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An Overview of Solar Cooling Technologies Markets Development and its Managerial Aspects

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Abstract

Commercial buildings consume a considerable amount of fossil fuel that directly has negative impacts on the environment. In fact this leads to significant greenhouse gas emissions and the production of non-environmental friendly materials. Hence global warming is the most common dilemma facing world governments at the present time. Solar cooling technologies proved to be a successful alternative for conventional cooling systems especially in hot and sunny climates. The solar cooling technologies are able to reduce electricity demand since it relies on solar energy to produce cooling. There are many research articles that focus on the solar cooling technologies technical and engineering developments meanwhile there are limited research activities detailing its barriers, opportunity, architectural and managerial aspects. This research paper outlines the potential markets of solar cooling systems, as well as their architectural and managerial implications. The article also discusses, and suggests recommendations to overcome issues and barriers during solar cooling systems installation phase. In addition the article presents the solar cooing systems industry markets development and the potential of implementing the solar cooling technologies in livestock storage facilities, crops drying business, hospitals,

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1. Introduction

The use of solar cooling systems to save energy, reduce moisture from the air and to improve indoor air quality is found to be efficient and environmental friendly due to its superior humidity control. Its

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basic characteristic refers to their capability of regulating temperature, humidity and the quantity of fresh air supplied to any conditioned space.

Solar assisted air conditioning is an ideal option a significant amount of energy savings and greenhouse gas emission avoidance. Solar assisted air conditioning systems are environmentally friendly because it is constructed in a way that minimises the need for chlorofluorocarbons CFC refrigerants and it use low-grade thermal renewable energy. Additionally solar assisted air conditioning can be used either as stand-alone systems or with conventional HVAC, to save energy and to improve indoor air quality.

In the last decade there are a substantial researches activities concerning solar cooling technologies which in nature are focused on the technologies performance including its technical, environmental and economic aspects. Worth mentioning Baniyounes et al have compared numerically different solar cooling techniques in regards of their technical, economic and environmental performance [1]. Antoni Gil et al have performed an experimental evaluation of a high temperature thermal storage tank for solar cooling applications [2]. Eicker et al have performed an economic evaluation of solar thermal and photovoltaic cooling systems in different European climatic conditions [3]. However there are a limited papers and research articles which focused on solar cooling technologies' standards and market availability. Meanwhile there are article addressed the solar cooing technologies markets development and its managerial aspects. Therefore this article will address the solar cooling technology market development and its managerial aspects.

2. Architectural Implications

The market potential for solar cooling technologies is large and still under development. However, at present, there is little awareness or understanding of solar air conditioning between architect developers and operators within Australia. Consequently uncertainty remains about the integration of solar cooling technologies with existing cooling systems into a complete system for older and newly constructed buildings which is economic, reliable and robust.

Certain problems and issues encountered in solar air conditioning systems designs which resulted from [4] are summarized as: excessive reliance on a backup heat source if using low efficiency collectors or using insufficient solar collectors, long and poor pipe insulation as well as poor collectors' fluid flow design and using inefficient pumps, fans and blowers which will lead to high parasitic energy draw. Building designers and architects who are concerned with solar cooling have to mind a certain tactics and design approaches include: designers and architects have to consider reducing building cooling loads by developing an effective and intelligent building design. Furthermore solar cooling architects and designers have to consider the solar collector areas that are needed in early design stages, as the collectors have a significant impact on building design. Another important aspect is fans, pumps and backup heater electricity consumption must be considered, as they affect the system's operation costs and its gas emissions. Rather more architects have to be aware of what effects economic evaluation of solar cooling system such as solar radiation, equipment efficiency, construction cost of various equipment and any additional costs associated with preparation and the operation of the system, future developments and energy prices.

