# An integrated plan for optimization of fuel consumption- a case study

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## *Abstract*

Unfortunately, there has always been an upward trend in fuel consumption in Iran. If the trend continues, it is expected that in the near future, there will be no more surplus oil to export. The oil-dependent economy of the country doubles the importance of the fuel consumption optimization. In the meanwhile, transportation sector allocates itself a large share of fuel consumption in Iran. Choosing an appropriate consumption pattern can annually bring enormous savings for the country's economy. Accordingly, the current study aims at presenting the most effective managerial strategies to optimize the fuel consumption of transportation sector in Tehran. Therewith, the key strengths, weaknesses, opportunities and threats towards achieving optimal fuel consumption were initially examined using matrices; External Factor Evaluation (EFE) and Internal Factor Evaluation (IFE). Thereafter, the most applicable strategies were identified through SWOT Analysis. Subsequently, the identified strategies were prioritized based on Quantitative Strategic Planning Matrix (QSPM). The obtained results indicated that refrain from multiplicity of decision maker units in the field of transportation and traffic is the highest priority strategy to manage the energy and fuel consumption in Tehran. Besides, the conservative (hold and maintain) strategy was recommended to meet the purpose of the research.

***Keywords:*** ***fuel consumption, public transportation, energy efficient vehicles, SWOT, QSPM, consumption manner, worn-out vehicles***

## Introduction

In the current era, energy supply is considered one of the most important economic characteristics played a key role in issues related to politics. It is clear that the world is faced with rising energy costs due to limited energy resources as well as extraction and exploitation expenditures. Since after the energy crisis in 1973, European industrialized countries, have attempted to implement energy-saving activities through Europe comprehensive energy policy [1-5] (Alpanda and Peralta-Alva, 2010; Donatos and Mergos, 1989; Davey 1987, Cofala, 1994; Mihajlov, 2010). Energy saving as an investment tool can reduce public spending [6] (Lin and Huang, 2010). It is regarded very useful and productive measure for organizations and energy consumer centers during the shortage of their financial resources and budgetary difficulties [7] (de Groot et al., 2010). Increasing energy consumption in all facets of life as well as limited energy resources, on one hand, and its indiscriminate use by the various communities on the other hand, are endangered the future life of humanity, along side the environmental pollution and waste of national wealth [8] (Schenk et al., 2007). The experiences of the countries over the last decade indicate that economic growth and industrial development as preconditions for political, cultural and national sovereignty depend on various factors, including energy supply and its optimum productivity [9-10] (Zhixin and Xin, 2011, Giannantoni et al., 2005). In spite of having the richest sources of energy in Iran, its misuse imposes irreparable damages on the country's annual budget [11-14] (Zamani, 2007; Hessari, 2005, Houri Jafari and Baratimalayeri, 2008, Mohammadnejad et al., 2011). Hence, it is necessary to assign a special priority to the rational use of energy. The complex network of interwoven energy fields calls for plenty of cases to be studied in relation to each other in order to achieve a principled management with a long-term attitude. Assessing the development of the complex energy network and answering various questions within decision-making process to present energy policy requires a systematic study of structural and technological developments. Implementation of energy management system in order to promote rational use means that energy flow should be monitored in all production processes and services of social and economic sectors. On other word, preventing energy loss and improving energy efficiency must be sustained as a responsibility and habit in society. To prevent the uncontrolled growth of energy consumption and maintain national energy reserves should pay more attention to energy consumption

