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Investigating the Sustainability of Energy Production and Consumption in Data Centers with the Design and Morphology Approach of the Building

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Abstract—**One of the biggest amounts of energy consumption in the telecommunications industry is related to energy consumption in data centers, which cause high costs imposed on companies that are interested in having data centers, so without using appropriate methods for reducing energy consumption instead of environmental problems It will also create many cost for companies. Today, companies choose and operate a variety of methods to optimize energy consumption in their data centers. In this research, we have tried to use new methods in architecture called changes in building morphology to reduce energy consumption in office and building applications in the construction of data centers to beautify the facade of the building, the required energy consumption to reduce the brightness and cooling of the data center. In this study, the effect of morphology design on energy consumption and costs in data centers will be investigated. Also, based on the hypotheses, a conceptual model has been considered to better understand the subject. The analysis of statistical data of this research was done with SPSS 25 and LISREL 8.5 software.**

Keywords—Data Center; Low Consumption Building; Solar Panels; Low Consumption Building Morphology; the Morphology Design; Double Shell Façade.

I. INTRODUCTION

According to the US Department of Energy, power consumption in data centers since 2000, is based on previous studies and data and consumption forecasts until 2020, based on new trends and the latest information available in 2014. Data centers in the United States consume about 70 billion kilowatt-hours of electricity, which is about 1.8 percent of total US consumption. The report also shows that data center power consumption increased by about 4 percent between 2010 and 2014 and is projected to continue at around 4 percent per year until 2020. That means something like 73 billion kilowatt-hours by 2020 [1]. It should be noted that according to Moore's law, the power consumption of data centers should have doubled every two years, but the following figure shows that the use of energy efficiency methods in data

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centers reduces the power consumption of data centers. Although the processing power of servers has increased significantly, using best practices and improvements in data center power management has been able to significantly reduce the increase in power consumption of data centers.

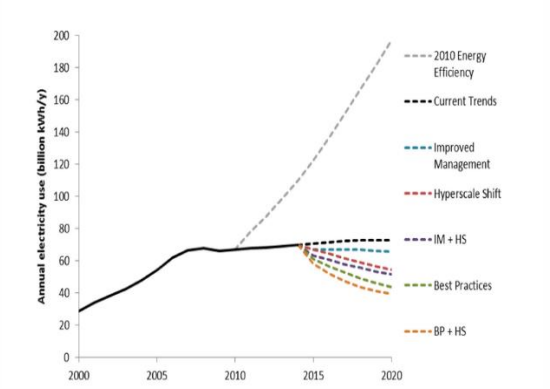

Figure 1. Predicting power consumption in US data centers by 2020 [2].

All of the above changes are the result of technological advances in the field of information technology, and the effects of changes in the science of architecture in this field are still unknown.

On the other hand, the impacts of high-tech industries on the planet are increasing rapidly due to technological changes and global innovations, and global developments, while concerns have led to the development of the concept of sustainability and greener and cleaner products in industries. [3]

Today, new approaches are used in the construction industry, which can be significantly reduced energy consumption. By combining these approaches with new technologies which are used in the data center manufacturing industry it's possible to significantly reduce the power consumption of data centers. Two of these methods are the use of double-shell facades and glass walls in data centers. These methods are used in new structures and there are several examples of this model of buildings. However, the reduction of energy consumption in-home use has been very significant, but considering that the overall amount of home consumption compared to data center consumption is small, it can be concluded that the use of structural change methods can be more effective in data centers.

This article tries to examine the effects that changes in the structure of data centers would have on the power consumption of data centers. Obviously, if, in addition to technological changes, other methods can use in the data center this will help reduce energy consumption, effective measures can be taken to combat air pollution.

In this article, we examine the effects of changes in building morphology on reducing energy consumption and economic cost savings of data centers, the results of it can be used to build new data centers with higher energy efficiency.

