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Research Article

PERFORMANCE ANALYSIS ON AIR CONDITIONING SYSTEM USING STORAGE OF COLD, APPLICATION LOCATED IN OUARGLA (EAST-SOUTH OF ALGERIA)

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ABSTRACT

The increase in refrigeration load demand coincides with peak periods of electricity consumption during the summer, representing a peak period of electricity consumption a new challenge, in this configuration, the use of refrigerated storage in residential complexes for reducing the energy consumption of electricity during peak periods, charging cold storage tanks outside the peak period until they are used to maximum cover the high cooling load, we have chosen a desert area of Ouargla (East-South Algeria) to determine the influence of different parameters on energy consumption and to compare the cost of consumption without storage and with storage.

Keywords: Storage Cold; Air Conditioning System; Performance; Energy Consumption

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1. INTRODUCTION

The need to reduce energy consumption, studies are still underway to store energy or savings in consumption in multi-residential buildings, these are the biggest consumers of energy [1].

A new challenge for electricity companies and consumers, electricity consumption in Algeria has increased in recent years by 4% per year and demand for electricity is expected to grow by 7% per year in the long term. Electricity has suffered serious disruption in recent years due to increased domestic demand mainly due to the increased use of air conditioners, especially in the residential and commercial sector. From 1971 to 1991, per capita, energy consumption in Algeria increased from 0.287 toes per person to 0.847 toes, an increase of 300%. In 2014, this consumption reached 1,089 toes, an increase of 130% compared to 1991 [2].

The storage of thermal energy has been used for several centuries by many ancient civilizations. However, ice harvesting is perhaps the oldest and most widely used form of using ice or snow as a method of energy storage [3]. This practice consisted of storing ice or snow to store food [4]. 60,000 m^3 snow storage system, designed at the Lulea University of Technology in 1999 [5], was built to meet the air conditioning needs of the regional hospital during the summer. China in November and December 2004 and the remainder of winter 2005 [6], Li participated in the design and experimental design of a seasonal energy storage system. In this project, the storage system consisted of two experimental geothermal wells of 53 m long U-tubes and one 20 m deep well. These geothermal wells have been used to move ethylene glycol at room temperature to the ground during the winter to measure cold storage capacity and the energy efficiency of the system demonstrated that the concept Seasonally store the cold air energy in winter is achievable [7].

The simulation of a seasonal ice storage system, for the air conditioning of a commercial or institutional building. The objective of this work was to evaluate, using digital simulation, the feasibility of an air conditioning system, supported by a seasonal ice storage system, for a commercial or institutional building [8], Optimization of the operating modes of refrigerating machines, The work will then consist of developing several strategies for implementing refrigerating machines which will then, when possible, be tested and validated by dynamic simulations under Energy [9].

2. STORAGE OF COLD

The storage of cold in urban air-conditioning networks is becoming popular because of the many advantages they have. Their operation in the field of air conditioning is interesting. Storage has a definite advantage; since it adds additional power to the network in summer. This added power by night storage of the excess energy compared to the need for a return on-peak hours is often economical if the storage cost is related to the power it produces [10]. Either ice water or ice is used to accumulate cold, cold water can store 10 kWh per m^3 of the tank, the use of ice is more efficient and can store 50 kWh per m^3 of storage [11].

2.1. Storage downstream of the evaporator

The storage tank is placed in series on the departure of the chilled water towards the cold batteries. The temperature of the supply water of the cold batteries is stable [12].

