



## The Basics of Developing Energy-Efficient Technologies in the Building Sector

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### Abstract

Iran is one of the known countries that has unfavorable energy efficiency, therefore the policy makers of the country have put the correction of this situation on the agenda. This paper has been compiled to review and study the basics of the road map for the development of high-efficiency building technologies and to present a picture of the current state of these technologies in the country. In this paper, the necessity and importance of these technologies and the necessity of developing a road map for this development are expressed. Gathering all the upstream documents in the field of these technologies, the current state of the technology and its characteristics, actors and stakeholders are examined. The strengths and weaknesses in the country for the development of energy-efficient technologies in the building sector have been identified, then the threats and opportunities caused by external factors (outside the country), which stand in the way of the development of energy-efficient technologies in the building sector inside the country, has been studied. A drawing of the existing situation is also provided. This article is useful and effective for policymakers and planners, managers and officials, researchers and academics, industrialists and builders, and in other words, all stakeholders in the field of electricity industry.

**Keywords:** Energy efficiency, Buildings, SWOT, Roadmap.

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### 1. INTRODUCTION

In current years, the issue of energy efficiency and energy saving are important issues in many national and international strategic plans to reduce the effects of climate change, improve the security of energy supply, increase competition, preserve and sustain resources. It is known to reduce environmental pollution and reduce or postpone investment for the expansion of energy infrastructure. Regardless of the existence of strong motivations, today in some countries, especially developing countries, the investment process for using high-efficiency technologies in buildings, industry and the commercial sector is far from the required amount. Among the reasons for the existence of this distance are the gaps in the support schemes in fields of scientific, executive, legal, financial, commercial, etc., to face the existing obstacles. Currently, Iran is known as one of the countries that has unfavorable energy efficiency [1], therefore the policy makers have put the correction of this situation on the agenda and have assigned a special place to it in the macro plans and upstream documents, including the five-year laws of cultural,

social and economic development of the country. It is very important to mention that topics such as improving energy efficiency and reforming the energy consumption pattern will play an important role in realizing the goals of the resilient economy [2] as the main development of the country in the era of the "second step of the Islamic revolution" [3].

In general, energy inefficiency is attributed to various factors that have their own advantages and disadvantages in different societies. Some experts believe that the main cause of this situation is the inappropriate culture of energy consumption in Iran, and others identify the low price of energy carriers in the country as the main cause of low energy efficiency. However, most experts agree that another key factor is the use of low energy efficiency technologies.

This paper is compiled with an emphasis on the realization of the strategic goals of the vision document of Iran in the horizon of 2026 [4] and in line with the improvement of energy efficiency in the building sector by using high-efficiency electrical appliances and equipment, as well as management and

monitoring systems of electrical energy consumption and the penetration of smart technologies.

This paper, focuses on promoting the culture of optimal use of energy and increasing the social welfare of the citizens of the Islamic Republic of Iran in such a way that it has the necessary excellence in the horizon of the program compared to other countries in the region. The issue of improving energy efficiency in buildings by focusing on the use of efficient

equipment and technologies has a wide scope and dimensions and various factors play a role in it. According to studies carried out by the International Energy Agency (IEA), energy consumption in buildings depends on six main factors, which are schematically shown in Fig. 1 [5]. These factors can be classified into two main groups: "dependent on the user" and "dependent on the building".



Fig. 1. Energy consumption in buildings

## 2. ASSESSMENT OF UPSTREAM DOCUMENTS

In this part, the upstream documents, laws and regulations approved in the country related to high efficiency electrical technologies will be introduced. In Fig. 2, these laws are shown from the perspective of different levels of governance, management and executive organization of the Islamic Republic of Iran. According to the above figure, firstly, the constitution and the general policies of the system in relation to high-efficiency electrical technologies, such as the twenty-year vision document, then the economic, social and cultural development programs from the first to the sixth are examined. Next, related clauses in the country's budget laws from 2013 to 2018 will be examined.