II. PROBLEM STATEMENT

One of the biggest amounts of energy consumption in the telecommunications industry belongs to data centers, which in addition to imposing exorbitant costs on companies due to the growing demand of human societies to reduce energy consumption and global warming, could cause huge changes. It has been in the environment and living conditions, forcing companies to use methods for optimizing their power consumption. Data centers are one of the industries that consume a lot of energy on Earth. Based on previous studies and data related to power consumption forecasts until 2020, based on new trends and the latest information available in 2014, according to the US Department of Energy report on data consumption data in data centers since 2000 Data centers in the United States have consumed about 70 billion kilowatt-hours of electricity, which is about 1.8 percent of total US consumption. The report also shows that data center power consumption has increased by about 4% between 2010 and 2014 and is projected to continue to grow by about 4% per year until 2020. That means something like 73 billion kilowatt-hours in 2020 (ETA, 2018, para1). Several existing methods that are widely used in data centers to reduce energy consumption are virtualization, closed corridors, hot and cold aisle, the use of free cooling, etc., all of them are based on engineering conditions. And have made a significant contribution to reducing energy consumption (Figure 1), but still, no specific method is used for data center building architecture, and structures are usually predicted according to the needs of data centers. The point that can be discussed here is whether it is possible to reduce energy consumption by changing the type of structure and its architecture and providing a standard way to design data centers? Therefore, how to integrate new architectures with data center standards and their requirements can be investigated.

About 25% of the energy consumed in the data centers belongs to the cooling system of the center and the other 12% is used for airflow in the center to cool the equipment, so in total, about 37% of the total energy consumption belongs to the cooling part of the center. It should also be noted that the above values are for data centers in which all construction conditions are observed, and if, for example, an office used as a data center with a change of use, the above values will increase sharply and In some cases, cooling energy consumption will reach up to 50% of the total data center consumption.

If the internal data centers cannot reduce their consumption in line with the solutions used in the world, in addition to wasting energy with the problem of not being able to allocate adequate space to their electronic equipment due to achieving maximum capacity and cooling of data centers They will face this, which will impose huge costs on companies to build new data centers.

In this research, the method of changing the morphology design of the building will be used to reduce the power consumption of the data center. The results of this research can be suitable and used for companies that intend to build new data centers or even have problems with their electricity and cooling capacity and intend to optimize their data centers.

III. THE IMPORTANCE OF RESEARCH

The grand plan of the Islamic Republic of Iran is the optimal use of fossil energy resources and the promotion of the utilization of various renewable energy sources to meet parts of the country's growing energy needs. Because Iran is one of the richest countries in the world in terms of various energy sources and in addition to the vast sources of fossil and non-renewable fuels such as oil and gas, has great potential for renewable energy such as wind, solar, biomass, and geothermal is.

Recently, a lot of research has been done on buildings that reduce energy consumption with changes in building architecture, given that one of the highest amounts of electricity consumption in the industry belongs to the data center sector and this amount is due to technological changes and needs. There is a lot of information about information, maintenance, new services, social networks, etc., it is still increasing, it is clear that in addition to the usual methods, you can also look at this new category, because if about 30% reduction Energy consumption at home is affordable. Certainly reducing energy consumption to about 5 to 6 percent in data centers in addition to current methods can become a competitive advantage for data center owners to grow their business and be more profitable. Because the average consumption of the world's 5 largest data centers is about 150 MW, which is equivalent to about 7 MW.

In any case, there is a need for research in this field with a team consisting of architects and designers of data centers to be able to localize the benefits of these projects according to the needs of data centers. Obviously, the results of this research can have commercial value and in addition to internal use, it will also be able to be implemented externally.

Owners of data centers try to save time in the construction and operation of data centers, or in other words, the construction time of the structure is more important to them than the architecture of the building, and if it can be researched the need for changes in structural architecture and the benefits that these changes can Explain to them in the long run, they can be expected to invest in this.

If the results are effective, companies that have a data center can use these methods to change their data centers, and by reducing their power consumption, they will be able to install more equipment in a specific space, which is the case. Having economic benefits for them can prevent a large amount of waste of company capital to build new data centers because a large amount of equipment that must be used to serve data centers in them, has nothing to do with the load inside them and therefore in If it is possible to use one data center instead of two, the costs will be greatly reduced. This research can also integrate the knowledge of two completely different areas of architecture and ICT.

