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Green Computing and New Energy Conservation Approaches by Geothermal Sources with a Case Study

Füsun S. Tut Haklıdır[1] Hakkı Urgancı[1], Raşit Yıldırım[1]

[1]Istanbul Bilgi University,Department of Energy Systems Engineering, Santral Campus Istanbul, Türkiye

fusun.tut@bilgi.edu.tr

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ABSTRACT

The energy demand is increasing rapidly due to the increasing population and the development of technology in the world. The selection of the right energy sources to meet this need is very critical in terms of the effects of increasing greenhouse gas effects. The use of environmentally friendly renewable energy technologies plays a very important role in meeting the energy need.

In this study, the term green computing and the major components of green computing are investigated. Nowadays, with the increasing use of data, various studies have been conducted on the standards, operating parameters and energy consumption of data centers, which are increasing in number. The energy consumption of data centers, the energy consumption of programming languages, the methods used in data center cooling, cooling systems and the effects of data centers on the environment have been investigated. The aim of this study is to investigate whether a data center can be cooled with a renewable source. For this purpose, the energy consumption and cooling needs of the data center were examined, the use of a geothermal energy supported LiBr-Water absorption system for a larger data center was investigated, the conceptual design of the system was made and the cost of such a system was tried to be revealed.

1. INTRODUCTION

The energy demand is increasing rapidly due to the increasing population and the development of technology in the world. The selection of the right energy sources to meet this need is very critical in terms of the effects of increasing greenhouse gas effects. The use of environmentally friendly renewable energy technologies plays a very important role in meeting the energy need.

Today, millions of data centers around the world store data which are provided internet usage such as; non-stop including the searched articles, the likes on photos, videos watched and more. Due to this intensive usage, internet servers in these data centers reach to high temperatures. Each computer has an optimum temperature range determined for an efficient operating. In order to keep computers within this range, some softwares and various cooling systems has been used energy which the latter consumes a lot of energy today.

In today's conditions, it is possible to meet this energy demand with emitting low carbon by using renewable energy sources. In addition to use a clean energy source for information technologies, it is possible to make the production, operation and disposal stages of electronic equipment both efficient and environmentally friendly with green computing. Green computing is an application that makes computers and devices working with computers more efficient by reducing their energy consumption. With the increase in the use of technological products, high amounts of electricity have been required to meet energy needs. Such an application is needed to enable such devices to consume less energy and to reduce the damage caused by electricity generation sources to the environment.

2. GREEN COMPUTING

Green computing is an environmentally friendly and new sustainable computing application. The main purpose of green computing is to maximize energy efficiency, reduce power consumption and reduce the use of hazardous substances when using devices. Another goal of green computing is to promote the recyclability of old products and factory waste[1].

2.1 Major Components of Green Computing

While green computing minimizes the effects of computers and electronic devices on the environment, the production and disposal stages of information technology (IT elements) are also important now. Some components of these elements are harmful for environment and they should not be disposed directly. Manufacturing stage of these elements also quite important and carbon emissions during this stage should be at least to accomplish green computing task on environment. Green manufacturing ensures that electronic components, computers and other related systems are developed with minimal impact on the environment while green disposal enables old computers to be recycled and reused, and rejected computers are recycled more efficiently along with electronic devices as well as production and disposal practices. Green design provides designing of IT components (computers, cooling equipment, servers and data centers) to workmore energy efficient while having least effect on environment.

It is the main application of green computing through the use of computing technologies and IT resources more efficiently. Reducing the environmental impact of IT resources and lowering energy costs is one of the most important responsibilities of human beings in today's world[2].

2.2 Energy Usage of Datacenters

In order to fulfill their everyday transaction processing needs, data centers are information warehouses that store a vast volume of data for various organizations. Data centers may be considered as a collection of different servers and network infrastructures, where servers are used to collect data, network infrastructures are used to utilize, keep and update servers data and users can access the data center servers by the network.

Data centers are known as industrial buildings that are extremely energy-consuming (Fig 1). This is due to the comparatively high power requirements of IT (Information Technologies) equipment, the high construction density of such equipment, and the related high energy requirements in service of such equipment for the cooling infrastructure[3].

