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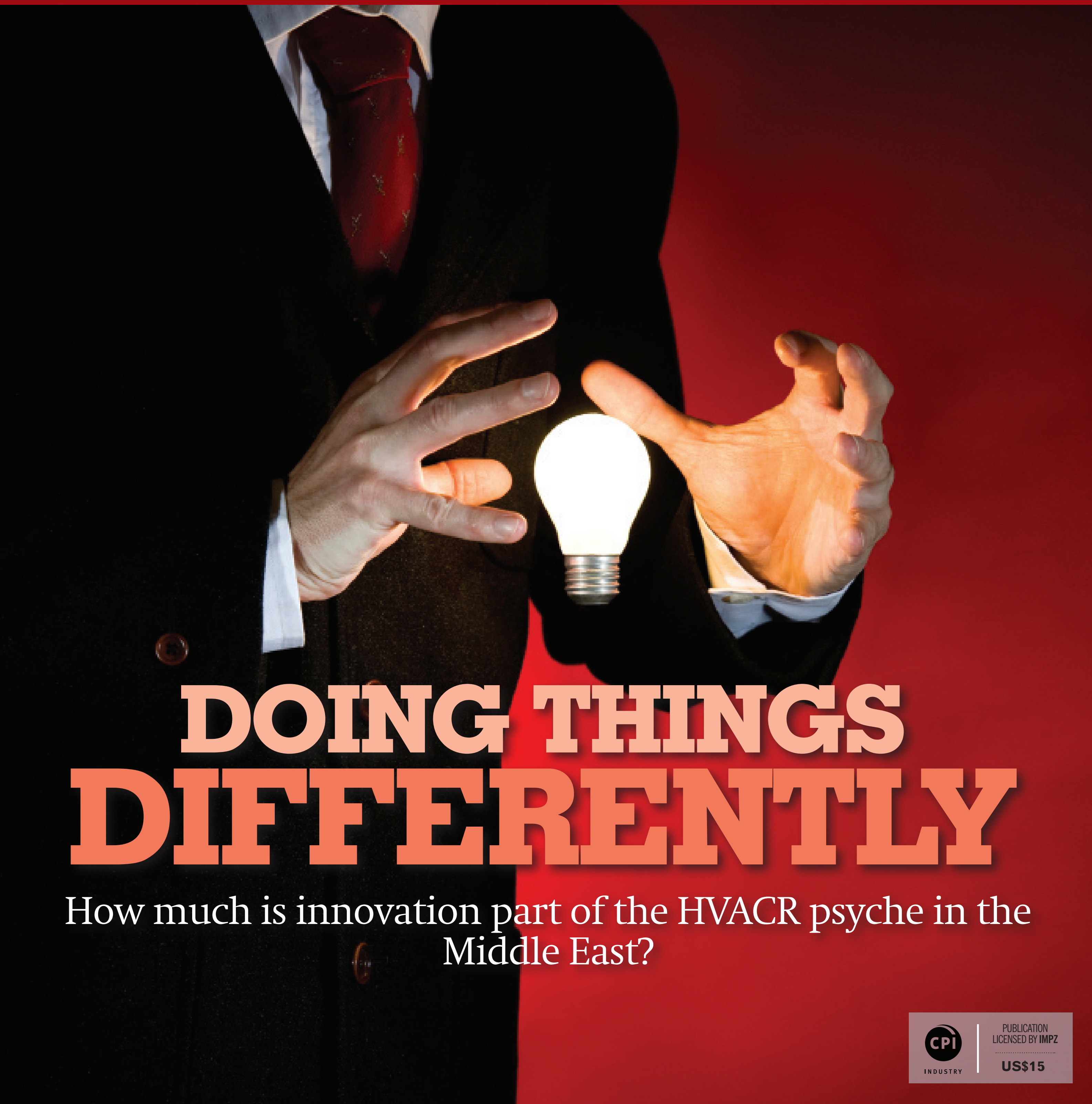
KEY PERSPECTIVES ON THE REGION'S HVACR INDUSTRY
OCTOBER 2011



DOING THINGS DIFFERENTLY

How much is innovation part of the HVACR psyche in the Middle East?

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Part 1

IN HOT WATER

Solar water heaters are sustainable alternatives to traditional heaters. However, a better understanding of their system design and safety measures will yield optimum performance efficiency and prevent potential hazards, says Aslan Al-Barazi, who provides detailed guidelines in this two-part article.

