Iran Chamber of Commerce,
Industrues, Mines & Agriculture

SAZEH PAIDAR
modern constructional and industrial material

Enhancing sustainable development through elastomeric insulation: a collaborative global approach to reducing Carbon Dioxide emissions and hindering climate change

The submitted report includes a summary of the statistical analyses of both completed and planned projects. It addresses the potential for international collaboration and offers recommendations for reducing carbon dioxide emissions in the context of mitigating climate change and advancing sustainable development in the country. This report is based on data and activities from the past four years of Sazeh Paydar Elahie Company, which holds the property and Intellectual rights to the Linkran brand, and has been prepared and compiled through the efforts of the research, development, and innovation team from October 4, 2024, to July 30, 2024.

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Abbreviations and acronyms

CO_2	carbon dioxide
$CO_{2\ eq}$	carbon dioxide equivalent
N_2O	nitrous oxide
CFC	Chlorofluorocarbon
GHG	greenhouse gas
IEA	International Energy Agency
NBR	Nitrile Butadiene Rubber
PVC	PolyVinyl Chloride
TPE	Thermoplastic Elastomer
PR	prandtl number
RE	Reynolds number
RA	rayleigh number
NA	not applicable
GWP	global warming potential

Table 1
Composition of the Expert Review Team

Sazeh Paydar Elahieh Company (Linkran Industrial Group)		
CEO of the company	Mohammad Hashemi	
Director of Research and Development (R&D)	Mohammad Javad Azizli	
project members	Mohammad Javad Akbari	Project Executive
	Farzam Lorestani	Calculations, simulations, modeling, and data analysis
	Ilia Jamali	
	Alireza Yaqoubi	
	Mohammad Mahdi Mosaheb	Collection and organization of data
	Amir Hossein Bagheri	
	Fatemeh Dargahi	
	Melika Ahmadi	
	Mohammad Sadegh Soleymani	
	Sina Lotfi	Writing and compiling a report
	Parmis Hashemi	
	Seyed Amir Majedi	
	Seyedeh Bahar Alamipour	

I. Introduction

A. literature review

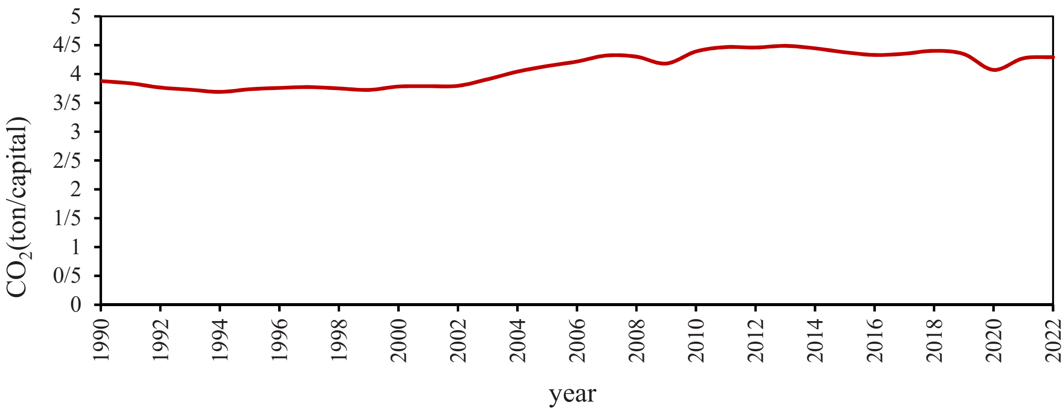
1. wood was not sufficient to cover the requirement fuel of industrial revolution, therefore consuming fossil fuels such as oil, coal and gas were commenced. Using this kind of fuels have resulted in carbon dioxide increase and thus global warming.

2. The climate change problem is one of the most environmental crises related to energy consumption known as global warming or greenhouse effect. This phenomenon occurs when the greenhouse gases concentration such as CO_2, CFC, Halons, N_2O, O_3, PROXY in earth's atmosphere increases.

3. These gases with the ability to absorb reflected heat from earth cause temperature increase on it. In recent century, the earth's average temperature has been increased by 0.6 Celsius degrees and because of that the sea level has also risen by approximately 20 cm. Figure 1 demonstrates CO_2 concentration increase from 1990 to 2020. In this period of time, CO_2 concentration has increased around 30% which is caused by human activities. In recent decades, on average, this emission has increased 0.4% every year. The life span of CO_2 in atmosphere is approximately 100 years and this case affects directly on CO_2 increase temperature leading to climate change and global warming. Because of that controlling and reducing emission of this gas is essential to confronting climate change [1,2].

Figure 1

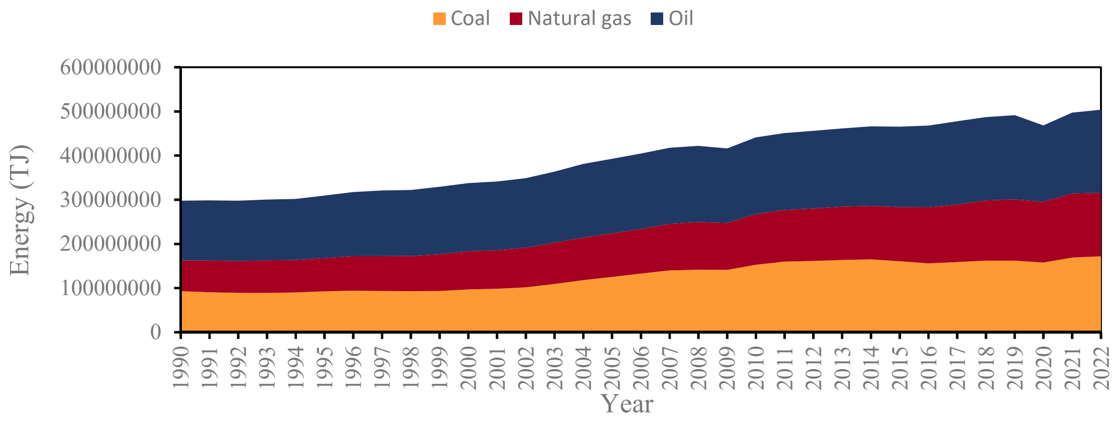
Global CO_2 emissions Levels



Source: International Energy Agency [2]

Figure 2

Global Consumption of Fossil Fuels



Source: International Energy Agency [2]

4. Despite repeated warnings about the dangers of greenhouse gas emissions, necessary measures to decrease environmental pollution has not been done and currently many researchers confess that global warming has turned into an undeniable truth. In the last two decades, common knowledge about these matters of fact have increased significantly and researchers and politicians work with more focus on subjects related to energy. Forecasts demonstrate that world population would double by the middle of the 21st century and sustainable development would most likely continue to grow. It is expected that the worldwide demand for energy would increase significantly up to three times by 2050 and in this regard environmental crises caused by producing and consuming energy like acid rain, o zone destruction and climate change will increase. This demand increase not only puts pressure on natural and environmental resources, but also demonstrates the necessity of urgent and effective measures for sustainable energy management and reducing negative effects on ecosystems and public health. In conclusion, it is required to implement policies and new technologies in order to use renewable energy sources and reduce greenhouse gas emissions in order to avoid more serious environmental crises [6].

5. Despite repeated warnings about the dangers of greenhouse gas emissions, necessary measures to decrease environmental pollution has not been done and currently many researchers confess that global warming has turned into an undeniable truth. In the last two decades, common knowledge about these matters of fact have increased significantly and researchers and politicians work with more focus on subjects related to energy. Forecasts demonstrate that world population would double by the middle of the 21st century and sustainable development would most likely continue to grow. It is expected

that the worldwide demand for energy would increase significantly up to three times by 2050 and in this regard environmental crises caused by producing and consuming energy like acid rain, o zone destruction and climate change will increase. This demand increase not only puts pressure on natural and environmental resources, but also demonstrates the necessity of urgent and effective measures for sustainable energy management and reducing negative effects on ecosystems and public health. In conclusion, it is required to implement policies and new technologies in order to use renewable energy sources and reduce greenhouse gas emissions in order to avoid more serious environmental crises [6].

6. This optimization includes exploiting efficient technologies, substructions improvement and promoting more sustainable habits. Thus, the society could save the natural sources more effectively and adhere to its obligations in fields of reducing greenhouse gases emission and natural ecosystems protection. Therefore, energy efficiency increase not only reduces the pressure on natural resources but also it can be used as an effective method to achieve sustainable development, protecting biodiversity and supplying next generation life quality, so it could be said that energy represents one of the key elements in sustainability [7].

7. Energy consumption optimization and energy efficiency improvement are known as the fastest, cheapest and most compatible way to supply energy demand in the world significantly. This improvement could decrease the requirement of energy supplying investment. Many actions where are related to energy efficiency increase, are currently affordable and they could be used to compensate the costs through energy consumption reduction in life span usage. Saving energy means any behavior that would lead to energy consumption reduction also Carbon Dioxide reduction, less demand for energy import and reducing the costs for each household and economy improvement are due to saving energy. The plans to reduce energy consumption not only benefit consumers and companies, but also they are beneficial towards the society. Especially while energy consumption reduction will lead to reduction of greenhouse gases and other pollutants emissivity in the environment. Energy conservation is crucial for sustainable development and while there are some challenges, using all possible sources to achieve sustainable development should be performed. This effort is not only currently necessary but it is also of great importance for future generations [7].

8. Construction and operation of structures play a significant role in energy consumption and greenhouse gases (GHG) production. According to data, existing structures assign more than 40% of total primary global energy consumption and 24% of Carbon Dioxide emission. To reduce these effects [7].

