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The Environmental and Energy Renovation of a District as a Step towards the Smart Community: A Case Study of Tehran

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Abstract: As the world's third-largest oil and natural gas producer, Iran consumed enormous amounts of non-renewable energy during the last twenty years. There are many obsolete buildings in the Iranian building stock, which required energy renovation. Many studies in the literature proposed energy retrofitting strategies to increase the efficiency of buildings, but few of them involve an energy network for the entire neighbourhood (such as district heating). Moreover, energy renovation is not sufficient to improve the smartness level of a community; in fact, it is essential to evaluate sustainable and social aspects. In this direction, this study aims to develop a comprehensive analysis of the current criticalities of a district in Tehran (District 5), proposing strategies to face the pollution of the city, provide a healthy environment for the citizens, and renovate the old buildings. The application of a decision support method is presented to set a priority ranking, pointing out the positive and negative impacts of each evaluated scenario. The energy renovation solution involved the installation of two storage tanks and solar collectors in each building and the connection with the district heating powered by waste to the energy plant. A multi-level car parking system and a noise mapping application were evaluated to solve mobility and pollution problems. Moving to the results, the priority ranking assesses that the most affordable action is the installation of a Solar Water Heater since energy and environmental indicators demonstrate its efficacy compared to the other solutions.

Keywords: environmental and energy renovation; smart community; waste-to-energy; district heating; multicriteria approach

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1. Introduction

As the world's third-largest oil and natural gas producer [1], Iran consumed an enormous amount of non-renewable energy from 1900 to 2019 [2]. Iran is one of the Asian non-OECD countries; that is, it is not a member of the Organisation for Economic Co-operation and Development (OECD) [3]. Between 2012 and 2040, non-OECD countries' energy needs are projected to increase by up to 2.1% per year, which is 1.5 times higher than OECD countries' estimates (1.4% per year). In parallel, the global warming of 1.5°C [4] declares that the world must be kept below a 1.5°C global average temperature rise. To face that, non-OECD Asia must reduce the impact of its energy consumption for each sector (buildings, transportation, and industry); following the global statistical trends, nearly 40% of total energy use is in buildings [5], which also emit 28% of CO_2 [6]. Moving to the environmental city's issue, the daily PM2.5 levels in Tehran, Iran's capital and one of the world's most polluted cities, exceeded the WHO standard, AQG 2021 (15 g/m^3) on 350 days [7]. The renovation of existing buildings to reduce energy use and improve the environmental sustainability of a city is therefore a key aspect of improving the building sector [8]. However, there are many obsolete buildings in the Iranian building stock, causing a high energy consumption [9–11]. Although the Iranian Ministry of Housing and Urbanism released building energy codes (e.g., Issue 19), few structures satisfy them [12]. Therefore, the increase in energy efficiency of existing buildings is still an urgent theme for the policymakers of Iranian cities, especially for the capital, Tehran. Inefficient heating and cooling systems and an uninsulated thermal envelope are responsible for poor energy performance [13,14]. An extensive amount of research has been published on possible renovation techniques [15]. Basically, some studies are focused on the renovation of facades [16,17], others on achieving NZEB requirements [18–20], and others consider improving the insulation of the external walls [21,22].

Most of the mentioned studies are not applied in Iranian countries; therefore, a literature investigation in this field is required. The work of [10] proposed a multi-objective optimisation of a set of solutions applied to a dwelling in Iran. This study confirmed that the installation of photovoltaic (PV) panels is the most cost-effective because the government buys the electricity produced at a higher price. However, other solutions are focused on the installation of punctual energy systems (such as PV panels, heat pumps, and so on), not including an energy network for the entire neighbourhood (such as district heating). The work of [23] presented the retrofit procedure of two typical schools built before and after 2000 in Iran, giving a prioritisation set of the energy scenarios developed. The positive impact of solar energy systems, such as PV systems and solar collectors, is also stated to cover the need for hot water disposal. By conducting expert interviews, the study of [24] identified and prioritised energy reduction measures for existing and historic buildings in Iran. On the other hand, a recent work of [25] evaluated the effects of using tensile material as a second skin as a retrofit action for an office building in terms of the primary energy savings, carbon dioxide equivalent emissions, and payback period.

The three dimensions of environmental, economic, and social parameters play a relevant role in sustainable growth [26,27]. In this regard, a recent study [28] proposed an analysis based on the level of social sustainability of a neighbourhood. The social sustainability of two districts of Tehran, new and old, was compared to investigate how the social sustainability of citizens is affected by the quality of new buildings. The results underlined the positive impact of the new neighbourhood for achieving a sense of place and a good level of social sustainability. Moreover, in the sustainable development of the cities, recent studies include the resilience goal [29,30], as well as the prevention of disaster events that may occur on the energy network/systems [31,32]. As mentioned, the inclusion of different fields of action, such as sustainability and community, contributes to increasing the benefits inside a neighbourhood.

