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FULL PAPER

# Investigating the feasibility of using nanomaterials in electricity and energy systems for urban use

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Nano Putians are a series of organic molecules whose structural formulae resemble human forms. One of the most severe issues in the world today, which has been significant in many countries, is the issue of saving and efficient use of resources and energy in the face of existing constraints, so according to experts, the use of new technologies, including nanotechnology in this area can be a way to discuss economic savings. The technology of simultaneous generation of electricity and heat is one of the technologies that has been highly developed in the last few decades. The management of the urban energy system in the supply sector using this technology has several issues and complexities that have prevented its operation in large cities. This research study discusses the feasibility of using the technologies of simultaneous production of electricity and heat in the urban energy system. The developed model was simulated to maximize fuel energy use for five different scenes. There is about 24% in fuel costs and a total of 20% savings in the main scene compared to the current scene. The total heat energy produced in these units during the year will be about 3.75 million MWh.

**KEYWORDS**

Economic analysis; urban energy network; optimization of energy supply.

## Introduction

Today, various batteries are responsible for storing electrical energy and have made it possible to use various portable electronic devices such as laptops and cell phones. Also, in addition to personal use, batteries are used in a wide variety of fields, such as the production of electric cars and aircraft and a variety of mobile robots, and the number of cases that require suitable batteries to store electrical energy is increasing day by day (Figure 1). Batteries supply energy stored chemically as electrical energy. Therefore, they are significant in various fields such as transportation, portable electronic equipment, medical and hospital equipment, and energy storage systems, especially renewable energy storage.

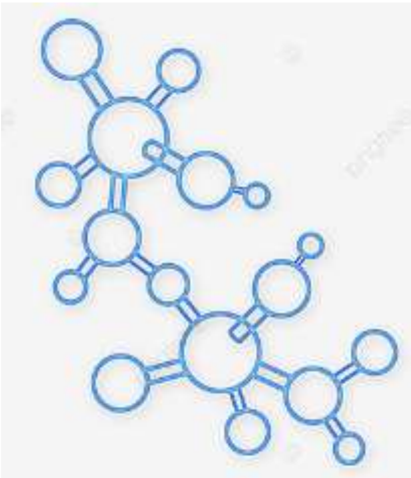

**FIGURE 1** Nano chemical structure [1]

Conventional batteries, also known as primary cells [1], are disposable and cause many environmental problems; their discharge releases various pollutants into the environment, such as harmful chemical compounds and heavy metals. This led to rechargeable batteries or secondary cells [2]. These batteries can be recharged and reused several times, saving a lot of money and significantly reducing environmental pollution due to the disposal of used batteries. Today, rechargeable batteries are produced and used in various dimensions. These batteries are made of different materials and are based on lead-acid batteries (the oldest type of rechargeable battery used in ordinary power cars), nickel-cadmium (Ni-Cd), lithium-ion (Li-ion). And lithium-ion polymer (Li-ion polymer) are produced. Among these, rechargeable lithium batteries are the most important and widely used rechargeable batteries used in various applications [3]. The main reason for the widespread use of these batteries is the high ability to store power and electrical energy and the long life of these batteries. Battery manufacturing technology has advanced a lot. The new wave of innovations in this part of technology relies on the achievements of nanotechnology. The most critical challenge in this regard is the cost of nanotechnologies, so we always ask that when a project is to be used in industry, there is a convincing technical and economic justification that there is a technical justification for nanotechnology, but in some cases, becomes economically challenging (Figure 2). Also, exploiting this science in the industry should not be a problem [4].

Life requires primary resources such as water, energy, food, and air. Various interactions and processes take place within it. Eventually, the waste and sewage of these processes are discharged into the environment. The urban energy system represents the collection (Figure 3) [5]. It is an interconnected process of energy supply and consumption to meet the population's needs in the city.

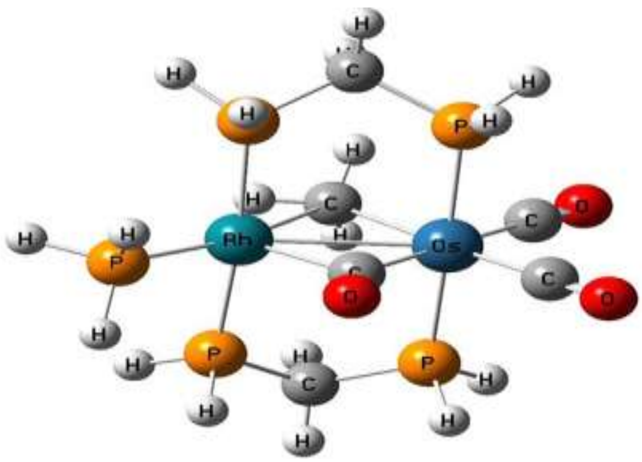


**FIGURE 2** Nano chemical structure in industrial [9]

In the past, this need was much simpler and generally summed up in need for general heating and energy needed for cooking. Today, this need has become much broader. It includes the need for cooling and heating of buildings, lighting of indoor and outdoor environments, electricity for public use, the energy needed for transportation, the energy needed for communications [6].