After that, the regular laws approved by the parliament related to high-efficiency technologies will be extracted, of course, the circulars and approvals related to these technologies will be presented in the presidential offices, the meetings of the government delegation, as well as policy-making bodies such as the Ministry of Energy, Tavanir Co., the construction engineering organization, and also the approvals of the meeting of the Supreme Council of Standards.

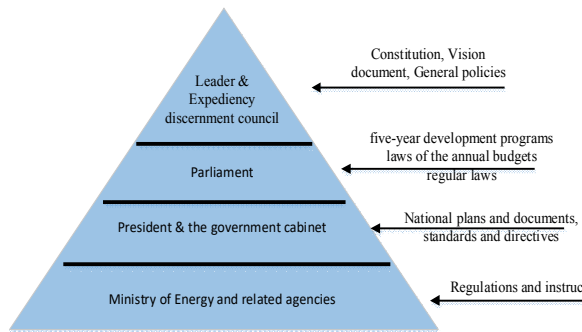


Fig. 2. The approved laws and regulations in Iran from the point of view of different levels of government

In the general policies of the system, the following axes are emphasized [6]:

- Achieving the first rank in economic, scientific and technological aspects in the region;
- Increasing the share of the private sector and cooperatives in the national economy;
- Improving the efficiency of economic enterprises and the efficiency of material, human and technological resources;
- Increasing competitiveness;
- Making diversity in the energy resource portfolio and increasing the share of renewables;
- Optimizing consumption and continuously reducing the energy intensity by 2/3 of the current situation (July,5, 2005) until the end of the fifth plan and 1/2 of the current level until the end of the sixth development plan;
- Trying to acquire technology and technical knowledge of new energies;
- Enhancing Iran's managerial role in energy distribution and transit, attracting capital and advanced technologies;
- Leading comprehensive and integrated studies of the country's energy system in order to optimize energy supply and consumption;
- Developing a national energy efficiency program;
- Giving priority to increasing efficiency in energy generation, transmission and consumption over creating new generation capacities;
- Applying mandatory national standards for the production and import of all energy-consuming devices and equipment and enhancing the monitoring system for their good implementation and requiring manufacturers to modify energy-consuming production processes;
- Expansion of electricity generation from dispersed, small-scale power plants and combined heat and power (CHP).

In reviewing the rules of the five-year development programs (first to sixth), the following axes have been emphasized in relation to high-efficiency technologies [7, 8]:

- Improving the operation of electricity industry facilities by increasing the utilization factor, load factor and efficiency of power plants and reducing losses in transmission and distribution networks;
- Policymaking and implementation of energy efficiency programs;
- Necessity of forming the Supreme Council of Consumption Patterns;
- Elaboration of energy consumption criteria and standards;
- Establishment of incentive policies in order to rationalize energy consumption;
- Empowering people in the use of low consumption technologies;
- Development and promotion of CHPs;
- Modifying the consumption pattern by execution demand side management;
- Using efficient equipment;
- In the laws of the annual budgets of 2013-2018, the following axes have been emphasized in connection with high-efficiency technologies;
- Emphasis on the development and promotion of demand side management programs;
- Improving the quality of services and products of executive organs;
- Installation of smart meters with the priority of high-consumption consumers;
- Allocation of foreign finance for projects with environmental justification;
- Construction of high-efficiency power plants such as combined generation of electricity and fresh water, CHP and CCHP through the issuance of participation bonds;
- Installation of small power plants and solar pre-heaters with the participation of 50% of the people and the government;
- Optimizing energy consumption in production, service and residential sectors through targeted subsidies.