pattern in metropolitans. Undoubtedly, one of the benefits of energy optimization in metropolitans is reduction of greenhouse emissions at global level [15-19] (Hamit-Haggar, 2011; Poudenx, 2008; de Ia Rue du Can and Price, 2008; Morrow et al., 2010; Kaygusuz, 2009). In connection with this subject, a conference under the title "United Nation Climate Change Conference" was held in Copenhagen, Denmark between 7th and 19th December, 2009 [20] (Macintosh, 2010). the conference which is also well-known as Copenhagen summit to be held in conditions that further increase in energy prices and gradual depletion of global resources have enhanced the modification importance of consumption patterns, more than ever before [21] (den Elzen et al., 2010). Iran has always had a rich abundance of natural resources and the highest natural capacities. Applying such a huge wealth, besides, the exploitation of capable and worthy human resources, in the framework of a reasonable and proper management, can conduct the country toward a sustainable socio-economic development. Nonetheless, achieving the forenamed goal requires a proper planning. Accordingly, motivating people for interest in preserving national wealth is quite essential. Tehran Metropolitan has a population around 7.8 million people. Its daily floating population reaches to 8.5 people. Tehran considered the biggest city amongst the Middle East countries, is faced with enormous serious problems at its transportation sector. By annual consumption of 147.4 million barrels of crude oil, the sector is regarded the largest consumer of oil products compared with other sectors [22] (Alipour et al., 2011). Currently, residential and commercial sectors consume 115.2 million barrels of crude oil while industrial and agricultural sectors consume 54.1 and 29.3 million barrels of crude oil respectively [22] (Alipour et al., 2011). It is important to know that exporting oil products, which is the country's most valuable export product, is just equivalent to 69.5 barrels of crude oil [22] (Alipour et al., 2011). All the mentioned issues reveal the significance of modification of energy and fuel consumption pattern in Tehran. Therefore, the current study focuses on presenting a comprehensive managerial plan to optimize energy consumption in Tehran metropolitan.

## Material and methods

The research ahead was conducted through the steps presented in Table 1. Each step is separately described in the followings.

**Table 1***: the stages of strategic planning for optimization of energy and fuel in Tehran Metropolitan*

| research stage | Activity type |
|---|---|
| Initial phase | • goal setting<br>• Determination of the vision and mission<br>• Definition of the research schedule |
| Study phase | • Identification of all major strengths and weaknesses in the functional environment using IFE Matrix<br>• Identification of all major opportunities and threats in the functional environment by EFE Matrix |
| Analytical phase | • Formation of SWOT Matrix<br>• Formation of IE Matrix |
| Decision making and executive phase | • Prioritization of the proposed strategies using QSPM<br>• Execution of the main strategies |

The Initial Phase of the current study includes the base activities like setting the main goal and vision of the research i.e. optimization of energy consumption in Tehran Metropolitan. A time table was considered for various kinds of the activities. Due to participatory nature of SWOT Analysis, Delphi Method was applied to proceed the further phases of the research. It is worth noting that the rectors of 22-fold districts of Tehran as well as academics who are expert in energy and environment affairs were invited as the members of Delphi panelists. Due to limitation of statistical population, totally 32 people were selected as the panelist group. The Study Phase attempts to cover all analysis to identify the current opportunities, weaknesses, strengths and threats facing the fuel optimization in Tehran. Accordingly, a questionnaire was initially prepared to find out the key internal and external factors. It should be mentioned that a five-point scale called Likrate was applied to determine the importance of the factors in which 1 indicates a minimal impact while 5 represents the highest possible influence of a factor. The overall reliability of the questionnaire was calculated using the Alpha Cronbach Coefficient (Eq.1).

$$a = \frac{k\overline{C}}{\overline{V} + (k-1)\overline{C}}$$

Where;

*K* is the number of components (*K-items* or *testlets*), the average variance, and the average of all covariances between the components across the current sample of persons. Based on Table 2 the internal consistency of the questionnaire can be computed. It is noteworthy that SPSS software version 11.5 was used to analyze the data.

**Table 2:** *description of internal consistency using Cronbach's alpha*

| Cronbach's alpha | Internal consistency |
|---|---|
| $\alpha \geq .9$ | Excellent |
| $.9 > \alpha \geq .8$ | Good |
| $.8 > \alpha \geq .7$ | Acceptable |
| $.7 > \alpha \geq .6$ | Questionable |
| $.6 > \alpha \geq .5$ | Poor |
| $.5 > \alpha$ | Unacceptable |

To finalize the questionnaire it was pre-tested by the panelists using open-ended questions as well as some interviews. Consequently, the first round polling was conducted to modify the questionnaire and determine all possible threats, opportunities, weaknesses and strengths alongside their weights. By the information gathered on the external and internal environments, a SWOT Analysis was used to identify the appropriate strategies. The analysis aims at developing a proper plan that takes into account lots of different internal and external factors, maximizes the potential of the strengths and opportunities toward optimization of energy consumption while minimizing the impact of the weaknesses and threats. Finally, QSPM was applied to prioritize the strategies and specify their executive emergency.