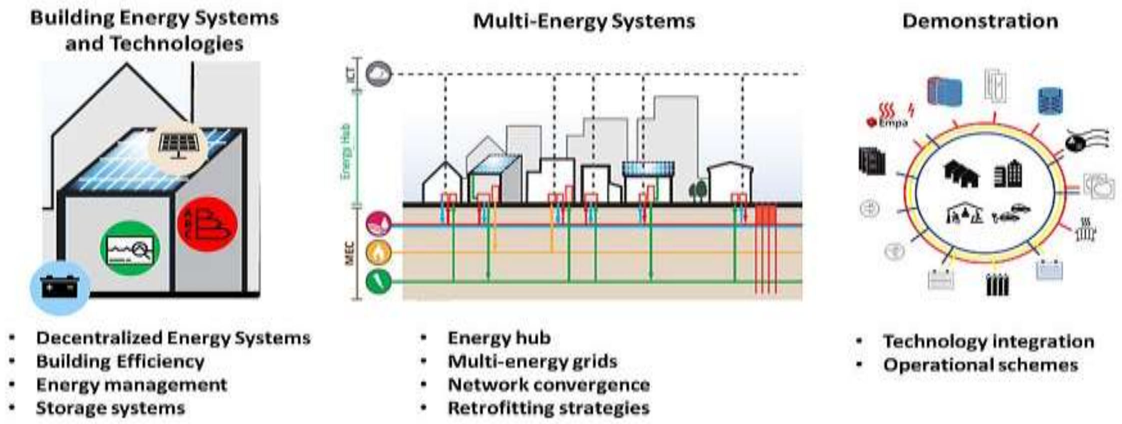


**FIGURE 3** Urban energy systems [5]

The international energy agency estimates that about two-thirds of the world's primary energy sources are currently used to meet the needs of cities, and this figure will reach 73% by 2030, resulting in emissions of 70% of total carbon dioxide emissions in cities. This significant volume of energy consumption has led to increased studies to improve energy production, distribution efficiency, and demand management. Moving to more sustainable sources and solutions instead of using the conventional fossil fuels of today is also a concern for researchers and governments. The urban energy system is directly dependent on heating, cooling, fuel, and electricity sources. Other sources such as air, water, and space in the city also indirectly affect this system, but their effect is usually significant and decisive [6]. From an economic point of view, tourism is one of the factors of economic improvement and growth.

Because by providing infrastructure in this field creates employment, income generation, and income generation, income generation, and added value of environmental resources. That tourism has significant effects economically and in terms of services and culture [7]. Because it proves the cultural values of the communities, introduces the indigenous values of the region, opens the communities to the people of foreign communities, and develops the regions' capacities, we should not separate tourism from urban planning. Old texture as one of the poles Tourism needs more attention and opinion to play a desirable role in tourism. In this regard, the research hypotheses are set as follows:

I. It seems that recognizing the tourist capacities of the cultural elements and components of the old texture (efficient advertising) can play an influential role in the development of tourism in the study area.

II. It seems that appropriate investment (in the direction of facilities and infrastructure) can play an influential role in developing tourism in the city (Figure 4).

Since its inception, human beings have made every effort to meet their needs and overcome obstacles in their path. So far, they have succeeded in obtaining some gifts, which has led to the emergence of culture and civilization [8]. Old and historical contexts can depict this feature and show it in buildings and components and elements of ancient and historical contexts. However, these tissues have many problems, such as welfare-civil-social problems. However, some experts have offered a way to deal with these problems by changing and evolving in this context. Still, others are opposed to any change due to this sector's cultural and historical importance. But regarding tourism in this part of the city, the old-historical context, it should be said that while accurate information about the existence of various historical attractions of our country at the international level can help attract tourists and generally develop the tourism industry [9].

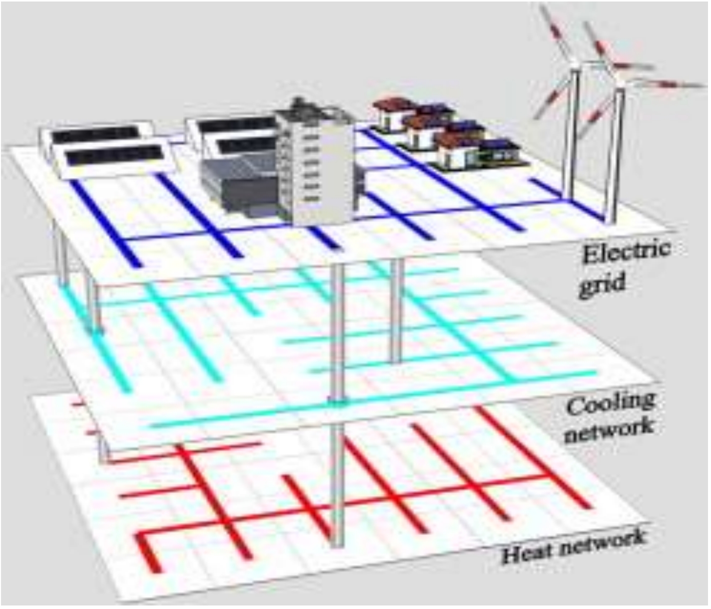


**FIGURE 4** Urban energy systems with smart multi-carrier energy networks [6]

**Investigating the place of old texture in the spatial organization and physical structure of today's city**

The city acts as a living body in its existence. This living body can be described as a living thing, a being whose vital tissues and biological organs are based on its ossification. Therefore, the city's physical structure can be called the ossification of the city. The ossification of the city is the same network of roads, and the flesh and skin are the same neighborhoods and uses of the city that are placed in this system (ossification) according to their importance. Neighborhoods create urban space in their spatial cohesion. Neighborhoods are unique and independent spaces, each of which has been formed and consolidated according to the importance of their existence. Today's observations and past maps of this texture indicate an organic and intertwined structure. In this context, the market is in the heart of the city, and the shape of the market and the city are affected by each other (the market and other elements of the urban index have been ultimately influential in the orientation of buildings and the surrounding urban context. Newly established streets). The bazaar has been developed in the city with rows, houses and its development has created passages, squares, and dead-ends in the city. With all its components, the bazaar has been an urban element that has met the city's needs at the macro level and has acted as the city's main thoroughfare. It was also a link with other cities and was the heart of its economy. What remains of this cohesive system today is the cutting off of neighborhoods by the streets, the change of use of neighborhood centers, and the violation of the specific boundaries of each neighborhood [8].