The typical power consumed (averaged over all types) by each server is in the range of 250W (or around 220W on average for server volumes). Low-density server installations can show loads of 2-4kW per 19-inch wide server rack based on these average estimates, whereas higher density installations using blade server setups may have average electrical loads of up to 10-20kW per server rack. Larger data centers are more closely associated with manufacturing plants than office buildings in terms of electricity consumption, with a high penetration of those dispersed loads. Larger data centers are more closely associated with manufacturing plants than office buildings in terms of electricity consumption, with a high penetration of those dispersed loads [3].

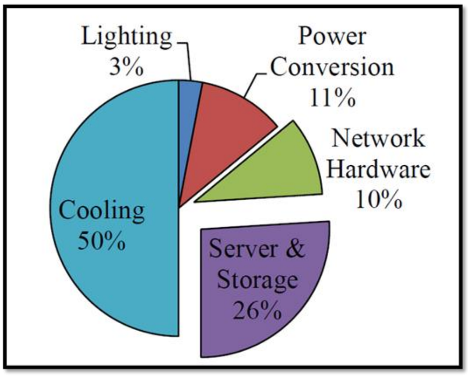

Figure 1:The energy consumption by different components of datacenter [4]

2.3 Cooling of Datacenters

The operation of IT equipment increases the heat in data centers (Fig 2). Cooling is the backbone for the efficiency of data centers in order to increase the usability by extending the life of IT equipment and ensuring healthier operation[35].

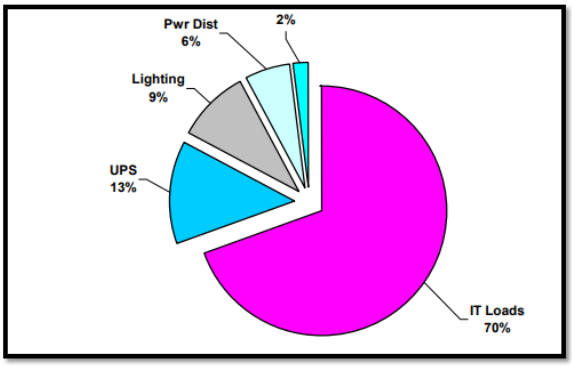

Figure 2: Total thermal output of a typical datacenter [5]

2.4 Environmental Effects of Datacenters

The number of data centers increasing day by day also increases energy consumption. While meeting the energy demand of data centers, its effects on the environment should not be ignored. The energy demands of data centers are particularly reflected in greenhouse gas (GHG) emissions. Energy obtained by using fossil fuels indirectly increases GHG emissions. Data centers are responsible for 2% of the GHG emissions that occur on our planet[6].

In 2019, electricity production from coal, natural gas and oil in the United States alone resulted in 1527 million metric tons of CO_2 emission[7].

3. CASE STUDY FOR ELECTRIFING A DATACENTER WITH RENEWABLE ENERGY

3.1 General Information About The Selected Building

B3LAB data center, which is a Cloud Computing and Big Data Research Laboratory, was selected for this study. The data center is located in Gebze (Kocaeli city) has an area around of 35 m^2. There are 8 cabinets in this data center, which has power systems, cooling systems and IT components. It is powered by 2 independent uninterruptible power supply (UPS). In other words, in case of a problem with the A UPS, the devices continue to operate from the B UPS. Energy can be drawn from UPSs at the same time. In this study, based on the B3LAB data center, the cost of the energy consumption of a data center and the energy used to cool the data center will be compared with the use of existing energy resources and renewable energy resources.

3.2 The Electricity Consumption and the Cost

The standard server with 2 processors has a 500 watt power supply unit (PSU). But this is the power that can be spent the most in full work. 1 server consumes 250 watts on average. An 80-core server consumes an average of 3,125 watts per core. This is the case for a server. Including the work of air conditioning systems and network devices, it will be necessary to spend 5 watts for 1 core processor. Considering that an average web service runs on 2 cores, it will be necessary to spend 10 watts for 1 web service. This calculation will vary according to the application. In general use, the cabins draw between 6-12 kWh. The average consumption per cabin is 8kwh, a system room with 8 cabinets will use 64 kWh of power. This is called cabin or system room load. The capacity of the UPS and air conditioning systems is calculated according to the cabin loads.
In the calculation of the average consumption of the system room, the consumption per cabin is taken as 8 kWh. Since there are 8 cabins in total, average consumption will be calculated from 64 kWh.

When the Energy = Power x Time formula applied;
The daily consumption of cabins are;
64 kWh x 24 h = 1.536 kWh.
The annual consumption of cabins are;
46,080 kWh x 12months = 552.960 kWh.

