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Registered at Dubai Media City  
PO Box 500024, Dubai, UAE  
Tel: 00 971 4 210 8000  
Fax: 00 971 4 210 8080  
Web: www.itp.com  
Offices in Dubai & London

**ITP BUSINESS PUBLISHING**

CEO Walid Akawi  
Managing Director Neil Davies  
Managing Director ITP Business Karam Awad  
Deputy Managing Director Matthew Southwell  
Editorial Director David Ingham

**EDITORIAL**

Senior Group Editor Stuart Matthews  
Tel: +971 4 210 8476 e-mail: stuart.matthews@itp.com  
Editor Gerhard Hope  
Tel: +971 4 210 8305 e-mail: gerhard.hope@itp.com

**ADVERTISING**

Sales Director: Construction Yazan Rahman  
Tel: +971 4 210 8351 e-mail: yazan.rahman@itp.com  
Advertising Director: Construction Andrew Parkes  
Tel: +971 4 210 8570 e-mail: andrew.parkes@itp.com  
Sales Manager Shirley D'Souza  
Tel: +971 4 210 8779 e-mail: shirley.dsouza@itp.com

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Designer Angela Ravi

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# Ice thermal storage heats up



In this issue we take an in-depth look at ice thermal storage. The latest research indicates that certain refrigeration systems with ice storage units need even less electrical energy than conventional systems. A building's cooling system, determined by interior and exterior loads, undergoes enormous fluctuations over a 24-hour period. At

night, no or very little refrigeration is required, whereas during the day the demand can be very high.

The capacity of conventional cooling and refrigeration plants has to be flexible enough in order to accommodate these peak loads. The obviously corollary is that most plants are over-designed for much of their operating time, implying a high investment cost versus a low utilisation rate. The end result is "an unfavourable degree of annual operating efficiency of the overall refrigeration system."

Another advantage is that the energy-storage potential of ice is twelve-fold that of water, meaning its chilling potential is much greater. Ice storage units have the advantage of simple plant technology, the use of an inexpensive and ecologically harmless storage medium and, in many cases, can today be employed economically. "The use of the latent energy of ice in the form of melting heat thus represents a simple possibility to store cooling energy and to keep the storage space and therefore also the investment cost as low as possible," reports Grandegger and Al-Barazi (see the full article starting on page 21.)

The preferred choice for air-con cooling is indirect storage systems, which offer the best operating conditions at the lowest cost. Ice storage units working on the indirect principle (also called 'internal melt system') have only one closed circuit to freeze the water in a vessel as well as to melt the ice. The system structure of such a storage unit, which is generally equipped with heat exchangers made of plastic rather than galvanised steel tubes, is very straightforward.

During the charging or freezing process, brine at about  $-5^{\circ}\text{C}$  is fed through the heat exchanger in the water-filled vessel. The ice builds up around the tubes and, by the end of the process, has formed a solid



AFAFCO ice bank system (single outdoor installation)

block of ice. When the ice is melting or discharging, the warm brine is fed through the heat exchanger again and the ice around the tubes melts first.

As the brine is always fed through the heat exchanger system, the formation of an ice block allows very compact design of indirect ice storage systems. The tank volume can be reduced by 30% to 40% compared to direct brine systems. The indirect heat transfer means that the discharge rate, depending on design, equipment and discharge temperature, corresponds to a discharge time of up to 3-4 hours, whereas discharging over a period of 6-10 hours would be the standard in air-con applications.

"Ice storage has become a common way of making refrigeration available. The simplicity of the system structure, the basic operating principle and low maintenance requirements mean that today the use of ice storage systems represents a cost-effective alternative to conventional refrigeration methods," state Grandegger and Al-Barazi.

However, in order to derive maximum benefit, "utilities need to encourage the consumer side and the district cooling providers to optimise the use of thermal energy storage at night by introducing the daytime/nighttime tariff system, which is still highly anticipated in the UAE region. This is already in place in Europe, the US and locally in Saudi Arabia, and awaited in our region for both the power generation as well as the HVAC industry to reap the mutual advantages of this combined system."