To manage and evaluate several factors (environmental, social, and so on), applying a decision support method is a proper path to follow.

A multi-objective model that integrates the indicators of resiliency and social responsibility dimensions to minimise the cost, non-resiliency, and negative impacts of social responsibility is developed and proposed by [29]. The importance of choosing proper indicators is an essential address to obtain a coherent model, and in this case, to improve the performance of the wheat supply chain. Another work of [30] defines a multi-criteria decision-making (MCDM) framework for sustainable and resilient building design solutions. This method is useful to optimise alternatives or rehabilitation strategies in a life cycle context, highlighting the advantages of the proposed framework over traditional ones. A decision-support method was developed by [33] to evaluate the capital cost and payback period of the renovation strategy, future energy savings, and fluctuations in energy prices. This approach is useful to set a priority rank for the refurbishment scenarios of multi-family social buildings. This prioritisation could also be drafted based on the life cycle method, considering economic and energy metrics [34]. Among the multicriteria approaches, the smart models also employed different processes to provide a holistic way of designing and planning cities [33–36].

According to the literature review cited above, energy renovation studies combined with multicriteria approaches are highly popular, resulting in a variety of measures being investigated. Despite the relevant contribution of previous studies, to the best of our knowledge, there is no study that provides a comprehensive framework for evaluating the impact of different solutions (building energy retrofits, air pollution management, and mobility issues) based on a multicriteria approach able to give a priority ranking (2) and investigate the opportunity to install a central district heating plant feed by waste to the energy system.

This study aims to develop a comprehensive analysis of the current criticalities of a district in Tehran (District 5), proposing strategies to face the pollution of the city and to provide a healthy environment for the citizens. Different energy and environmental strategies were simulated and computed with MATLAB–Simulink. The application of a smart methodology is finally presented to set a priority ranking, pointing out the positive and negative impact of each evaluated scenario. In Materials and Methods (Section 2.1), the characteristics of the case study are illustrated. Section 2.2 describes the fields of actions, mobility, environment, and community and energy, respectively, as well as the solutions proposed. Section 2.4 summarises the heat demand calculation of buildings; Section 2.5 describes the peculiarities of district heating and energy generators; and Section 2.6 describes the performance indicators employed in this study. Section 3 contains the main outcomes obtained per each scenario, also evaluating the most influencing strategy within the assessed priority ranking.

2. Materials and Methods

2.1. Case Study

The neighbourhood of Ponak (located in District 5) is in the northwest of Tehran (Figure 1, black circle). Tehran is characterised by 22 zones (as shown in Figure 1), 122 districts, and 375 urban neighbourhoods. District 5 of Tehran used to be a cluster of villages but has been faced with the growing construction of residential units, which present a major part of residential townships. The presented district has several subway stations, bus, and taxi terminals, and is the main gate for the entrance of passengers from the west of Tehran into the city. The length of the freeways is about 45 km and there are eight different neighbourhoods inside District 5 [37].

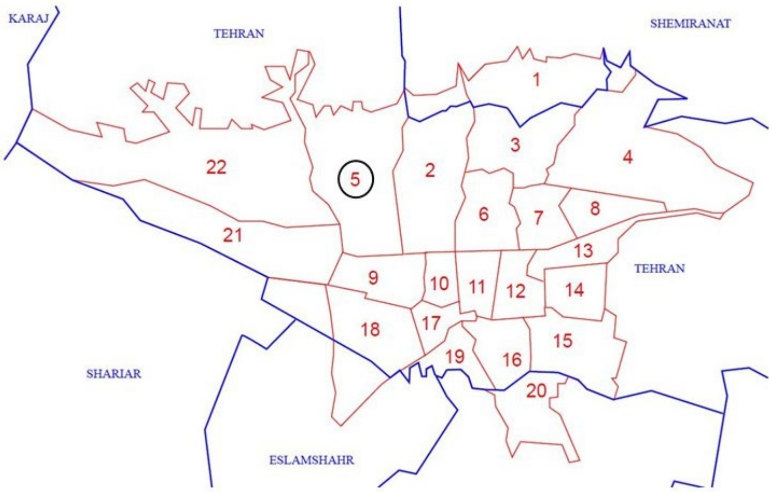

Figure 1. The map reports 22 zones of Tehran, wherein District 5 is highlighted in black.

Given some figures, the district is five thousand hectares; 25% of the district surface is dedicated to residential use. Moving to the population, almost 700,000 citizens live in District 5. Approximately 18% are below 14 years of age, 21% are between 14 and 25 years of age, 56% are 25–64 years old, and 5% are +65 years old. The household number in this district is approximately 200,087 [37].