9. One of the fastest and most efficient strategies in the residential and commercial building sector is the increased use of thermal insulation. This measure can significantly contribute to reducing the costs associated with

each ton of carbon dioxide equivalent (CO2e) that is prevented from being emitted. Additionally, it plays a crucial role in energy optimization. Therefore, optimizing energy consumption and enhancing its efficiency can substantially reduce the greenhouse gas emissions related to energy use. [7]

B. Objective

10. The unprecedented increase in carbon dioxide emissions in recent years, driven by industrialization and the consumption of fossil fuels, has accelerated global warming and caused severe climate changes. This global crisis poses a threat to food security, water resources, and the survival of various species, necessitating immediate international action. To address this issue, Alieh Sustainable Structures Company, as a knowledge-based entity and the legal owner of the Linkran brand, has emerged as one of the leading companies in the field of elastomeric insulation production worldwide. In alignment with its global mission, the company established a Sustainable Development Working Group on March 21, 2023, in collaboration with its Energy Systems Department and Materials and Polymers Department within its Research, Development, and Innovation Unit.

11. The objectives of this working group include examining the impact and role of elastomeric insulation in reducing carbon dioxide emissions to prevent the exacerbation of climate change. Additionally, it focuses on exploring and presenting environmentally friendly and innovative solutions for minimizing carbon dioxide released during the production process. The group aims to design a sustainable process for the disposal of elastomeric insulation at the end of its useful life to mitigate associated environmental harm. Furthermore, it seeks to develop a comprehensive web application for insulation calculations, aiming for optimal use with maximum efficiency across various operational conditions and climatic environments. Finally, the group plans to produce educational content and conduct specialized training courses to raise awareness and educate professionals active in this field, as well as general public courses to promote cultural understanding and highlight the significance of the climate change challenge.

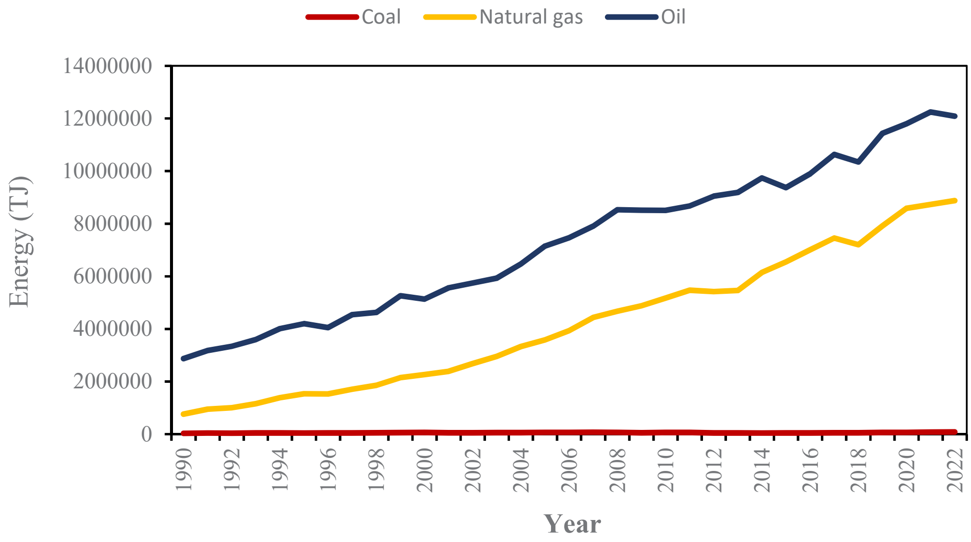
II. Technical Review of Information

A. Iran Total Energy Consumption

12. Iran, with an area of 1,648,195 square kilometers, is the seventeenth largest country in the world, and has a population of approximately 89.4 million, making it one of the most populous countries globally. As a resource-rich nation in energy, Iran holds 17.3% of the world's total natural gas reserves, ranking second only to Russia. In recent years, concerns about fossil fuel consumption and greenhouse gas emissions, particularly carbon dioxide, have increased. Unfortunately, Iran is among the high-energy-consuming countries, ranking tenth in the world for fuel consumption and seventh in

carbon dioxide production. According to data from the International Energy Agency (IEA), Iran's total energy supply is heavily reliant on fossil fuels. The charts presented in Figures 3 and 4 clearly illustrate the levels of fuel consumption and carbon dioxide production in this country.

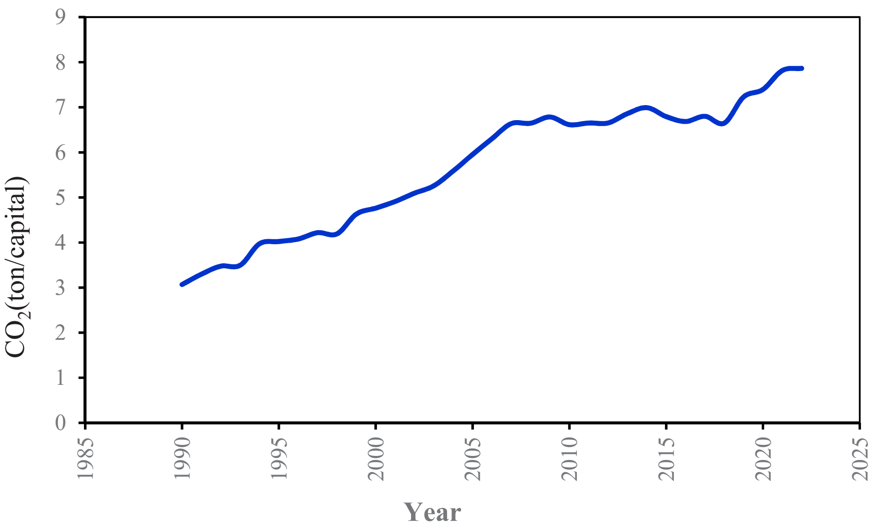
Figure 3
Fossil Fuel Consumption in Iran



Source: International Energy Agency [2]

Figure 4

The amount of CO2 production in Iran



Source: International Energy Agency [2]

B. Insulation

13. Thermal insulations reduce the energy required to maintain indoor temperatures. This energy is typically supplied through the combustion of fossil fuels for heating or cooling buildings, either directly or indirectly through electricity and gas, which in turn leads to greenhouse gas (GHG) emissions. Thermal insulation must possess sufficient durability and lifespan to maintain optimal performance throughout the designed life of a building, which often spans decades.

14. Since ancient times, the focus on efficient energy use has driven humanity to seek ways to conserve and prevent its waste. In this context, humans began searching for materials capable of fulfilling this responsibility. It can be confidently stated that glass fibers, as one of the first industrial materials used in this field, have played a significant role in achieving this goal.

15. In the early 19th century, this topic took on a more industrial aspect, and glass fibers began to be used on a larger scale in industry and construction. With the onset of World War, I and II, advancements in engineering sciences and dwindling mineral resources led to a greater emergence of other engineering insulations. After World War II and the subsequent need for global reconstruction, it became evident that the insulations being used were themselves causing large-scale environmental and health pollution. This prompted the design, production, and use of alternative insulations.

16. Simultaneously, polymer sciences and technologies made significant leaps and entered the realm of insulations. Initial efforts began in 1947 with vinyl resins aimed at producing foam products for thermal and acoustic insulation in the U.S. Navy for use in warships. Concurrently, advancements in the synthesis of vinyl resins and the synthesis of acrylonitrile-butadiene rubber (NBR) began in Germany during the 1950s, along with capabilities for alloying polyvinyl chloride (PVC) in a cured form.

17. Today, polymers have extensive applications across various sciences and industries. By combining and alloying them with one another, their role and application in creating new materials can be expanded. Through melt blending to produce foamed NBR/PVC polymer compound creating closed-cell structures using blowing agents and adding suitable fillers compatible with the compound matrix an elastomeric thermal insulation has been produced. This elastomeric insulation plays a crucial role in energy savings for industrial and domestic applications based on reducing fossil fuel consumption and energy costs. This product is recognized as an environmentally friendly option that can lead to significant economic savings by reducing energy consumption and preventing waste. The main challenges related to insulation production, especially polymer insulations, include achieving a product with low cost, high efficiency, environmental compatibility, non-toxicity, and cost-effectiveness. Therefore, this field is continuously evolving and updating. The growing trend of fossil fuel use due to population growth and expanding industries worldwide, along with the resulting environmental pollution, has

made thermoplastic elastomeric (TPE) insulations an innovative product with unique appeal.

18. These elastomeric insulations are formulated as a binary compound of NBR/PVC using mixing at PVC flow temperatures with an internal batch mixer along with other additives (including curing agents, blowing agents, ozone resistance agents, UV resistance agents, oxidation inhibitors, and fire retardants). Once complete mixing is ensured, the final blend moves into the rolling stage. Subsequently, to relieve stress and cool down, the product is transferred to a batch-off machine. After 24 hours of storage for uniformity in the final blend and optimal shaping, it enters a single-screw extruder with six heating zones. Finally, after exiting the die, to activate blowing agents and create foam, the product enters an oven with nine heating zones.

C. Evaluation Method

19. In this study, data from the climatological records of Tehran Province is utilized, encompassing the average parameters of temperature, relative humidity, and wind speed throughout the year 1402 (2023-2024). Additional parameters employed for this analysis include the average temperatures of hot and cold building pipes, as well as the standard dimensions of urban pipes in accordance with Chapter Fourteen of the National Building Regulations. Furthermore, this research focuses exclusively on calculations and simulations related to energy loss in hot water pipes.

