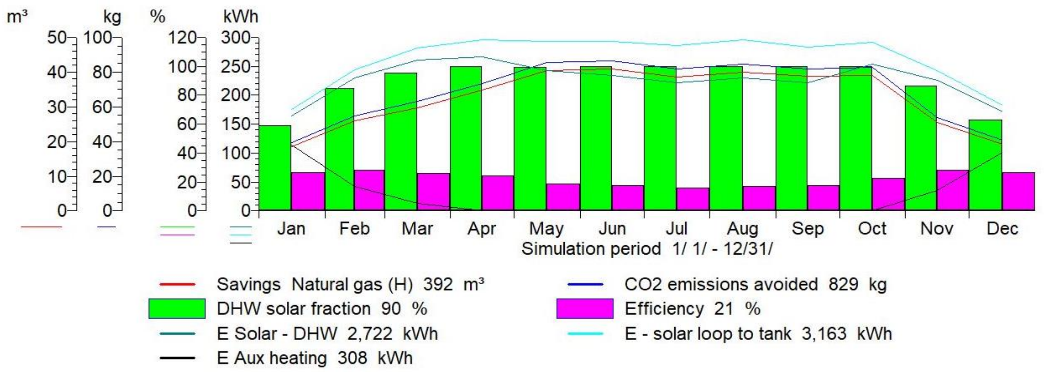
The efficiency of the system, natural gas storage, energy stored in the system and CO2 emissions for the three cities in the first arrangement are shown in Fig. 4. In the first scenario, despite the higher efficiency of Tehran, the use of a solar collector and an indirect hot water storage tank with gas boiler, first in Shiraz due to better performance in saving natural gas consumption and reducing CO2 emissions and then in Tehran and Tabriz have great effects.

In the second scenario, despite the higher efficiency of Shiraz, the use of a solar collector and 2 indirect hot water storage tanks with gas boilers, first in Tabriz to save natural gas consumption and reduce CO2 emissions and then in Tehran and Shiraz It has great effects.

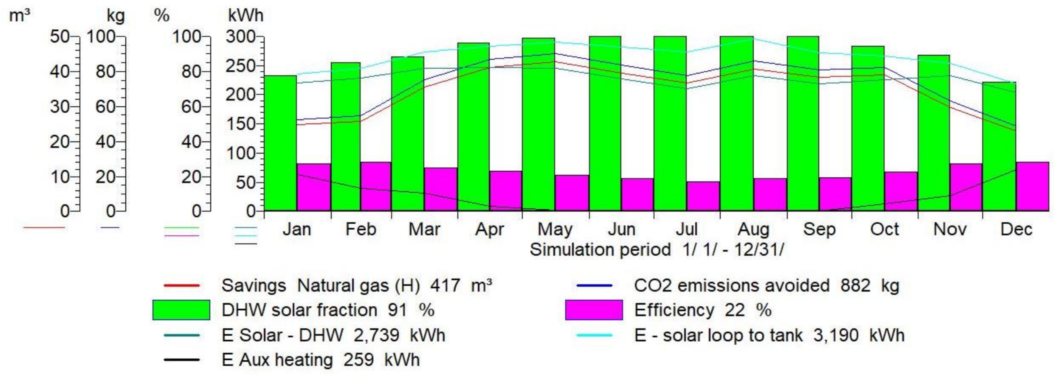
In the third scenario, despite the higher efficiency of Tabriz, the use of thermosiphon solar heating system first in Shiraz due to saving natural gas consumption, less energy consumption and reducing CO2 emissions and then in Tabriz and Tehran has significant effects. The percentage of total solar energy consumption for the second scenario in three different cities is shown in Fig. 5.

Based on the similar results obtained for the third scenario, the following result can be stated.