**GERHARD HOPE**

Editor

[gerhard.hope@itp.com](mailto:gerhard.hope@itp.com)



## COMMENTS

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# Ice thermal storage in air-con

**Klaus Grandegger** from Fafco SA of Biel/Bienne, Switzerland and **Aslan Al-Barazi** from IMEC Electromechanical Engineering of Sharjah look at the key factors involved in making ice thermal storage a success.

Ice thermal storage units can be the solution to possible problems in modern refrigeration and air-conditioning. In certain cases they are even the most economical investment. Over and above which new research has shown that certain refrigeration systems with ice storage units need even less electrical energy than conventional systems. Ice storage units today represent a popular method to provide refrigeration. Although there is a wide choice of different ice storage systems on the market, the predominant system for air-con applications is the so-called indirect brine system using plastic tube heat exchangers. The advantages of this system are obvious, which makes it the first choice when ice storage is considered.

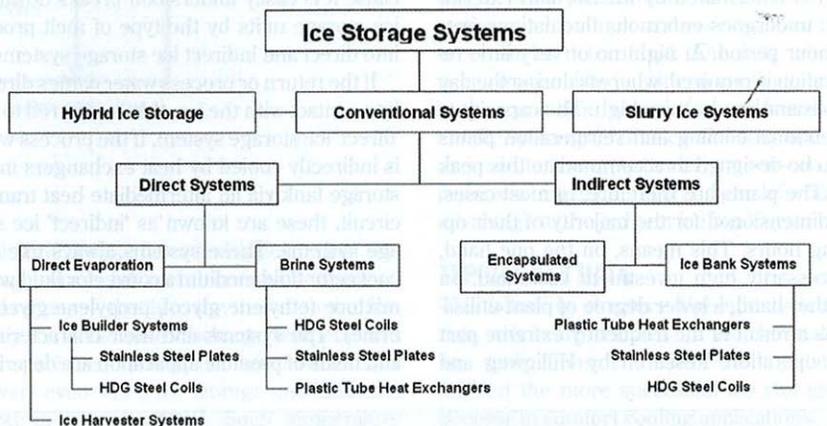
## WHY USE ICE STORAGE?

At an ice melting heat of 333 kJ/kg and sole utilisation of the latent energy, there is theoretical storable energy of 84.5 kWh/m<sup>3</sup> water as ice available. This is about twelve-fold the storable energy in comparison to direct use of the sensible energy from water – or, looked at differently – the required storage size is only 1/12. In practical use it can be assumed that there is a 50-60 kWh ice storage capacity latent per m<sup>3</sup> vessel volume, depending on design and melting method.

The ice melting point of 0°C means that typical applications for ice storage units are in the temperature range between +2...+6°C. Ice storage units have the advantage of simple plant technology, the use of an inexpensive and ecologically harmless storage medium and, in many cases, can today be employed economically. The wide range of ice storage unit application opportunities in the temperature range mentioned above is unbeatable. The following aspects are generally pivotal for the cost-effectiveness of ice storage systems:

- Basically anywhere where high refrigeration capacity is required;
- Where there is a requirement for high refrigeration capacity but short operating times;
- Where water-saving, modern, dry cooler systems are used;
- Where the annual operating periods are gen-

**FIG. 1: DIFFERENT TYPES OF ICE STORAGE SYSTEMS**



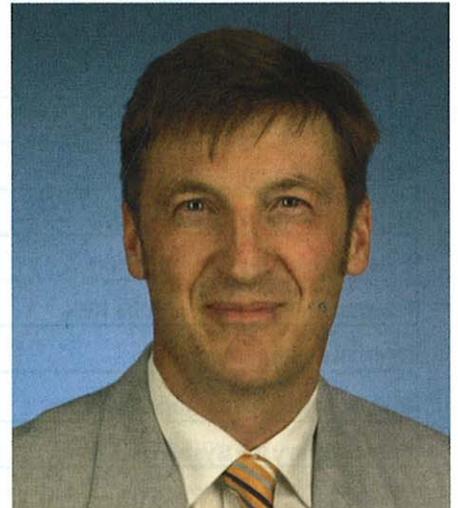
erally short (purely comfort air-con, low plant utilisation);