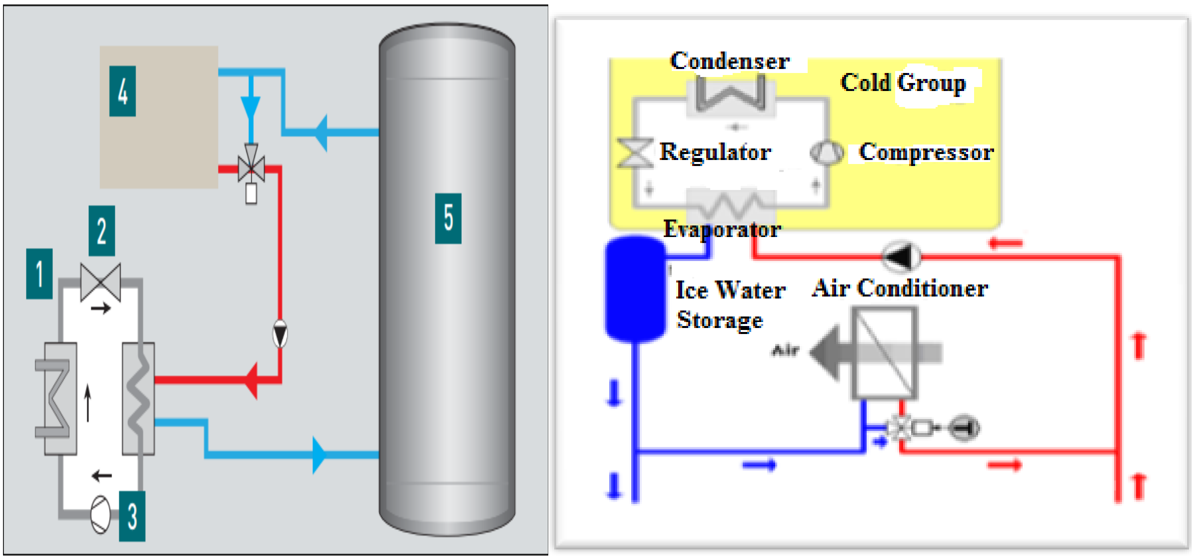

Fig.1. Storage diagram downstream of the evaporator

1**:** Refrigeration unit -2**:** Regulator- 3**:** Compressor- 4**:** Air conditioner- 5**:** Chilled water tank

3. OPERATING

store cold to cover the required cooling load of the building with the cold tank, in times of high electricity consumption, to accelerate the production of cold by the cooling unit using a refrigerant, cold water is obtained in the tank to be stored, and the tank drain is when the electricity consumption is high, the cold water is routed to the air conditioner where the chilled water is heated by contact with the air in the room and then returned to the refrigeration unit to be cooled again [13].

For chilled water storage tanks, a heat increase constant which is calculated as follows [14]:

$$Ca = \frac{[Q] \times 24\ (h)}{[\Delta T \ \ x\ V]} \quad (I.1)$$

Q: Exchange flow (W)

Ca: constant heat increase (Wh / °Kl)

ΔT: The temperature difference between the ambient air and the water stored in the tank

V: Actual tank volume in litres (complete filling with chilled water).

4. RESULTS AND DISCUSSION

The human being is often confronted with problems of adaptation to the climatic conditions that prevail around him. Air conditioning is a means capable of creating a micro-climate of comfort in a given room by ensuring certain conditions known as conditions of comfort.

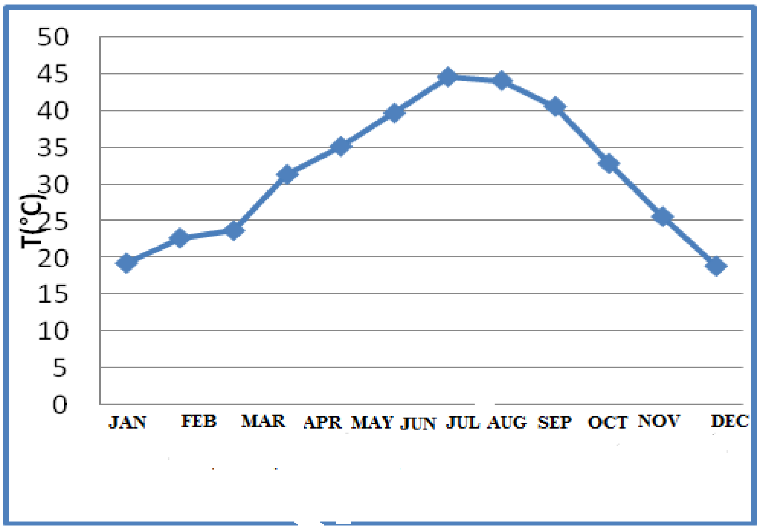

Fig.2. Temperature variation

Fig.2. Presents the temperature change during one year in the Ouargla region, The maximum temperature is reached in July, this is one of the factors that increases the heat input of the room, which has an influence directly on the compressor power.