## Result and discussion

Using Delphi consensus method, a panel of rectors and academics who were expert in the field of fuel optimization affairs was selected. Out of 90 experts invited, 32 people accepted to participate in the polling process. They were asked to make decisions on what they thought was the best for the factor weights. The scores were expressed on a range of 0-1. The median and quartiles of the ratings of each item were returned to the experts. Then, by knowing the responses obtained from the first round, the weights of the factors were evaluated by the panelists once again. Besides, Cronbach's a, was used as a measure of homogeneity for the ratings. The final rating for each factor was corresponded to the average rating obtained at the last Delphi round. Consensus was acheived at the third round as indicated by Cronbach's a value (0.99 (95% CI 0.98-1.00)). Therewith, the Delphi sequence was stopped.

Consequently, IFE Matrix including the identified strengths and weaknesses prepared (Table 3). Totally, 9 strengths and 10 weaknesses were recognized in the internal environment. Amongst the identified strengths can be pointed to “Standards for energy consumption in

transportation sector", "replacement of worn-out vehicles", and "The existence of intelligent traffic control systems". It should be note that "Development of special bus lines" is the most significant strength identified for fuel optimization in Teheran while the slightest importance belongs to "Possibility of attracting the investments of the private sector and foreigners". In spite of the mentioned strengths, there are also some weaknesses in the internal environment which play a deterrent role during optimization of energy and fuel in Tehran. "Lack of appropriate capacity in urban light rail transit (LRT)"is regarded the most remarkable weakness amongst the others while the "Administrative bureaucracy" has the slightest importance.

**Table 3:** *IFE Matrix for optimization of fuel consumption in transportation sector of Tehran Metropolitan*

| Symbol | Internal factor | weight | Importance | Final score |
|---|---|---|---|---|
| | *Strengths* | | | |
| $S_1$ | Removal of fuel subsidies | 0.05 | 4 | 0.2 |
| $S_2$ | Electronic Services Agencies and possibility of development of Internet purchases | 0.05 | 3 | 0.15 |
| $S_3$ | Religious beliefs regarding waste of resources and appropriate consumption | 0.02 | 3 | 0.06 |
| $S_4$ | Standards for energy consumption in transportation sector | 0.07 | 4 | 0.28 |
| $S_5$ | Possibility of attracting the investments of the private sector and foreigners | 0.02 | 3 | 0.06 |
| $S_6$ | Withdrawal of old cars | 0.06 | 4 | 0.24 |
| $S_7$ | Development of special bus lines | 0.1 | 4 | 0.4 |
| $S_8$ | Spreading vehicle technical inspection centers | 0.03 | 4 | 0.12 |
| $S_9$ | The existence of intelligent traffic control systems | 0.06 | 4 | 0.24 |
| | *Weaknesses* | | | |
| $W_1$ | Failure to allocate sufficient funds for development of urban public transport | 0.05 | 2 | 0.1 |
| $W_2$ | Low price of vehicle tax and its disproportion with the emission rate of automobile manufacturing | 0.03 | 2 | 0.06 |
| $W_3$ | Stock and commodity gathering in downtown Tehran | 0.04 | 1 | 0.04 |
| $W_4$ | Lack of appropriate capacity in urban light rail transit (LRT) | 0.1 | 2 | 0.2 |
| $W_5$ | Using old technology to produce domestic cars | 0.06 | 2 | 0.12 |
| $W_6$ | Old texture of subway routs | 0.04 | 1 | 0.04 |
| $W_7$ | Willingness to use private cars | 0.06 | 2 | 0.12 |
| $W_8$ | administrative bureaucracy | 0.02 | 1 | 0.02 |
| $W_9$ | Poor structure of good distribution | 0.06 | 2 | 0.12 |
| $W_{10}$ | High fuel consumption by domestic vehicles and using non-standard gasoline | 0.08 | 2 | 0.16 |
| Total | | | 2.73 | |