- Where there is a difference between day/night tariff for power and where there is demand charge for electricity;
- Where an existing plant is to be extended;
- Where an outdated plant is being renewed;
- Where there are layout constraints;

- Where part loads predominate;
- Where there are frequent refrigeration machine cycles (here there is a distinct improvement in efficiency);
- Where there are irregular cooling demands (shopping malls, office buildings, universities, exhibitions, stadiums, theatres, museums);
- For emergency refrigeration applications,



**Aslan Al-Barazi**



**Klaus Grandegger**

# ICE THERMAL STORAGE

where emergency refrigeration is only required for short periods; and

- Where substitution/replacement of absorption refrigeration machines is required, particularly where the transformer station cannot be enlarged or the power source is limited.

The use of the latent energy of ice in the form of melting heat thus represents a simple possibility to store cooling energy and to keep the storage space and therefore also the investment cost as low as possible.

## ICE STORAGE UNITS IN BUILDING AIR-CON

The refrigeration requirement in buildings, which is determined by interior and exterior loads, undergoes enormous fluctuations over a 24-hour period. At night no or very little refrigeration is required, whereas during the day the demand can be very high. The capacity of conventional cooling and refrigeration plants has to be designed to accommodate this peak load. The plants are therefore, in most cases, over-dimensioned for the majority of their operating hours. This means, on the one hand, unnecessarily high investment costs and, on the other hand, a lower degree of plant utilisation as a result of the frequently extreme part loads operation. Research by Hilligweg and

Kalb [1] has clearly shown that especially the part load behaviour, more so than stop-start behaviour of many cooling plants, can lead to an unfavourable degree of annual operating efficiency of the overall refrigeration system.

## OVERVIEW OF ICE STORAGE SYSTEMS

Depending on the application, capacity and performance demands, certainty of reliability and refrigeration temperature consistency, various ice storage systems are used in process refrigeration and air-con. A classification method which is not very common in literature but does nevertheless make sense because it is easily understood breaks down the ice storage units by the type of melt process into direct and indirect ice storage systems.

If the return or process water comes directly into contact with the ice, this is referred to as a 'direct' ice storage system. If the process water is indirectly cooled by heat exchangers in the storage tank via an intermediate heat transfer circuit, these are known as 'indirect' ice storage systems. These systems always use as a convector fluid medium a convector fluid-water mixture (ethylene glycol, propylene glycol or brine). The systems and their characteristics and fields of possible application are described

in [2]. Fig. 1 gives an overview of the different designs which are applicable today. Table 1 shows a summary of the important key data of common ice storage systems.

## APPLICATIONS FOR ICE STORAGE UNITS

Ice storage units can be used anywhere that cyclical refrigeration exists. The following conditions are typical for air-con applications in different applications (office buildings, shopping malls, hospitals, exhibitions, hotels, etc.):

- Consumer system temperature about 2-6°C;
- Discharge capacity corresponding to approximately 6-10 hours discharge time;
- Variable daily load profiles dependent on internal and external loads;
- Easy handling;
- No maintenance staff permanently available;
- Very high operating safety required, e.g. district cooling plants [3].