In the law on the targeting of subsidies, the following axes have been emphasized in connection with high-yield technologies [9]:

- Emphasizing the realization of electricity prices until the end of the fifth development program;

- Modifying the technological structure of production units to increase the efficiency of electrical energy;
- Developing energy efficiency activities and encouraging energy saving;
- Consumption Pattern Correction Law (March 9, 2011);
- The aforementioned law is one of the most complete laws in the field of energy consumption optimization, but it has just been implemented and its executive regulations are being prepared and completed.

In the study of the comprehensive scientific map of the country, it was found that, unfortunately, there was no discussion about high-efficiency technologies in the field of electric energy.

According to the debates related to the actualization of energy prices and the removal of related subsidies, the increase in energy consumption costs seems likely. Therefore, the need to use building management system (BMS) will become stronger in the near future. In addition, due to the finiteness of fossil based energy sources and the destructive effects of its excessive consumption on the environment, it is possible to contribute to the reduction of energy consumption in step with the global community by using new technologies. The BMS, in addition to its role in optimizing energy consumption, also brings comfort and well-being, and we can hope that in the modern lifestyle, it will be a suitable solution to create more comfort and speed up daily affairs.

### 3. ACTORS OF EFFICIENT ELECTRICAL EQUIPMENT IN THE BUILDING SECTOR

The following five main groups are related to the issue of efficient electrical equipment in the building sector.

- The first group: the government represented by the Ministry of Energy

Institutions related to energy consumption management in Iran include policy-making and legislative institutions, executive institutions and regulatory institutions.

- Second group: consumers and contacts of electricity consumption management programs

The audience of electric energy consumption management programs are groups and clusters of electricity consumers in different consumption sectors, including the household sector, industrial sector, commercial sector, agricultural sector and

public sector, whose electricity consumption pattern changes with the implementation of the designed programs, or more accurate and scientific, they become a flexible institution. Identifying and valuing this flexibility is one of the most important and complex issues in the planning process of electricity consumption management. Since this study emphasizes the issue of energy efficiency, therefore, the consumers affecting the pattern of electricity consumption (with emphasis on electric energy consumption and not consumption demand) are considered from this point of view.

- Third group: Contributors

The contributors are ministries, institutions, organizations and institutions whose activities are in various fields, their missions and duties are not directly related to the issue of electricity consumption management, but their entry into this field can have many effects and benefits and therefore in here these institutions are introduced under the title of electricity consumption management contributors. Some of these institutions are the Ministries of Industry, Mine and Trade, Ministry of Petroleum, Ministry of Interior (Municipalities), Ministry of Transport and Urban Development (Construction Engineering Organization), Ministry of Science, Research and Technology (Universities and Research Centers), National Standards Organization, Customs Administration, Trade Union related to electrical appliances and equipment, costumer protection organization, government penal departments, etc.

- Fourth group: Allies

This group of stakeholders are actors whose activities have a direct effect on the demand side management and without their involvement, it is not possible to achieve the goals of demand side management programs, or it progresses slowly or with many challenges. Among these actors, we can mention the manufacturers of electrical equipment and appliances, energy service companies, contractors and consultants.

- The fifth group: innovators

This group includes new actors whose entry into the field of demand side management programs can be the basis for more acceleration in the development of this type of activities in Iran's electricity industry. The entry of some innovators (such as startups) in other fields such as transportation, ICT, etc. has led to

significant successes in the country. In many countries of the world, the entry of some of these actors into the field of electric energy consumption management has been emphasized.

#### 4. SWOT ANALYSIS

One of the most common methods of developing strategic plans and documents is the analysis of internal strengths and weaknesses, as well as external opportunities and threats, known as SWOT analysis. In this section, the weaknesses and strengths found in the upstream documents and the current state of electrical equipment and appliances are explained from different points of view, as well as opportunities and external threats (extracted using the opinions of experts).