Considering the obtained results, optimization of fuel consumption in Tehran faces with 8 opportunities and 7 threats in the external environment (Fig. 1). In this respect, the most important opportunity is "a high potential for savings in transportation sector" ($O_8$) with weight of 0.4 while the least score tantamount to 0.04 ($O_4$) belongs to "production potentiality for high quality fuel in the country". "Possible reduction in fuel consumption due to price increases" ($Q_2$) and "possibility of remote working at relevant jobs" ($Q_3$) with the same weights of 0.24 allocate themselves the next priority. "Adequate financial resources resulting from the optimization of fuel consumption"(Q7), "new technologies in automobile production" ($Q_5$), and "fair distribution of opportunities due to the elimination of subsidies" ($Q_1$) are considered amongst the opportunities enjoyed lower scores. The final outputs of EFE Matrix are presented by Figs. 1 and 2.

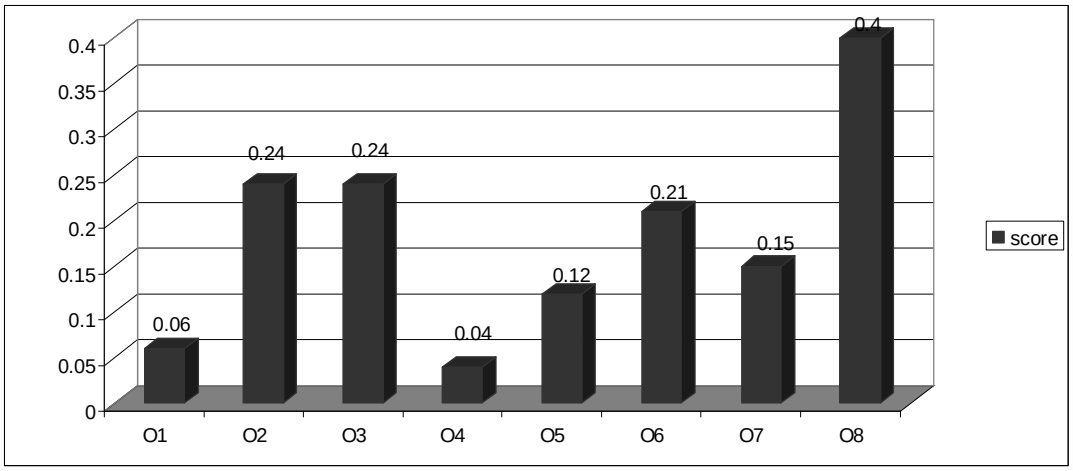


**Fig.1:** *potential opportunities for optimization of fuel consumption in Tehran*

As has already been mentioned, 7 threats were totally identified through the study ahead. "Structural and social behavior leading refusal to use public transportation" with weight of 0.36 is considered the most important threat toward optimizing fuel consumption in Tehran. In the meanwhile, "international sanctions on numerous economic subjects" ($T_6$) weighted 0.1 cannot be regarded so serious threat. "Rising cost of public transport" ($T_5$) scored 0.07 is regarded the least significant threading factor. "Inappropriate pattern of commuting" ($T_3$) weighted 0.16 is another important threat should be paid enough attention. "Lack of a unit decision making center for traffic management in Tehran" ($T_5$) and "No support for private sector" ($T_7$) with equal score of 0.14 are accounted rather serious threats.