Today, with the creation of streets, commercial activities in the city have become decentralized. The uses that are appropriate for the day and the incompatibility of these uses with the market have disturbed the traditional shape of the market and reduced its power and certainty. Activities are mainly focused on the textured wall and the edge of the street. Several old houses with original architecture and local materials have been abandoned and are now being demolished. Today, nanotechnology has emerged as the fourth wave of the industrial revolution and a significant phenomenon in all fields and scientific trends. It is one of the new technologies that is developing rapidly. According to statistics in 2016, more than 700 billion tomans were sold by knowledge-based companies in this field. Over 35 million dollars were related to exports to 47 countries as target countries (Figure 5). However, many experts believe that the capacity to use this science is more than this. More importantly, Iranian society has not yet felt the effects of this science despite producing various products and nanotechnology in their daily lives [7].

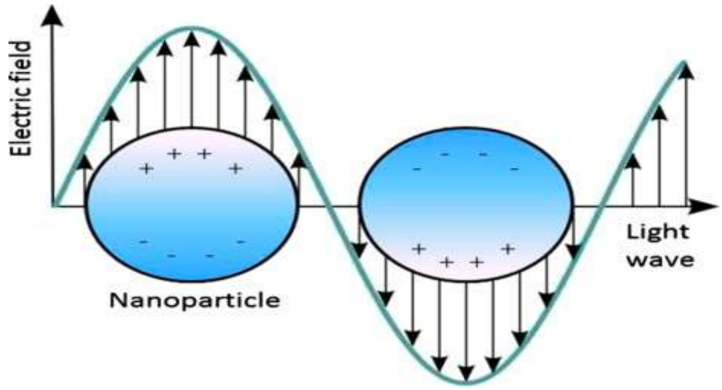


**FIGURE 5** Nanoparticles in the electrical industry

**The concept of old urban texture**

The old texture is an interconnected set of urban components and elements, including residential units, dilapidated, restored, and destroyed valuable historical monuments, markets, facilities, grids, architectural form, and a particular unique body that is the gradual product of gradual development and organic growth of the city. In historical periods, it is based on pre-industrial transportation technology and has a distinct construction in terms of function and appearance compared to new urban areas [1].

Therefore, it is not very compatible with the economic and social conditions of the present age, especially transportation technology, and horse access, a narrow network of roads, lack of green space, training, and burnout are among its significant problems. In this part of the city, where the fundamental core of the city is formed, unique historical, cultural, and artistic works called historical sources can be seen, an objective symbol of past civilization and urban life. The office has named such parts within the old texture as the old texture, which must be maintained. In this context, in addition to valuable cultural monuments and dilapidated buildings, there are also ruins, restorations, and being destroyed, which in some cases have been turned into slums, sheds, etc., or have been left in a dilapidated and unusable condition [5].

Therefore, they have no historical value, known as the old texture. In addition to the above buildings, there are several new units with durable materials and suitable real estate value. The need to maintain them is not hidden from anyone. Therefore, the old urban texture is a mosaic of different components and elements with various functions. The spatial order of these elements and functions creates a particular structure for this part of the city that a one-sided approach makes it impossible to change the structure. Hence, its organization requires a comprehensive approach to its socio-economic, physical, and physical dimensions. A one-sided physical attitude, such as widening the passages, alone does not solve the problem of the old texture. The social and economic issues of the residents are also of particular importance. That is, the context of tissue erosion should be considered in the social and economic conditions of its inhabitants, such as issues of ownership (inheritance, endowment), income, jobs, change of role and function, as well as the transfer of activities to new urban sectors such as markets and working capital searched [8].

The historical texture is the areas located in the old parts of cities that formed the city's surface before the beginning of the present century, the beginning of new urbanization in Iran. Such textures are now located in the center of cities. They have a position in the city, and a relatively large level and strong, vital performance (metropolitan and regional, and national scales) have added to its importance. Traditional urban markets as trade centers and other important buildings such as religious centers are located in these contexts [8].

**Old texture**

The old texture also began to form around the original core of cities (historical and continuous texture). This part of the city, formed in the interval between the transition from quiet urbanization to rapid urbanization, is neither historical nor new. Even its spatial organization is something between a historical and a new context. It can be imagined that the body of Iranian cities in the first three decades of the fourteenth century (AD) was composed of historical and ancient context [9].

**New texture**

In the early 1940s, the growth of Iranian cities began faster than in previous decades and around the old texture. At first, this growth usually took place along the streets that connected new elements to the city. And if there were natural, historical, and religious elements around the cities, the city would expand towards them [2] (Figure 6).