##### 4.1. Strengths

- The existence of appropriate rules and regulations to support the penetration of high-efficiency equipment;
- Society's relative awareness of energy issues;
- The public acceptance of the energy saving approach;
- Existence of some appropriate standards;
- Large investments made in technology commercialization;
- The interest (and prejudice) of the majority of the people and the order of the country's officials and religious authorities to use domestic products;
- The existence of well-known brands (even insufficient) in the country in the field of electrical appliances;
- The presence of high market potential to attract efficient building technologies;
- The number and variety of users available for the technology;
- Availability of technical manpower related to the desired technology;
- High degree of convergence among different governing bodies to use high-efficiency technologies;
- Effective support of the desired technology in the media;
- Existence of high-efficiency technology support groups in parliament, government and industry;
- The existence of sufficient basic knowledge and specialized manpower in the field of high-yield technologies inside the country;

- The documents refer to the optimization of energy consumption and the use of new technologies and upgrading of equipment;
- Referring to the strategies to replace some high-efficiency electrical devices with solar ones and provide energy by renewable energies;
- Existence of strategies for the culture of energy consumption and support for the production and distribution of high-efficiency devices;
- The existence of comprehensive and numerous documents in this field;
- Codified customs rules to monitor the import of equipment in the construction sector;
- Frequent attention and emphasis on the discussion of energy efficiency in the macro documents of the country;
- Consumers' positive attitude towards using more energy-efficient equipment;
- The branding culture in Iran, which in turn has a direct effect on the purchase of energy-efficient equipment;
- Existence of specific energy efficiency criteria and indicators for each electrical equipment;
- Comprehensive awareness of consumers regarding the choice of energy equipment based on the energy label due to appropriate advertising;
- Existence of definite standards in order to optimize energy consumption;
- The strategic nature of the penetration of high efficiency equipment technologies in the electricity industry of the country;
- Synchronization of hardware and advanced technologies in the high-efficiency equipment industry of the country;
- The use of young experts and the potential of the country's specialists;
- High employment.

##### 4.2. Weak points

- Non-intervention of innovative companies in the field of technology commercialization;
- Non-offering new products and services in the field of technology inside the country;
- Holding small and low-profile technology fairs in different cities inside the country;

- People's lack of trust in the quality of domestic goods and acceptance of world famous brands;
- Promotion of foreign goods (and mis-promotion of domestic goods) by the media, importers and sellers of home appliances;
- Absence of domestic brands that are famous for producing efficient products;
- The small number of domestic and international patents in the field of technology;
- The small number of active research institutions (R&D) in the field of technology;
- The small number of reference laboratories to perform standard tests on technology;
- The weak role of universities, research centers and knowledge-based companies in this field;
- The failed performance of the government in preventing the entry and construction of low-efficiency equipment;
- Lack of associations and NGOs in this field;
- The negative role of market fluctuations, indiscriminate imports, lack of economic justification, lack of effective government support in the production and expansion of high efficiency technologies;
- The absence of a leading international position for the country's industries in this field;
- Producers complaining about the lack of national resources, liquidity, and lack of economic justification for operating in efficient industries;
- Low entry rate of entrepreneurs and investors in this field;
- Lack of proper communication between industry and university;
- Importing of efficient foreign products without providing the necessary technical knowledge;
- Failure to allocate appropriate budget and take necessary measures to reduce the intensity of energy consumption through efficient technologies;
- Lack of tax incentives/exemptions for importers, producers and users of these technologies;
- People's lack of attention and awareness of energy labels and the amount of energy consumption of household appliances;
- Inadequate communication between prominent foreign and domestic researchers;
- Lack of necessary support for master's and Ph.D. theses related to the development of efficient technologies in the construction sector;
- Insufficient scientific visits to factories and reputable industrial companies for students and trainees;
- Lack of strict monitoring of the quality of imported goods and consideration of penalty in case of low product quality;
- Lack of preparation of cultural programs and public awareness and promotion regarding the benefits of using high-efficiency technologies;
- Absence of official institutions to monitor the implementation of mandatory standards for each equipment;
- The possibility of entering or producing equipment outside the energy efficiency group defined in the relevant standard (with unacceptable energy labels defined in the standard);
- The impossibility or difficulty of importing electrical equipment with higher efficiency due to heavy sanctions;
- Failure to update the standard of electrical equipment and, as a result, the possibility of their incompatibility with the current state of the consumer society;
- Delay in the entry of the latest technologies of any equipment into the country;
- Failure to refer documents and strategies to emerging technologies and controlling and predicting the consumption of their devices such as; Cryptocurrencies, ICT, IOT and 5G;
- A consumption-oriented rather than a value-oriented approach (creating added value) to efficient building equipment;
- Weakness of strategies in strengthening the private sector to manage the consumption of high-efficiency devices;
- A top-down and enterprise-oriented approach and not a supervisory and management approach regarding the culture of consumption and the production and distribution of high-efficiency devices;
- Absence of a strategy or plan to collect and create a database and information related to the energy consumption of high-efficiency equipment;