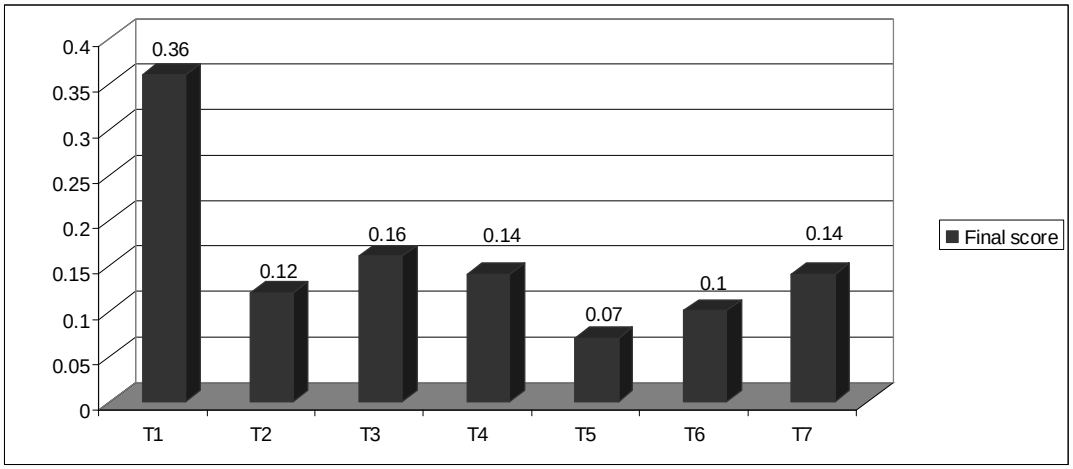


**Fig.2:** *potential threats towards optimization of fuel consumption in Tehran*

After identification and quantification of the internal and external factors, now is the time to visualize how the factors work together using SWOT Matrix (Table 4).

**Table 4:** *SWOT Matrix for optimization of fuel and energy in transportation sector of Tehran Metropolitan*

| Internal factors / External factors | | Strengths (S) | | | | | | | | | Weaknesses (W) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_5$ | $S_6$ | $S_7$ | $S_8$ | $S_9$ | $W_1$ | $W_2$ | $W_3$ | $W_4$ | $W_5$ | $W_6$ | $W_7$ | $W_8$ | $W_9$ | $W_{10}$ |
| Opportunities | $O_1$ | ü | | | ü | ü | ü | | ü | | | | | | | | ü | | | ü |
| | $O_2$ | ü | | | | ü | | ü | | | | | | | ü | | ü | | | |
| | $O_3$ | | ü | | | | | | | | | | ü | | | | | ü | ü | |
| | $O_4$ | ü | | | | | ü | | | | | | | | ü | | | ü | | ü |
| | $O_5$ | ü | | ü | ü | | | | | | | | ü | | | ü | ü | | ü | ü |
| | $O_6$ | ü | | | | ü | ü | | | | | | | | ü | ü | | | | ü |
| | $O_7$ | ü | | | ü | ü | ü | ü | | ü | ü | ü | | | | | | | | ü |
| | $O_8$ | ü | | ü | | | | | ü | | ü | | ü | ü | | | ü | | | ü |
| | $O_9$ | ü | ü | | ü | ü | ü | ü | ü | ü | ü | ü | ü | | ü | ü | ü | ü | ü | ü |
| Threats | $T_1$ | ü | | | ü | ü | | | ü | | ü | ü | | | | ü | ü | | | ü |
| | $T_2$ | ü | | | | | ü | ü | | ü | | ü | | ü | | | ü | | | ü |
| | $T_3$ | ü | | | | | | | | | ü | ü | | | | | | | | |
| | $T_4$ | | ü | ü | | | | | | | ü | ü | | | | | ü | | ü | |
| | $T_5$ | | | | | | | | | | ü | ü | | | ü | | | ü | ü | |
| | $T_6$ | ü | ü | ü | ü | | | | ü | | ü | ü | | | ü | | | | ü | |
| | $T_7$ | ü | ü | | | | | | ü | | ü | ü | ü | ü | | | | | | ü |
| | $T_8$ | ü | | ü | | | ü | | | | ü | | ü | ü | | | | | | ü |
| | $T_9$ | | | | | | ü | | | ü | | | | | | | | | | |