The preferred choice for air-con cooling application is indirect storage systems. The reason why is that those kind of systems offer the best operating conditions at lowest prices. Direct brine systems would be suitable, too. But due to higher operating costs, outlet temperatures and discharge rates which are not required in air-con systems, much more space

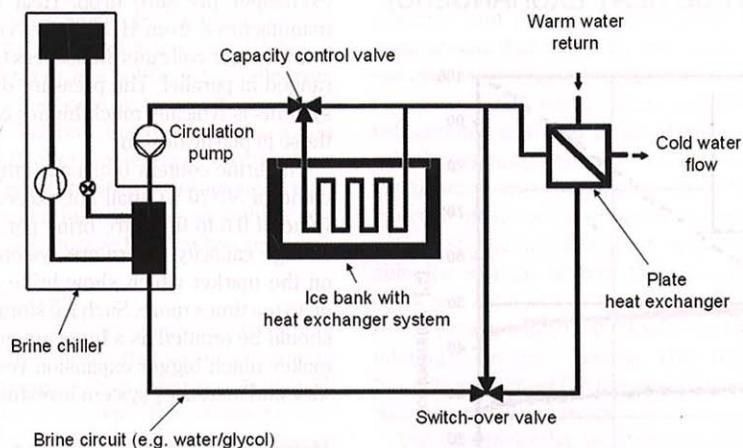
**TABLE 1: KEY DATA ON ICE STORAGE SYSTEMS**

Type of System	Standard Chiller	Customized Refrigeration Plant	Storage Capacity per Tank Volume [kWh/m <sup>3</sup> ]	Final Charging Temperature ( evaporation or brine) [°C]	Ice Thickness at the End of Charging Process [mm]	Discharge Temperature [°C]	Effective Heat Transfer Fluid: Water	Effective Heat Transfer Fluid: Ethylene-/Propylene Glycol	Consumer Side Open/Closed Loop	Suitable for A/C-Applications	Suitable for Process Cooling	Suitable for District Cooling
Hybrid Ice Storage	√		45..50	-4..-5	10	+1..2	√	√	Open		√	√
Harvester Systems		√	50	-2..-4	10..20	+1..2	√		Open		√	
External Melting/DEV-Systems		√	40..50	-4..-8	35..50	+1..2	√		Open		√	
External Melting/Brine-Systems	√		40..45	-6..-10	35..50	+1..2	√		Open		√	√
Internal Melting/Plastic Tube HEX	√		50..60	-4..-5	10..15	+2..10		√	Closed	√	√	√
Internal Melting/Steel HEX	√		40..45	-6..-10	35..40	+3..10		√	Closed		√	
Encapsulated Ice Storage Systems	√		40..45	-6..-10	40..80	+4..10		√	Closed/ Open	(√)	(√)	
Flo-Ice/Slurry Ice Systems		√	30..40	-8..-12	-	0..+4	(√)		Open		√	

Legend: DEX = direct evaporating system HEX = heat exchanger

Legend: DEX= direct evaporating system HEX = heat exchanger

**FIG.2: DIAGRAM OF AN ICE BANK SYSTEM**



requirement and higher investment costs, they are normally not the preferred choice. Direct systems are relatively large builds and are considered to be less safe from an operational point of view and less economical in terms of operating costs compared to indirect systems.

### INDIRECT BRINE SYSTEMS

Ice storage units working on the indirect principle (also called 'internal melt system') have only one closed circuit to freeze the water in a vessel as well as to melt the ice. The system structure of such a storage unit, which is generally equipped with heat exchangers made of plastic rather than galvanised steel tubes, is very straightforward, as per Fig.2.

During the charging process, that is to say the freezing of the water to become ice, brine at a temperature of approximately  $-5^{\circ}\text{C}$  is fed through the heat exchanger, which is situated in the water filled vessel. The ice builds up around the tubes and, by the end of the process, has formed a solid block of ice, as per Fig.3, hence the designation ice bank storage unit. When the ice is melting, that is to say when discharging, the warm brine is fed through the heat exchanger again and the ice around the tubes melts first. As the brine is always fed through the heat exchanger system, the formation of an ice block allows very compact design of indirect ice storage systems. The tank volume can be reduced by 30..40% compared to direct brine systems.