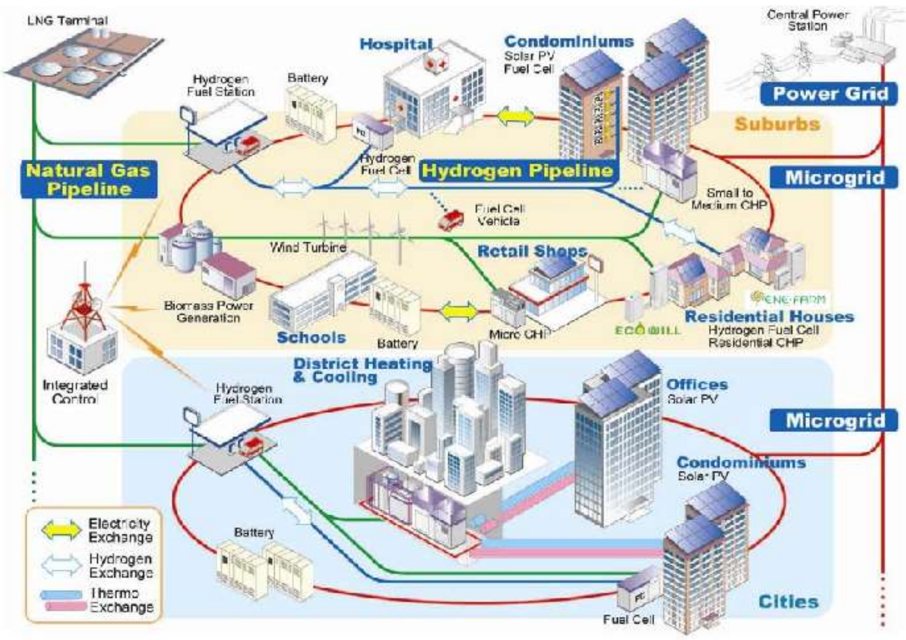


**FIGURE 6** A reliability assessment approach for the urban energy system and its application in energy hub [9]

**Energy systems**

The models developed for energy systems fall into seven general categories: simulation, scenario evaluation, balancing, top-down, bottom-up, performance optimization, and investment optimization. Patterns such as markers are scenario-based and are used in many countries. Its purpose is to study different scenarios in a single energy system defined in a small to national geographical range and a maximum period of 50 years. This group of models is the framework of economic balance, and they are used in energy policy-making at the national level. This software optimizes predefined tools and technologies based on the criteria that the user chooses to minimize. The time intervals in this software can be very short. For example, for one-year analysis, one-hour intervals can be defined.

The solution method is also linear programming. Other models, such as modest, minimize investment and operating costs when the entire demand is being met. In this method, because the linear programming model is used, it is possible to solve big problems. In this model, the initial investment costs are considered a linear function of the installed capacity, so in the answers obtained from the analysis, sometimes unattainable or minimal capacities are presented, which is one of the weaknesses of this model. Another limitation of this method is that it does not consider storage technologies and spatial distance [6].

- Energy combines GIS with hybrid integer linear programming equations to design heating and cooling networks. Annual demand for heating, hot water, cooling, and electricity is extracted from building information in the GIS. The reciprocating fluid temperature is then selected to meet the total need and the communication paths of the different regions that exchange energy with each other. This model can also use various technologies such as simultaneous production systems with engine and gas turbine and heat pumps in its analysis.
- Extensive research has been conducted to optimize the cogeneration system of buildings. For example, linear integer linear programming has recently been used to design the layout and optimize the simultaneous generation of electricity, heat, and cold to minimize annual costs and meet the needs of heating, hot water, cold, and electricity. Other research has examined the preference of technologies for minimizing energy consumption or cost in a cogeneration system.

For example, the use of absorption or compression chillers in residential complexes independent of the national grid has been compared in a study. Various studies have been conducted to determine the strategy of optimal operation and optimal cogeneration system design. For example, two computer programs have been developed to provide heat and electricity consumption of the residential complex. With the help of these programs, sensitivities related to changing system parameters have been studied and investigated [7]. In another study, the technical and economic feasibility of using small production systems simultaneously using nonlinear integer programming to determine the optimal capacity for the five climates of Iran has been investigated, and the results and sensitivities have been analyzed. Energy demand simulation is one of the most critical issues in the accuracy of results for real cases. In a study, household energy demand based on the socio-economic and Nemes models has been simulated in three sections: electrical appliances, hot water consumption, and required cooling heating. Some research has also been conducted for accurate residential complexes. For example, the optimal production system strategy with electrical management for the futuristic complex has been investigated. The difference between the actual fuel price and its supply price in Iran, for similar issues in Iran and other countries, leads to different solutions [2]. This research investigates the operation and determination of the optimal dimensions of the cogeneration unit of electricity and heat for the sample residential complex using stochastic optimization. Finally, the output results for the current situation of energy carriers in Iran and the world price of energy carriers are presented. Simulation of systems that work with multiple energy carriers has its complexities, and usually, different methods are used to analyze these systems. For example, the hierarchical decision-making method has been used to optimize capacity and performance in systems with multiple energy carriers. In this study, energy poles, defined as nodes of energy production, play a significant role in analyzing and modeling these systems [9]. The model used in this design is called a train, which considers resources and technologies in a network. In the trained model, the city is divided into sections, each with a specific demand for each resource over a while. (Demand is a function of time and place). The proposed template for this article is very similar to this template. Urban energy systems, in addition to the inherent complexities of energy systems, have specific issues in the social and cultural fields as well as limitations in the production of pollutants, allocation of space for the construction of power plants in the city, and change of existing structure and infrastructure to optimal structure [3].

## Methodology

The operation of the cogeneration system in cities is limited for several reasons. For example, restrictions on the release of air pollutants and noise pollution may allow equipment to be installed in the suburbs instead of within the city or use smaller, more limited-capacity equipment. Similarly, the lack of space (land for equipment installation) creates constraints in areas where the population and building texture are dense. Such restrictions may lead to smaller power plants and equipment, which are less efficient than large equipment and require more initial investment (cost relative to MW output). In this paper, the effect of such constraints on the urban energy system is quantitatively investigated, and the optimal model for the sample city is presented. The model chosen presents the optimization of the urban energy system based on the combination of technology and the network of energy production and distribution to meet the needs of consumers, which is a function of place and time. The method used for optimization is from whole to part.