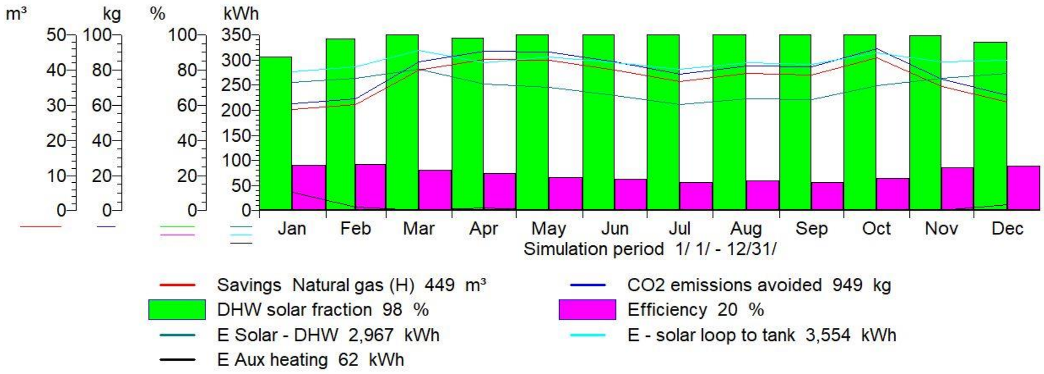
Based on the simulation results in the three arrangements studied, the efficiency of solar heating systems, natural gas storage, energy stored in the system and also the amount of CO2 emissions for different cities are shown in Tables 3 to 5.