In addition to the consumption of cabin room load in data centers, sensitive air conditioners responsible for cooling also consume a considerable amount of energy. This consumption varies according to the EER (Energy Efficiency Ratio) values of the air conditioners. The EER value is the ratio of the output cooling energy to the energy consumed by the cooling system. The air conditioner required to cool the mentioned data center must have a power of 100 kW. While calculating the cost caused by the cooling, Vertiv brand's PX104 [8] model suitable for this data center was used. The EER value of this air conditioner is 3.10.The hourly consumption of the air conditioner is: 64 kWh / 3.1 = 20.6 kWh. The annual consumption of the air conditioner is: 552.960 kWh / 3.1 = 178.374 kWh. Both cabins and the air conditioners annual consumption is: 552.960 kWh + 178.374kWh = 731.334 kWh.

Consumption values in cost calculation are taken from the B3LAB data center, which is a public institution, and these values are assumed to be consumed by an enterprise. The tariffs used are taken from the table published by the Energy Market Evaluation Board for the second quarter of 2021. All taxes and other operational costs are not included. According to the table, the usage price of kWh electricity in one-time tariff for commercial enterprises is 0.763637 TL.

In this case, the hourly consumption cost of the datacenter is;

84.6kWh x 0.763637 TL = 64.6 TL. The annual consumption cost is; 46.512TL x 12months = 558.144 TL.

When the energy consumption of the data center is met from renewable energy, the green tariff table for businesses published by the Energy Market Evaluation Board for the second quarter of 2021 was used. Sum of green energy and distribution costs per kilowatt hour is; 0.747372 TL + 0.170228 TL = 0.9176 TL. Annual green energy usage fee of the data center is; 55.893 TL x 12 months = 670.714 TL.

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4. CASE STUDY FOR COOLING A DATACENTER USING LITHIUM BROMIDE ABSORPTION SYSTEM

Data centers consumes high amounts of energy. These systems work uninterruptedly and the ambient temperature can directly affect their working conditions. For this reason, data centers should be at the appropriate ambient temperature. Cooling systems that provide the appropriate ambient temperature also work uninterruptedly with the data centers. Therefore, they consume a considerable amount of energy.

In this study, the pre-feasibility and cost of air conditioning of a data center with Lithium Bromide absorption chiller working with the support of geothermal energy, which is a renewable resource, will be examined. It is assumed that this system will be established in Balçova town in İzmir city in Türkiye.

4.1 Lithium Bromide Absorbtion Cooling System

LiBr-Water absorption cooling systems are frequently used in air conditioning applications. In the LiBr-Water composition used in the system, lithium bromide acts as an absorbent and water acts as a coolant. When LiBr, which is solid under normal conditions, is mixed with water, which is liquid under normal conditions, it forms a liquid solution[9].

4.2 Advantages of Lithium Bromide Absorption System

Li-Br is a non-volatile desiccant, there is no need to enrich the working fluid. This mixture contains water as a refrigerant with a high evaporation heat. The Li-Br – Water System is a little more straightforward, as it runs at a lower pressure and has a greater coefficient of performance (COP), requiring less pumping power (Fig.3). The mixture is non-flammable and non-toxic[9].

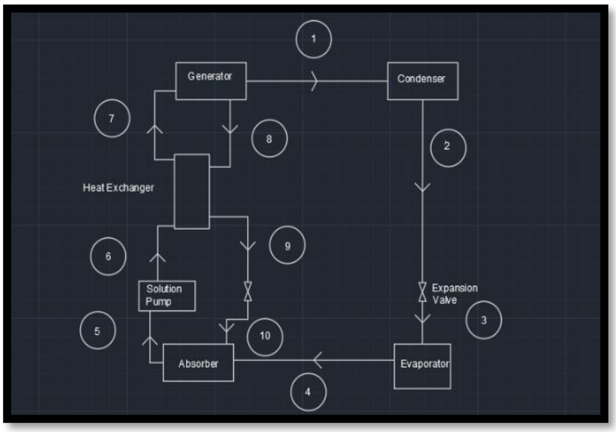

Fig.3. Li-Br-Water solution single-stage absorption refrigeration cycle [9]