Table 2

Climate Data of Tehran City

Row	Date	AD date	Average Temperature (°C)	wind speed (km/h)	Pressure (Hpa)	Relative humidity (%)
1	1402/01	Mar-23	14.6	12.6	1,011.0	39.1
2	1402/02	Apr-23	19.0	14.7	1,008.8	25.9
3	1402/03	May-23	23.8	16.3	1007.1	21.8
4	1402/04	Jun-23	28.8	13.9	1,000.2	22.0
5	1402/05	Jul-23	31.5	12.8	999.2	19.3
6	1402/06	Aug-23	30.6	11.3	1,003.2	18.8
7	1402/07	Sep-23	26.8	10.6	1,007.1	19.6
8	1402/08	Oct-23	20.4	12.2	1,013.6	28.9
9	1402/09	Nov-23	14.9	8.6	1,015.8	42.5
10	1402/10	Dec-23	10.5	7.9	1,019.8	39.7
11	1402/11	Jan-24	8.8	9.8	1,017.8	36.4
12	1402/12	Feb-24	7.6	11.8	1,018.7	48.8

The source of the data is the Iranian Meteorological Organization

Table 3

The standard average of construction pipes in Tehran is defined by the equation in which kp represents the thermal conductivity coefficient of the pipe, and do denotes the external diameter of the pipe.

Nominal Diameter	thickness	D_o	k_p
65 mm	2.6 mm	76.1 mm	$65\,\frac{w}{Km^2}$

Table 4

The Location of Construction Pipes

indoor	outdoor
80%	20%

Table 5

Residential Pipe Temperature

Min temp	Max temp	Avg Weight
30	60	45

Table 6

Specifications for Insulation in Buildings in Tehran

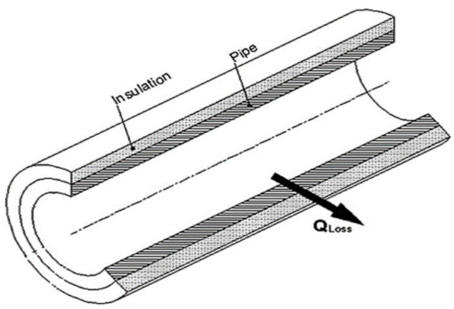
Conductivity coefficient	Thickness								
$0.036\,\frac{w}{K.m^2}$	1	3	6	16	19	25	32	40	50

D. Pipe structure

20. Pipes are integral components of modern buildings used for the transfer of fluids or energy. In buildings, pipes carrying energy or hot water are surrounded by cooler ambient air. This temperature differential leads to heat loss from the pipeline, resulting in energy wastage.

Figure 1

Annual amount of CO_2 production based on the amount of insulation production



20. For pipe $U(\frac{q}{m^2.k})$ The total heat transfer coefficient is determined by equation 1:

$$(1)\ U = \frac{1}{R_p+R_i+R_A+R_r}$$

22. Rp is the wall thermal resistance for cylinder that can be calculated using the following equation:

$$(2)\ R_p = \frac{\ln\left(\frac{r_o}{r_i}\right)}{2\upsilon K_w L}$$

23. where r_o is the outer radius of pipe, r_i is the inner radius of pipe, L is the length of the pipe (considered 1 meter), and K_w is the thermal conductivity of pipe. R_i is the insulation resistance for cylinder that can be calculated using the following equation.

$$(3)\ R_i = \frac{\ln\left(\frac{r_o + t}{r_o}\right)}{2\pi K_i L}$$

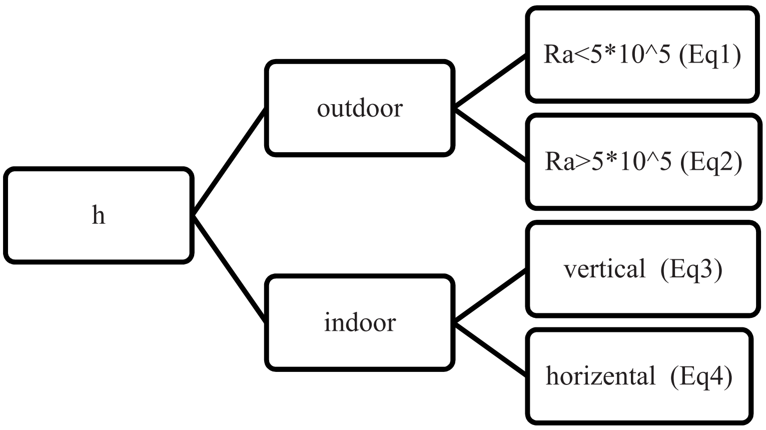
24. In this formulation, *t* represents insulation thickness, ،K_i is insulation thermal conductivity and *L* denotes insulation length (considered 1 meter). R_A is the thermal resistance of the air outside the pipe, where its general relation is as follows below.

$$(4)\ R_A = \frac{1}{Ah}$$

25. In the equation above, (A) represents pipe cross section and the following relations are used to define h.

Figure 6

Types of displacement coefficient



$$(5)\ h = \frac{k}{l}(0.332 * Re^{0.5} * pr^{\frac{1}{3}})$$

$$(6)\ h = \frac{k}{l}(0.037Re^{0.8} - 871)pr^{\frac{1}{3}}$$

$$(7)\ h = \frac{k}{l}\left(0.825 + \frac{0.387 * Ra^{\frac{1}{6}}}{\left[1+\left(\frac{0.492}{pr}\right)^{\frac{9}{16}}\right]^{\frac{8}{27}}}\right)$$

$$(8)\ h = \frac{k}{l}\left(0.6 + \frac{0.387 * Ra^{\frac{1}{6}}}{\left[1+\left(\frac{0.559}{pr}\right)^{\frac{9}{16}}\right]^{\frac{8}{27}}}\right)$$

26. where Pr is determined based on the characteristics of the air in Tehran.

where for outdoor:

$$(9)\ Re = \frac{\rho^* \upsilon L}{\mu^*}$$

And for indoor:

$$(10)\ Ra = Gr.Pr = \frac{g\beta(T_s - T_\infty)L_c^3}{\nu^* \alpha^*}$$

27. In this study, g represents the gravitational acceleration, β is the density coefficient, Lc denotes the characteristic length, and ν and αα are properties of moist air. Considering the temperature profile inside the tube, the average properties of moist air in Tehran can be used to report the heat transfer coefficient.

28. The method for calculating the Prandtl number is mentioned in articles 1 and 2. The resistance due to radiation (R_r) is defined as follows:

$$(11)\ Rr = \frac{1}{\sigma A(ts^2 + to^2)(ts + to)}$$

29. The Boltzmann constant (σ), the surface temperature (Ts), and the ambient temperature (To) are included.

heat loss load

30. To calculate the heat loss load, the following equation is used:

$$(12)\ q = U\Delta T$$

31. Where U represents the total heat transfer coefficient, and ΔT is the temperature difference between the inside of the pipe and the outside air.

Then, all previous steps are repeated for the uninsulated condition, with the difference being that there is no longer any insulation resistance (R_i), and the surface properties are no longer those of an insulator; rather, they pertain to the pipe itself.

$$(13)\ q_{save} = q_{unisulated} - q_{isulated}$$

32. The amount of energy saved through insulation is calculated from the above equation. The calculation for the annual stored heat is as follows:

$$(14)\ q = 365 * 86400 U\Delta T$$

Figure 7
Natural gas specifications

Fuel	Hu $[\frac{J}{m^3}]$	Fuel efficiency	Chemical formula
Natural gas	33526000	*0.93*	$C_{1.05}H_4O_{0.034}N_{0.022}$

E. annual requirement

33. Annual energy requirement:
(15) $E_A = \frac{365*86400U\Delta T}{\eta}$

34. Required gas volume
(16) $V_f = \frac{365*86400U\Delta T}{\eta.H_u}$

35. Volume of lost gas in the uninsulated state:
(17) $V_{f,unisulated} = \frac{365*86400U_{unisulated}\Delta T}{\eta.H_u}$

36. Volume of lost gas in the insulated state:
(18) $V_{f,isulated} = \frac{365*86400U_{isulated}\Delta T}{\eta.H_u}$

37. Volume of stored gas:
(19) $V_{f,save} = V_{f,un} - V_{f,in}$

F. The amount of Carbon dioxide emitted:

38. The continuous increase in the world's population constantly raises the demand for energy, where is also evident in household consumption. To meet the fuel needs for domestic use, natural gas is utilized directly or indirectly.
The combustion of natural gas (NG) results in the emission and release of CO_2, where operates according to the following equation:
(20) $C_mH_yO_wN_t + \alpha A(O_2 + 3.76N_2) \rightarrow mCO_2 + \frac{z}{2}H_2O + yBO_2 + EN_2$
(21) $A = m + \frac{z}{4} - \frac{w}{2}$
(22) $B = (\alpha - 1)\left(m + \frac{z}{4} - \frac{w}{2}\right)$
(23) $E = 3.76\alpha\left(m + \frac{z}{4} - \frac{w}{4}\right) + \frac{t}{2}$
The amount of CO_2 produced is calculated using the balance of the complete combustion equation for natural gas, where is 0.65 kg/m³, and the reaction balance:
(24)$m_{CO_2} = V_{f,Save} \times \frac{0.65kg\ NG}{1m^3NG} \times \frac{kmol\ NG}{1kg\ NG} \times \frac{1.05kmol\ CO_2}{kmol\ NG} \times \frac{44\ kg}{1\ kmol\ CO_2}$
Optimization of Cost Calculation:

39. Cost of Wasted Fuel in Uninsulated Condition:
(25) $C = V_{f,unisulated} \times C_f$
40. Cost of Wasted Fuel in Suspended Condition:
(26) $C = V_{f,isulated} \times C_f$
41. Cost of Stored Fuel:
(27) $V_{f,Save} \times C_{f,NG} = C_s$

42. To calculate the costs, the amount of gas stored is first multiplied by the price per cubic meter. In this way, the annual cost associated with storing this amount of gas can be determined.

43. Theoretical calculations often differ from the actual values for various reasons. To improve the accuracy of these calculations, a correction factor is introduced into the equations. This factor is derived from the estimation of multiple real data points.