IV. RESEARCH BACKGROUND

Foreign research background

The issue of energy efficiency was first raised in 1973, and following the world's oil crises, Western countries made many advances and policies in this area. Energy efficiency approaches and regulations for the 11 member countries of the International Energy Agency (IEA) led to the storage of 65% of energy consumption in these countries by 2010 and prevented the burning of 1.5 billion tons of fuel since 1974. [4]

Energy consumption for cooling and heating accounts for a significant share of office energy consumption, and the energy consumption of the ventilation system (HVAC) accounts for more than 40% of the total energy consumption of the building sector. [5] According to Wang et al. (2013), energy consumption can be saved by effectively adjusting temperature values; at the same time, according to Kamaki et al. [6], energy savings can be achieved by using the optimal control method.

If the room temperature rises by only 4 degrees Celsius, the employee's concentration and productivity will drop by 15 to 20 percent. In buildings where the room temperature is significantly higher than the outside temperature, the efficiency of each employee is reduced by 37 hours per year, and in a building with 100 employees and a salary of about 70 euros, the company loses 259,000 euros per year. Gives.

According to scientific and weather forecasts show that: the number of summer days in each year with a temperature of more than 25 degrees will double and the number of hot days with a temperature of more than 30 degrees will double 4 times and also the number of frosty days to The rate will be reduced by 50%, the importance of this discussion in the space of office buildings can be realized.

The utilization of energy resources and renewable technologies is a key component in sustainable development. There are three main reasons for this:

1- Considering that there is no source of energy without impact on the environment; They have fewer biological effects than other energy sources. There are a variety of options for switching to renewable energy that can provide a cleaner energy system than conventional energy systems.

2- Renewable energy sources, unlike fossil and uranium sources, cannot be depleted and if used wisely and correctly, they can provide almost reliable and unlimited energy. In contrast, fossil fuel sources and uranium are consumable and unstable due to consumption.

3. These resources support the inefficiency and problems of the regional and national electricity system, thus increasing the efficiency of the system and the supply of economic electricity even in small towns. This is why many different renewable energy technologies are potentially available for use in urban areas [9].

In new office buildings, energy consumption takes place in the following areas:

- Heating
- Cooling
- Lighting
- Hot water

• Ventilation

• Appliances

In the late seventies and early eighties, there were articles in which terms such as zero energy house, an energy independent house or neutral energy houses, etc. were used, so the word zero energy is not a new concept but a use. One of the new technologies is energy reduction and production in buildings. (Rezvani 1393).

In the study of documents related to energy efficiency and cost optimization in the field of construction, the terms zero energy building and low energy building are used together.

Combining open office plans with Green Architecture Transparent and flexible spaces, using daylight, and maintaining the connection between the office environment and the outside space are all solutions to achieve quality office offices for the future. This approach in design leads to the construction of quality office space that will lead to job satisfaction of employees and consequently their greater productivity. Google has used all of these design criteria for its headquarters in Dublin, Ireland.

Modern office buildings and offices serve several purposes. In addition to being a workplace for employees, these buildings should represent a company and meet the needs of individuals.

Office buildings with standard facilities and an average cost of € 1,200 per square meter with an optimal combination of architecture, building materials, and technology can comply with applicable laws. These energy-efficient buildings heat up optimally and often do not require cooling.

An energy-efficient office building not only reduces investment costs but also has the potential to save 40-40% of operating costs compared to a building that is fully equipped with ventilation, dehumidification, dehumidification, and air conditioning systems. Works independently of open ambient temperature.

These buildings represent a long-term investment. Planned decisions have long-term implications, and most wrong decisions can only be remedied at a great cost [10].

The actual level of energy consumption in a building is determined by the quality of its shell, the technical equipment of the building, and the behavior of the users. Heating still represents a major part of building energy consumption. However, due to global warming and rising summer temperatures, the energy demand for air conditioning is expected to increase significantly. [10]

One of the main reasons for the high energy consumption in offices for air conditioning in summer is the solar radiation that enters the space through the windows. Adopting effective shading measures is an efficient way to store energy in the building. In addition to reducing the load of air conditioning, shading facilities can control the amount of sunlight entering the room and help to improve the natural light of the environment by further reducing the energy consumption of artificial light.