The indirect heat transfer means that the discharge rate, depending on design, equipment and discharge temperature, corresponds to a discharge time of up to 3-4 hours, whereas discharging over a period of 6-10 hours would be the standard in air-con applications. The

discharge performance is highest when the storage unit is full and decreases as the load level reduces – that is to say, the amount of ice. Today the achievable discharge temperatures with special equipment (air injection with air blower) even when the storage unit is almost empty is around  $+2\text{--}3^{\circ}\text{C}$ . Such temperature normally is low enough for air-con cooling applications in buildings. Air agitation in indirect systems is only an option. If there is no need for it (e.g. ice inventory  $>50\%$ ) it will be kept switched off. Other systems permanently re-

quire air agitation systems with air compressors running all the time during discharging and sometimes also during charging.

Ice formation during charging – for example, in FAFCO systems – is perfectly uniform due to reversed return piping arrangement and a very particular heat exchanger design including an orifice device. A perfect ice block is formed at the end of the charging period. There is no necessity to discharge such kind of ice banks frequently. Recharging is easily possible at any time; absolutely no limitations in charging and discharging schedule occur.

Furthermore, by changing the water level due to an increased volume of ice in this quasi-static vessel, a simple and very exact ice inventory can be determined. The fully adequate performance data for air-con applications and, at the same time, straightforward installation, simple system schematics and easy operation and maintenance, particularly for air-con applications in buildings, apply and give a favourable advantage to the indirect ice bank systems.

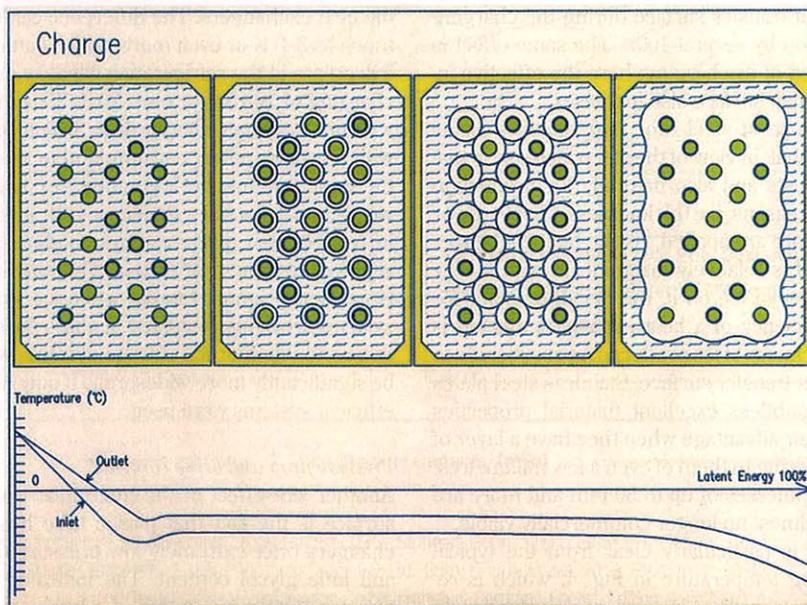
### TYPICAL KEY DATA

The following chapters highlight typical key data which are relevant for ice thermal storage applications. The better the key data are fulfilled the more successful ice storage can become in comfort cooling applications.

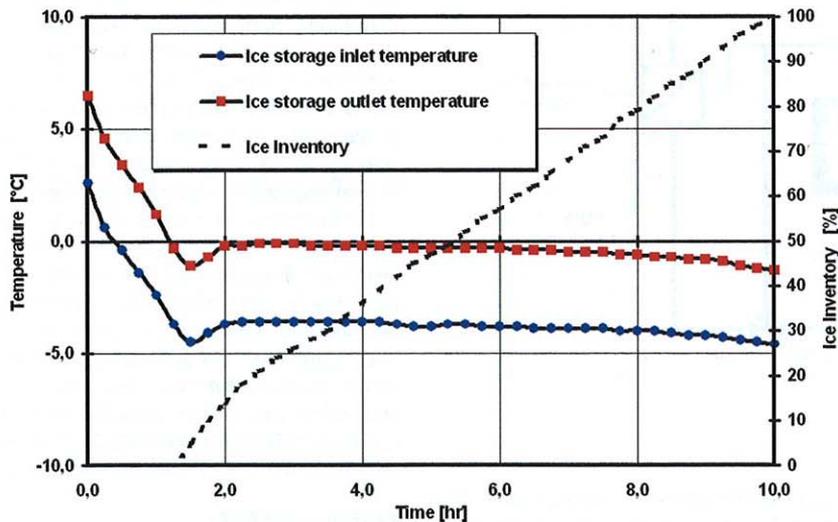
#### Heat transfer surface of heat exchangers