III. Results

44. These studies were conducted based on the climatic and environmental conditions of hot water pipes in Tehran. The impact of insulation on three factors: energy consumption, gas consumption, and Carbon Dioxide emissions were examined in the calculations. These calculations were performed using the Linkran web calculator software developed by the Linkran Industrial Group.

45. Based on the results of calculations performed by the Sazeh Paydar Elahieh company's calculator, it was found that insulation on building pipes reduces heat transfer and acts as a barrier to heat loss. As seen in Figure 1-1, with increasing insulation thickness, heat loss decreases, and heat retention increases.

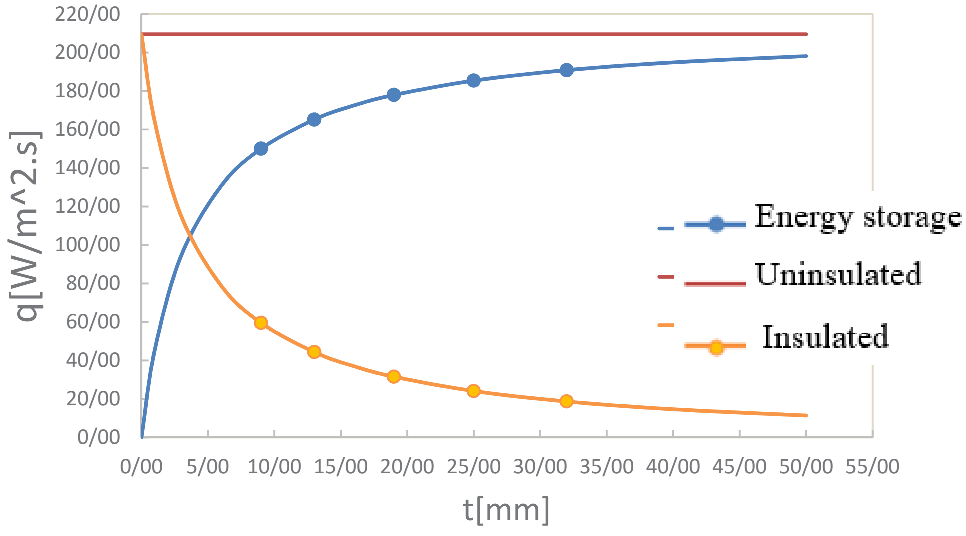


Figure 1-1 The effect of insulation thickness on heat loss and energy saving per m^2 of insulation

46. To supply energy, natural gas is combusted. The amount of energy stored and lost can be related to the amount of gas consumed. This indicates the effect of insulation on natural gas consumption. As seen in Figure 1-2, with increasing insulation thickness, natural gas loss decreases, leading to gas storage, which indicates lower consumption of fossil fuels.

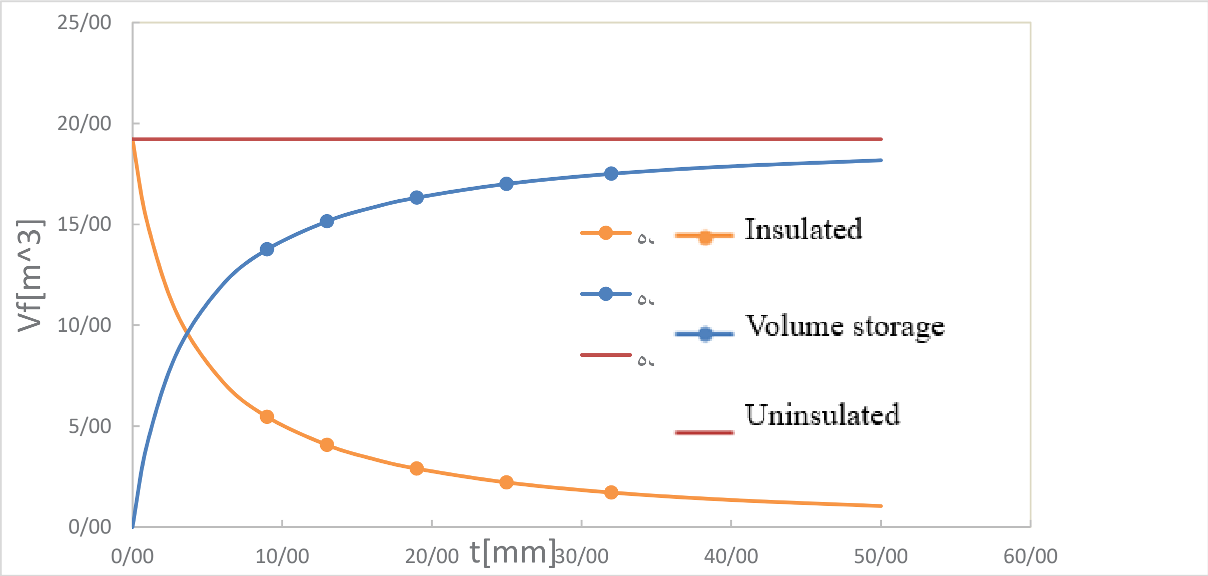


Figure 1-2 The effect of insulation on town gas using 1 m^2 of insulation

47. The combustion of natural gas used in residential buildings in Tehran produces Carbon Dioxide. This indicates a relationship between the amount of insulation and the reduction of Carbon Dioxide emissions. As shown in Figure 1-3, increasing the thickness of insulation reduces the amount of emitted Carbon Dioxide.

48. Finally, the reduction in Carbon Dioxide emissions based on the thickness of insulators produced by Sazeh Paydar Elahieh Company was investigated. As shown in Figure 1-4, with increasing insulation thickness, the efficiency of Carbon Dioxide storage and energy storage increases. This efficiency is calculated as the ratio of Carbon Dioxide emitted due to wasted energy before and after insulation, and represents the amount of energy and Carbon Dioxide saved due to insulation.

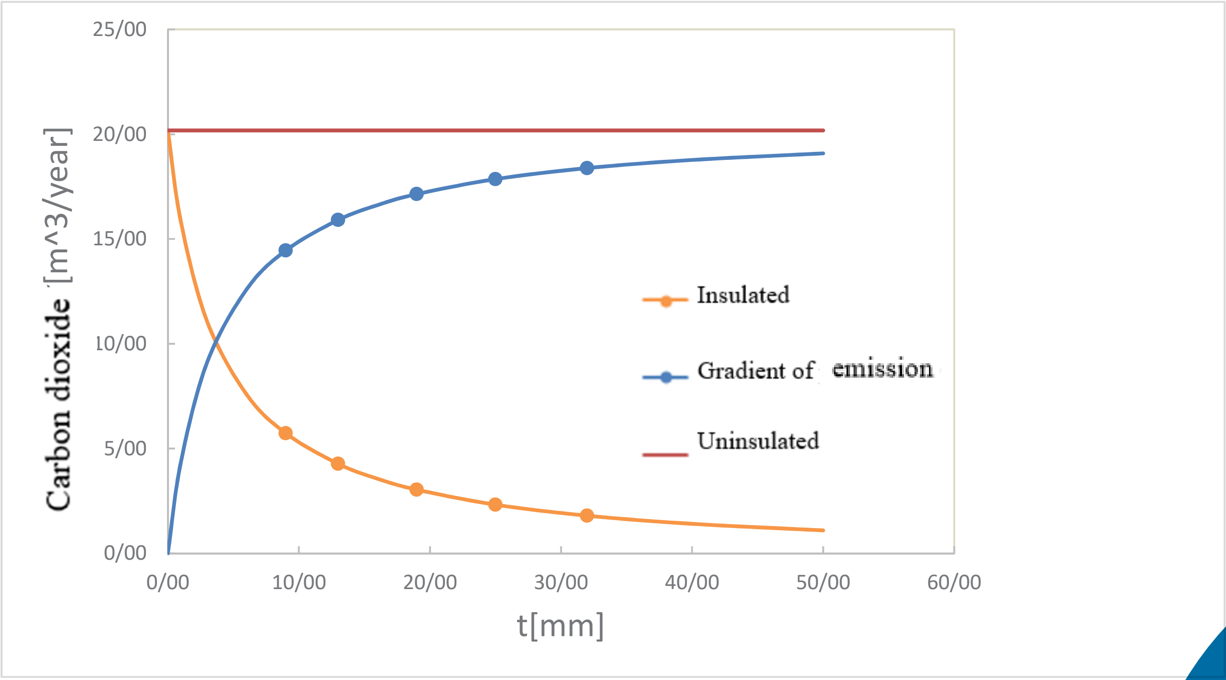
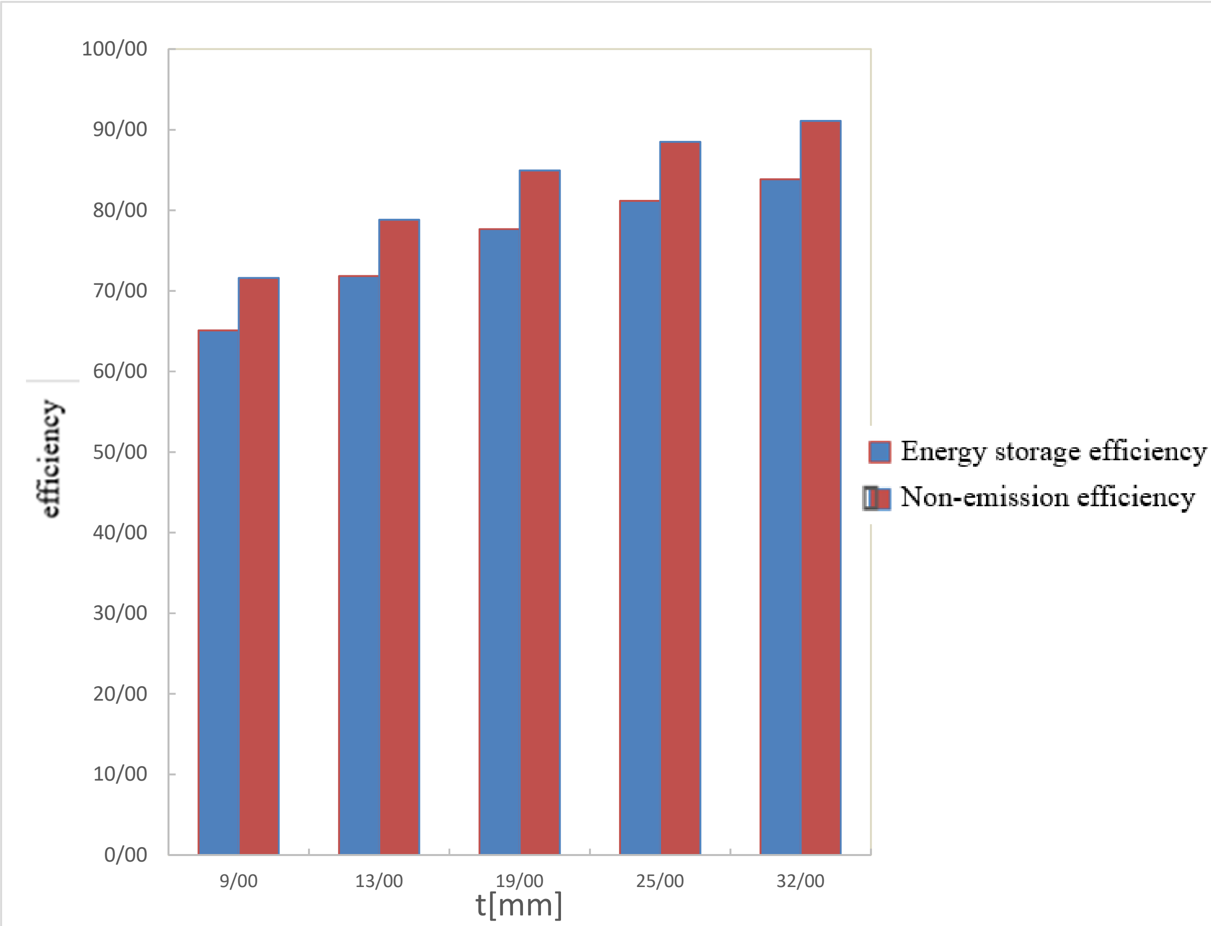