The room is located in Ouargla in the south-east of Algeria
Climatic data:
Max outside temperature: Tmax = 49.6 ° C
Average outside temperature: Tem = 44.6 ° C
Average outdoor relative humidity Φem% = 30%
Temperature inside the room: Ti = 20 ° C
Indoor relative humidity Φi% = 50%
Average wind speed: v = 4 (m / s)

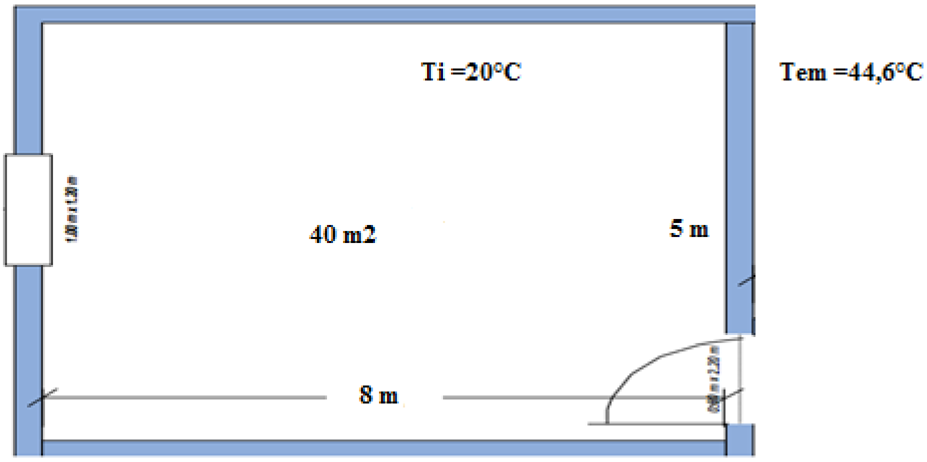

Fig3. Room dimensions

The average surface of houses in Algeria are assumed to be 80m², and the living space is assumed to be the half 40 m².

Table.1. Cost of energy consumption

Month	Q0 [kwh]	Pt no storage	Pt with storage	cost no storage	cost with storage
May	118.566	27.57	17.57	721.64	459.89
June	130.9	30.44	20.44	796.77	535.01
July	147.98	34.41	24.41	900.68	638.93
August	146.72	34.12	24.12	893.09	631.34
Sep	134.37	31.24	21.34	817.71	558.57

Table.1 By observing the results shown in the table above, we notice that the maximum cost of energy consumption is in July without cold storage, since the maximum temperature is reached in July, which increases the power of the compressor, and without cold storage, no reduction in energy consumption