- Weak reference and transition to the subject of smart buildings, energy consumption management of high-efficiency equipment, and failure to provide specific strategies to achieve this important goal;
- Failure to explain the time period (at least in general or according to upstream documents such as the country's development plans) to achieve the mentioned strategies;
- Focusing and paying attention to the quantity and not the quality of energy consumption of high-efficiency building equipment;
- Lack of documents and roadmap to achieve the mentioned strategies such as; Roadmap for the development of smart building systems for high-efficiency equipment, roadmap for the development of high-efficiency equipment in the field of ICT, development roadmap for the information management system for high-efficiency equipment, ecosystem design for the development of high-efficiency equipment, etc.;
- Failure to consider an effective executive guarantee for the prepared documents;
- Lack of efficient updating of documents and especially standards in recent years, due to the increasing slope of technological progress;
- Lack of official notification to consumers regarding the existence of codified standards of high efficiency equipment in the construction sector;
- Lack of legal requirement for consumers to use relatively efficient equipment in the construction sector, in existing documents and laws;
- Generalization and lack of clarification in most of the specialized documents in this field;
- The approach of fear and not hope to encourage consumers to use high-efficiency equipment in the construction sector;
- Lack of legal and executive clarification regarding the consequences of ignoring requirements and laws;
- Non-optimal use of equipment by the consumer;
- Absence of an ecosystem for the production of high-efficiency parts and technology;
- The possibility of disrupting the integrity of the implementation of documents and laws

due to the lack of efficient executive guarantee and coherent monitoring system;

- Increasing provision of out-of-class services and goods (from the point of view of energy efficiency standards: goods labeled with low energy and high consumption) in the market due to the lack of on-time updating of documents and standards;
- Occurrence of problems caused by lack of proper culture as a result of not paying attention to emerging technologies;
- Lack of public use of high efficiency equipment due to insufficient information of consumers, or their relatively higher price than less efficient equipment;
- The possibility of multiple and sometimes deliberate interpretations of specialized documents in this field due to the generality and lack of clarification of the above mentioned documents.

#### 4.3. Opportunities

- The presence of sanctions and the depreciation of the national currency, which has caused an increase in the price of imported goods, is a good opportunity for domestic production (both domestic sales and exports);
- The existence of new prospects for the development and improvement of technology;
- Technological growth in developed countries;
- Competitiveness at the regional level in the discussion of energy efficiency;
- Development of the field of export of high-performance equipment;
- Establishing a connection between the knowledge of energy efficiency and its technologies with the discussion of foreign trade;
- The proper situation for job creation in order to create an opportunity to use, manufacture, sell, supply and service energy-efficient equipment and the formation of a large labor market;
- Relying on domestic power and reducing dependence on imports;
- Creating ancillary industries;
- Moving towards self-sufficiency in the production of high-efficiency technologies.