(a) Tabriz

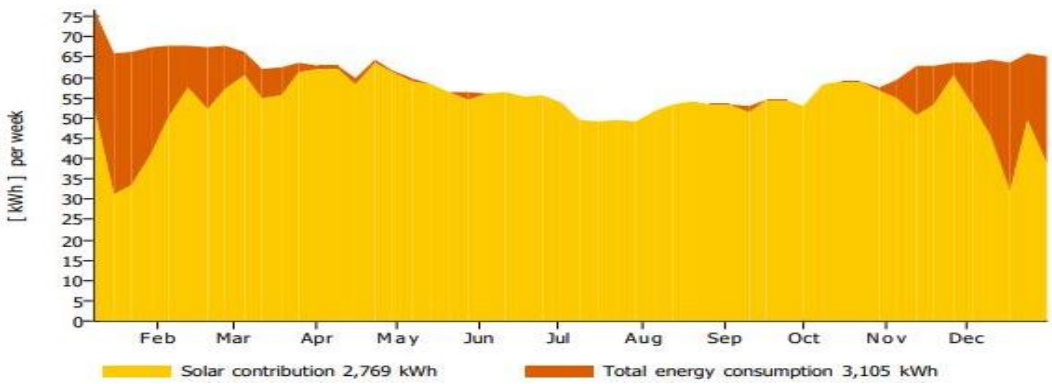


(b) Tehran

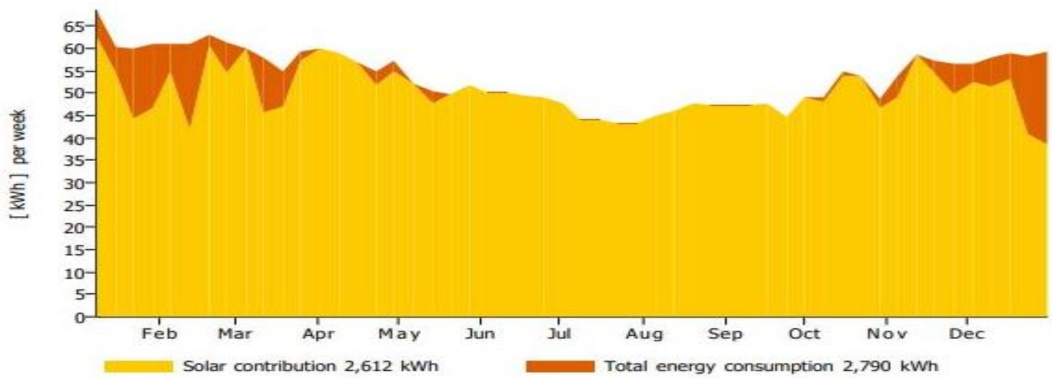


(c) Shiraz

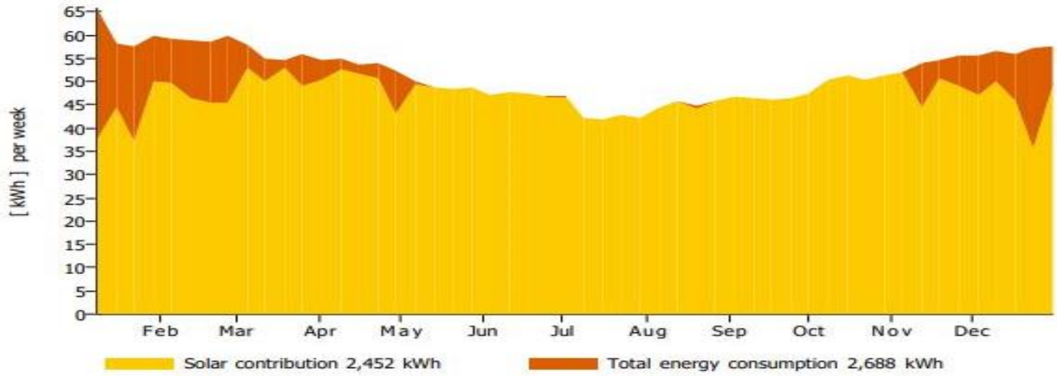
Fig. 4. System efficiency, natural gas storage, energy stored in the system and CO2 emissions for three different cities in the first arrangement



(a) Tabriz



(b) Tehran



(c) Shiraz

Fig. 5. Percentage of total solar energy consumption for three different cities in the first arrangement

Table.3.
Results from the study in the first arrangement

City	*System efficiency*	*Save on natural gas consumption*	*Stored energy*	*Reduce CO2 emissions*	*The amount of energy consumed*
Tabriz	%21	392 m^3	3.163 kWh	829 kg	3.030 kWh
Tehran	%22	417 m^3	3.190 kWh	882 kg	2.998 kWh
Shiraz	%20	449 m^3	3.554 kWh	949 kg	3.029 kWh

Table.4.
Results from the study in the second arrangement

City	*System efficiency*	*Save on natural gas consumption*	*Stored energy*	*Reduce CO2 emissions*	*The amount of energy consumed*
Tabriz	%22	399 m^3	3.297 kWh	843 kg	3.105 kWh
Tehran	%21	396 m^3	3.160 kWh	837 kg	2.790 kWh
Shiraz	%34	376 m^3	2.889 kWh	795 kg	2.688 kWh

Table.5.
Results from the study in the first arrangement

City	*System efficiency*	*Save on natural gas consumption*	*Stored energy*	*Reduce CO2 emissions*	*The amount of energy consumed*
Tabriz	%31	344 m^3	535 kWh	727 kg	2.506 kWh
Tehran	%29	314 m^3	370 kWh	663 kg	2.167 kWh
Shiraz	%27	348 m^3	122 kWh	735 kg	2.115 kWh

Table.6.
Results from the study for Tehran

Arrangement	System efficiency	Save on natural gas consumption	Stored energy	Reduce CO2 emissions	The amount of energy consumed
First	%22	399 m^3	3.297 kWh	843 kg	3.105 kWh
Second	%21	396 m^3	3.160 kWh	837 kg	2.790 kWh
Third	%29	314 m^3	370 kWh	663 kg	2.167 kWh

Table (6) shows the results for three different arrangements in Tehran for comparison.

As can be seen in the first arrangement of Tehran, the system has the highest efficiency, Tabriz has the highest amount of energy consumption and Shiraz has the highest saving in natural gas consumption, stored energy and the highest reduction of CO2 emissions. In the second arrangement of Shiraz, the highest system efficiency and Tabriz had the highest savings in natural gas consumption, stored energy, the highest reduction of CO2 emissions and energy consumption, and finally in the third arrangement of Shiraz with the highest savings in natural gas consumption and reduced emissions CO2 and Tabriz gas have been associated with the highest system efficiency, stored energy and energy consumption. It should be noted that the use of thermosiphon solar heating system due to its effective performance in reducing CO2 emissions and energy consumption has a significant role in environmental performance. The efficiency chart of Tehran is shown as the highest efficiency in the first arrangement of Fig. 6. In the first arrangement of Tehran, it had the highest yield from 10 December to 10 January and from 12 February to 9 March and the lowest yield from 11 June to 9 September.