2.2. Analysis of the Criticalities

The application of a smart decision support method is required to evaluate the impacts of the solutions proposed, based on the criticalities of the district [38]. The smart approach, therefore, will set the priority of the solutions to provide a smart action plan for the policymakers and city designers. The first step is to highlight the current problems of the area and define the relative strategies. This process is applied to the different fields of action (Smart Axis) as follows: Mobility, Environment, and Community and Energy.

2.2.1. Mobility

District 5 hosts 10% of the total ways and 7.15% of the network of freeways in Tehran. In Ponak, the road is not sufficiently adapted to the volume of traffic, and it is especially related to car spots. The population density is very high in various housing blocks which is the result of poorly organised planning that responds to the high demand for housing that existed in the city of Tehran after the years of the rural exodus of the last century. Another consequence of the high population density of Ponak is the traffic jams. As there is not enough space for parking cars, many of these vehicles park their cars on the sidewalks, reducing the passing area and worsening the traffic problem.

2.2.2. Environment

Pollution is a prevalent problem in Iran's megapolises. In Tehran, pollution, especially the excess values of particulate matter, is a relevant issue. The Air Quality Index (AQI) in 2021 (January-June) shows only 23 days of fresh air while 109 days of air were moderately polluted, and 21 days had a highly polluted situation (Figure 2) [39]. This could be considered one of the main problems of Tehran due to its high population density resulting in high pollution which is mainly a result of using gas boilers for heating and hot water. Noise is another problem that city life causes for human health, mainly due to increased road traffic. Tehran, due to its high population density and traffic problems, suffers from the same problem. The average noise level in the metropolitan area of Tehran was higher than the standard levels for any other land use.

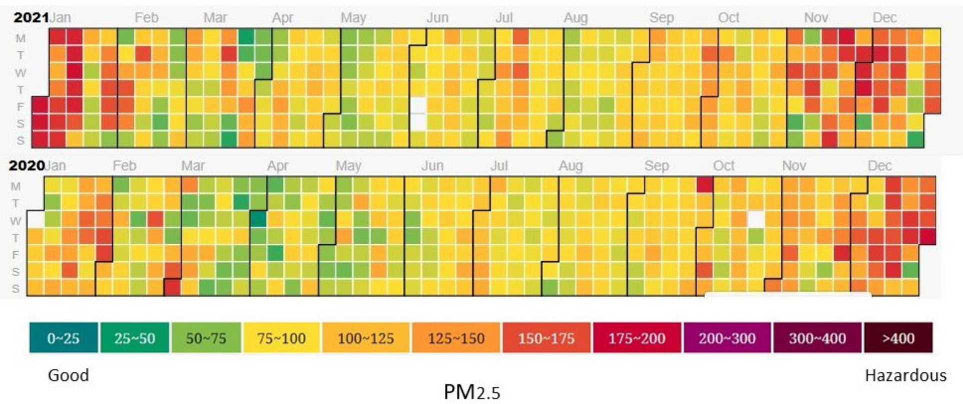

Figure 2. The daily AQI is based on the 24-hour average of hourly readings [37].

2.2.3. Community and Energy

Since 2015, Tehran has grown by 120,000 people, which represents a 1.36% annual change, as reported in the estimation of World Urbanization Prospects. These estimates represent the urban agglomeration of Tehran, which typically includes Tehran's population in addition to close suburban areas. Tehran's population is projected to increase by approximately 1,400,000 inhabitants in the next 17 years, which means 10,700,000 inhabitants will be living there in 2035 [40]. The comfort and quality of life of citizens are also affected by the sustainability design and energy systems/services applied to households [41]. Given the fact that most of the buildings in Tehran have been built in the 1960s and

1970s, or even past decades, the energy efficiency of these buildings is very low and the average amount of energy consumption (especially heating) per household is very high concerning the current standards. The heat used in most of the buildings comes from the gas boilers which are used for space heating and hot water.

2.3. Identification of Strategies

Table 1 collects the problems and the relative solutions proposed for the district, as well as the relative smart axes involved.

Table 1. A summary of the problems and solutions.

Smart Axes	Criticalities	Solutions
Mobility	Lack of parking spaces Traffic jam	Multi-Level Car Parking System
Environment	Pollution Noise	Noise Mapping Application
Community and Energy	Unsuitable condition of buildings High energy consumption A small share of energy use	Rehabilitation of the old buildings (Central District Heating System (CDHS) and Solar Water Heating System (SWHS))

The parking space problem could be solved using multi-floor parking. A new multi-level rotating car parking system could be installed. This system is already available with different capacities from 6 to 16 passenger cars or SUVs. The area occupied by the equipment is the parking space allocated for two cars which, in the case of using the highest capacity, would lead to an 88% saving in spaces. This system allows the user to book the parking space using an app or online. This system works automatically, and no staff are needed. One of the other advantages of this system is the short installation and dismounting time which is between 4 and 7 days. Different companies in the market propose similar products with prices in the range of EUR 70,000–100,000 for 16 parking lot systems. One of the main reasons for choosing this type of parking system is that installing one of these towers in each street could free a length of 12 meters at each intersection (considering 3 meters as the parking length for each car). Thirty-five of these systems have been considered (one for each secondary street) to ease the district's traffic and noise problems, which would need a budget of EUR 2,975,000 and about 17 weeks of work.