INTRODUCTION

The Middle East region is ideally suited for using solar power for water heaters, as bright sunshine is assured almost all year round with not much cloud cover that would affect their design. However, the advantages come with a few caveats:

- The solar panels need to be regularly cleaned because of the high level of dust in the region.
- The right material with correct specifications needs to be chosen
- The equipment needs to be correctly installed, particularly in areas in the vicinity of the sea, as sea breeze and humid conditions could harm them.
- Design safety is a priority due to the possibility of solar panels overheating.

It is, thus, evident that many factors go into the solar water heating system design. This article aims to give a general overview of the significant factors that need to be considered while installing solar water heating (SWH) systems in the region. It also provides design guidelines.

A CHECKLIST

Solar irradiance:

The solar constant is defined as the amount of incoming solar electromagnetic radiation per unit area. It is measured on the outer surface of Earth's atmosphere in a plane perpendicular to the sun's rays. It includes all types of solar radiation, such as infrared rays, UV rays and visible light. It is measured to be roughly 1,366 watts per square metre (W/m²), though this fluctuates by about 6.9% during the year due to the Earth's varying distance from the Sun, and typically by much less than one part per thousand from day to day.

However, to obtain an accurate solar thermal forecast, it is best to contact the local meteorological authorities to get the monthly average solar irradiance to gain better understanding of how much the sun (solar factor) may be relied upon and how much one may have to depend upon auxiliary supportive energy, like an electric or gas-fired water heater or boiler.

Panel tilt:

It is important to consider the correct solar panel tilt angle in the design process for optimum benefit. For the sunbelt region, an average tilt angle design of around 20 degrees for the daily, seasonal and yearly sun fluctuations would suffice. This angular tilt has an added advantage of facilitating maintenance by helping in draining the solar panel or removal of any air in the solar panel as and when required.

Two things need to be noted here:

1. The natural inclination of inclined roofs of villas or townhouses is sufficient for solar panel installation.
2. An automatic tracking system that may be used for a solar photo voltaic system is not normally used for a solar water heating system on the grounds of feasibility, though it may nevertheless be considered.

Roof area and shading factor:

When considering the SWH design, it is important to find out if sufficient usable roof area is available for the solar panels. If the area is insufficient, it is still possible to use them by reducing the solar factor and increasing the auxiliary source of energy. This will actually improve the total system design efficiency. (This will be demonstrated later in the article.)

The shading aspect needs to be incorporated into the design, factoring in the present and projected future development of the neighbourhood, keeping in mind the potential shading effect, as this can reduce the performance of the system. This also applies to trees in the area – present and future – and any other potential shading effect.

The sun rise/sun set directions is another important factor to be considered. It should be in line with the direction and tilt of the solar panels.

TYPES OF SWH SYSTEMS

SWH systems may be classified as either direct or indirect systems. A direct system is one in which the hot water from the solar panels goes directly into the storage tank and from there to the hot water taps. An indirect system is one where the solar hot water remains in the primary solar circuit and the heat is, then, transferred via a plate heat exchanger to the secondary hot water circuit, which then delivers the hot water to the storage tank, and from there to hot water taps.

An indirect system incorporating a plate heat exchanger is recommended for the region, as it is considered a safer option compared to a direct system due to two important reasons:

- There is a danger of the system overheating, particularly in summer due to the possibility of water getting over heated. In a direct system, this poses the danger of scalding the user.

> AN INDIRECT SYSTEM INCORPORATING A PLATE HEAT EXCHANGER IS RECOMMENDED FOR THE REGION, AS IT IS CONSIDERED A SAFER OPTION.

- In a direct system, there is a possibility of system contamination including bacterial colonisation, where users, particularly, children maybe using hot water.

The SWH system design may incorporate one or more heat exchangers. The heat exchanger may be situated: a) Inside the solar panel system (ie, the heat transfer medium between the solar absorber and the welded copper/steel pipes to it; b) A heat exchanger coil inside the water storage tank; or c) A plate heat exchanger separating both the primary solar panel circuit from the secondary water storage, leading to the hot water taps circuit.