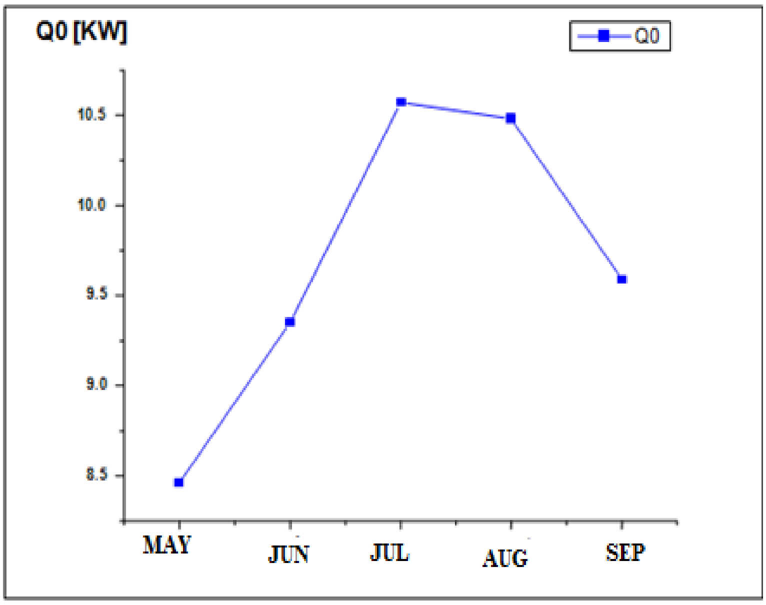

Fig.4. Change in calorific intakes during the summer period in Ouargla

Fig.4. The results show during the summer period for the region of Ouargla where the local is located, the value of the maximum calorific input is recorded during July, because the temperature reaches its maximum during this month knowing that there is a proportional relationship between calorific intake and outside temperature and the minimum calorific intake during May.

1- 4.1. Thermodynamic Analysis

Power consumption is defined as follows:

First, the annual need for air conditioning

$$E_c = \frac{Qc}{COP} \qquad \text{(I.2)}$$

E_c: annual air conditioning requirement, (kWh / m²)

Q_c: Heat loss. (KWh / m²)

COP: coefficient of performance of the air conditioning system

$$Cop = \frac{Q0}{P} \qquad \text{(I.3)}$$

Q_0= cooling capacity

P = compressor power

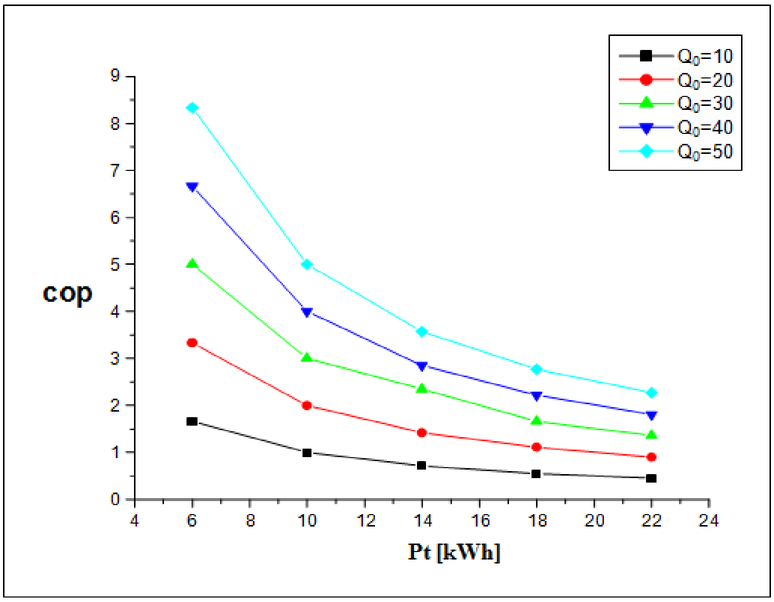

Fig.5. Influence of the power consumed by the compressor on the COP

Fig.5. the coefficient of performance increases by decreasing the power consumed by the compressor, a better coefficient of performance is obtained for a reduced compression work, it is known that the compression work influences the power consumed by the compressor

(P = Q .W) , the coefficient of performance is proportional to the cooling capacity and inversely proportional to the power consumed by the compressor (Cop = Q_0 / P).