Because Tehran is a district with a high population density and old and energy-inefficient buildings, which also faces a pollution problem, it would be useful to include renewable sources for heat production. A concentrated heat source would allow choosing among different methods of heat production, especially renewable energy systems. Individual gas boilers are the main source of this pollution, which could be replaced by the central district heating system. Solar domestic hot water systems can be a cost-effective strategy to generate hot water for the building. Considering the available surface on the roofs of the apartments, it could be a smart way to profit from solar energy to decrease the load the central network has to supply.

Noise pollution in urban environments can have negative impact on citizens' health. Smart city applications for acoustic monitoring become essential to cope with the overall increasing noise pollution in residential areas. Based on the successful results obtained using visual mapping applications, the creation of a noise mapping application represents an attractive solution. Capturing the sounds of the surrounding environment is possible for almost all smartphones. Access to the microphone with the GPS information goes a long way to provide the real-time situation on the spot. The audio stream recorded by the phone could have a definite length which is set by the user. The user of the audio stream can relay audio packets into the stream and have these processed as soon as they are received by the underlying subsystem. Each noise data are combined with the last valid GPS location information [42]. Every time the software on the mobile phone is run, the noise data are displayed graphically on the phone screen along with the other location information. A matching interface using the data available on the applications such as Google Maps would also help to provide a more desirable environment for the application. Considering incentives such as free access to various sightseeing in the district (which could be attractive for visitors) would also help to construct a more coherent and comprehensive mapping database. There is a wide range of costs for launching such an app, but the moderate prices are in the range of EUR 60,000–120,000. Having more features would increase the price, and to this, we have to add 20% costs of maintenance per year. The time needed for the construction of the map increases with its degree of complexity. A cost of EUR 120,000 and a six-month timeframe [42] were evaluated for the proposed project.

2.4. Energy Characteristics of the District

2.4.1. Heat Demand of the Buildings in Tehran

Since the measured energy consumptions of existing buildings are often not available, the most common method is to estimate the heat load demand based on the heat consumption in the past. While the measured load curves of old buildings may show a large weather-dependent share of room heat demand, this is almost non-existent in new buildings. In Tehran, most of the buildings are old and thus weather dependent. For the rehabilitated buildings, the calculated energy savings will be considered. Based on the research on the distribution of residential energy consumption for heating in Iran and more specifically Tehran [41], different regions have been classified according to:

- Size of the municipality: Understanding their situation in a rural environment in a group of up to 20,000 inhabitants, or urban environments or conglomerates of more than 20,000 inhabitants.
- Typology: Distinguishing between single-family and multi-family dwellings.
- Number of floors: Distinguishing those with up to three floors and more than three, which affects both the construction systems used in facades, roofs, etc., as well as the proportions between them and concerning their inhabited surface. This issue is important both in their energy efficiency and in the evaluation of the intervention costs in these homes.
- Construction stage: Considering that buildings built before the 1960s have different constructive characteristics and benefits compared to those built after 1960 or 1980.

Tehran is situated in the north of the central plateau of Iran, latitude 35.7° and longitude 51.2°, and its climate is semi-arid and continental varying from the mountains in the north and desert in the south. To simplify the energy demand estimation of the district, only residential buildings were considered and the other types of buildings were ignored, which, given the high number of residential buildings and the absence of industrial entities, should not lead to a significant error in the calculations. The number of buildings renovated during the recent rehabilitation projects was also taken into account, which according to the measurements would improve the heat consumption of the apartments by 70%. Table 2 divides the houses according to class and number.

Table 2. Typical energy consumption of apartments in Tehran based on their construction characteristics [41].