The advantages of using a plate heat exchanger are:

- The hot water reaching the user does not have the potential of becoming contaminated with the primary water used on the solar panel circuit from such factors as bacteria in the water
- Does not get diluted with chemicals from special types of aggressive water treatment ▶

■ Does not keep the solar primary circuit), isolated from the DHW (Domestic Hot Water) circuit, which may use a mixture of water with monoproyplen gycol in the solar fluid circuit used for anticorrosion purposes (and as antifreeze in cold regions)

■ A counter-flow plate heat exchanger provides added flexibility in the design as well as allowing the heat transfer to occur faster, given that there are two fluids being pumped opposing each other, compared to the relatively static storage tank heat transfer. But the plate heat exchanger decreases the temperature of the hot water reaching the storage tank by about half a degree to one degree centigrade, as well as the added pump energy losses due to friction and other factors.

However, fortunately, many design options for SWH system and its components are available. The final choice needs to be based on the project requirement, client preference, design preference and cost. Needless to say, the piping between solar panel, storage tank, auxiliary heating source and hot water tap source should be as close as possible to each other, in order to not only to reduce pump energy, but also heat losses through the piping, even with proper insulation. Also, it is better to use a small diametre piping to reduce the amount of stagnant or wasted volume of hot water in the system, when the system is switched off, to reduce further heat loss. This, however, should be done factoring in the efficiency and safety of the pump design. This is so that the hydraulic energy and safety matters (due to potential overheating) are kept in balance.

THE PIPING BETWEEN SOLAR PANEL, STORAGE TANK, AUXILIARY HEATING SOURCE AND HOT WATER TAP SOURCE SHOULD BE AS CLOSE AS POSSIBLE TO EACH OTHER.

Piping insulation:

While selecting piping insulation, in addition to choosing the standard mineral wool or EPDM insulation, it is recommended that it is further protected with PVC cladding or aluminum protection in order to avoid bird or rodent menace.

AUXILIARY BACKUP HEATERS

Though sunshine is in abundance in the region, one cannot entirely rely upon solar water heating systems. Therefore, an auxiliary backup support heater is necessary due to the following reasons:

■ To meet late night or very early morning hot water demands in the building's load profile

■ To augment solar water heating capacity during winter months

How to calculate SWH demand:

To calculate the proportion of SWH to the total hot water required (SWH plus auxiliary backup water heating), in what is termed the solar factor, one may either use accurate forecasting methods of daily or monthly metrological weather profiles and make the average monthly assumptions, or follow a rule of thumb ascertained on the basis of the type of climatic conditions in the region. In the region, for example, a solar factor of 60% to 70% may be assumed (in colder unpredictable areas like Northern Europe, the solar factor would be assumed to be about 30% to 40%).

Baymak-BDR Thermea Group Solar Water Heater Installations in Germany.

Integrating SWH and backup systems:

As stated earlier, an auxiliary backup heating source is required to ensure continuous and consistent supply of hot water throughout the year to the user, to obviate underperforming of the SWH system in cold weather, cloudy days or late night and very early morning hot water demands.

Other reasons for using an auxiliary source of energy include:

■ To make up heat loss in the hot water storage tank and in the hot water system circulation from the solar panel to the hot water taps

■ For hot water sterilisation, which is useful, especially when domestic water is not in use for a long time, for example, during the holiday season, so that the auxiliary system helps eliminate or minimise bacterial colony formation

It is, therefore, important to note that combining SWH and the auxiliary water heater or boiler is a complex operation requiring expert knowledge, as not all backup boilers/water heater sources work efficiently when integrated with the SWH design.

Integration of the SWH system and the auxiliary backup water heating system needs careful execution. Attention needs to be paid to choose the right type of design with proper controls and with sensors positioned in the right place. Care needs to be taken so that the auxiliary energy is not overused or used by default while the solar heating is in operation, leading to waste of precious energy. This requires meticulous calibration of the combined systems design.

In the light of this, it is preferable that the same manufacturers manufacture the two systems or have within their ambit of work the auxiliary boiler or water heater backup source as well. It is also preferable that the complete SWH system design is either in the total scope of the consultant or of the manufacturer of the SWHs. Care should be taken to see that energy wastage does not occur by unnecessary overuse of the auxiliary backup heating source. This issue can be addressed by using the right system design integration with proper controls such as temperature and pressure sensor controls in the system, with devices that don't allow unnecessary hot water mixing between the SWH system and the auxiliary water heating system such as appropriate use of check valves and motorised valves.

