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The impact of technology on architecture in Iran with focus on saving in energy consumption

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Abstract

Growth and development of technology caused enormous transformation and change in the world after Industrial Revolution. The contemporary human has prepared the platform for their realization in many activities that the humans were unable to do it in the past time and struck the dream of their realization in their mind so that today doing many of those activities have been apparently practical by human. This accelerating growth accompanied with consuming a lot of energy where with respect to restriction of the given existing resources, it created energy crises. On the other hand, along with growth in industry and requirement for manpower and immigration from village to city and basic architectural changes in houses, which have emerged due to change in social structure it has led to change in lifestyle and type and quantity of consuming energy in contemporary architecture. Inter alia, with increase in human's capability, cooling and heating and acoustic and lighting technologies were also changed in architecture and using mechanical system was replaced by traditional systems. Application of modern systems, which resulted from growth of industry and development of technology and it unfortunately, caused further manipulation in nature and destruction of it by human in addition to improving capability and potential of human's creativity. With respect to growth of population and further need for housing and tendency to the dependent heating and cooling systems to them in this article we may notice that the housing is assumed as the greatest consumer of energy to create balance among the exterior and interior spaces in line with creating welfare conditions for heating and cooling and lighting. The tables of energy demand prediction in Iran show that these costs and energy consumption will be dubbed with energy control smart management in architecture.

Keywords:Energy, Technology, Architecture, Cooling, Heating, Smart

Introduction

Demand for energy and inadvertent consuming of it caused emerging of three oil crises during 70s and 80s and year 2005. These three important events of energy caused rising prices of crude oil and energy among which the industrial countries tended to save energy with change in technology and benefitting from modern techniques in energy consumption. Alternately, the high statistical quantity of energy consumption in architecture and great deal of dependency of this sector on energy to meet heating and cooling needs represent further attention and preparation of ground to create energy crisis in architecture to the extent that employing modern technologies in taking optimization strategies in energy consumption and improving efficiency and correction of exploitation pattern may play crucial and noticeable role in heating and cooling comfort at buildings and signify the effect of new paradigms in creating new facilities. The comprehensible point that is latent beyond these modern facilities includes selective impact and contemporary human's dependency and life on these subsequent and incessant developments in his/ her culture and life change.

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Technology parameters:

These components are deemed as constituent elements of technological package including as follows:

1- *Human*: It includes individual and community that cover from thinking to knowledge and practice of human.
2- *Nature*: It comprises of the surrounding environment. At first place, nature includes the inhabitat around human where this environment is called synthetic environment after manipulation by human.
3- *Tools*: They include the devices which are employed by human to utilize from nature. By definition, tools mean management of technology as a facility that converts raw material or nature into the product.

4- *Product*: It is a new form that the material appears similar to its shape. In fact, product is the human's conscious move in utilization from nature by the aid of tools (1).

Types of philosophy around technology from this view:

1- *Instrumental*: In instrumental perspective, technology is merely assumed as tools and it is deemed as equivalent to devices and instruments.
2- *Essence-oriented*: In this viewpoint, technology is not observed as a neutral tools but some essence is considered for technology that differs from technology per se. in essence-oriented viewpoint, some risks are assumed against humans by technology.
3- *Critical*: In this approach, technology mainly includes destructive and detrimental aspect from practical perspective. Presence of technology in different individual and social life scenes and its impact on human has intensified the criticism against technology and using it widely (2).

Heidegger assumed topic of technology in article of question from technology and tried to reveal nature of technology as a type of apparent existence in which the reality of being is discovered. Heidegger does not oppose technology and he does not believe that we should revolt anxiously against it at present. Technology is not a hazardous and devilish subject. The technological potentially- lethal machineries and devices are not followed by threat. Technological threat originates from the heart of determinism. The risk is placed where the human fails to meet technological conflict-seeking with reliance on his/ her existential nature and instead s/he may be converted into a technological action and disciplined under technological process (3).

Technology and architecture:

Architecture and technology are especially related to each other since without technology and its use; architectural plans may be realized only on paper. Architecture and technology designs are usually two separate topics in academic trainings and educational disciplines but they are related together in realization of the designated projects. Even when designers continually and permanently skim and concern with concept of design technology actualizes and manages design process and it is entirely related and linked with architecture. At the end of twentieth century, a new technique and order emerged in architectural technology and evolved gradually. It was an order in which the objectives may be summarized in three main themes including follow-up qualification of buildings through design, technology, and management (4).