External shading has a greater effect on energy storage compared to the internal type due to the reduction of internal heat intake [11].

Another way to reduce energy consumption in buildings is to double-walled walls or windows because this extra wall creates thermal insulation by discussing the air between the two walls, separating the air inside the offices from the outside environment, and reducing consumption. Energy is used in the building to heat or cool the building. [12]

Using solar panels to generate energy consumption for the building is another way to save energy. There are several rules for designing and calculating photovoltaic systems. Some countries have specific regulations for this purpose, while others use a set of general principles. In general, in the "Energy Standard" the area of photovoltaic panels required for a building is considered 17 times the occupancy of the building. To get the platinum rating in the "LEED" standard, this amount is equal to 10 times the occupation bucket and in the "self-sufficient building" regulation, it is equal to 7 times the occupation bucket. However, it seems that with the increase in the scale of buildings and the advancement of technology regarding the use of the photovoltaic system, the ratio of the bucket of photovoltaic panels to the substructure of the building becomes less and less [13].

Internal research background

In Iran, energy consumption in the country's buildings as a non-productive sector has the largest share among all consumption sectors, according to the country's energy balance, more than 40% of energy consumption is spent directly on meeting the needs of this sector. . However, most studies show that more than half of this consumption is wasted for various reasons. If the condition of buildings is addressed by implementing energy consumption optimization strategies, improving efficiency and modifying the operating pattern can be done with less than half of this energy consumption providing the desired comfort in the buildings. [7]

According to internal studies and estimates, about 4800 million kilowatt-hours of electrical energy (equivalent to 2.5% of the total

Energy consumption of the country (consumed in government offices. The results of audits show that at least 20 percent of this energy can be saved, the Rial value of this savings based on the cost price of about 1200 Rials and annual amounting to 1150 billion It will be Rials. [14]

In fact, in most existing buildings, more than 50% of the potential for saving and reducing energy consumption will be achieved. Meanwhile, energy waste is higher in most government and public buildings. Buildings with office use have special conditions and require special attention due to the existence of non-personal ownership in them and as a result the relatively unfavorable pattern of electricity consumption, as well as the functional and operational status of residential and commercial buildings. According to the data contained in the detailed statistics of the country's electricity industry in 1394, the public sector - a significant share of which includes office

buildings - consumed 22196 million kilowatt hours of electricity, more than 9.6 percent of total electricity consumption Dedicated to this year. This amount of consumption has increased by 12.3% compared to 1993 and by 2.8% for 10 years compared to 1983 [8].

Research on hundreds of large office buildings around the world has shown that the quality of the interiors of these buildings is mediocre and many employees are dissatisfied with their work environment and many are suffering from diseases caused by buildings. Are affected. These diseases have a great impact on the efficiency and working time of employees and have important economic consequences for countries. In Iran, the lack of necessary standards to determine the comfort zones in office spaces, in addition to heat loss and reduced staff productivity, has led to an increase in energy consumption. [15]

The advantages of a double-skinned facade can be 1. Reduction of peak wind pressure; 2. Improve facade energy efficiency; 3. Increased use of solar heat in winter; 4. Reduction of heat loss in winter; 5. General reduction of solar heat increase in summer; 6. Use of natural ventilation; 7. Prevent noise; And 8. Useful use of daylight. [16]

The use of solar energy in a country like Iran, which has rich sources of solar energy, can be very effective in buildings that intend to move to the zero energy building, because if all or part of the energy is produced through the sun or The sale of solar power to the Ministry of Energy and the grid offset some of the energy costs [17].

V. Research Methods, Research process, and statistical community

Research Methods

In this research, the applied research method has been used. It is research that uses statistics to gather information, and this research can be extended to the whole community. Quantitative research has been used in the present study. In this research, we also describe and study what is, so the appropriate research method is the descriptive.

The present study is a cross-sectional survey in terms of the type of survey method used in it. The cross-sectional method is used to collect data on one or more traits in a period of time (one day, one week, one month) through community sampling. Such research describes one or more variables.