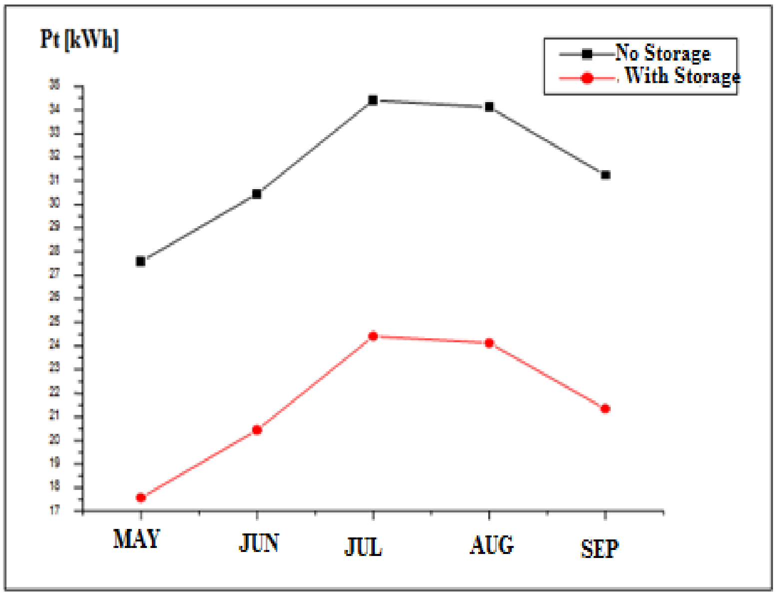

Fig.6. variation of the compressor power (Pt) of the clam load

Fig.6. Shows the variation in compressor power as a function of heat inputs. The maximum value of energy consumption is recorded during July when there is more heat input, we also note that the energy consumption without storage is higher than that with storage, because the cold storage allows the reduction of electricity consumption and decreases in May and September when the temperature decreases.

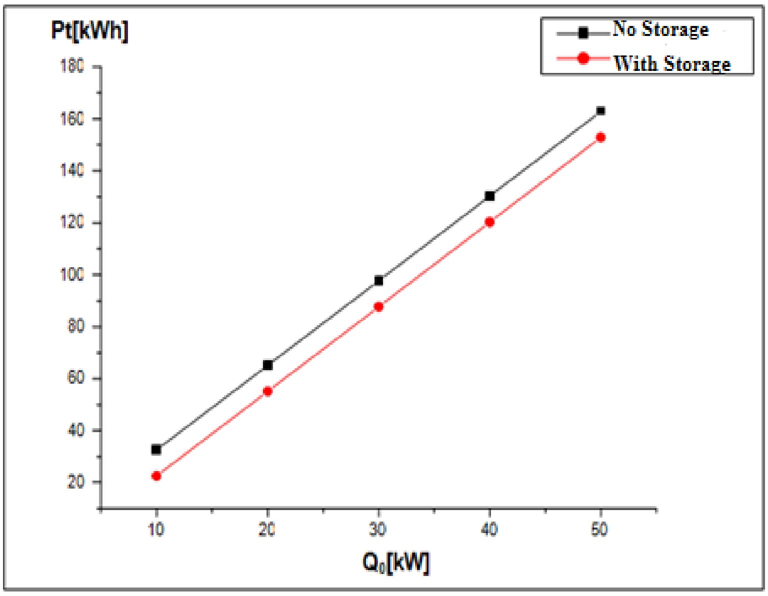

Fig.7. Variation of the power consumed by the compressor

As a function of the refrigerating capacity

Fig.7. The figure shows the variation in compressor power as a function of heat inputs. The cooling capacity depends on the heat input of the room. According to the curve above, the cooling capacity is proportional to the capacity of the compressor, knowing that the dimensions of the room and the outside temperature have a significant influence on the cooling capacity. The power of the compressor without cold storage is greater than the power of the compressor with storage; the cold storage allows the reduction of electrical consumption, thus saving energy consumed.