Impact of technology on architecture

Technology has imposed a systematic order to architecture and affected on its configuration and foundation and separated architecture from its theme and created alienation in it and referred its goal and attachment to the past and created new interests and values in architecture and advanced a culture proportional to its fundamental characteristics toward technology in which the final architecture is turned into global process so that to be product of technology in the world while it sidetracks cultural, ethnic, and climatic attributes to the margin and architecture is converted into a consuming good in the world. The physical dimensions prevail over its spiritual dimensions. That type of architecture has not originated from its own theme and environment and it is in diversity and conflict with the nature and plays essential role in destruction of environment.

Overall, from the perceptive of building management upon exploitation, the relationship among technology and architecture may be comprehensible based on two following perspectives:

1) Technology from viewpoint of heating and cooling and lighting
2) Technology from smart point of view

In the following, the role of technology is explored from perspective of building management at time of exploitation and its relationship with energy consumption in Iran.

1) Technology from viewpoint of heating and cooling and lighting

Generally, this technology in architecture includes heating technology- cooling technology- and lighting technology. The heating and cooling systems in architecture are the greatest energy consumers in the contemporary world. At these systems, an enormous portion of energy is used for providing heating and cooling in the building and it is spent for preparation of heating and cooling comfortable conditions in a building. In order to

clarify energy status during several recent years and amount of demand for it that is proportional to growth of industry and rising population, it seems necessary to present the following statistics from perspective of energy consumption in architecture sector compared to other sectors in Iran.

A glance at status of energy consumption in Iran with focus on household and commercial sector

The status of energy consumption during 8-year period is drawn in the following tables that represent the condition of energy consumption in Iran to interpret this subject graphically.

Sector/ year	2012	2011	2010	2009	2008	2007	2006	2005
Household, public & commercial	405.4	430.2	422	429.7	415	433.9	410.5	369.2
Industry	303.7	293.6	281.5	258	252.7	236.0	194.3	181.3
Transportation	299.7	288.2	283.2	300.5	274	261.7	263	247
Agriculture	47.6	45.8	45.5	43.3	41.9	37.6	36.8	33.7
Other consumptions	2.1	2.2	1.2	2.2	2.4	2.7	2.7	2.5
Consumptions other than energy	122.5	24.6	100.6	124.5	120.2	109.2	82.7	62.8
Total final consumption	1181.0	1184.6	1134.9	1158.3	1106.3	1081.1	990.1	896.6

Table 1- Energy balance sheet during eight-year period (2005-2012: equivalent to million barrels of crude oil)

Sector/ year	2012	2011	2010	2009	2008	2007	2006	2005
Household, public & commercial	405.4	430.2	422	429.7	415	433.9	410.5	369.2
Total final consumption	1181.0	1184.6	1134.9	1158.3	1106.3	1081.1	990.1	896.6
Percentage of total consumption	34.32%	43.45%	39.03%	38.84%	35.82%	38.23%	34.65%	31.26%

Table 2- Energy balance sheet for eight-year period from 2005 to 2012 (i.e. million barrels of crude oil) in household, public, and commercial consumptions

Role of architecture sector in energy consumption:

Total comparison of final consumption with rate of consumption in household sector during eight-year period is as follows: In the following diagram, the comparison of status of energy consumption during eight- year period from 2005 through 2012 (million barrels of crude oil) has been implied among household, public, and commercial consumption with total energy consumption in the diagram.

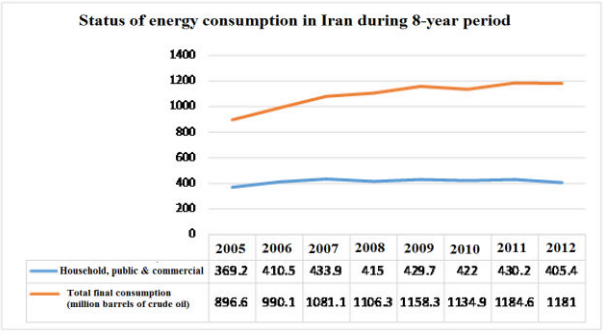

Diagram 1- The status of energy consumption from 2005 to 2012 (million barrels of crude oil)

Source: Author by means of reference (5)

Based on the above statistics, about 40% of total energy consumption in our country belongs to building (household, public, and commercial).