Research process

The present study examines the impact of changes in the morphology of the data center architecture on the personnel perspective of the MCI (Mobile Communication of Iran). This research examines the issue by examining and studying various sources in the field. Then, morphological design indicators are introduced and some of them are considered in this research. Then, by introducing various models for reducing energy consumption and saving energy consumption in data centers, a conceptual model is considered to better understand the issue.

The statistical population of the study includes managers and experts of Iran Mobile Communications Company (Hamrah Aval), Deputy of Information Technology. A questionnaire with twenty-one questions was designed to collect information. To evaluate the reliability of the research, 10 questionnaires are provided to the experts and specialists of Hamrah Aval Company, which calculates the reliability of the research using SPSS software and Cronbach's alpha.

The statistical population of this research is the experts and managers of the IT industry active in Hamrah Aval Company and the Deputy of Information Technology. The number of these people is 125. Using Cochrane ferrule and random sampling, the sample size of the research is equal to:

$$n = \frac{125 * (1.96)^2 * 0.5 * (1 - 0.5)}{(0.05)^2 * 125 + (1.96)^2 * 0.5 * (1 - 0.5)} = 94$$

As can be seen in the formula, the sample size is 94 people who are randomly selected from the statistical population of the research.

General questions of the research: In general questions, an attempt has been made to collect sufficient and demographic information about the respondents.

TABLE I. Demographic characteristics of the studied sample (number of members = 94)

Title	Title	Percentage of respondents
Gender	Female	29%
	Man	68%
	No answer	3%
education	Bachelor	34%
	Masters	57%
	P.H.D	9%
Work Experience	Between 1 and 10 years	57%
	Between 10 and 15 years	28%
	Between 15 and 20 years	11%
	Over 20 years	4%
Administrative Department	Business systems support	34%
	IT infrastructure support	37%
	Organizational systems planning management	29%

Specialized questions: This questionnaire includes 21 questions in the field of acceptance of IoT innovation. In this regard, a questionnaire with a Likert scale was set, which assigned scores of 1 to 2, 3, 4, and 5 to the first to fifth options from strongly disagree to strongly agree, giving each option a score. The following are the components of the questionnaire along with the subsets of each of them and the number of questions:

TABLE II. SECTIONING THE QUESTIONNAIRE QUESTIONS

Questionnaire	Components	Questions Numbers
Impact of changes in data center morphology design	Use of solar panels	7-1
	Use double glazed facade	14-8
	Use two-layer inner wall	21-15

Research hypotheses

The main hypothesis

1- Changes in the morphology design of the data center building affect the economic savings and energy costs of the data center.

Sub-hypotheses

1- Changes in the morphology design of the data center building affect the economic savings of the data center.

2- Changes in the morphology design of the data center building affect the energy costs of the data center.

3- Changes in the morphology design of the data center building affect reducing the construction time of the data center.

4- Changes in the morphology design of the data center building affect reducing the costs related to the maintenance of the data center.

5- Changes in the morphology design of the data center building affect reducing the energy consumption of the data center.

6- Changes in the morphology design of the data center building affect reducing the energy consumption of cooling units.

7- Changes in the morphology design of the data center building affect reducing the consumption of data center fans.

Proposed model

Based on the hypotheses, the proposed model is proposed as follows:

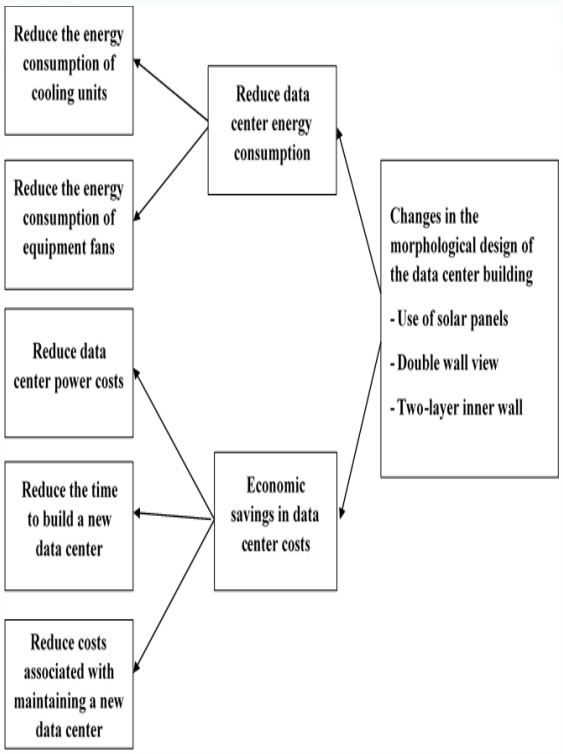

Figure 2. Proposed research model.