## Calculations and findings of research

The critical indicator selected is cost. The ultimate goal is to minimize the cost of providing the resources needed by the city. Assuming demand is stable, supply system management can reduce costs. The selected sources are natural gas, electricity, and heat (in hot water 70-90 °C) (Table 1).

**TABLE 1** Population distribution in each area of the hypothetical city

| Y/X | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **1** | 8510 | 7950 | 8530 | 9970 |
| **2** | 8860 | 1050 | 12625 | 14950 |
| **3** | 8060 | 7650 | 12680 | 14550 |
| **4** | 8490 | 7810 | 12350 | 15780 |
| **5** | 7550 | 7020 | 12470 | 11740 |

To obtain the amount of electricity, heat, and gas consumption, a one-year reference was made to the energy balance statistics and the information of the statistics center of Iran in one year. The number and types of electricity subscribers are also presented in Table 2, the number of electricity sales according to the type of consumption in Table 3.

**TABLE 2** Number and types of electricity subscribers

| Free consumption | Commercial | industry and Mining | Agriculture | General | Homemade | Year |
|---|---|---|---|---|---|---|
| | | | 1138 | 117034 | 1794701 | **2010** |
| 850 | 346064 | 6468 | 1645 | 91236 | 744851 | **2011** |
| 4091 | 84401 | 18814 | 8294 | 92227 | 764536 | **2012** |
| 6469 | 80917 | 20464 | 2961 | 89766 | 776658 | **2013** |
| 3882 | 98898 | 28623 | 3222 | 88868 | 1514898 | **2017** |
| 4867 | 98322 | 98525 | 3019 | 110645 | 1517043 | **2018** |
| 6457 | 772872 | 33688 | 3575 | 315441 | 1512691 | **2019** |
| 12888 | 814257 | 35618 | 3663 | 314315 | 1977473 | **2020** |

**TABLE 3** Amount of electricity sales by type of consumption (MWh)

| Free consumption | Commercial | industry and Mining | Agriculture | General | Homemade |
|---|---|---|---|---|---|
| 9167 | 942037 | 422321 | 33018 | 209171 | **6011570** |
| 703072 | 153158 | 90396 | 9414 | 116164 | **7658759** |
| 77821 | 226365 | 96396 | 78202 | 936103 | **10318479** |
| 87381 | 152388 | 94345 | 74362 | 111114 | **10775102** |
| 77942 | 154323 | 114311 | 653054 | 116177 | **10792463** |
| 76674 | 1555758 | 622353 | 747257 | 118124 | **10891860** |

The per capita electricity and gas consumption is presented in Table 4 using the collected data. Reference does not consider the direct consumption of natural gas for applications such as cooking. However, in the model developed in this article, direct consumption of natural gas for non-heating and heating uses is separated. It is assumed that, on average, 90% of gas consumption is for heating purposes and 10% for non-heating uses such as cooking be allocated.

**TABLE 4** Per capita gas and electricity consumption in the hypothetical city (kW per capita)

| Assumed value for calculations | Based on reference | Based on balance sheet information and statistics center | |
|---|---|---|---|
| 0.38 | 0.10 | 0.48 | **Electricity consumption per capita** |
| 3.34 | 3.12 | 1.41 | **Heat consumption per capita (Heating consumption)** |
| 0.19 | | | **Gas consumption per capita (Cooking, etc.)** |

The periods are for four seasons and two consumption periods in each season (normal and peak consumption). The duration of each of these eight periods is presented in Table 5.

**TABLE 5** Periods and duration of each of them

| Time | Delta_t (hour) | Delta_t % |
|---|---|---|
| **Spring-Normal** | 1167 | 0.28 |
| **Spring-Peak** | 265 | 0.08 |
| **Summer-Normal** | 960 | 0.29 |
| **Summer-Peak** | 272 | 0.09 |
| **Autumn-Normal** | 1710 | 0.18 |
| **Autumn-Peak** | 250 | 0.06 |
| **Winter-Normal** | 802 | 0.19 |
| **Winter-Peak** | **534** | **0.060959** |

Accordingly, as well as the variable with a random coefficient between 0.9 to 1.1, each city area's consumption functions (needs) were extracted. The average consumption for each region in eight time periods is shown in Table 6.

**TABLE 6** Average annual demand for heat, electricity and natural gas in each region (MW)

| Heat | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **1** | 19.7 | 10.5 | 1.2 | 1.4 | 1.5 |
| **2** | 19.7 | 10.5 | 1.2 | 9.7 | 6.2 |
| **3** | 19.9 | 10.5 | 2.1 | 8.2 | 5.2 |
| **4** | 18.7 | 10.8 | 23.4 | 3.7 | 7.7 |
| **5** | 18.4 | 5.9 | 15.7 | 2.3 | 1.1 |
| **Elec.** | 1 | 2 | 3 | 4 | 5 |
| **1** | 2.1 | 2.6 | 2.8 | 3.7 | 1.5 |
| **2** | 8.1 | 8.3 | 8.6 | 4.4 | 1.3 |
| **3** | 8.1 | 2.5 | 2.6 | 5.8 | 1.8 |
| **4** | 8.5 | 4.9 | 4.5 | 2.4 | 1.1 |
| **5** | 2.1 | 3.3 | 3.4 | 4.4 | 2.1 |
| **NG** | 1 | 2 | 3 | 4 | 5 |
| **1** | 1.3 | 1.4 | 1.1 | 1.2 | 1.7 |
| **2** | 1.9 | 1.4 | 2.6 | 2.6 | 1.2 |
| **3** | 1.7 | 1.9 | 2.2 | 3.1 | 1.9 |
| **4** | 1.2 | 2.3 | 2.6 | 2.9 | 1.6 |
| **5** | 1.6 | 1.7 | 1.5 | 2.3 | 1.8 |

Four resource generation technologies were considered as follows:

**1- Small household boiler:** produces natural gas consumption and heat required for a building.

**2- Large boiler:** produces natural gas consumption and heat required for several buildings.

**3- Small cogeneration unit (one megawatt):** Consumes natural gas and generates heat and electricity.

**4- Medium cogeneration unit (sub-megawatt):** Consumes natural gas and generates heat and electricity.

The large boiler is a fire-tube type and produces 10 tons of saturated steam per hour (22,000 per hour). The specifications and assumptions of all technologies are presented in Table 7. The alpha coefficient in Table 7 is derived from table (8) assumptions.