Prediction of population of Iran and energy consumption

The continuous rising population has exposed the world nations to problem of energy deficit and threatened human life more than ever. [3] Based on study of UN Population Office, the growth rate of national population will be 1.02%, 1.014%, 0.87%, 0.63%, 0.53%, and 0.52% during periods (2012-2016), (2017-2021), (2022-2026), (2027-2031), (2032-2036), and (2037-2041), respectively (6).

Population/ year	2016	2021	2026	2031	2036	2041
Urban	58.0	63.3	68.0	71.7	75.1	78.4
Rural	20.9	20.1	19.2	18.2	17.2	16.3
Total country	78.9	83.4	87.1	89.9	92.3	94.7

Table 3- Prediction of Iranian population from 2016 to the horizon of 2041

The need to energy is increased with rising population as a result demand for energy will be also increased.

Prediction of demand for energy in Iran by horizon of year 2041

With respect to the following diagram, proportional to rise of Iran population at horizon 2041 and noticeable growth of urban population within this time interval, the heating of architectural space devotes the maximum portion of useful energies.

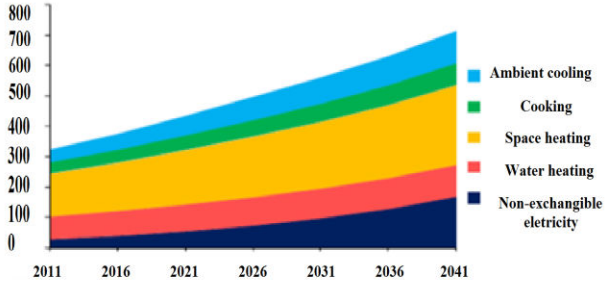

Diagram 2- The energy consumption in various architectural sectors (million barrels of crude oil)

Lighting technology

The main part of electrical energy is used in lighting and fan-coils and household electric appliances. According to a report from Iranian Energy Productivity Organization (SANA) in 2014, the buildings have consumed more than 47%, total electric power consumption in the country and the cooling load in public buildings consists of about 34% of total energy consumption in buildings. Therefore, potential in sector of energy consumption for cooling is comprehensible. The aerator heating terminals (fan-coil- gas cooler) are assumed as the major consumers of electricity in this sector and in most of cases due to leaving these units switch-on after the end of work in building they impose double cooling and heating loads to mechanical rooms and increase consuming gas and power. Employing smart mechanical rooms is one of the strategies for energy consumption management. [1]

Portion of technology of electric devices in rate of energy consumption

The following diagrams have been drawn to compare the amount of portion of the consuming electric power by the electric devices in house at normal and hot seasons. The rate of consumed electricity by cooler during hot seasons of year expresses the high portion of cooling technology in high energy consumption in Iranian house.