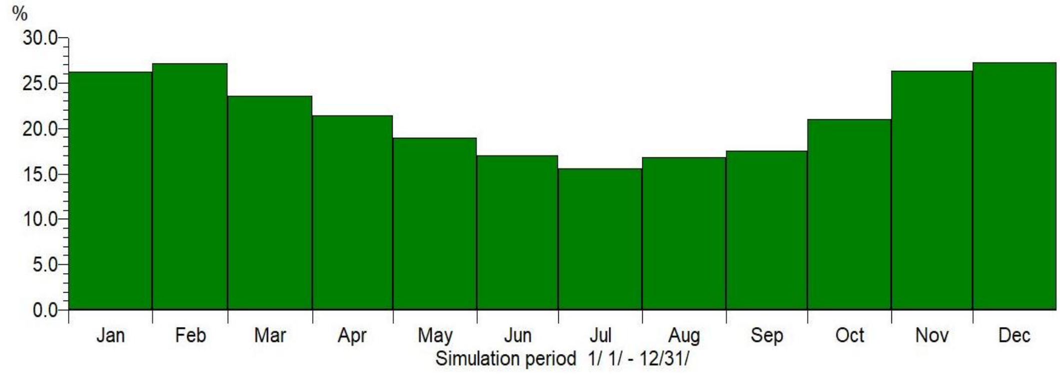


Fig. 6. Tehran city efficiency chart as the highest efficiency in the first arrangement

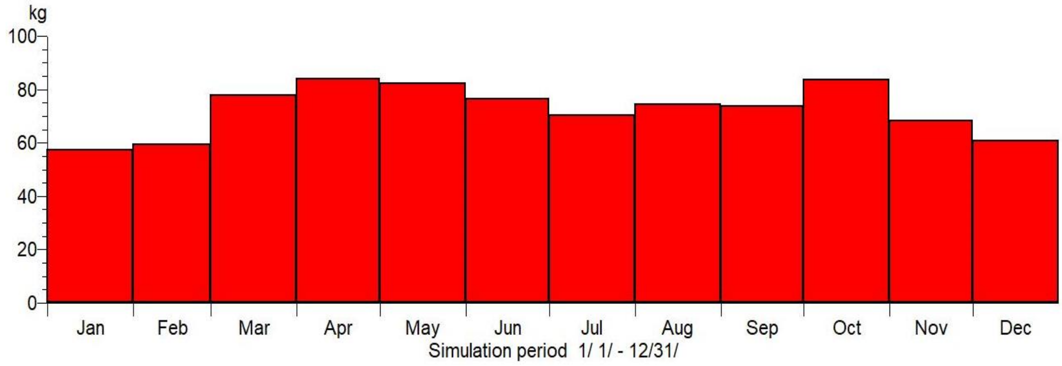


Fig. 7. Graph of CO2 emission reduction in Shiraz as the most effective city in the first arrangement

The graph of CO2 emission reduction in Shiraz as the most effective city in the first arrangement is shown in Fig. 7. Shiraz in the first arrangement from 9 October to 9 November had the most impact on reducing CO2 emissions and from 11 January to February had the least impact and Tabriz in the second arrangement had the most impact from 11 May to 9 July and from 11 January to 11 February had the least impact

4. Conclusion

In this paper, the technical and environmental performance of solar heating systems in Iran and the effect of buffer tank type on their performance using Valentin T*SOL software in 3 different configurations and in climatic conditions of 3 cities of Tabriz, Tehran and Shiraz have been studied. Is. The results showed that the highest system efficiencies for the three arrangements belonged to Tehran, Shiraz and Tabriz, respectively. The highest savings in natural gas consumption and reduction of gas emissions in three arrangements belonged to Shiraz, Tabriz and Shiraz, respectively.

The use of thermosiphon solar heating system due to its effective performance in reducing CO2 emissions and energy consumption has a significant role in environmental performance.

In the current situation, solar heating systems for hot water production are not cost-effective from the perspective of a private investor. Given the current prices of fossil fuels, none of the solar systems studied can be economical. This result is correct even considering their low maintenance costs or the provision of 50% subsidies. This is due to the very high subsidies offered to stabilize energy prices for the entire range of customers. The cost of oil for Iranian households is about one-twentieth the price of crude oil in the world market.

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