Figure 1-3 The effect of insulation thickness on Carbon Dioxide emissions per 1 m^2 of insulation

Figure 9
The percentage of energy storage efficiency and carbon dioxide emissions avoidance based on thickness.

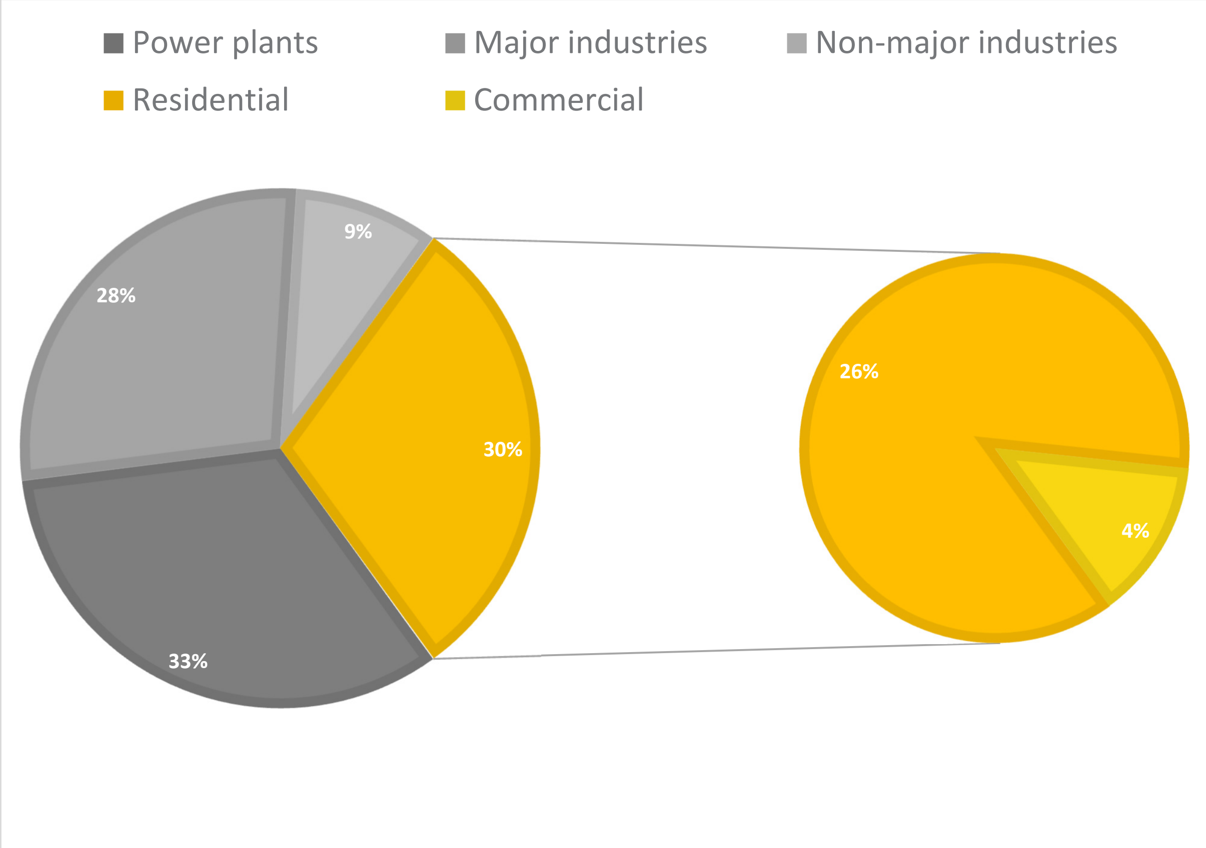


49. This section calculates the town gas consumption and Carbon Dioxide emissions for the city of Tehran, both with and without insulation. The calculations demonstrate that insulation, when implemented on a large scale, significantly reduces Carbon Dioxide emissions and town gas consumption. Beyond contributing to sustainable development and environmental protection, this process also leads to decreased gas consumption costs. This simulation was specifically conducted for Tehran.

50. To calculate the gas consumption and Carbon Dioxide emissions in Tehran, data on household gas consumption is required. An analysis of natural gas consumption across various sectors reveals that the organizational sector (encompassing residential and commercial use), consists of 30% of the country's total gas consumption, is the second largest consumer after power plants. A comparison of the growth rates of natural gas consumption in different consumer sectors indicates that changes in final gas consumption align with changes in the household sector, highlighting the substantial influence of this sector on the overall consumption. Other consumptions tied to power plants, major and minor industries, generally maintain a constant consumption rate throughout the year.

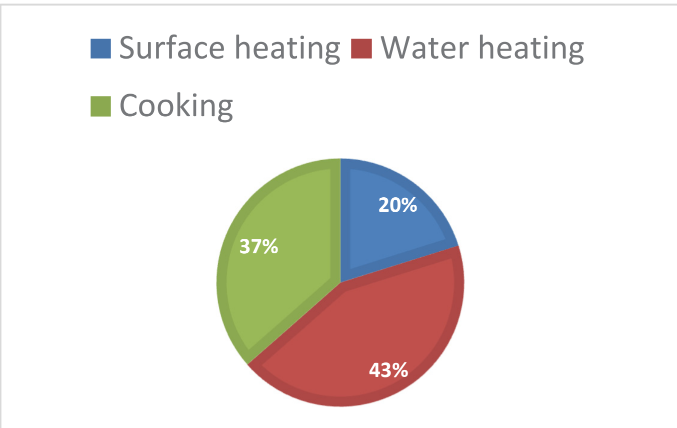
51. Over 70% of natural gas consumption in the residential and commercial sectors during cold seasons is attributed to heating. consumption levels fluctuate in accordance with weather conditions. In this study, the focus is merely on the residential and commercial sectors, as illustrated in Figure 1-5.

Figure 10
The Percentage of Natural Gas Consumption by Sector



52. As observed in Figure 10, 30% of gas consumption is attributed to organizational uses, which are further subdivided into residential and commercial categories. In this study, focusing on the thermal loss of hot water pipes, only the relevant sectors are considered. These sectors encompass cooking, space heating, and water heating, with space heating utilizing both a heating system and direct gas consumption. Given that the heating system operates by warming the hot water pipes, it is essential to account for a portion of both space heating and water heating (via water heaters or boiler systems) when calculating gas consumption for heating these pipes. The distribution percentages of these sectors are illustrated in Figure 11.

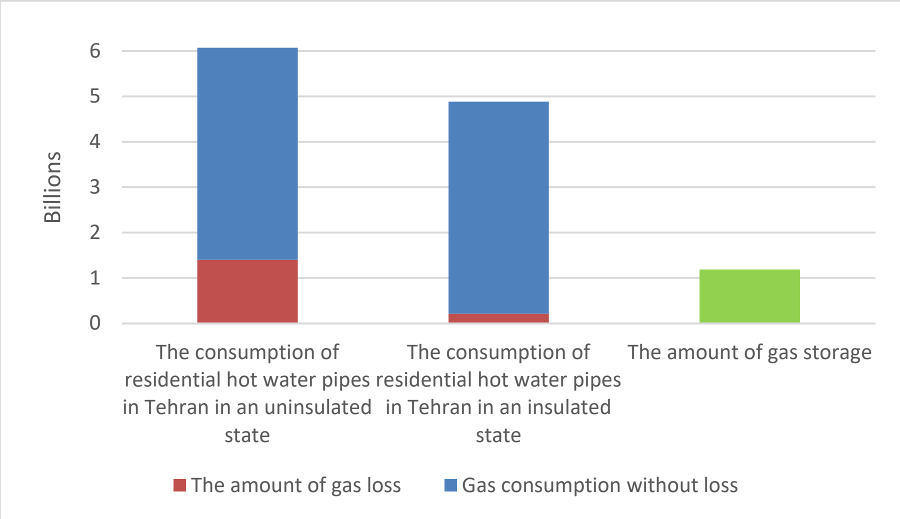
Figure 11
Chart of Organizational Consumption Classification



Statistical Report Eurostat, European Commission, Gas Consumption Pattern File in Housing, DEBCO Research Center.