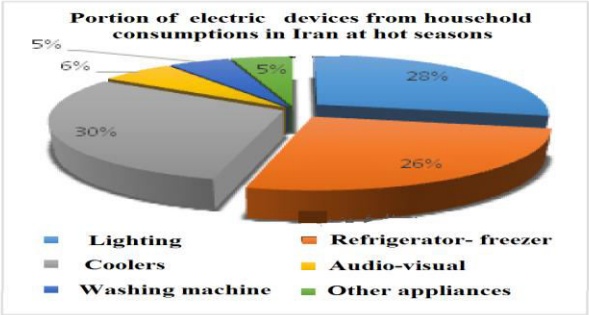

Diagram 3- Drawn by author using reference

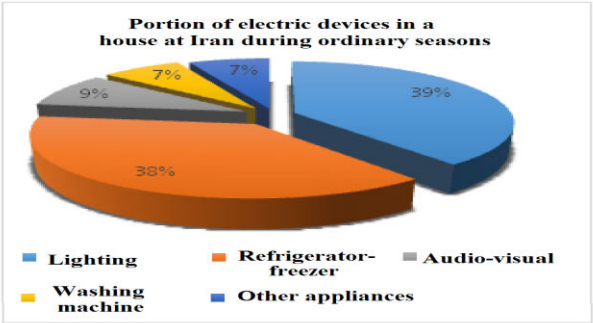

Diagram 4- Drawn by author using reference

2) Technology from smart point of view in architecture

After Industrial Revolution and wide development during twentieth century, technology entered quickly in human's life and caused essential change and transformations in it. Motivated by achieving further welfare and security, human used various technologies every day more than the past so that over the time, technocracy was proposed in human communities in such a way that the tools and devices played key role in humans' life step by step. Technology gradually met all human's expectation in all fields. As a result, the way was paved for emerging technopoly (exclusion of technology). It was at this time when technology excluded tradition and culture from life of people intangibly and substituted the definition, which discerned for them, for all keywords in their life. Thus, this trend was led to the point that technology was replaced by anything and human was entrapped totally by it so that technology left dramatic impacts on all perspectives of human life such as culture, environment, employment, economy, and any other imaginable cases (7).

With respect to scientific and technological expansion and developments in history of

architecture, one can recognize three periods or memorial waves. The first wave is agricultural age that emerged pursuant to human's needs to provide subsistence and dated back to three millennia ago. The second wave id age of industry where its start point may found in Industrial Revolution with over five hundred years history that dramatically affected on architecture from time of arising and not only changed form and shape and way of construction but also spatial concepts. Third wave belongs to electronic age where presence of computer and invention of internet may be assumed as its start point and it was another turning point in the field of architectural design (8).

Some other factors are effective along with climatic issues and direction of building proportional to climatic conditions and their used materials. Among them, opening units play important role in heating and cooling exchange because of their higher thermal coefficient compared to other elements and materials as well as passing light and radiated heat resulting from passing of light through them particularly in glass parts. These two factors increase cooling and heating in building that is followed by rising energy consumption to meet the requirement for the exploiter.

With change in lifestyle in recent time some changes have been exerted in concept of house and settlement. Thus concept of house as the meaning of quasi-natural product and responsive to human's physical and spiritual requirements has been replaced by housing unit as a type of abnormal and mechanical product and settlement as meaning of comfort has been substituted with housing as meaning of location (9).

The conducted studies in USA and UK and the recent investigations in Greece are concerned with temperature- cooling and heating days that represent significant climatic changes and thus energy consumption in buildings (10).

Determinant factors of energy consumption in building

A group of determinant factors and agents for rate of energy consumption in building are classified as follows:

- Climatic conditions on site of construction of building
- The materials used in building shell and external walls
- Type of architecture and structure of building
- Building central installations (heating, cooling, HVAC and lighting)
- Consuming devices and equipments (electric appliances and official equipments) (11)

Building smart architecture

Today, buildings are deemed as a variety of technology per se. They are adapted to technology and benefit from them. As a structure, buildings will become smart as they possess potential of computer. In the first smart building, technology was employed for preparation of a secure and comfortable and energy- producing environment. The paradigm of a smart building puts forward the relationship and continuity among access, lighting access, security, management, and telecommunication. The integrating factor gives this potential to systems to enable them to exchange information mutually. Data exchange between these systems causes the data output that is the same as final result to be implemented without any disruption. On the other hand, data output systems and or final decision- makers are responsive systems, which provide appropriate response for the transmitted data that imported from various sources into the system [2].

Smart materials and structures are the objects, which sense environmental events and process those sensual data and react versus it in the environment [12].

Through development in materials, products, and innovative construction techniques, it seems necessary to move toward buildings with higher efficiency and better cost-effectiveness, and eco-friendly. At present, we are at the threshold of next generation of buildings; the buildings behave totally ecologic with modern technologies at different levels and they are capable to react versus direct and indirect changes in their surroundings with benefitting smartly from compatible materials and appropriate performance and thereby to adapt to suitable conditions (13).

2- Smart buildings

In general, smart building is deemed as a requisite for the future and smart building is a building that is equipped with a strong communicational infrastructure, which may constantly react to environmental conditions and adapt to them and it also allows building inhabitants to consume the existing energy more efficiently and improve their security and comfort. The plan of smart building

causes saving remarkably in energy consumption and at the same time facilitates their management extremely. Computerized systems are employed noticeably in this regard. These systems are characterized under various titles [3].