Year of Construction	No. Buildings	No. Homes	Heating Consumption of Each Dwelling (kWh/Year)	Total Heating Consumption (GWh/Year)
Built in 1976–1996	595	10,172	12,373	125,858
Renovated buildings	76	849	3712	3151
Total	671	11,021	11,709	131,921

Considering that the average surface of each apartment is approximately 100 m² because the apartments in the Ponak neighbourhood are mostly characterised by three rooms [41], including a kitchen and one bathroom, a value of 171 kWh/m² year can be obtained as the average heat demand of an apartment in Tehran [43]. The heat consumption of a household in hot months is related to the domestic hot water (DHW) consumption. According to [43], the total DHW consumption of a household in a month is 234 (kWh/month). The annual consumption of electricity in the residential sector in Tehran in 2018 was about 580,6 GWh. Since the industrial sector in Tehran almost does not exist and most of the electricity use is for domestic use, an estimate for the electricity demand of the district would be about 8% which would amount to 46.4 GWh/year. On the other hand, the energy consumption report in Iran [44] shows that the electricity consumption of a household is almost 30% of the total energy consumption. It means that electricity demand could be considered as 43% of the heat demand which would result in 54 GWh/year for the district which is close to 46.4 GWh/year. Taking the average of the two values, the yearly electricity demand is assumed to be 50 GWh/year.

2.4.2. Temperature Variation in Tehran

Considering the old structure of the buildings, the outside temperature is an important factor that should be considered. Using the online weather database [45], the yearly temperature of Tehran in the last three years is shown in Figure 3.

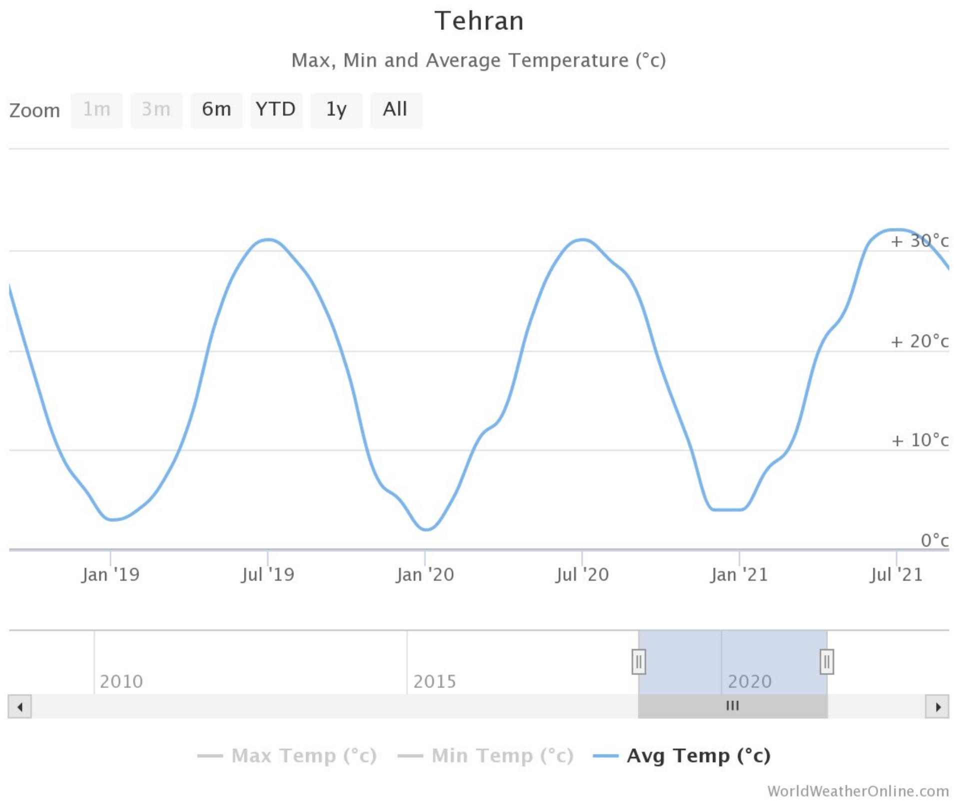

Figure 3. Weather temperatures throughout three years in Tehran [44].

The mean temperature range is between 5 and 33 °C with the maximum and minimum temperatures, respectively, in July and January (Figure 2).

2.5. Storage Tanks and Solar Collectors

Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats the water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

Moving the solar collector, a collector of area A_P exposed to radiance G measured in the plane of the collector gives a useful output (Equation (1)).

$$P_C = A_P\, q_u = \eta_c\, A_P\, G \tag{1}$$

where P_C is the power produced by the panel and η_c is the efficiency of the panel. The power available has to be transferred to the water passing through the panel. At s steady state, it could be possible to apply the Equation (2).

$$H_c\, A_P\, G = \dot{m}c\ (T2 - T1) \tag{2}$$

where T2 and T1 are the inlet and outlet water temperatures and $\dot{m}$ is the mass flow of the water. The efficiency of the panel depends on various factors such as the optical performance of the panel (which is usually constant, assuming a clean surface and no shading on the panel) and the heat loss from the surface which has an optimum value below which the full capacity of the panel is not used and above which the losses will reduce the efficiency. Another factor is the irradiance which as it increases, also increases the efficiency of the system. The other important factors here are the ambient temperature and the pressure through the panel. The convection heat transfer to the ambient temperature reduces the efficiency of the panels.