3. Solar cooling technologies barriers

There are a number of barriers confronting the solar air conditioning industry in adapting to the market potential and to supply a significant part of Australia's cooling demand. These barriers are caused by technology lack of awareness, the limited number of demonstration projects, system first installation cost and components' market availability. Additionally there is technology lack of awareness among potential users such as hospitals, museums, libraries, etc. about the nature of solar cooling technology, its technical details and its benefits. In addition most of HVAC systems' engineers and technicians are not familiar with this technology and they do not recommend it. One of the most significant brier is that, solar cooling technologies are a lot more expensive in comparison to conventional cooling systems. Economic analyses of solar cooling systems proves solar cooling technologies will not be competitive compared with conventional cooling systems at present. Thus significant effort is required to develop the technology in order to reduce its cost and improve its efficiency.

4. Technology markets

Mature solar thermal technologies are commercially available for the building sector, but further development is needed to provide new products and applications, reduce the cost of systems and increase market deployment.

Efficient and reliable air conditioning systems offer an excellent opportunity to replace conventional cooling systems and also it can address the expected rise in cooling demand in most Australian regions. However solar assisted air conditioning is still not a mature technology and it is in an early phase of development with many issues needed to be addressed in order to enable the technology to advance in terms of HVACs' applications.

4.1. Industrial markets potential

In industrial markets, solar air conditioning systems cannot compete with conventional cooling techniques because cooling is a necessary process as long as required (day and night). Cooling process reliability, availability and quality are the main parts of the industrial process and cannot be compromised. In addition, in industrial plants, cooling demand is not necessarily aligned with solar irradiance availability. Another major concern in using solar cooling within industrial plants is discounted prices of bulk used electricity.

Despite the difficulty of installing solar assisted air conditioning in industrial plants there are certain fields where this technology can be applied and can be cost competitive. Solar assisted air conditioning systems are ideal in industrial applications where dry air is permanently required, such as in the drying of agricultural crops and in livestock plants.

Livestock stations: Animals need food, water, shelter and a dry place to live and breed. Indoor air quality is a very important breeding factor in livestock industry. Animals, throughout all stages of their lives, need adequate food and water, comfortable and dry surroundings, ventilated areas and manure removal. Installing a solar desiccant cooling system in livestock space can be an ideal solution for the dilemma of indoor air quality within this industry, as for example, each mature cow exhales about 12 litters of water a day into the air [5]. This condition will create a very condensed and humid atmosphere and consequently will create mould, germs and create viruses.

Crops drying machines: Crops' drying is defined as lowering down the crops moisture content to a safe limit. This process is very important in maintaining crop viability and vigour, which may otherwise deteriorate quickly due to mould growth, heating and increased micro-organism activity [6]. To perform drying normally, there are the direct sun drying method and the forced air drying method. Using sun direct drying in large commercial quantities will delay harvest, risk weather damage and increase mechanical problems. So using the forced air drying method in a commercial scale is the right crop drying solution. However using the forced air drying method consumes significant amounts of energy.

Using solar desiccant machines to dry crops is cost effective, is a fast producer and is reliable. The process is achieved by drying the ambient air in the dehumidifier. The dried air is then blown on to the bin which contains the wet crops. Using solar desiccant crop dryers can make drying crops more viable in the tropics.

4.2. Commercial buildings market potential

Installing solar cooling systems in commercial buildings requires an area of sufficient size to install the cooling system's solar collectors. Therefore, not all commercial buildings are suitable for solar assisted air conditioning. The most suitable buildings to install solar cooling systems are commercial buildings with large roof areas, such as supermarkets, shopping centers, hotels, hospitals and convention centers. Buildings' star ratings and the carbon tax rate are new concerns that are facing commercial building managers and owners. So installing solar cooling system will boost the buildings star ratings and will reduce the carbon tax. Most commercial buildings require reliable and big capacity cooling systems as well as large volumes of dry air. Solar absorption cooling systems are renowned for their high capacity and as well as producing dry air, cooling can be achieved using solar desiccant cooling techniques.