Figure 12

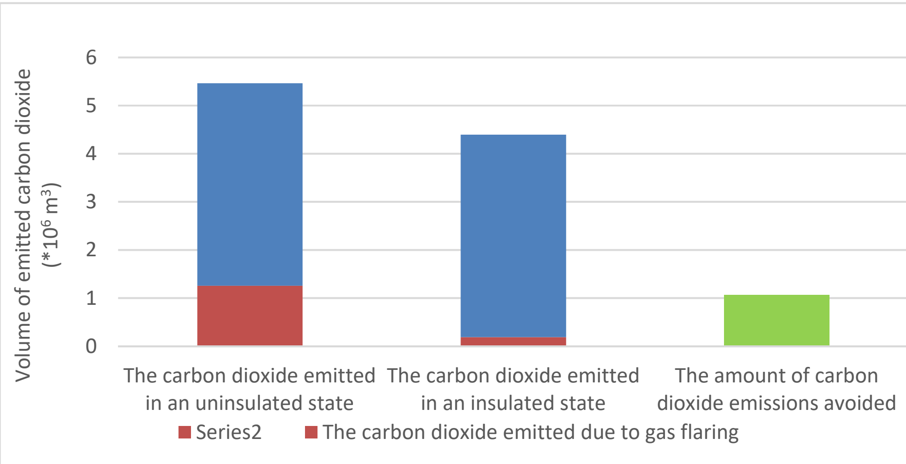
Gas Consumption and Energy Storage in Tehran



Research Center of the Parliament

Figure 13

The Amount of Carbon Dioxide Emitted

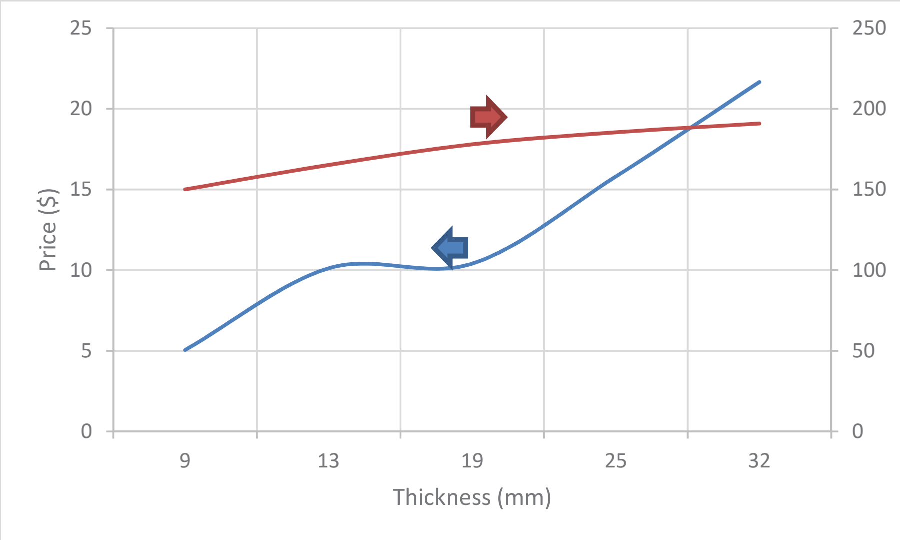


Research Center of the Parliament

53. Considering the energy storage capacity and the cost of insulation materials based on thickness, an analytical approach can lead to the determination of an optimal thickness. Accordingly, Figure 14 is examined at two specific thicknesses of 9 mm and 19 mm, as
54. these points yield the highest energy storage relative to their associated costs. Analyzing the graph reveals that a 19 mm insulation thickness is optimal for insulation applications in Tehran.

Figure 14

The price and amount of energy stored per square meter in relation to thickness



55. In accordance with the calculations conducted by the Linkran web calculator, the specifications for each insulation thickness, including the amount of carbon dioxide emissions, are presented in Table 8. This information is also provided in Table 9 based on the volume of insulation applied.

Table 8

The Rate of Carbon Dioxide Emission Based on Each Square Meter of Insulation at Specified Thicknesses

Thickness (millimeters)	Energy Storage Watts per Square Meter	The volume of gas stored annually, expressed in cubic meters.	The volume of carbon dioxide emissions not released, measured in cubic meters per year.	The yield of carbon dioxide non-emission (%)	The savings incurred in Iran on an annual basis, expressed in U.S. dollars.	The annual savings in the world, measured in U.S. dollars.	The price per square meter of insulation, expressed in US dollars.	Break even point in Iran (Year)	Break even point
1	45.42	7.41	6.12	21.68	0.427425	1.399452	---	---	---
3	94.6	8.68	7.44	45.19	0.8897	2.913008	---	---	---
6	130.70	11	9.428571	62.38	1.1275	3.6916	---	---	---
9	150.02	13.76	11.79429	71.60	1.4104	4.617856	5.052	3.58	1.09
13	165.16	15.15	12.98571	78.83	1.552875	5.08434	10.115	6.45	1.99
16	172.53	15.83	13.56857	82.35	1.622575	5.312548	---	---	---
19	177.96	16.33	13.99714	84.94	1.673825	5.480348	10.404	6.23	1.90
25	185.40	17.01	14.58	88.4٩	1.743525	5.708556	15.801	9.08	2.77
32	190.85	17.51	15.00857	91.09	1.794775	5.876356	21.656	12.10	3.68
40	194.88	17.88	15.32571	93.01	1.8327	6.000528	---	---	---
50	198.14	18.18	15.58286	94.57	1.86345	6.101208	---	---	---

Information file of Linkran Company

Table9

The Rate of Carbon Dioxide Emission Based on Insulation Volume for One Cubic Meter of Lincrusta Insulation (Average of All Thicknesses)

Volume of insulation (m^3)	Energy Storage Watts per Square Meter	The volume of gas stored annually, expressed in cubic meters.	The volume of carbon dioxide emissions not released, measured in cubic meters per year.	The yield of carbon dioxide non-emission (%)	The savings incurred in Iran on an annual basis, expressed in U.S. dollars.	The savings incurred in Iran on an annual basis, expressed in U.S. dollars.	The price per square meter of insulation, expressed in US dollars.	Break even point in the Iran (year)	Break even point in the world (year)
1	9366.32	859.45	773.24	84.94	88.09	288.42	546.58	6.23	1.90

56. With reference to the insulation data from Linkran and the measures taken to mitigate carbon dioxide emissions over the past four years, it is evident that the company has undertaken significant and effective actions aimed at achieving sustainable development. The amount of carbon dioxide emissions prevented is illustrated in statistical figure 14.

Table 10

A portion of the sales volume of Linkran in the years 1402 and 1403, categorized by thickness.

Thickness (millimeters)	The Volume of Insulation Sold in the Year 1402 (Square Meters)	The Quantity of Insulation Sold in the Year 1403 (Square Meters)	Total Volume of Insulation Sold (Cubic Meters)	The volume of gas stored (cubic meters per year).	The Rate of Carbon Dioxide Emission Cubic) Meters per Annum)	The annual savings in gas costs, expressed in dollars (based on the price of imported gas).
6	106699.2	73080	179779.2	1977571	1695061	663672.9
9	150264	77568	227832	3134968	2687117	1052095
13	252180	70324.8	322504.8	4885948	4187954	1639724
16	84712.8	10742.4	95455.2	1511056	1295191	507110.3
19	152988	105000	257988	4212944	3611094	1413864
25	21955.2	22488	44443.2	755978.8	647981.9	253706.5
32	6956.4	1814.4	8770.8	153576.7	131637.2	51540.34
40	5620.8	7816.8	13437.6	240264.3	205940.8	80632.7
50	0	2851.2	2851.2	51834.82	44429.85	17395.76
Total				16924141.7	14506405.8	5679742

57. The results indicate that this segment of insulation work carried out in the years 1402 and 1403 will subsequently contribute to a reduction in the consumption of 16.92 million cubic meters of natural gas annually, valued at 5.68 million dollars. Furthermore, it will prevent the emission of 14.51 million cubic meters of carbon dioxide into the atmosphere.

Table 11

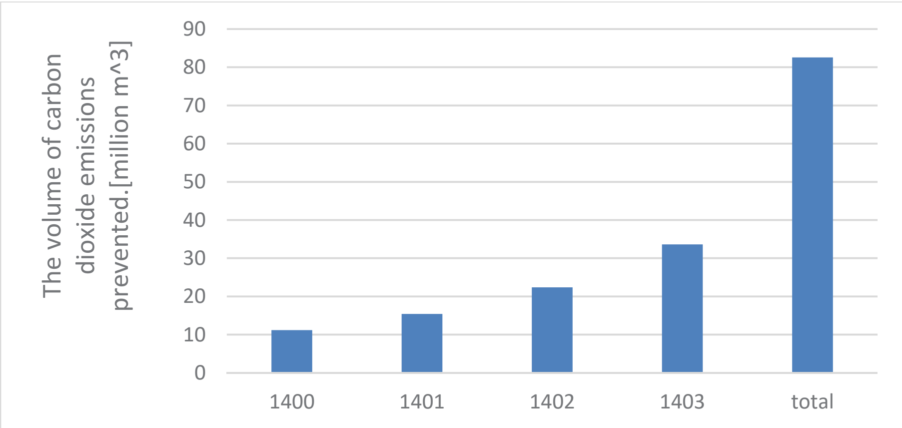
The total amount of insulation applied in the last four years.