4.2. Cost calculation

The annual cost of electricity[15]

$$C_c = \frac{Qc.Ce}{COP} \tag{I.4}$$

C_c: annual cost of electricity

C_e: electricity cost

COP: coefficient of performance of the air conditioning system

$$Cop = \frac{Q0}{P}$$

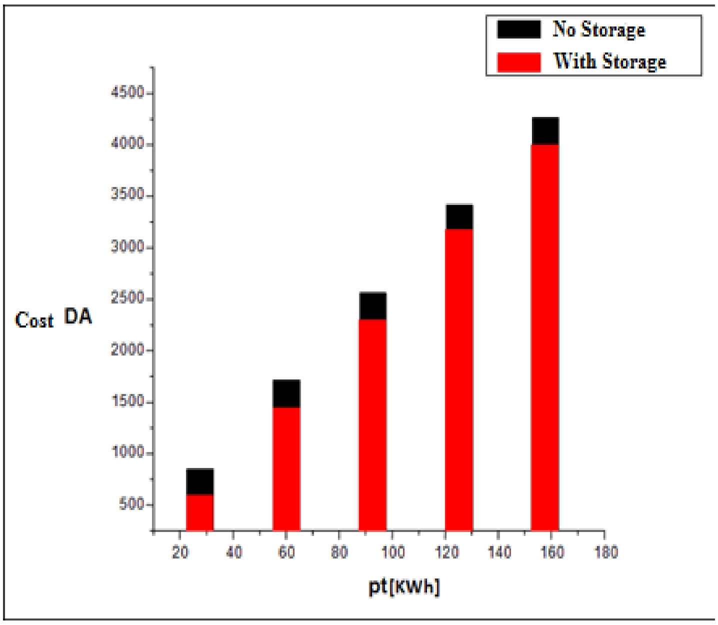

Fig.8. Cost of consumption of the power consumed by the compressor

Fig.8. It can be seen from the graphs that the cost of energy consumption increases with the increase in compressor power, because the compressor is the element that consumes the most electrical energy which is very expensive, and the cost of electrical energy consumption without cold storage is higher than the cost of electrical energy consumption with storage, because cold storage allows the reduction of electrical consumption, so can reduce the cost of energy consumption.

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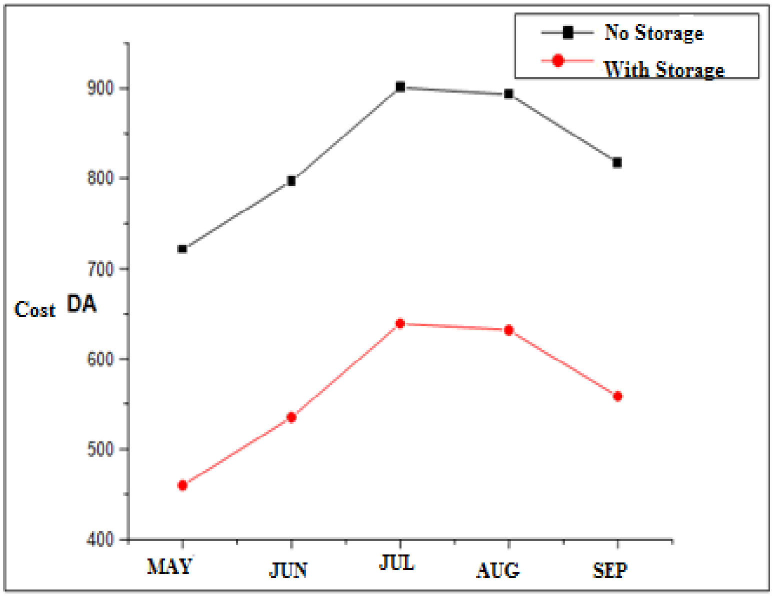

Fig.9. Comparison of the cost of energy consumption without storage

And with storage of cold during the summer period

Fig.9. shows that the maximum value of the cost of electricity consumption is recorded during July because the temperature reaches its maximum in July and decreases in may and September in the region of Ouargla, and it is noted that the value of the cost of electricity consumption without cold storage is higher than the cost of electrical energy consumption with storage Because cold storage is one of the responses to energy management, and therefore reduction of electricity consumption, by moving of electricity consumption from peak to off-peak hours.

5. CONCLUSION

The storage of cold is one of the answers to energy management: Shifting electricity consumption from peak hours to off-peak hours, and managing power consumption and improving energy management, more efficient night-time production, reducing Electric power, limited additional power consumption.