Institutional buildings: Due to the high occupational density within institutional buildings, condensed water and humidity have always been issues for institutional building's HVAC design engineers. Institutional buildings in subtropical climate areas suffer from mould growth on walls, ceilings and other surfaces. Improper humidity control in institutional buildings leads to occupant discomfort, sick building syndrome and building related illness, as well as, early building deterioration due to mould and bad odour [7]. The most common practice in an institutional building cooling system under subtropical climate is to curb the humidity issue by overcooling using a large recirculation airflow to remove the moisture content to from the air or by relying on over-ventilated buildings, which is considered as an expensive practice. By installing a solar desiccant cooling system in institutional buildings, the issue of mould growth will be controlled at minimum energy consumption and less negative environmental impact. Desiccant cooling systems allow a higher amount of fresh air to enter the building which improves indoor air quality.

Hospitals and health care facilities: Hospitals and health care units have specially designed operation theatres, isolation units, laboratories unlike any other commercial building as they are required to operate special HVAC systems. Indoor air Quality (IAQ) is more critical in healthcare facilities due to the presence of hazardous microbial and chemical agents present and the increased susceptibility of the patients and health care staff.To build effective HVAC system designs which are able to enhance healthcare facilities' indoor air quality is a designers' main concern. In certain areas, air handling unit dampers are forced to be 100% open to allow 100% of conditioned air extraction and hypo filters are used in conjunction with dampers to ensure the quality of air despite the very long working hours 24/7. In addition, hospitals are characterised by their high latent load productivity due to high occupational density, machineries and ambient conditions. In other words hospitals' and health care facilities' cooling processes do not use economisers which are represented by recycled air, because they mostly use fresh air. Accordingly using solar desiccant machines to extract vapours and water contents out of the air is economic, environmentally friendly and can boost hospitals and health care units indoor air quality.

Libraries and book shops: It is very important that library buildings maintain a humidity level between 40-60% as stated by [8]. Libraries are a book storage facility; the preservation of books and their quality is one of the main concerns when designing their air conditioning systems due to the high volume of stored books which are subject to excessive humidity and airborne water vapour. High humidity is the main contributor to the deterioration of library materials and contents. Consequently the lack of active dehumidification and ventilation in libraries can have a significant effect on the books quality and most likely to cut their lifespan down remarkably.

In general installing a permanent dehumidifier in libraries helps to reduce airborne water vapour contents of conditioned air. Regular dehumidification and ventilation will draw a considerable amount of electricity. Alternatively, employing solar desiccant cooling technology to regulate temperature and humidity levels can be the ultimate practice in maintaining a dry and freshly ventilated environment by cost effective and efficient methods.

Museums and art galleries: Museums host mega expensive collections. These collections must be stored and displayed in an optimal climate. Museums air conditioning designers must mind and take into account all museums' surroundings, visitors and staff thermal comfort, as well as assets and collections. The most important factor for museums' HVAC designers is humidity control because there is no range of relative humidity that is ideal for various museums, objects and contents.

[9] and [10] recommend maintaining a non-fluctuating relative humidity which is above 35% and below 55% for mixed collections. Hence most museums around the globe maintain their indoor relative humidity around 45%. Low relative humidity in museums can cause shrinkage of hygroscopic materials such as leather and paper and high relative humidity can lead to mould growth and metal corrosion. Museums can also benefit from solar desiccant cooling technology due to its superior humidity control as well as condensed water removal.

5. Management implications

This section describes a set of rules which should be undertaken by operators, supervisors and project managerial team to ensure Occupational Health and Safety (OHS) guidelines, site preparation, site security, environmental considerations and identification of general hazards and their control are dealt with appropriately. These are briefly described as:

Occupational Health and Safety (OHS) management: The aim of managing OHS is to create a safe working environment whilst achieving the project's goals in the conduct of the day to day business of the organisation. This is important for moral, legal and financial reasons.

Site preparation: Only workers, who are competent, licensed and legally contracted, should be allowed to carry out work, because during installation of the solar cooling system, specialist activities such as lifting, piling or steel work need to be carried out on site.

Environmental considerations: The public must be protected from environmental hazards resulting from construction, installation and operation such as dust and noise

Protection against falling objects: Workers must supply and maintain their own head protection. Visitors to construction sites should always be supplied with head protection.

Site Security: This is required to ensure that equipment and accessories are safe.

Fire and other emergencies: Emergency procedures relevant to the site should be active and in place to prevent fire, flooding or structural collapse.

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