4.3 The Concept of Absorption Cooling System

The area of the system assumed to be built in Balçova town (İzmir) is 16.500 m^2. In this study, engineers working in İzmir Geothermal were consulted and it was assumed that there would be a cooling load of 0.15 kW per m^2 when calculating the cooling load for a place in İzmir. The cooling load of the data center is calculated as 2,475 kWe according to the area of the determined system (Fig 4). It is assumed that geothermal wells with an outlet temperature of 125 °C in the region will be used for the data center with this cooling capacity. The well flow rate was calculated as 11 l/s, assuming that the temperature change could decrease to 70 °C, which is the lower limit for cooling specified in the Lindal diagram. Generator temperature for calculation, T_G = 100 °C, evaporator temperature, T_E =10 °C, condenser temperature, T_C = 40 °C. Condenser temperature and absorber temperature are considered equal.

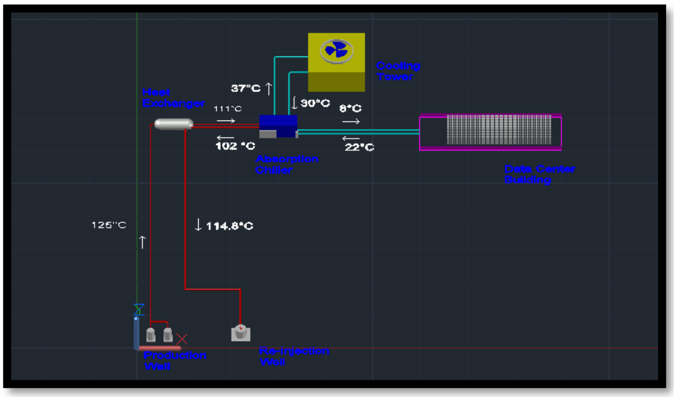

Figure 4: Technical Drawing of the LiBr-Water Absorption Cooling System

4.4 The Thermodynamic Assumptions for the Selected System

The study of Ravul (2010) assumptions were used in this study. Some critical thermodynamic assumptions are;

*The thermodynamic analysis of the system was made for steady-state conditions.

*The temperature and pressure of the refrigerant vapor leaving the generator are at the generator temperature and pressure.

*The refrigerant leaving the condenser is pure water under saturated liquid conditions and leaves the condenser at the condenser temperature.

* Pressure losses in the system are neglected.

*Elements such as absorber, generator, condenser and evaporator do not lose heat to the environment.

*The work input into the system is neglected, the pump work is very small.[9]

4.5 The Main Cost of the System

In the Table.1 in below;, suitable equipment that can be used in this system and their prices are given. Equipment and prices were obtained from the study of Ravul (2010) [48]. In the cost calculation, it is stated in Turkish Lira based on the exchange rates of June 2021.

Table 1: Equipment used in the cooling system and their prices [9]

Equipment	Model	Price
Absorption Chiller	RXZ-250F	1.224.557 TL
Cooling Tower	BL (II) J400	23.560 TL
Heat Exchanger	MIT 643 78	38.708 TL
	Total	**1.286.825 TL**

5. CONCLUSION

Data centers require high amount energy and cooling process is the one of the important part of a data center.

In this study, cooling of data center by green energy are examined. In this scope, geothermal energy is selected for cooling of a data center. Because, Türkiye has great geothermal energy potential and required geothermal fluid temperature can be seen at the each part of the country.

The required information was obtained from an operating data center with an area of 35 m^2 and the annual energy consumption of the cooling system was calculated as 178,374 kWh. In this study, if the data center, which is assumed to have an area of 16,500 m^2, is cooled with the same cooling system, the annual energy consumption is calculated as 84,090,600 kWh.

This data center can be cooled in an environmentally friendly way through the LiBr - Water absorption cooling system supported by geothermal energy. The temperature of the well investigated in this study is 125 °C, but for areas with lower cooling loads, the same system can be used in similar cooling applications by using the medium enthalpy geothermal wells, which are more common in Türkiye. Large amounts of energy are consumed for heating and cooling. The use of fossil fuels to meet this energy demand harms the environment. Providing the energy needs of heating and cooling applications with renewable energy helps to reduce the use of fossil fuels. In these applications, green energy tariffs can be used, as well as systems designed through renewable and sustainable resources. These systems have high installation costs. With the widespread use and the development of technology, these costs may decrease. The use of such systems is of great importance in reducing carbon emissions and supports to decarbonization goals of European Green Deal Act.

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