2.6. District Heating and Energy Source Employed

Figure 4 depicts the power plant where the yellow lines represent the piping routes. The district heating centre is powered by two heat pumps to satisfy 70% of the peak heat demand, each heat pump providing 35% of the power needed [46]. In case the demand is higher than 70% of the peak value, the rest of the power is provided by a Combined Heat and Power (CHP) plant. The heat pumps chosen for the project are two Unitop 33/28C with a COP equal to 2.9.

Figure 4. Sketch of the district heating network.

Since solid wastes produce methane and prove harmful to the environment, using unrecycled municipal solid waste as the energy source would solve this problem; furthermore, it provides a constant energy source for the CHP plant. Using the characteristics data of a common waste-to-energy CHP power plant, we reach the proportional values of heat and power produced in a power plant with such a capacity. Here, considering the minimum calorific value for the Municipal Solid Waste (MSW) feed, it is possible to produce 1.08 MWh/t of heat. This means that to reach 180.3 MWh/day, the needed MSW feed must equal 167 tons per day. Finally, the energy systems equipped in the buildings (10 apartments per each) are listed: the hot water and space heating consumption subsystems in which the consumption behaviours of the building are implemented; two separate storage tanks for the hot water; and solar water heaters installed on the roof. MATLAB–Simulink was used to simulate the entire energy model.

2.7. List of the Performance Indicators

Table 3 presents a list of the chosen indicators for evaluating the effects of each intervention on the smart axes involved. As mentioned in the introduction, the step of choosing proper indicators is relevant to obtain a coherent model [29]. Nowadays, several performance indicators were drafted, from energy [29,47] to the environmental [28,48].

Table 3. Key Performance Indicators selected.

Smart Axes	Indicators	Description	Unit of Measurement
Mobility	Adjusted saturation flow (ASF)	Number of vehicles passing through a point in an hour	Number/hour
Environment	Air quality (AQ)	Greenhouse gas emission per capita	Tonnes per capita
Community and Energy	Renewable energy consumption (REC)	Percentage of renewable energy consumed in the district in a year	Percentage
	Residential thermal energy consumption (RTEC)	Total consumption of thermal energy per capita	GJ/year/capita
	Electricity (EC)	Total consumption of electrical energy per capita	kWh/year/capita

3. Results and Discussion

3.1. Heat Demand of District 5 (Ponak) and Sizing of the Power Plant

According to the research performed to analyse the energy consumption habits and trends of occupants in nearly 50 homes in France and Spain [49], there was a strong relationship between the outside temperature and the heat consumption behaviour of the families (in apartments or single-family houses). In this work [49], the authors proposed a linear relationship between the outside temperature and the amount of heat consumption for each apartment. Consequently, the heat demand profile is expected to show higher values at the beginning of the year and gradually decrease as the hot season arrives and surge again towards the end of the year. To obtain a consumption profile based on the outside temperature, it is essential to assume the consumption as a linear function of temperature (Equation (3)) [49].

$$HC = f(T) = aT + b \tag{3}$$

where a and b are constants, and HC is the daily consumption of a household in Ponak. To find these constants, we already have the minimum value of consumption during the hot season (we suppose the minimum heat consumption in September at 28 °C, which is 3.9 kWh/day). The yearly average consumption of a household (32.07 kWh/day) was evaluated throughout the simulations. The heat consumption profile for the whole year is obtained (Figure 5).