**TABLE 7** Source production technology assumptions

| | Small CHP | Medium CHP | Small Boiler | Large Boiler | |
|---|---|---|---|---|---|
| **C_P_o ($/year)** | 3100 | 310000 | 81 | 1000 | Exploitation cost |
| **C_P_i ($)** | 1.00E+26 | 1.22E+07 | 825 | 11200 | Investment cost for purchase and installation of equipment |
| **Age_P (Year)** | 22 | 20 | 25 | 25 | Usable life |
| **Cap_P (MW)** | 4 | 14 | 0.425 | 4.2 | Capacity |

**TABLE 8** Efficiency of source production technologies

| Small cogeneration unit | Medium cogeneration unit | Boiler (Small and large) | |
|---|---|---|---|
| 50% | 49% | 90% | Heat recovery |
| 31% | 60% | - | Electrical efficiency |

## Discussion

Strategies for revitalizing regeneration include;

1- Injecting new content into the old body means bringing life and life into the space, which is also in line with the spirit of the space.

2- *Emphasizing the opportunities in the place:* means using religious and cultural capacities. The region's strength as the historical-cultural-religious heart of the city is revived. In this regard, the capacities and talents of tourism and actual and potential tourism of this part of the historical context can also be helpful. Continuity of urban collective memories: This collective memory makes this historical part a pillar of urban identity. Which becomes a suitable platform for dialogue between the past and the future.

3- Strengthening the ancient ossification of the complex and its public spaces about the whole city,

4- Emphasis on the historical and aesthetic value of the texture during revitalization: It is a city to improve the quality and identity of the city.

5- To promote a sense of responsibility towards the collection among the urban people. It can be found that over time, due to the focus of life and construction in the new context, it causes forgetfulness on the old texture. However, its revitalization gives identity to the city, and in addition to the use of residents, it has the potential to attract tourists from all over the country. This contributes to the city's economic and social growth and development.

Among them, the existence of valuable historical-cultural elements with identity, the existence of historical-religious memory and the function of identity and memorial of buildings and spaces in this part of the historical area, and the existence of historical backbone and center as well as functional values of texture as a religious center. Cultural-tourism (tourism) of the city due to the existence of markets and commercial orders in the context can be considered strengths in the revitalization and revitalization of this part of the historical context. Finally, the quantitative and qualitative improvement of civic life by revitalization institutionalizes the cultural heritage of the old context as a public heritage and turns it into cultural heritage. Not except with the participation of citizens in the affairs of the city and related matters. The template was simulated for five different scenarios:

**1- Main Scene:** All technologies (small and large boilers, small and medium cogeneration units) can be used in this scenario. The optimal solution is obtained based on minimizing equipment and fuel costs.

**2- Small boiler scene:** small boiler technologies, small cogeneration unit, medium cogeneration unit

**3- Small generator stage:** small boiler and cogeneration unit.

**4- Ideal scene:** All equipment is used except the large boiler. The capacity of the generators is optimal and incorrect.

**5- Current scene:** Use only a small boiler.

The result of the main scene is examined in detail, and for other scenarios, it is only introduced and compared with the main scene. In the main scene, there will be all four defined technologies. According to the hypotheses described, the key performance indicator is cost. Therefore, the variables that directly target the problem, which is to minimize this index, are the effect of installation and operation of resource production equipment, resource transfer equipment, and the import and export of resources to the city. In the small boiler room, the value of these variables and each share are obtained, which can be seen in Table 9.

**TABLE 9** The share of each of the cost decision variables in the main scene

| Parameter | Millilon $ |
|---|---|
| **Resource Production Technology** | 11.36 |
| **Transfer Technology** | 1.11 |
| **Resource Import** | 8 |

A summary of the average balance of imports, demand, production, consumption, and transfer of city resources over one year is shown in table 10 in the main scene. Electricity imports were at the peak of summer and winter consumption.

**TABLE 10** Average cost and balance sheet of import, demand, production, consumption, and transfer of city resources in one year, in the main scene

| Import (MW) | | Demand (MW) | |
|---|---|---|---|
| **Heat** | 0.10 | Heat | 439.7 |
| **Electricity** | 1.65 | Electricity | 83.7 |
| **NG** | 6.75 | NG | 41.4 |
| **Produced / Consumed (MW)** | | **Transferred (MW)** | |
| **Heat** | 477.77 | Heat | 12.8 |
| **Electricity** | 92.70 | Electricity | 118.1 |
| **NG** | -573.1 | NG | 176.9 |
| **Production Units** | | **Costs** | **258.5 M$** |
| **Small CHP** | 1 | Production Technology | 8.9% |
| **Medium CHP** | 19 | Transfer Technology | 0.8% |
| **Small Boiler** | 1 | Resource Import | 98.6% |
| **Large Boiler** | 187 | | |

In a small boiler room, it is assumed that the heating of the buildings is either through the heat recovered from the production units or through the home boilers located in each building. Assuming that small boilers need to be purchased and installed in this scenario, the initial investment and operating costs are obtained, as shown in Table 11.