Based upon the SWOT Matrix, the following strategies were extracted:
$ST_1$: Development and promotion of modern systems and technologies in the areas of transportation to reduce energy consumption; $ST_2$: Development of public transportation as the main factor of traffic reduction with emphasis on the express train and subway lines, $ST_2$: public enlighten toward using public transportation and reducing the use of personal vehicles on the basis of religious beliefs in order to avoid waste of resources, $ST_3$: Upgrading vehicle standards with modern technology to reduce fuel and energy consumption, $ST_4$: removing worn-out vehicles, $ST_5$: actualization of fuel prices and elimination of subsidies as a control agent to reduce fuel consumption, $ST_6$: using encouraging methods, granting facilities to the users of public transport and supporting low energy consumption individuals, $ST_7$: performance of limiting systems and regarding real penalties for excessive energy consumers, $ST_8$: Building and developing infrastructures required for clean transportations such as bicycling and walking, $ST_9$: $ST_{10}$: Development of electronic services by creating suitable infrastructures for electronic purchasing and providing administrative services in electronic form to reduce traffic, $ST_{11}$: Organization and improvement of good transportation systems, $ST_{12}$: Improvement and development of transportation infrastructures, development of pathway networks as well as suitable access roads to reduce traffic and energy consumption, $ST_{13}$: Proper use of the private sector in order to participation in development projects of public transportation by providing appropriate investment conditions, $ST_{14}$: Refrain from multiplicity of decision maker units in the field of transportation and traffic, $ST_{15}$: Government support in financing the development of clean public transportation and $ST_{16}$: Development of technical examination centers to control fuel consumption.
After extracting the appropriate strategies, it was necessary to provide a suggestive model using Internal and External (IE) Matrix. The matrix is formed based on the overall scores of IFE and EFE matrices. It is noteworthy that the total weighted score calculated for IFE Matrix is 2.73 which indicate an above-average internal strength towards optimization of fuel consumption. Besides, the final core of the EFE matrix was computed equal to 2.55 which suggests a slightly more than average ability to respond to the external factors. Thereby, conservative (hold and maintain) strategy was highly recommended to meet the purpose of the research. Fig. 3

illustrates the IE Matrix of the optimization of fuel consumption in Tehran Metropolitan.

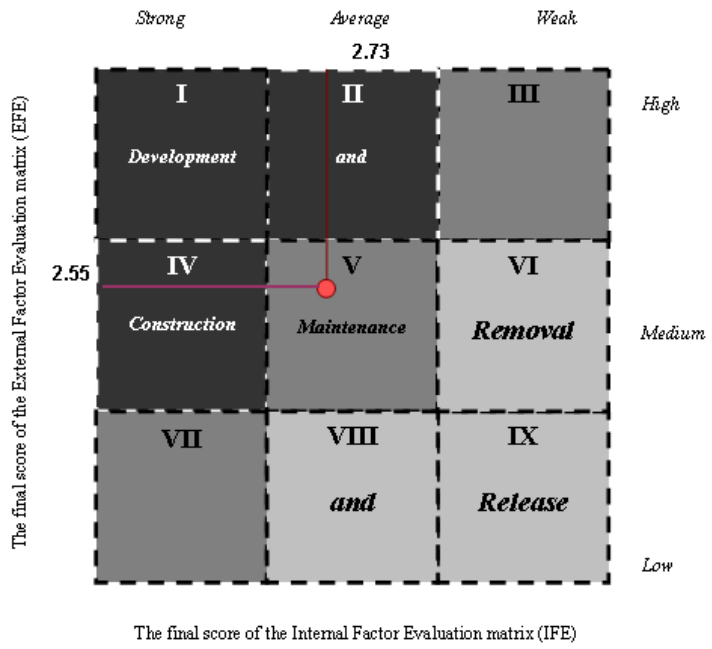


**Fig.3:** *Internal and External (IE) Matrix of optimization of fuel and energy in Tehran Metropolitan*

As regards, it is not possible to implement all the strategies obtained from SWOT and IE Matrix, QSPM was applied to narrow the number of strategies by determining the relative attractiveness of each one. Therewith, a prioritized list of strategies was provided in which the key managerial approaches are apparent (Table 4).

**Table 4:** *the relative attractive of the strategies to optimize fuel and energy in Tehran*

| No. | Strategy | Relative importance | No. | Strategy | Relative importance |
|---|---|---|---|---|---|
| 1 | $ST_1$ | 1.38 | 9 | $ST_9$ | 2.62 |
| 2 | $ST_2$ | 3.27 | 10 | $ST_{10}$ | 3.35 |
| 3 | $ST_3$ | 3.4 | 11 | $ST_{11}$ | 2.66 |
| 4 | $ST_4$ | 2.12 | 12 | $ST_{12}$ | 2.7 |
| 5 | $ST_5$ | 2.12 | 13 | $ST_{13}$ | 3.04 |
| 6 | $ST_6$ | 3.28 | 14 | $ST_{14}$ | 4.21 |
| 7 | $ST_7$ | 1.75 | 15 | $ST_{15}$ | 3.4 |
| 8 | $ST_8$ | 2.62 | 16 | $ST_{16}$ | 2.55 |