Year (Based on solar calender)	Total Volume of Insulation Sold (Cubic Megameters)	Volume of Stored Gas Million) Cubic Meters per Year)	The Rate of Carbon Dioxide Emission Measured in) million cubic meters per year)	The annual cost savings of gas, measured in millions of dollars (based on the price of foreign gas).	The cumulative savings from gas costs in millions of dollars from the beginning
1400	0.8	13.06	11.20	4.38	4.38
1401	1.1	17.96	15.40	6.03	14.79
1402	1.6	26.13	22.40	8.77	33.97
1403	2.4	39.19	33.59	13.15	66.3
Total	5.9	96.35	82.58	32.33	66.3

58. Considering the results of insulation efforts over the past four years, it is projected that from this

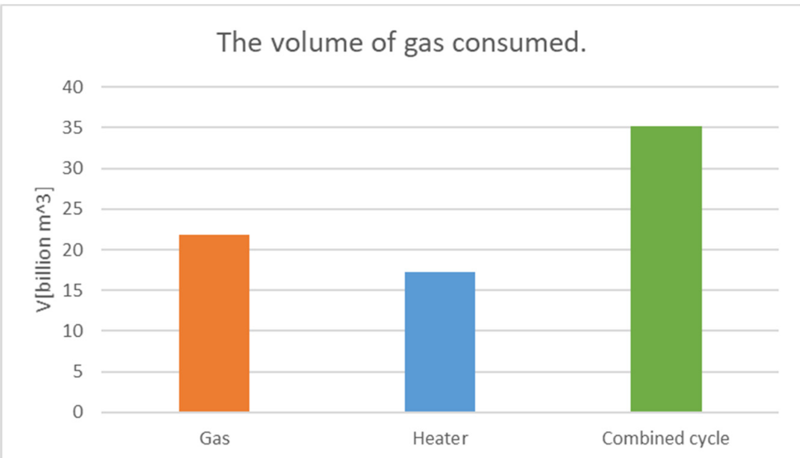
point forward, an annual reduction of 96.35million cubic meters of gas will be achieved, valued at approximately 32.34 million dollars. Furthermore, this initiative will prevent the emission of 82.58 million cubic meters of carbon dioxide each year. Additionally, considering the durability of elastomeric insulation performance, it can be stated that, in general, it has resulted in savings of $66.3 million over four years.

figure 15
The volume of carbon dioxide emissions mitigated through insulation by Linkran Company over the past four years has significant implications for environmental sustainability and energy efficiency.



59. To ensure energy supply, the establishment of energy production resources is essential. Among the most significant sources of energy generation are thermal power plants. These plants vary in type and operate through different mechanisms to produce energy. A critical aspect of thermal power plants is the type of fuel they utilize. Subsequent analyses reveal that the predominant fuel consumed by these facilities is natural gas. Utilizing the volumetric percentage of gas consumption illustrated in Chart 16, along with data provided by the Research Center of the Islamic Consultative Assembly, the volume of gas consumed by existing power plants in Iran has been reported in accordance with their types as depicted in figure 16.

Figure 16
The Impact of Power Plant Types on Gas Consumption Volume



Draft 1 – Development Program for the Construction of Thermal and Renewable Power Plants in the Eleventh Government, InfoSaba informational

60. In the following, the amount of production capacity of power plants has been examined according to their types, and figure 17 has been drawn to separate the types of power plants based on their

production capacity.

Figure 17

Capacity of Power Plants Dependent on the Type of Power Plants Across the Country

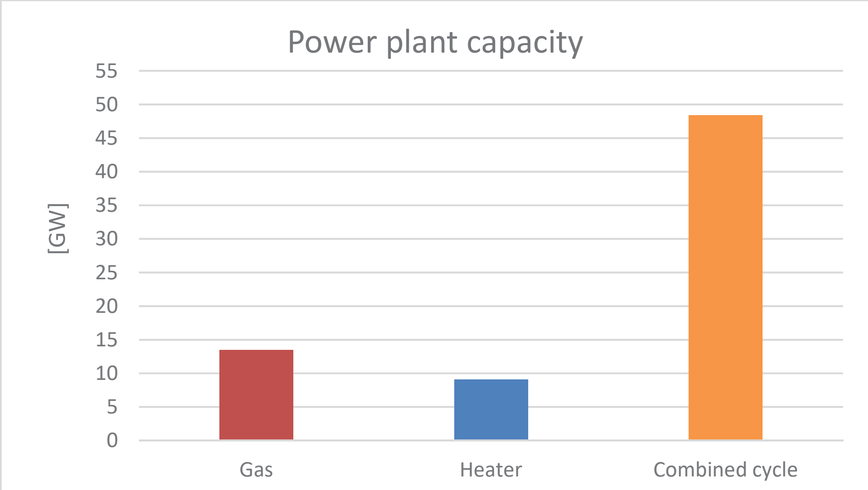


Diagram 1 – Development Program for the Construction of Thermal and Renewable Power Plants in the Eleventh Government, InfoSaba Information Website

61. In figure 16, it is evident that a significant percentage of the natural gas consumption in power plants is attributed to combined cycle power plants. Furthermore, as indicated by figure 17, the highest level of energy production among power plants across the country is currently allocated to this type of facility. This translation employs an academic tone and precise language to convey the original message effectively.

62. According to the online calculator provided by Linkran, if the entire city of Tehran were to be insulated and natural gas loss were reduced, it would be possible to conserve an energy capacity of 410.55 megawatts annually. To facilitate a better understanding of this conserved energy capacity, a discussion will focus on five power plants currently under construction in Iran, as detailed in Table 10.

Figure 12
Power Plants Under Construction and Their Capacities

Power Plant Name	Type of Power Plant	Capacity Under Construction
Petrochemical of Kermanshah	gaseous	10
A Small Gas in the Mianrood	gaseous	25
A Small Gas in the Zahedan	gaseous	42
Caspian Pasargad	gaseous	320
roodshour	Combined Cycle	345
Arian	Combined Cycle	546
Quds Semnan	gaseous	644
Damavand Petrochemical Company	gaseous	1900

The source of the research commitment is the Statista website.

63. Assuming a capacity of 410.55 megawatts of stored energy due to the insulation of the entire city of Tehran, the need for the construction of several power plants is alleviated. For instance, this would eliminate the necessity for the establishment of a 25-megawatt small gas power plant in Mianroud, a 42-megawatt small gas unit in Zahedan, and a 345-megawatt combined cycle power plant in Roudshour. Furthermore, this development would contribute to a reduction in carbon dioxide emissions, even as the aforementioned power plants are currently under construction.

64. The cost of constructing a combined cycle power plant is $1,226 per kilowatt of energy, while the cost for a gas power plant is $1,100 per kilowatt. The construction cost for a gas power plant with a capacity of 410 megawatts amounts to $451.61 million, whereas the construction cost for a combined cycle power plant with the same capacity is $502.66 million. Considering the aforementioned examples, the savings achieved through insulation and the avoidance of constructing these power plants amounts to $496.67 million.

A. Innovative Projects Aimed at Reducing Carbon Dioxide Emissions

65. Project for the Production of Panel Insulations from Production Line Waste The NBR/PVC elastomeric insulation, like other manufactured products, occasionally encounters waste due to errors in the production line. These errors may stem from human mistakes, equipment malfunctions, unforeseen incidents, and other factors, making waste an unavoidable aspect of this process. Given that this waste consists of a thermoplastic elastomer (NBR/PVC), it transforms into a hard, non-biodegradable material that exhibits high resistance to biological, physical, and chemical degradation. Consequently, it requires an extended period for decomposition in the environment. When degradation does occur, the material does not assimilate into the ecosystem, rendering it a hazardous pollutant and categorizing it as hazardous waste. The disposal of this waste can lead to numerous issues, including various diseases, environmental pollution (such as contamination of oceans, seas, groundwater, etc.),

and endangering the lives of humans and other living organisms. Furthermore, considering that these products are composed of valuable engineered materials, their waste can result in significant energy and capital loss.

66. Linkran, while striving to enhance the quality and competitiveness of its products in the global markets, has not overlooked the issue of generated waste. Beyond addressing various challenges, the company remains committed to its primary mission: the protection of the Earth. This commitment aims to ensure responsible utilization of resources to foster improved living conditions and to safeguard this legacy for future generations. In line with this mission, the company currently produces a product known as panel insulation, which is designed to prevent energy loss in walls and flooring.

B. Microalgal Bioreactor

67. The primary aim of this project is to assess the feasibility of wastewater treatment and carbon capture using a microalgal bioreactor. This initiative seeks to design a flexible process tailored for polluting industries, addressing environmental challenges and managing industrial pollution. Linkran is focused on exploring and advancing microalgal reactor technology in two key areas: industrial wastewater treatment and carbon dioxide absorption. To this end, the feasibility phase of the project commenced on November 22, 2023, in collaboration with the Chemical Engineering Faculty of Amirkabir University, under the supervision of Dr. Narges Fallah. If successful, this project could lead to the development of a flexible and scalable process applicable to other industries and factories. With national support, it has the potential to evolve into an innovative technology aimed at achieving net-zero greenhouse gas emissions. The overall process consists of two main components, which will be briefly outlined along with its integration into the panel insulation production project from manufacturing waste. This project not only represents a significant step toward sustainable industrial practices but also highlights Linkran's commitment to environmental stewardship through innovative technological solutions.