SAFETY FIRST

Above all, the most important design aspect in an SWH system is safety. It should be noted that temperature and pressure of the system may superheat and change water into steam with temperatures reaching above 100°C, in addition to high pressure buildup. This is particularly a potential hazard in very hot regions like the Middle East during summer, when the solar panel temperatures may easily reach 300°C or above. As such, every SWH design needs to incorporate adequate safety measures.

There are several safety measures to prevent problems of overheating from occurring. They are:

- Covering the solar panels with an opaque surface cover that would protect the panels on very hot days
- Draining the solar panel section of hot water on very hot days or when the solar pump is not needed, in what is termed as a 'drainback system'. This will prevent a hazardous situation even if the solar collector itself overheats (without water), as it is designed to withstand high temperatures
- Having in place safety relief valves, safety vent pipes and expansion pressure vessels with inert nitrogen gas incorporating an internal flexible membrane in the pressure vessel, in order to remove any overheated fluid from the SWH system by reducing excessive pressure, temperature and water/steam volumes
- Keeping the system open to atmosphere, though water loss and contamination, including bacterial growth may become an issue
- Incorporating controls, such as differential thermostat controls and temperature and pressure sensors for safety as well as optimised efficiency
- Installing tempered valves next to the water draw-off point and using it to mix cold water from the source with overheated hot water from the SWH system. However, this may be considered a waste of energy, though some engineers find it a practical measure

An aside: when a pressure vessel is used as a safety device, it is a good idea to oversize it a little as a precautionary step.

An advanced measure that can be put in place is to connect the SWH system to a computer, for added safety and control and for preventive maintenance. This ensures that when there are symptoms of a potential problem, the system sounds a warning and informs the user about the appropriate action needed to be taken even before the problem actually occurs.

It needs to be remembered that a plate heat exchanger may also be classified as a safety device, as it also acts as a deterrent. It prevents overheated water from coming in direct contact with the user, thereby reducing the hazard of scalding from hot water. In addition, it eliminates bacterial contamination of the DHW, in case it exists. Plate heat exchangers also ensure that no contaminants in water, including chemicals or elements of corrosion in water enter hot water taps or showers and accidentally imbibed, especially by children.

That said, here is a word of caution: additional water treatment to reduce lime scale formation as well as removing any potential growth of water and airborne bacteria is required for optimum system efficiency and safety. The water treatment chemicals need to be added to the primary and secondary water circuit in appropriate doses and specifications.

It should be noted that limiting excessive water temperature not only helps address safety issues, but also ensures system performance by limiting energy loss. Water temperature above 60°C tends to radically increase the potential of lime scale deposits, which reduces heat transfer performance and undermines the system performance further. It is important to note here that a 2mm deposit corresponds to an efficiency decrease of 20%, while a 5mm deposit leads to a 40% decrease in efficiency. Moreover, a delta temperature gradient between the inlet and delivery temperatures of the coil should not be higher than 15°C.

It should also be noted that when water reaches a high temperature, oxygen begins to be released from it, forming bubbles, which need to be released through air vents to ensure that pump cavitation does not occur. Corrosion from oxygen release is also an important issue a designer needs to address by either using corrosion inhibitors and or use corrosion-free material in the SWH system design. Another important issue that needs to be addressed is the formation of lime scale deposits from minerals in the water. The right kind of water treatment is, therefore, needed to ensure that there is minimal reduction in efficiency and performance of piping and solar absorbers. ■

Part II in the next issue

Note from the writer: Details of images, references and schematics that are included in the article (both Part I & II) are listed below:

REFERENCES:

1. Solar Domestic Water Heating. Author: Chris Laughton. Publication Date 2010. www.routledge.com
Page References: 13, 27-29, 38, 47, 53, 67, 68, 83, 86-89, 92,96-103, 112, 122-125, 129, 139-141, 143-148, 157-159, 197 and 198.
2. Baymak-BDR Thermea Group. Solar Water Heaters Catalogue. Page References: 4, 5, 7, 13, 14, 15, 18, 20, 24, 25 and 26.
3. Baymak-BDR Thermea Group. Solar Thermosyphoning Systems Catalogue
Page References: P2.
4. Baxi Group Storage Tank User Guide. Page Reference: P8.

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