One of the most decisive evaluation criteria for ice storage systems today is the available heat transfer surface for the heat exchangers and

**FIG.3: CHARGING SCHEMATIC OF AN INDIRECT BRINE SYSTEM**



**FIG. 4: SAMPLE CHARGE TEMPERATURES FOR MAXIMUM ICE THICKNESS 10 MM (FAFCO PLASTIC TUBE HEAT EXCHANGERS)**



therefore the necessary ice thickness around the tubes or plates in order to provide the desired storage capacity. Indirect storage systems with plastic heat exchangers show clear advantages compared to direct brine systems as far as operating costs are concerned. The possibility to build in an enormously large heat transfer surface of up to 0.43 m<sup>2</sup>/kWh latent storage energy, using plastic heat exchangers, results in very little ice thickness being needed. Very good ice storage units have a thickness of 9-10 mm of ice at the end of the charge time. Apart from which, tubes allow increase the heat transfer surface during the charging operation by several 100%. The same effect is achieved in discharging; here the effective internal melt surface also increases.

The use of steel tube and stainless plates means that, in view of the steep increase in material costs and also naturally for production facility reasons, ice thicknesses of 35-50 mm or even more are applied. As the heat exchanger material is relatively insignificant with a very thin layer of ice on it, the deciding factor for the efficiency of a heat exchanger system is the thickness of ice produced, proportionate to the heat transfer surface. Stainless steel plates with doubtless excellent material properties lose their advantage when they have a layer of ice adhering to them of even a few millimetres. Ice thicknesses of up to 50 mm and more are today almost no longer commercially viable.

This is particularly clear from the typical charging temperature in Fig. 4, which is required to charge an ice storage unit of a certain

capacity within a given time. The greater the thickness of the ice – that is, the smaller the available heat transfer surface – the lower the charge temperature drops during the charging period. The median charging temperature of a highly efficient ice storage system today is about -4...-5°C. This temperature relates to an ice thickness of around 10 mm.

The median charging temperature becomes worse by some °C at ice thicknesses up to 35...50 mm, whereby plate heat exchangers fair even worse (no growing ice surface by increasing ice cylinder diameter) than tube bundle heat exchangers. The difference can be as much as 3-4°K or even more, which can mean a decrease in the refrigeration capacity during charging of 10-15 % or even 20 %. This means a distinctly longer charge time, which brings with it greater power consumption to produce the same amount of refrigeration – or, in other words, a substantially greater investment cost in refrigeration machines and condensers to achieve the same charge time. This standpoint is frequently ignored today, when ice storage systems are being evaluated. It poses the question as to whether ice storage systems would be significantly more widespread if only highly efficient systems were used.

#### Pressure drop and brine content

Another side-effect of the huge heat transfer surface is the fact that plastic tube heat exchangers offer extremely low pressure drops and little glycol content. The indicated heat transfer surface is a result of a huge number

of tubes with narrow diameters arranged in parallel on plastic headers. The huge number of tubes arranged in parallel minimises heat exchanger pressure drop. Heat exchangers manufactured from HDGS steel coils provide much longer coil runs, hence less tubes are arranged in parallel. The pressure drop of such systems is typically much higher compared to those in plastic design.