**TABLE 11** The share of each of the cost decision variables in the small boiler room

| Parameter | Millilon $ |
|---|---|
| **Resource Production Technology** | 19.66 |
| **Transfer Technology** | 0.97 |
| **Resource Import** | 211.10 |

A summary of the average balance of imports, demand, production, consumption, and transfer of city resources over one year can be seen in the small boiler scene in Table 12. Electricity imports were at the peak of summer and winter consumption.

**TABLE 12** Average cost and balance sheet of import, demand, production, consumption, and transfer of city resources in one year, in the boiler room of a small boiler

| Import (MW) | | Demand (MW) | |
|---|---|---|---|
| **Heat** | 0.00 | Heat | 49.9 |
| **Electricity** | 1.90 | Electricity | 99.8 |
| **NG** | 69.8 | NG | 49.4 |
| **Produced / Consumed (MW)** | | **Transferred (MW)** | |
| **Heat** | 49.7 | Heat | 9.3 |
| **Electricity** | 85.2 | Electricity | 11.8 |
| **NG** | -61.1 | NG | 202.16 |
| **Production Units** | | **Costs** | **269.60** M$ |
| **Small CHP** | 12 | Production Technology | 6.1% |
| **Medium CHP** | 82 | Transfer Technology | 0.13% |
| **SMALL_BOILER** | 3252 | Resource Import | 91.2% |

In the small generator scene, it is assumed that only one-megawatt co-production units and small boilers are used. The difference between this scenario and the small boiler scene shows the effect of the optimal capacity of medium generators on the key performance index. A summary of the average balance of imports, demand, production, consumption, and transfer of city resources over one year can be seen in the small generator's scene in Table 13.

**TABLE 13** Average cost and balance sheet of import, demand, production, consumption, and transfer of city resources in one year, in the field of small generators

| Import (MW) | | Demand (MW) | |
|---|---|---|---|
| **Heat** | 0.00 | Heat | 322.9 |
| **Electricity** | 2. 8 | Electricity | 88.8 |
| **NG** | 333.9 | NG | 35.7 |
| **Produced / Consumed (MW)** | | **Transferred (MW)** | |
| **Heat** | 45.17 | Heat | 0.01 |
| **Electricity** | 6.5 | Electricity | 3.59 |
| **NG** | -433.08 | NG | 232.34 |
| **Production Units** | | **Costs** | **272.16** M$ |
| **Small CHP** | 125 | Production Technology | 9.4% |
| **Medium CHP** | 0.01 | Transfer Technology | 0.3% |
| **SMALL_BOILER** | 2557 | Resource Import | 95.13% |

The number of generators installed in each region is a decision variable that belongs to the range of integers. In the ideal scene, the number of correctness is not considered to obtain the optimal (incorrect) capacity for installing cogeneration units in each region. In the current scene, the city's heating source production, only the boiler, and electricity is provided only through imports. This scenario is very similar to the current state of the city's resources. The average cost and balance sheet of import, demand, production, consumption, and transfer of city resources in one year are presented in the current scene in Table 14.

**TABLE 14** Average cost and balance sheet of import, demand, production, consumption, and transfer of city resources in one year, in the current scene

| Import (MW) | | Demand (MW) | |
|---|---|---|---|
| **Heat** | 0.00 | Heat | 62.19 |
| **Electricity** | 4.46 | Electricity | 86.98 |
| **NG** | 66.79 | NG | 46.47 |
| **Produced / Consumed (MW)** | | **Transferred (MW)** | |
| **Heat** | 46.20 | Heat | 0.01 |
| **Electricity** | 0.00 | Electricity | 89.3 |
| **NG** | -559.1 | NG | 5521.1 |
| **Production Units** | | **Costs** | **314.17** M$ |
| **Small CHP** | 0 | Production Technology | 1.16% |
| **Medium CHP** | 0 | Transfer Technology | 0.12% |
| **SMALL_BOILER** | 5078 | Resource Import | 88.13% |

As can be seen from this diagram, there are about 17% savings in total costs in the small boiler scene and about 21% in energy import costs compared to the current scene. There is about 24% in fuel costs and a total of 20% savings in the main scene compared to the current scene. In other scenarios, the current saving ratio is shown in Figure 7.