#### 4.4. Threats

- The existence of strong companies and global competitors in the field of efficient building technologies;
- Sanction on raw materials needed for technology development (from abroad);
- The presence of sanctions has prevented the transfer of high-tech and productive technologies;
- The high growth rate of highly productive foreign technologies and the backwardness of domestic industries;
- Dominance of cheap and low-efficiency products of some countries in domestic markets;
- The possibility of infiltration of counterfeit goods instead of original goods due to the sanctions imposed on the country;
- Powers dominating the international market;
- The existence of fierce competitors;
- Not having a suitable native model;
- Software and hardware technological gap with today's technologies;
- Poor interactions with international technology companies;
- High cost of parts for high performance equipment.

#### 5. THE CURRENT SITUATION

The issue of increasing energy efficiency in activities, various energy-consuming processes, equipment and supplies has always been on the agenda of policymakers, legislators, planners and relevant officials in the past few decades. The development of macro policies at the highest levels of the system, the establishment of progressive laws and appropriate to the country's development process by the legislator, as well as the development of regulations and standards related to energy efficiency by the institutions and organizations in charge, indicate the special attention of the country's government to this important issue. However, the high energy intensity index (more than the world average) in Iran and the failure to achieve the major goals predicted in the country's five-year development plans, indicate the fact that despite the existence of relatively complete laws and regulations regarding increasing energy efficiency and energy efficiency in the country in practice, not many successes have been achieved.

Undoubtedly, the weakness in implementing the very good laws and regulations that the legislator has established is one of the most important factors in not achieving a favorable position in the problem of energy efficiency and energy efficiency. On the other hand, the lack of quality and continuous monitoring of the implementation of laws and regulations is a double factor for not achieving the goals related to reducing the intensity of electric energy consumption in the country. These factors, along with the relative cheapness of energy carriers in Iran, have created a situation where the proper foundation for the penetration and expansion of high-efficiency technologies has not been provided. Furthermore, the society's general acceptance of the approach of saving in various fields, including energy, which mostly originates from religious teachings (and media advertisements have played a lesser role), as well as the relative awareness of the younger generations of the society regarding energy issues, as well as the existence of sufficient basic knowledge and specialists in the field of high-efficiency technologies in the country has provided very favorable conditions for achieving the high goals of the system for optimal use of energy resources, reducing energy intensity and improving energy efficiency. In this paper, challenges such as the low price of energy carriers, weak monitoring of the implementation of laws, the high cost of high-efficiency equipment, the slow process of domestic resources to produce high-efficiency appliances and equipment, the lack of proper guidance of facilities and subsidies to support and encourage people to use high-efficiency technologies and the weakness of cultural and media activities in raising public awareness has been pointed out as important weaknesses in the current situation. Further remarkable points are the existing state of high-efficiency building technologies, the lack of widespread involvement of the building sector in the issue of intelligent energy management systems, and the lack of widespread use of new approaches to meeting energy needs in buildings, including CHP systems, modern electricity distribution systems in high-rise buildings, and systems based on renewable energies, energy storage systems, etc.

#### 6. CONCLUSION

In summing up the current situation and in order to overcome many of the mentioned challenges and achieve national goals such as reducing the country's energy consumption intensity (increasing energy efficiency) which is affected by the increase in energy

efficiency and in order to accelerate the penetration of high-efficiency technologies in the building sector, the country needs to take some major actions and moves at the national level:

- a) Determining the central trustee for the energy intensity reduction program in the country (Plan and Budget Organization);
- b) Market transformation in the supply chain and the use of energy-efficient technologies;
- c) Accurate, capable, scientific, specialized, continuous and powerful monitoring of the implementation of relevant programs, laws and regulations;
- d) Reviewing the structure of tariffs and prices of energy carriers;
- e) Supporting entrepreneurs, innovators, removing obstacles to high-quality production, providing extensive support for applied research in universities and research centers;
- f) Establishing incentives, providing facilities, targeting subsidies to support the penetration of high-efficiency technologies in various sectors, including construction.

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