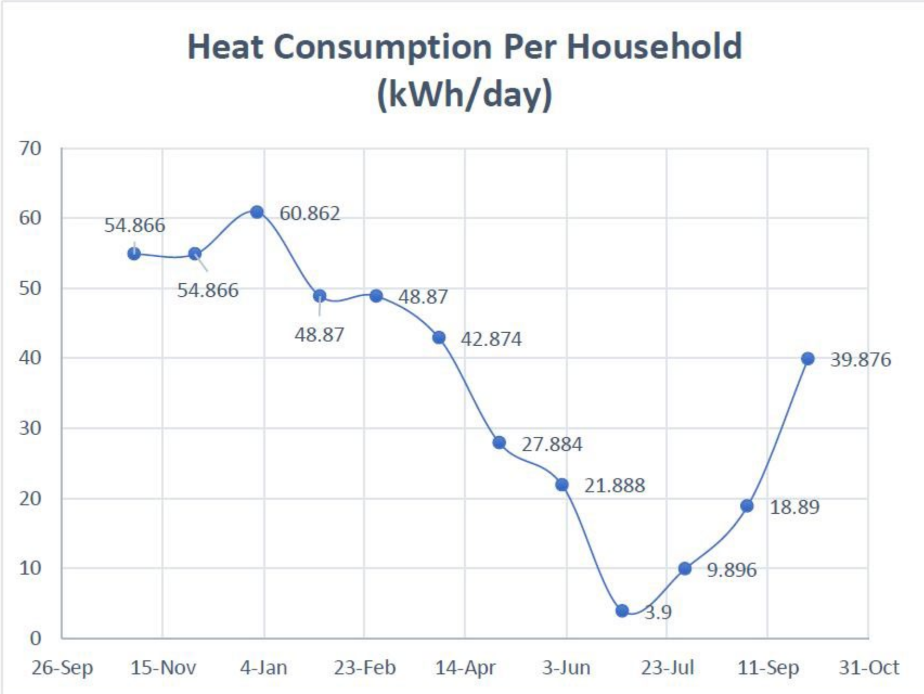

Figure 5. Heat consumption per household in Tehran (year 2020).

Using a duration curve, it is possible to know how many days we need to supply a certain load. Figure 6 shows the annual load duration line, which represents the annual heat demand, divided into base load and peak load.

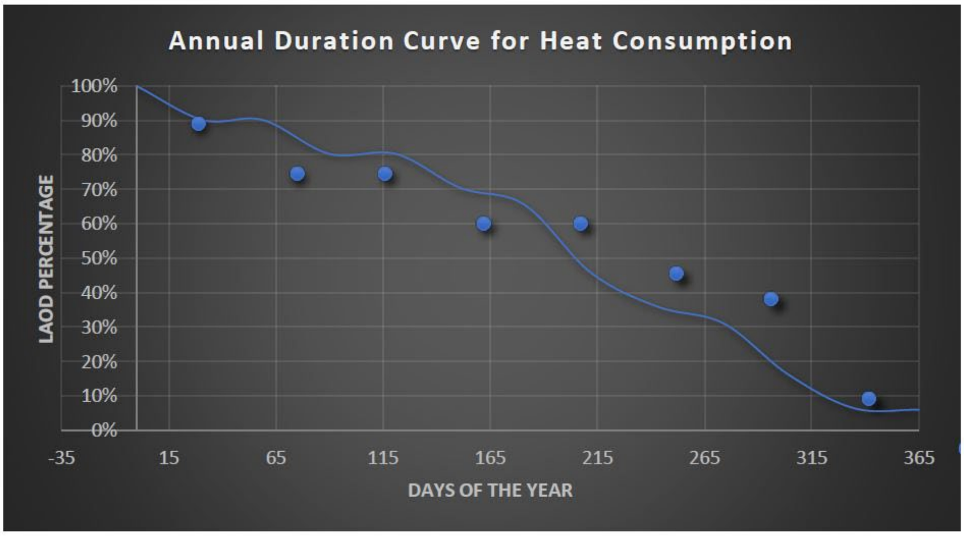

Figure 6. The duration curve of the heat demand for a household.

After taking into account the heat loss and the diversity factor, the peak load is around 601 MWh/day. Two heat pumps were involved to cover 35% of the peak load. The remaining peak load demand is produced by a CHP plant with a heat production capacity equal to 180.3 MWh/day or 7.5 MWh.

Moving to the power produced by the solar panels for May, July, and September, the solar panels produced, respectively, 75, 170, and 95 kWh/day. Considering the highest production in July, the solar fraction would be around 32% which is desirable, taking into account the fact that the efficiency of the buildings could be improved via retrofitting which in turn increases the solar fraction.

3.2. Waste-to-Energy Plant

Considering 150 working days for the CHP plant, the plant requires 25,050 tonnes of waste per year. This value is approximately the amount of unrecycled waste produced by 50,000 people in a year, which is provided by the waste produced in the district and the rest of it provided by other regions of the district. The other side benefit of this CHP plant would be the production of 55.11 MWh/day electricity which for a period of 150 days would amount to 8266 GWh electricity which is used to power the plant itself. The electricity consumption of the plant is assumed to be 1.2 times the electricity demand of the heat pumps with the assumption that the extra energy needed for the CHP power plant is provided by the plant itself. Therefore, the electricity demand of this power plant could be obtained by the following relationship (Equation 4):

$$Electricity\ demand\ of\ the\ power\ plant = \frac{heat\ demand\ of\ the\ discrict}{2.9*1.2} = 49\ \text{GWh year} \quad (4)$$

3.3. Total Costs and Construction Period

The capital investment needed for such a high-capacity system is very complex to predict. However, the capital costs of the project for one year (considering the maintenance) can be calculated according to the capacity of the plant (Table 4).

Table 4. Cost estimation of the district heating system.