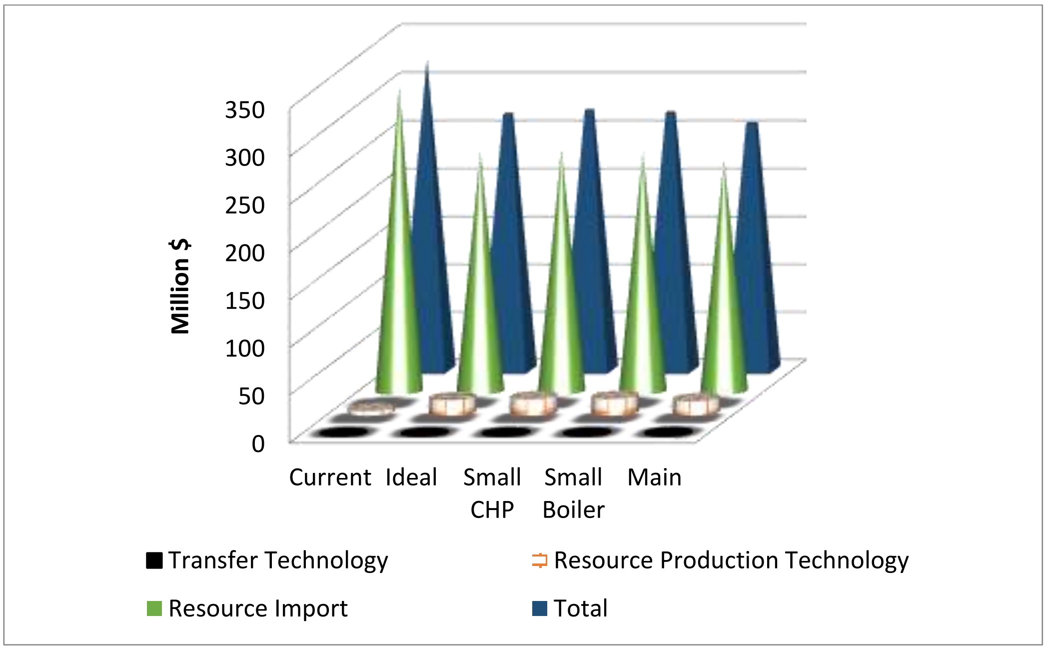


**FIGURE 7** Compare cost details in each scenario

**TABLE 15** The amount of cost savings in each scenario compared to the current scene

| | Main | Small Boiler | Small CHP | Ideal |
|---|---|---|---|---|
| **Fuel Cost Reduction** | 24% | 21.3% | 20.4% | 21.4% |
| **Total Cost Reduction** | 20% | 17.0% | 16.2% | 17.5% |

The proximity of the small boiler stage and the ideal stage shows that the selected capacity is suitable for small and medium generators. A comparison of the number of installed equipment shows a 13.4% reduction in the need to install a boiler in the boiler room of a small boiler compared to the current stage. The number of devices installed in each scenario is presented in Figure 8.

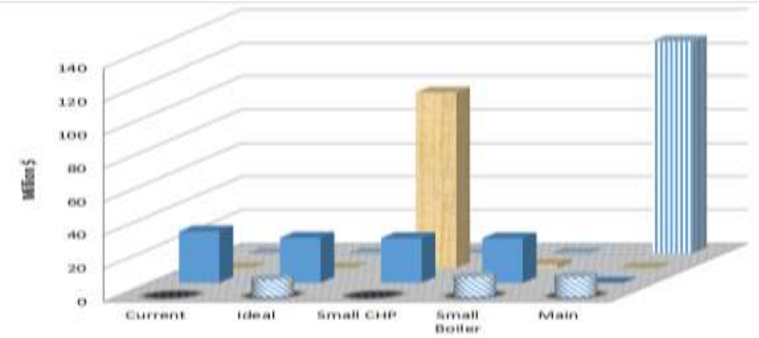


**FIGURE 8** The number of equipment installed in each scenario

## Economic analysis and conclusion

Assuming that the buildings in each area have an average of 5 floors and 5 people live on each floor, the cost per MWh of hot water is consumed according to Table 16.

**TABLE 16** Cost of hot water used in the traditional method

| $ | 835 | Initial investment for the engine room |
|---|---|---|
| kW | 25 | **Engine room capacity** |
| year | 15 | **Engine room life** |
| $/MWh | 43 | **Gas prices** |
| unit | 5 | **Number of floors** |
| person/unit | 4 | **Average number of inhabitants per floor** |
| kW/person | 1.49 | **Average per capita gas consumption** |
| kW/person | %90×1.5=1.341 | **Share of thermal consumption of gas** |
| kW/person | %10×1.5=0.149 | **Share of direct gas consumption (cooking)** |
| MWh/ (building. year) | 1.341×0.001×8760×5×4=234.9 | **Annual thermal energy consumption of each building** |
| KW/building | 5×4×1.2=24 | **Minimum engine room capacity** |
| $/year | 835/15=56 | **Annual depreciation of the engine house investment cost** |
| $/year | 85 | **The annual cost of maintaining the engine room** |
| $/year | 234.9×43=10101 | **The cost of motor home fuel** |
| $/year | 10101+56+85=10242 | **Total annual costs of the engine room** |
| $/MWh | 10242/234.9=43.6 | **Cost of heat energy** |

The average heat generated in cogeneration units is about 429 MW, and the total heat energy produced in these units during the year will be about 3.75 million MWh.

## Conclusion

One of these tourism cases among tourism communities is among the old contexts of cities. With the advent of modernism and non-indigenous cultures, a new culture of urbanization has emerged that contrasts with cities' old culture and have made our ancient cities anonymous. But even now, the involvement of responsible and irresponsible bodies in this field is one of the fundamental problems regarding old tissues.

These ancient textures and elements are the historical and cultural values of societies and even reflect the culture and architectural art of their time, which connects the past and the present. So, we must be diligent in maintaining and improving them. Unfortunately, it can be said that the cities of Iran are the only areas whose old texture has changed. While in developed countries such as England (London), Italy (Venice), Paris, etc., old textures have been preserved. Due to the long history of urbanization, Iran has many ancient cities and ancient settlements in various terrestrial ecosystems. Old structures are on the verge of destruction in many cities and need urban restoration planning. The concept of urban restoration has undergone many changes since the 1980s. Urban renovation today introduces the concept of returning home. This means home, not in the sense of place, city, or building, but in remembering and living. And return to oneself without the grief of emigration and homelessness. And return to itself to move towards the future in which the citizen is an active member and will intervene in matters related to the city and himself. This is why citizens' participation and action are possible and inevitable in this urban restoration. However, the revival of actions unites space's lost parts and returns to the previously known state. That urban restoration tries to create a creative link between the past and the future. And the goal in it is something beyond physical and spatial action. That even this is a scientific-cultural restoration and can be a culture builder. And it tries to transfer the embodied values of the place to the future, and the goal is to add contemporary values to the old stable values. And in this transfer of values, what makes sense is the material and spiritual preservation of the hidden values embedded in ongoing historical work.

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