Research variables

Independent research variable:

1- Making changes in the morphological design of data center building architecture

Research dependent variables:

1- Reducing data center energy consumption,

2- Economic savings in data center costs

Checking the normality of research variables:

H_ (0): The mentioned research variables are normal in the research population

H_ (1): The mentioned research variables are not normal in the research population

One-way Kalmogorov-Smirnov test was used to evaluate the normality of variables in the population.

The results of this analysis are presented in the table below. Based on the results listed in the table and considering the level of significance that is greater than alpha 0.05 in all variables, then it can be inferred that the distribution of the variables in the community is normal and the hypothesis H_ (0) is confirmed and parametric tests are used.

TABLE III. KALMOGOROV-SMIRNOV TEST RESULTS

Title	Score z	Significance level
Morphological design of building architecture	0.17	0.06
Reduce data center power consumption	0.16	0.09
Economic savings in data center energy costs	0.15	0.14
Reduce data center build time	0.13	0.22
Data center maintenance costs	0.12	0.20
Data center power consumption	0.13	0.22
Reduce the energy consumption of cooling units	0.11	0.20
Reduce the consumption of fans of data center units	0/18	0.12

VI. DATA ANALYSIS

Results of structural model study

TABLE IV. RESULTS OF STRUCTURAL MODEL STUDY

Hypothesis	Path coefficient	T-test	Result
Changes in the morphological design of the data center building affect the economic savings and energy costs of the data center	0.487	5.3	Confirmation
Changes in the morphology design of the data center building affect the economic savings of the data center	0.487	0.487	Confirmation
Changes in the morphology design of the data center building affect the energy costs of the data center	0.578	0.714	Confirmation
Changes in the morphological design of the data center building affect the reduction of data center construction time	0.184	0.188	disapproval
Changes in the morphological design of the data center building affect the reduction of data center maintenance costs	0.198	0.168	disapproval
Changes in the morphological design of the data center building affect the reduction of datac enter energy consumption	0.546	0.90	Confirmation
Changes in the morphological design of the data center building affect the reduction of energy consumption of cooling units	0.355	0.24	Confirmation
Changes in the morphological design of the data center building affect reducing the consumption of data center fans	- 0.075	- 0.053	disapproval

Analysis of findings

According to the research findings, the following are announced:

1- The main hypothesis of the research, ie making changes on the economic savings and energy costs of the data center has a positive effect was confirmed and in the opinion of the participants in the survey, these changes have been able to significantly reduce the energy costs of the data center. Have. It is worth mentioning that the practical results also show that with these changes, we have been able to add 100 kW more load in the data center without the need to make changes in the cooling units of the center.

2- The first sub-hypothesis of the project, ie the positive effect of changes in the design of the data center morphology on the economic savings of the data center was confirmed by the participants in the survey and the opinion of the survey participants if changes are used in the morphology design of the data center It will also bring economically. This is in line with the measured facts because the increase in load in the center of the unit has not added more cooling, and we have also been able to provide more services in the center that has reached its maximum capacity and there was no need to build a new data center. Many costs have been avoided.

3- Regarding the second sub-hypothesis, ie the positive effect of changes in the morphology architecture of the data center on the energy costs of the data center, according to the participants in the test, the hypothesis was confirmed, which is due to the reduction of consumption of load units in Load is equal It has a data center at the expense of electricity.

4- Regarding the third sub-hypothesis, ie the effect of changes in the morphology design of the data center on reducing the construction time of the data center, this hypothesis was not confirmed by the participants in the survey. The inner wall is double-layered, which increases the data center build time.