Section One: Assessment and Feasibility of Industrial Wastewater Treatment

68. The objective of this section is to evaluate the effectiveness of microalgal reactors in treating wastewater from industrial units. Given that microalgae possess a high capacity for absorbing nutrients and pollutants, they can significantly contribute to reducing the pollution load in wastewater.

- **Analysis of Wastewater Quality**

This involves assessing the levels of pollutants such as nitrogen, phosphorus, and heavy metals in the wastewater from the examined factories.

- **Biological Treatment and Pollutant Reduction**

An exploration of how microalgae function in decreasing pollutant concentrations and enhancing the quality of the effluent water.

- **Economic and Environmental Studies**

Analysis of Operational Costs and Environmental Benefits of Using This System Compared to Traditional Wastewater Treatment Methods.

Section Two: Carbon Sequestration Potential and Flexible Process Design

69. This section explores the potential of microalgae in carbon dioxide absorption, with the goal of designing a flexible process that can be applied to various industries with high CO_2 emissions.

- **Carbon Sequestration Potential**

Microalgae absorb carbon dioxide during photosynthesis and utilize it for growth. This section examines the amount of carbon that can be sequestered on an industrial scale.

- **Flexible Process Design**

The design of a modular and adjustable system that can be easily implemented in industries with high CO_2 production, ranging from thermal power plants to cement factories.

- **Case Studies for Various Industries**

An analysis of the potential for implementing this process across different sectors, including power generation units, refineries, and petrochemical plants.

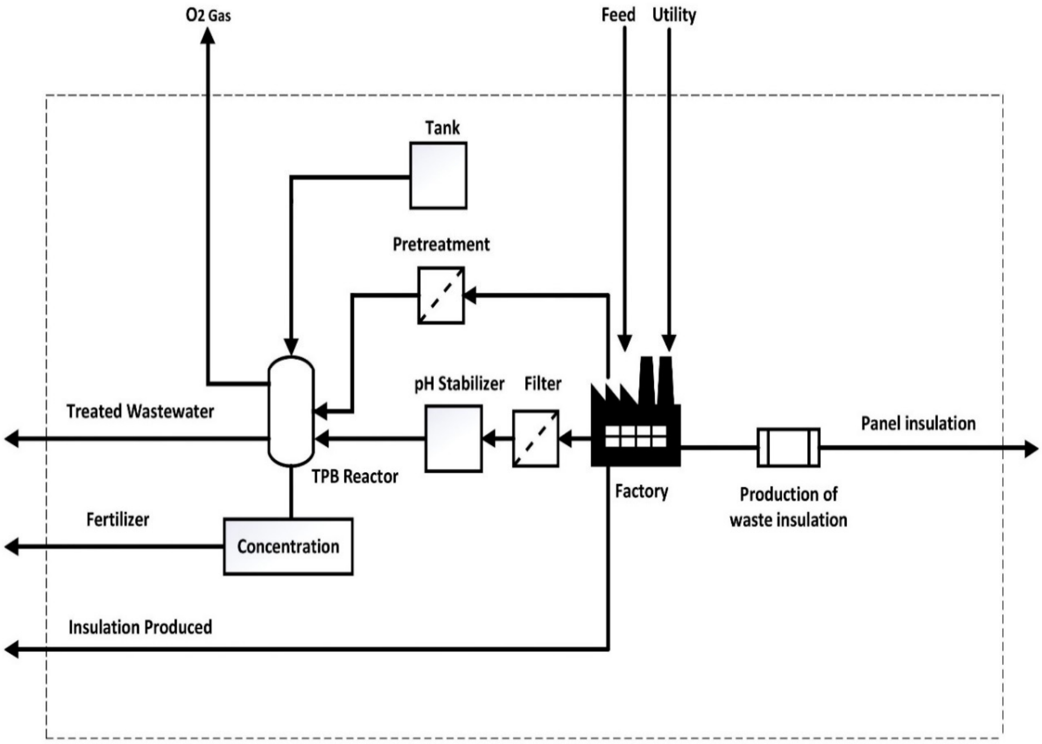
70. This section on microalgal reactor technology not only has significant potential for reducing carbon dioxide emissions and treating wastewater, but it can also be introduced as a comprehensive solution for many polluting industries in the country through the design of a flexible process. It is recommended that this technology be gradually expanded on a national scale by implementing various pilot projects and collaborating with major industries.

71. Figure 5 presents a comprehensive schematic illustrating the operational process of converting the CO2 generated into O2, as well as the biological treatment of wastewater from the elastomeric insulation production facility. This process is facilitated by a microalgae reactor, positioned alongside the panel insulation production unit, utilizing waste from the production line.

72. The objective of the planning process is to design and transform the Linkran elastomeric insulation production line into an industrial unit with zero carbon emissions and minimal environmental impact. This initiative aims to serve as a successful model for other industries, paving the way for a new path towards sustainable development on both national and global scales.

Figure5

The amount of CO2 production in Iran



73. Linkran is focused on developing modern technologies, particularly in the field of elastomeric insulation, and is seeking to establish international collaborations. This group aims to interact and cooperate with leading companies in this industry globally by developing a unique web application in the area of elastomeric insulation. Our goal for these collaborations is to leverage global experiences and innovative technologies to enhance the quality of our products and better meet customer needs.

74. Linkran has planned programs to enhance the skills and technical knowledge of its human resources by engaging with leading global companies. This interaction includes organizing training courses and exchanging information, which can strengthen employee capabilities and increase productivity.

75. In addition, an examination of the import and export potential of Linkran's elastomeric insulations shows that, considering the competitive pricing of these products compared to others and their desirable quality, there are good opportunities for expanding international markets. These factors could play an important role in the economic development and increase the company's market share globally.

Conclusion and Recommendations

76. In the past four years, Linkran has successfully prevented energy loss of approximately 49.20 megawatts through its insulation production alone. Additionally, it has mitigated the emission of around 82.54million cubic meters of carbon dioxide into the atmosphere. This conserved energy has effectively eliminated the need for establishing a combined cycle power plant with a capacity of 49.20 megawatts, which would have incurred construction costs of approximately 60 million dollars.

77. Based on the calculations conducted, proper insulation of Tehran could prevent energy loss of about 410.55 megawatts. This would eliminate the country's need to construct a new power plant to supply this amount of energy, resulting not only in a significant reduction in carbon dioxide emissions but also representing a substantial step towards sustainable development and mitigating climate change both nationally and globally.

78. According to estimates, the gas conserved through effective insulation in Tehran would hold an annual value of approximately 398.39 million dollars. Furthermore, considering the useful lifespan of elastomeric insulations—up to 25 years even under the worst usage conditions—the total savings would amount to approximately 9.96 billion dollars.

79. When juxtaposed with the estimated insulation costs of around 756.89 million dollars, this figure underscores the economic value of the insulation process alongside its numerous environmental benefits, which can significantly contribute to the country's economic development in alignment with sustainable growth.

80. Moreover, for every cubic meter insulated, there is a prevention of approximately 772.23 cubic meters of emissions annually, culminating in an overall reduction of about 1.19 billion cubic meters of carbon dioxide emissions per year for Tehran.

81. Statistical and comparative analyses reveal that the payback period for insulation in Iran is approximately 6.23 years, compared to just 1.9 years internationally (considering differences in gas pricing between Iran and global rates). This indicates that one of the primary barriers to implementing energy reduction and optimization strategies in Iran is the low price of energy carriers.

82. This situation has led both industries and individuals to exhibit limited motivation for optimizing energy consumption. Consequently, the implementation of insulation and other energy-saving technologies appears economically unfeasible for many individuals and industries due to the low cost of energy, which diminishes financial incentives for investment in this sector.

83. Additionally, the low rates for energy carriers not only reduce motivation for adopting energy optimization strategies but also exacerbate excessive and irresponsible energy consumption. Such mismanagement leads to wastage of natural resources and inflicts severe damage on the environment. Given that a significant portion of the country’s energy consumption is derived from fossil fuels, this inefficient usage contributes to increased greenhouse gas emissions and accelerates climate change. In essence, low energy prices indirectly expedite global warming and intensify environmental crises.

84. This scenario poses risks not only to the environment but also to the country’s economy. Economic calculations presented in this report indicate that if excessive energy consumption continues unabated and energy efficiency does not improve, there will be long-term negative impacts on the country's economic growth. The low prices for energy carriers deter innovation and productivity enhancements within industries, preventing the nation from competing effectively on a global scale. Consequently, this trend may restrict industrial growth and lead to further economic and energy-related challenges.

85. Implementing punitive regulations such as carbon taxes could serve as an economic incentive for reducing greenhouse gas emissions. In conjunction with this, providing financial support and incentives for projects aimed at improving energy efficiency and reducing carbon emissions would

enhance industries' and businesses' motivation to pursue sustainable development.

86. The execution of innovative projects can also play a significant role in this regard. For instance, initiatives such as producing insulation from production waste and utilizing microalgae bioreactors as green technologies can significantly contribute to carbon emission reduction and waste management efforts. Bioreactors possess the capability to absorb carbon dioxide generated during industrial processes while treating some pollutants found in industrial wastewater. Moreover, biomass produced from these processes can be utilized as fertilizer for green spaces, thereby reducing environmental impacts and moving industries closer to achieving net-zero carbon status. In this context, it is recommended that various pilot projects be executed in collaboration with major industries to gradually expand this technology on a national scale.

87. The interaction between universities and industry plays a crucial role in developing innovative solutions to combat climate change. Collaboration between academia and industry can bridge theoretical knowledge with practical needs, paving the way for effective projects aimed at reducing greenhouse gas emissions and energy consumption. In pursuit of this goal, Linkran intends to foster dynamic interactions by collaborating with leading universities such as Amirkabir University of Technology and Tehran University to enhance these projects further.

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