The results show during the summer period for the Ouargla region where the local is located, the maximum calorific value is recorded during July, and a better coefficient of performance increases by decreasing the power consumed by the compressor, so reduced compression work.

The results show that the maximum value of energy consumption is recorded during July and August, and decreases in May and September. It is also noted that energy consumption without storage of cold is higher than that with storage, (thus saving energy consume) and the cost of consuming electrical energy without storage of cold is higher than the cost of electricity consumption with storage.

6. REFERENCES

[1] Chan, Apple L. S., Tin-Tai Chow, Square K. F. Fong et John Z. Lin. 2006, Performance evaluation of district cooling plant with ice storage, *Energy,* vol. 31, no 14, p. 2750-2762.

[2] Chen, Huei-Jiunn, David W. P. Wang et Sih-Li Chen. 2005, Optimization of an ice-storage air conditioning system using dynamic programming method, *Applied Thermal Engineering*, vol. 25, no 2-3, p. 461-472.

[3] Eames, Ian W., et Kamel T. Adref. 2002, Freezing and melting of water in spherical enclosures of the type used in thermal (ice) storage systems, *Applied Thermal Engineering,* vol. 22, no 7, p. 733-745.

[4] Elsayed, Amr O. 2007, Numerical study of ice melting inside a rectangular capsule under a cyclic temperature of heat transfer fluid, *Energy Conversion and Management*, vol.48, no 1, p. 124-130.

[5] Fang, Guiyin, Xu Liu et Shuangmao Wu. 2009, Experimental investigation on the performance of ice storage air-conditioning system with separate heat pipe, *Experimental Thermal and Fluid Science*, vol. 33, no 8, p. 1149-1155.

[6] Hankey, Ronald. 2012, Electric Power Monthly January 2012, Washington, DC: U.S. Department of Energy.

[7] Fang, Guiyin, Xu Liu et Shuangmao Wu. 2009, Experimental investigation on the performance of ice storage air-conditioning system with separate heat pipe, *Experimental Thermal and Fluid Science*, vol. 33, no 8, p. 1149-1155.

[8] Li, Z. J., M. Y. Zheng, F. Wang et W. Liu. 2009, Seasonal underground cold energy storage conception and its experimental study, *Journal of the Energy Institute*, vol.82, no Copyright

2010, The Institution of Engineering and Technology, p. 57-60.

[9] Eames, Ian W., et Kamel T. Adref. 2002, Freezing and melting of water in spherical enclosures of the type used in thermal (ice) storage systems, *Applied Thermal Engineering*, vol. 22, no 7, p. 733-745.

[10] Wang, W. P., et C. D. Ho. 2001, The effect of recycling on cool-thermal discharge systems by melting ice with producing chilled air, *International Communications in Heat and Mass Transfer*, vol. 28, no 6, p. 783-792.

[11] Yamada, Masahiko, Shoichiro Fukusako et Tsuyoshi Kawanami. 2002, Performance analysis on the liquid-ice thermal storage system for optimum operation, *International Journal of Refrigeration*, vol. 25, no 2, p. 267-277.

[12] Kiatsiriroat, T., S. Vithayasai, N. Vorayos et A. Nuntaphan. 2003, Heat transfer prediction for a direct contact ice thermal energy storage, *Energy Conversion and Management*, vol. 44, no 4, p. 497-508.

[13] Hamada, Yasuhiro, Makoto Nakamura et Hideki Kubota. 2007, Field measurements and analyses for a hybrid system for snow storage/melting and air conditioning by using renewable energy, Applied *Energy*, vol. 84, no 2, p. 117-134.

[14] Kousksou, T., J. P. Bédécarrats, J. P. Dumas et A. Mimet. 2005, Dynamic modelling of the storage of an encapsulated ice tank, *Applied Thermal Engineering*, vol. 25, no 10, p. 1534-1548.

[15] Bolattürk, A. 2006, Chronological Systems in the Turkish World, Erciyes University Journal of Social Sciences Institute, 20/1: 239-272.

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