The brine content (normally ethylene-water blend of 30/70 %) shall not exceed a specific value of 0.6 to 0.75 litre brine per kWh latent storage capacity. There are systems available on the market which show brine contents of up to ten times more. Such ice storage systems should be omitted as a huge amount of glycol makes much bigger expansion vessels necessary and increases system investment costs.

#### Maintenance and corrosion aspects

The use of several heat exchanger modules affords the best reserve and allows for easy repair and, in extreme cases, the replacement of defective modules. Here plastic heat exchangers have an evident advantage. No special openings and lifting devices would be required. Ceiling height could be minimised as plastic heat exchangers can be bent and removed easily. Due to their weight, they can be carried by hand without any problems.

Steel coil heat exchangers, on the other hand, are heavy in nature and impossible for workers to remove manually in case of maintenance such as coil leakage repair. A crane would in most cases be out of the question for clients after the job is complete, particularly when the ice storage is located underground or in an inaccessible location. Plastic-type ice storage heat exchangers with an average weight of 20 kg can be lifted by any worker and, due to its flexibility in material nature, can go through an area as small as 1.5 m X 1 m area for 'in and out' accessibility, after project installation and commissioning is complete.

In countries like the UAE with highly corrosive atmospheres due to the high humidity with added sea air salt content and high air temperatures, material specifications are higher – that is, steel should be in SS304 or higher grades (SS316), as hot dip galvanised steel would be subject to fast corrosion. Moreover, when an ice storage system uses the air bubble system for increasing the heat transfer efficiency of the system, the air effectively comes in contact with the ice storage heat exchanger surface, which advances the effects of corrosion further. Hence it is recommended that the ice storage heat exchanger material be in either plastic or stainless steel. It is worth mentioning here that, on cooling towers, across Europe and most of the US, the material of construc-

tion used for structure and panels is HDGS, not SS, due to the mild climatic conditions. In the UAE, Qatar and related areas, due to the aggressive climatic conditions, the industry in most cases uses SS304, SS316 or plastic material to make it corrosion-free, not HDGS. It can be said there is a subtle yet parallel condition with ice storage systems, albeit a lesser one due to different thermal conditions and subjection effect of ambient air. Nevertheless, ice storage is still subject to the aggressive air conditions when injecting the air bubble system into the ice storage heat exchanger.

### Space requirements

Surface area is in short supply in 'investment buildings'. This means that today ice storage systems making the best possible use of available space are in demand. This means it is necessary for ice storage types to have optimum modification and repair possibilities. Compact and space efficient design is preferred. Ice storage units in concrete tanks, which can be installed within or as part of the building and are more or less hidden, are ideal.

The number of installed vessels should be kept to a minimum to maximise available space. Ice storage systems which are constructed on-site have enormous advantages with regard to flexibility in the use of space, and allow a more even flow for individual units as well as the units in the whole system.

### Investment costs

Due to the simple structure and inherently smaller tank volume, indirect ice storage systems would have the lowest overall initial cost when all system and related components are considered in the equation. The greater the outlay on refrigeration equipment (e.g. direct evaporative and harvester systems), the greater will be the investment requirement for plant technology and construction. The fact that quite a huge number of manufacturers in the field offer factory-made chillers is also a crucial factor. The pressure in the marketplace to keep costs down is enormous, and means that efficient and inexpensive refrigeration machines have a place in the market. The latter results in the fact that direct and indirect brine systems show the lowest investment costs compared to other systems. Direct brine systems ('external melting') are more expensive than indirect systems ('internal melting') because much larger tank volumes and a secondary discharging circuit are required (Fig 5).

## CONCLUSION

Ice storage has become a common way of making refrigeration available. The simplicity of the system structure, the simple operating principle and the low maintenance requirement means that today the use of ice storage systems represents a cost-effective alternative to conventional refrigeration methods. The refrigeration provided by ice storage systems substitutes refrigeration machine cooling at given times, and therefore enables the cost-effective operation of refrigeration plants.

Care should be taken when selecting a suitable ice storage system that the operating costs are kept as low as possible by having the largest possible heat transfer surfaces and minimum pressure losses. This represents the optimum cost-effectiveness of ice storage plants as employed today.