Building Management System

Building Management System (or BMS) is a system that monitors the activities and affairs in buildings and automatically exerts the needed changes in environmental conditions as they need under the required conditions. The building that is equipped with BMS management system is typically called smart building. This system provides this facility for inhabitants to use these equipments more effectively and it improves sense of security and welfare in them and may also lead to saving energy consumption. Using integration of four main elements including systems, structure, service, and management and through communication between them, these buildings may create a dynamic and cost-effective environment. The equipments, which are controllable through BMS, are as follows: lighting- protective and security systems- door, window, curtain, and shade- cooling and heating systems (HVAC)- audio-visual systems, official equipments- imaging iPhone system and control of transport of guests or referents- control of pool, sauna, Jacuzzi systems- communication systems- and building electric devices and irrigation system (11).

The main advantages of smart building are Comfort- security- flexibility- saving in energy consumption- lower cost- and integrated control.

Smart buildings with nanotechnology

Rapid growth in technology and information in the future heralds valuable services of technology in human life. Whereas heating and cooling systems play great role in energy consumption and has widely tried to reduce energy and using it optimally in providing heating and cooling for building in order to meet this requirement for technology with exploitation from modern techniques but this growth is so quick that it has been permanently effective toward change in human's lifestyle and made the human dependent to variable and developing technologies more than ever. The nanotechnology has dramatically affected in construction industries while heralding very bright future. Of these noticeable cases of this technology one can refer to improving mechanical properties of cement and concrete- nano-coatings on self-cleaning surfaces and thermal and cooling insulators- nano-colors with capacity of air filtering- nanocomposites and water and sewage treatment materials and more importantly self-cleaning smart and fire- resistant glasses where these glasses may play essential role in reduced energy losses with control of light intensity in building and without need to curtain and cover.

Nanotechnology, which is included in modern sciences and efficient in architecture, may dramatically affect in architectural industry; for example, with development in the field of materials, products and innovative construction techniques, it seems necessary to move toward buildings with higher efficiency and better cost-effectiveness, and eco-friendly.

At present, we are at threshold of next generation of buildings; the buildings with several levels of modern technology that totally acted ecologically and are able to be benefitted smartly from adaptable materials with suitable performance and react versus direct and indirect changes around them and to become adapted to the suitable conditions (23). With potential of flexibility, smart houses act similar to a robot and evaluate and measure the changes around the building and react automatically with acquisition of data on proper and correct time and by the aid of sensors they may change internal and external structure of building under necessary conditions and in exposure to environmental changes they may suitably and duly react as action for responsiveness and adaptation to ambient conditions and try to cover the exerted efficient abnormalities to the building and being accountable to it in line with thermal comfort of exploiter.

Conclusion:

With emerging of Industrial Revolution and its dominance over industry and arising of novel technologies the construction scenes were transformed in architecture and the ground was prepared for technological dominance over architecture to the extent that technology developed its dominance over architecture. Alternately, the ground was prepared for expansion of migration to cities and increase in their population, social changes and changing family structure, and new

lifestyle and typically new transformations in architecture of Iranian housing as well. In this way, technology was imported from industrial community into the traditional societies and due to possessing the intrinsic features it was placed in conflict with their culture and affected on national and cultural values of traditional communities and their culture so that traditional organizational structures could not be adapted to these developments and responsive to them. Inevitably traditional heating comfortable techniques proportional to local climate were replaced with industrial heating and cooling systems and electric and lighting equipments and mechanical instruments were changed. This change in technological structure caused growing increase in energy consumption and crisis in the world and restriction of fossil energies and ever-increasing environmental pollution and energy loss in contemporary architecture at high level. Therefore, the ground was prepared for concern about two main topics of energy in technology under title of change in efficiency of consumption sources and change was exerted in correction of consumption pattern and necessity for application of modern heating comfortable technologies became important in architecture sector and recent housing and a new generation was created from technology as smart building. In today perspective, smart building means a building that includes all different aspects of exploiter human life and proportional to his/ her lifestyle. This type of building is constructed by aiming at improving productivity and high efficiency and through saving energy appropriately and heating comfort and reducing life cost for the exploiter with modern technology in addition to log life for the building. However, acceptance of technology is not always helpful and in some cases lack of proper application and proportional to exploiter's culture causes irrecoverable losses and damages, especially for communities with non-productive technology.

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