	Heat Pumps (Million EUR)	District Heating (Million EUR)	CHP (Million EUR)	Capital Costs (Million EUR)	Operation and Maintenance (Million EUR/Year)
Capital rations	1/MW	2.2	0.7/MW	-	10% of capital costs
Estimated costs	17.5	2.2	5.25	27.5	2.5

The lead time needed to obtain equipment may determine the time required to build the district heating system. In some cases, the lead time on major components in the central plant can be over a year. The installation time of the distribution system depends in part on the routing interference with existing utilities. For the proposed case, considering the high population density of the district and the time needed for constructing the network, seven years to build the whole system are estimated. On the other hand, the average cost of buying and installing a solar water heater and other equipment is in the range of EUR 3000–5000 on which a 30% tax credit could be received. Considering 10 panels for each building, it would roughly amount to EUR 28000 for each building. The cost and time feasibility were also evaluated per each action and integrated in the calculation of the final scores reported in Table 5 [49].

3.4. Performance Indicators and Priority Raking Results

In this section, the first step of the calculation of the indicators is performed according to the formulas mentioned for each indicator (Table 5).

Table 5. Calculated values for each indicator.

Indicators	Units	Base	MLCPS	SHW	ROB	NMA	CDHS
(ASF)	%	1050	2100	2100	2100	2100	2100
(AQ)	Tones of CO2/year/capita	1.126	1.126	0.732	1.098	1.126	1.126
(REC)	%	18	18	37	19	18	61
(RTEC)	GJ/year/capita	20.192	20.192	20.192	19.695	20.192	20.192
(EC)	kWh/year/capita	2173	4304	2173	2173	2173	2176

Applying the scaling and normalisation methods [50], obtaining the priority ranking of the proposed strategies is possible. The results obtained are negative due to the application of a correction factor that evaluates if the indicator gives positive or negative impacts (Table 6).

Table 6. Final ranking of the interventions.

Rank	Strategy	Score
1	Solar Water Heater (SWH)	−6.48
2	Retrofitting the Old Buildings (ROB)	−8.58
3	Multi-level Car Parking System (MLCPS)	−14.11
4	Central District Heating System (CDHS)	−15
5	Noise Mapping App (NMA)	−23.14

According to the ranking, the intervention at the top of the priorities is the installation of solar water heaters followed by retrofitting the buildings and a sustainable urban drainage system. This seems to be logical given the considerable energy improvements we can achieve by installing solar water heaters and retrofitting the buildings. It is worth mentioning that some limitations need to be acknowledged, which set the stage for future studies. First, the inclusion of citizens in the decision process of a district renovation is required, using a survey or similar approach. Sharing the knowledge about the positive impact of energy renovation buildings, not only in economic terms but also in environmental ones, it a significant issue in this country. Despite the comprehensive approach adopted in this study, the realisation of the mentioned strategies requires an in-depth analysis, starting from the collection of measured energy data of the district. In this way, a global renovation of the neighbourhood could be developed, becoming a pilot case study for the city.

4. Conclusions

Iran has increased its primary energy consumption in the last decade, with building energy use being the most significant demand. On the other hand, the world policy path is moving forward with the transition to sustainable energy. Therefore, each country must decrease the use of fossil fuels and reduce emissions into the atmosphere. In these directions, this paper proposed an energy renovation of residential buildings located in District 5 of Tehran. As pointed out in the literature, the energy requalification has to be combined with a sustainability assessment, to create a positive impact in the different fields that characterise the city. Several scenarios are indeed evaluated to overcome the criticalities of the case study, involving the mobility, environment, and energy aspects. Regarding energy, the energy renovation involved the installation of two storage tanks and solar collectors in each building and the connection with the DH powered by waste to the energy plant. A multi-level car parking system was evaluated to solve car congestion and a noise mapping application to monitor the air quality of the district. The MATLAB–Simulink tool was used to develop each selected scenario. Then, a smart method was applied to evaluate the impact of the proposed solutions, using performance indicators. Moving to the results, the definition of the energy strategies, district heating with a waste-to-energy plant, was conducted based on the energy needs of the neighbourhood. A peak daily heat load of 601 MWh/day was evaluated. Two heat pumps were involved to cover 35% of the peak load. The remaining peak load demand is produced by a CHP plant with a heat production capacity equal to 180.3 MWh/day (7.5 MWth). The first position is obtained by Solar Water Heater (SWH) action since REC and AQ indicators demonstrate their relevant efficacy compared to the other solutions. The second position is reached by the energy renovations of residential buildings followed by the development of the car parking system. A noise mapping application seems to be the less powerful action in terms of energy impacts. Further development of this study will move in two directions. Firstly, the involvement of citizens in the district renovation decision-making process is required, either through surveys or similar measures. Then, an in-depth analysis of the energy renovation of buildings will be conducted, starting from the collection of the real energy consumption to provide accurate energy models.

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