The ice thickness, as a pivotal criterion of the cost-effective use of ice storage, should be a maximum of 10 mm. Tube bundle heat exchangers, whether plastic or steel, are preferable to plate heat exchangers. The increasing heat transfer surface available during ice formation offers enormous thermodynamic advantages. Plastic tube heat exchangers for ice thermal systems offer major advantages over other systems in terms of operating conditions, pressure drop, brine content, corrosion and maintenance.

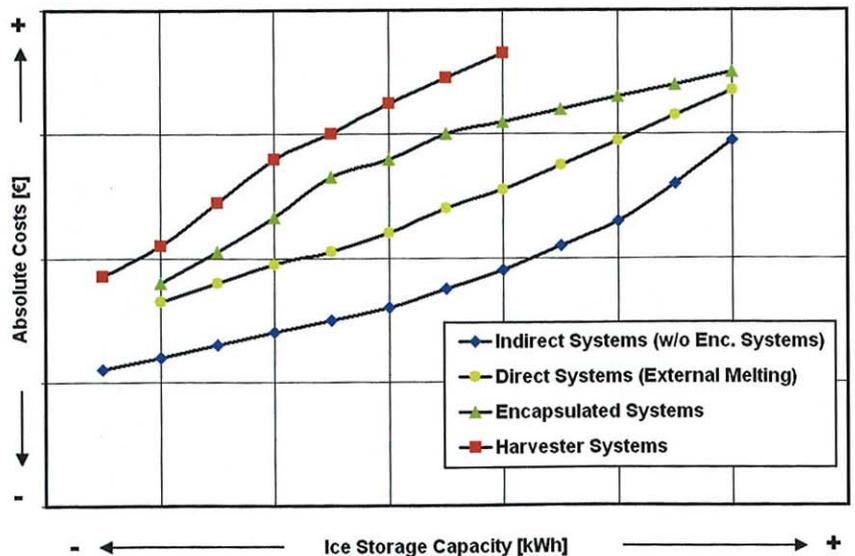
The overall size of ice storage plants today is practically unlimited, whereby the number

of units should be kept to a minimum. Today, modular systems offer the best solutions on the market for the wide range of possible applications for ice storage technology. Only the best ice thermal storage system with optimised properties and minimal investment costs can be successful in air-con applications. This may well be the reason why ice storage systems using plastic heat exchangers have gained their preferred position in the marketplace.

Turbines operate more effectively at night due to better thermal conditions, and thus with less energy requirements and less carbon emissions produced. In direct consequence, when turbines are engaged in optimum nighttime operation, not only would the power plant design engineer reduce the sizing of his overall power plant system design, but also from an operating standpoint, the power plant operator would reduce his energy consumption and therefore the power plant's carbon emissions.

For that to happen, however, the utilities need to encourage the consumer side and the district cooling providers to optimise the use of thermal energy storage at night by introducing the daytime/nighttime tariff system, which is still highly anticipated in the UAE region. The daytime/nighttime tariff is already in place in Europe, the US and locally in Saudi Arabia, and awaited in our local region for both the power plant as well as the HVAC industry to reap the mutual advantages of this combined system.

**FIG. 5: QUALITATIVE INVESTMENT COST COMPARISON**



## LITERATURE

- Hilligweg, A., Kalb, A., Less power consumption with Ice Storage, TGA Fachplaner, Alfons W. Gentner Verlag GmbH&CO.KG, Stuttgart, Germany (11/2005), p. 40-44
- Grandegger, K., Application opportunities for Ice Storage systems. CCN Climate Control News, Yaffa Publishing Group Pty. Ltd., Surry Hills, Australia, 2010, February, p. 38-43
- Schmid, W., Ice Storage unit improves efficiency of district cooling network, EuroHeat&Power, VWEW Energieverlag GmbH, Frankfurt, Germany, English Edition, 4, (11/2007), p. 32-35