## Conclusion

The experiences of Iran over the past decade show that the economic growth and industrial development depend on a plenty of factors like energy and optimum productivity of its resources. Although, Iran has one of the richest energy sources, its waste imposes irreversible damages on the country's annual budget. Hence, planning in the context of the rational use of energy has a special priority. Specifically, compilation of policies and procedures for energy efficiency is critical for all economic sectors. However, the proper compilation of such policies and consequently, the effectiveness of energy efficiency programs require accurate identification of effective components.

One of the major consumers of energy is transportation. This sector accounts itself around 27% of the country's total energy consumption. It is the second large energy consumer in Iran. By allocating 55% of total consumption of liquid petroleum products, transportation is the largest consumer of such products. The findings of the researches indicate that during the last decade, the trend of energy consumption by transportation sector has been obviously upward. All the mentioned statistics reveal the extent of Tehran's major problems in optimization of fuel consumption which requires an efficient tool for solving and improving. As has been raised in current study, despite low car ownership per capita in Iran than in other countries, energy consumption is so high in the country due to many reasons such as the worn-out transportation system, cheap energy prices, failure to meet fuel economy standards, production of vehicles with high energy consumption rate, inappropriate development of infrastructures, improper e-Government structures and insufficient attention to the development of intelligent transportation systems. Therefore, the optimal utilization of energy in the transportation industry has become a requirement which seeks a national will. One of the strategies to optimize energy consumption is application of appropriate management. Although, energy efficiency measures can also include technical issues but these measures will be costly. Hence, while considering the technical issues, the research ahead pays more attention to the managerial aspects. The strategies presented in the research can be helpful to close energy consumption to the global average. Undoubtedly, the strategies wouldn’t be able to access the global average lonely. Therefore, the technical, managerial and training measures should be simultaneously codified and come into force. According to the research findings, centralizing the

decision maker units in the field of transportation and traffic can be the most effective management agent in order to optimize fuel and energy consumption in Tehran. Besides, the findings indicate that public enlightenment in order to use public transportation and reduce the use of personal vehicles is the second most important strategy to manage fuel consumption in Tehran. During the past ten years, by increasing car ownership as well as relative prosperity, traveling rate has been raised from 1.5 roadway trip per person so that there are approximately 15 million roadway trips at Tehran's thoroughfares during a day. Such a number of trips are the origin of many other problems in Tehran Metropolitan, so that almost 12 million liters of gasoline is daily used by vehicles, which in turn, increases environmental pollution and energy consumption [22] (Alipour et al., 2011). In the meanwhile, the government role can not be ignored in financing the development of public and clean transportation systems. Development of public transportation as the main basis of the traffic reduction with emphasis on expanding subway lines and Bus Rapid Transit (BRT) is another important management strategy proposed in the research ahead. Currently, around 1 billion passengers are annually transported by the bus transit system in Tehran. Moreover, the subway transit system of Tehran transports 200 million passengers throughout a year. It is noteworthy that the mentioned statistics are still rising. In this context by providing suitable conditions for investment can invite private sectors to participate in development projects of public transportation. Finally, it should be noted that public awareness in the field of modification of consumption patterns will impose a very dramatic impact on fuel consumption optimization. Considering that Iran is an oil-rich country, whole community suffers from a wrong attitude in fuel consumption. According to CIA World Factbook 2010, with annual consumption of ۱۱۹،۰۰۰،۰۰۰،۰۰۰ m3, Iran has the world's fourth place in consumption of natural gas. It allocates itself the 14th position in the world by consuming ۱،۷۵۵،۰۰۰ million barrels of oil per day. In the meantime, actualizing the fuel coast through eliminating subsidies as a control agent can be effective on reduction of fuel consumption. Alongside, development of electronic services by creating infrastructures required for e-shopping and electric administrative services will be very useful in reducing urban traffic and fuel consumption rate.

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