5- Regarding the effect of changes in the morphology architecture of the data center on reducing the costs related to the maintenance of the data center, the hypothesis was not confirmed by the participants in

the survey and in their view, the maintenance costs of solar panels and double walls on the cost Currents are added.

6- Regarding the fifth sub-hypothesis, ie the effect of changes in the morphology of the data center on the reduction of energy consumption of the data center, the hypothesis was confirmed by the participants in the survey, but in fact due to the reduction of energy consumption of cooling units and about 30 Percentage of consumption of consumer units in the total energy consumption of the center, this reduction reduces the overall energy consumption of the data center.

7- Regarding the effect of changes in the morphology of the data center on reducing the energy consumption of cooling units, this hypothesis was also confirmed by the participants in the survey, although the results of the integrated monitoring system also confirm this view.

8- Regarding the effect of changes in the morphology of the data center on reducing the energy consumption of fans of data center units, according to the survey participants, there is no significant relationship between the energy consumption of fans and cooling of the data center and in practice, this amount is a function of other conditions such as The load of the systems is at the time of measurement and therefore this hypothesis was not confirmed.

VII. COMPARISON OF RESEARCH HYPOTHESES WITH PREVIOUS STUDIES

TABLE V. COMPARISON OF RESEARCH HYPOTHESES WITH PREVIOUS STUDIES

Hypothesis	The result of the present study	Comparison of results with previous research
Changes in the morphological design of the data center building affect the economic savings and energy costs of the data center	Confirmation	Zarbakhsh [14] had confirmed that the use of morphological changes reduces the energy consumption of offices.
Changes in the morphology design of the data center building affect the economic savings of the data center	Confirmation	H. Lound [18] emphasized the importance of using renewable resources in energy saving.
Changes in the morphology design of the data center building affect the energy costs of the data center	Confirmation	Cortese [13] stated that zero energy buildings drastically reduce building energy costs.
Changes in the morphological design of the data center building affect the reduction of data center construction time	disapproval	Grynning [12] has announced that changes in the architecture of buildings will not change much during the construction of them and in some cases will even reduce the construction time of buildings.
Changes in the morphological design of the data center building affect the reduction of data center maintenance costs	disapproval	Barbosa [19] stated that changes in building architecture reduce building maintenance costs due to reduced equipment operation.
Changes in the morphological design of the data center building affect the reduction of data center energy consumption	Confirmation	Zarbakhsh [14] had confirmed that the use of morphological changes reduces the energy consumption of offices.
Changes in the morphological design of the data center building affect the reduction of energy consumption of cooling units	Confirmation	UNESCO [20] emphasizes that the most important effect of using new approaches to reduce energy consumption for heating and cooling buildings
Changes in the morphological design of the data center building affect reducing the consumption of data center fans	disapproval	According to the BICSI data center standard [21], if the data center hall cools down, the energy consumption of the fans will be reduced.

VIII. CONCLUSION

Since the most important need of companies that need to use the data center is to install more equipment in a smaller area, the equipment in this area has moved towards becoming High Density, and therefore the electricity consumption of racks from about 2 kW per rack It has increased to about 14 kilowatts per rack and this rate is still increasing. This trend is forcing companies to use methods that make the most of that amount of electricity to overcome the problem of shortage of input power allocated through the power company, because of the maximum capacity of the transformer. To reach their center, they have to build a new data center, and this construction, in addition to the long time required to build, requires a high investment.

The solutions studied in this research are changes in the morphology of the building and the installation of solar panels.

Regarding solar panels, because the amount of electricity used in these centers is very high, if companies want to get all the electricity through solar panels, they need to purchase and equip a solar farm with a size of about one hectare. Due to the price of land in the cities where data centers are located, it is practically not affordable, and the construction of this farm in remote areas to the center will cause the electricity company to deliver to the electricity company in an area and Delivered in the data center, which due to administrative problems, companies usually do not choose this solution. The method proposed in this research is to use the walls of the data center itself to install panels, which in addition to not imposing the cost of land purchase on companies,

creates a shadow on the wall and prevents energy wastage through the walls. Becomes.

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