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Indian Scenario of Solar Energy and its Application in Cooling Systems: A Review

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Abstract

Degradation of fossil fuels due to increasing world population, industrialization and urbanization give rise to develop highly efficient and compact thermal systems. Out of many renewable energy resources, solar energy is one of the conspicuous source of energy which can only supplying the increasing demand of energy. The absorption cycle has recently attracted much research attention because of the possibility of using waste thermal energy or renewable energies as the power source, thus reducing the demand for electricity supply. Policies need to established for more and more usage and applications of solar energy.

Keywords: Solar absorption system; scenario; policy; energy.

1. Introduction

In recent years, scientists have increasingly paid more attention to solar energy. There is a sudden demand in the utilization of solar energy for various applications such as water heating, building heating/cooling, cooking, power generation and refrigeration [1]. Solar energy is the result of electromagnetic radiation released from the Sun by the thermonuclear reactions occurring inside its core. All of the energy resources on earth originate from the sun (directly or indirectly), except for nuclear, tidal and geothermal energy. The sun actually transmits a vast amount of solar energy to the surface of the earth [2]. The term “solar constant” signifies the radiation influx of solar energy. The mean value of solar constant is equal to 1368 W/m2 [3]. In Romania the annual solar energy flow ranges between 1000̃1300 kWh/m2/year in more than half of the country. This climate allows the operation of solar collectors from March until October, with conversion efficiency between 40% and 90% [4]. Thus, an important solar potential

exist. Most countries are now accepting that solar energy has enormous potential because of its cleanliness, low price and natural availability. For example, it is being used commercially in solar power plants. Sweden has been operating a solar power plant since 2001. Romania's experience in solar energy represents a competitive advantage for the future development of this area, the country being a pioneer in this field. Between 1970 and 1980 were installed around 800,000 m^2 of solar collectors that placed the country third worldwide in the total surface of photovoltaic cells. Between 1984- 1985 was achieved the peak of solar installations, but after 1990 unfavorable macroeconomic developments led to the abandonment of the production and investments in the solar energy field. Today about 10% of the former installed collector area is still in operation [5]. In recent years, many countries have been facing difficulties with the issue of refrigeration systems. Specifically, the demand of air conditioning for both commercial and residential buildings during the summer is ever increasing [2]. There is a lack of electricity and storage in developing countries to accommodate high energy consumptive systems such as refrigeration and cooling. The solar cooling techniques can reduce the environmental impact and the energy consumption issues raised by conventional refrigeration and air conditioning systems. Therefore, in this paper are presented theoretical basis and practical applications for cooling technologies within various working fluids assisted by solar energy and their recent advances. Also, a comparison of various solar cooling systems is performed and some suggestions about the use of these systems are given.

Energy security is the ability of a nation to deliver the energy resources needed to ensure its welfare and implies secure supply and stable prices. Energy is vital for progress and development of a nation's economy. The economic growth and technological advancement of every country depends on it, and the amount of available energy reflects that country's quality of life. Economy, population and per capita energy consumption have caused the increase in demand for energy during the last few decades. Fossil fuels continue to supply much of the energy used worldwide, and oil remains the primary energy sources. Therefore, fossil fuels are the major contributor to global warming. Along with the global warming impacts and climate changes, the demands for air-conditioning and refrigeration have increased.

2. Power Scenarios in India

The average electricity consumption in India is still among the lowest in the world at just 630kWh per person per year, but this is expected to grow to 1000kWh in the near future. According to Central Electricity Authority (CEA), the peak electricity demand in 2008 was 120GW of power, while only 98GW could be supplied. According to an analysis by the Indian PV project developer Aston field, this deficit is likely to grow to 25GW by2012.The Ministry of Power has set an agenda of providing ''Power to All'' by2012. India plans to bridge the peak deficit using a number of avenues. Many of them rely on increasing the fossil fuel foot print and hence indeed increase our reliance and dependence on these fossil fuels. At the same time, the government also making

serious efforts to accumulate the growth of renewable contribution to power. Some of the highlights of the current power production status in India had given in Tables 1and 2. It is inferred that the total installed capacity of power plant in India as on December 2012 is 210,952 MW. The major source for power production is coal based power plants. From Table 1 the private sector is contributing the major amount of power production in India [6].

Table 1
Installed capacity of power plant in sector wise.

S. no	Sector	MW	Contribution (%)
1	State sectors	86715.85	41.11
2	Central Sectors	62826.63	29.78
3	Private Sectors	61409.24	29.11
	Total	210951.7	100.00

Table 2
Installed capacity of power plant in fuel wise.

S. no	Fuel	MW	Contribution (%)
1	Coal	120873.4	57.30
2	Gas	18903.05	8.96
3	Oil	1199.75	0.57
4	Hydro	39339.4	18.65
5	Nuclear	4780	2.27
6	Renewable energy*	25856.14	12.26
	Total	210951.7	100.00

* SHP=Small hydro project, BG=Biomass gasifier, BP=Biomass power, U & I=Urban & Industrial waste power, RES=Renewable energy sources.

3. Solar Hotspots in India

Today a low-carbon energy transition at varying rates has been noticed in both the poor as well as rich countries. India has the second highest population in the world with an escalating energy demand. Electricity meets a major portion of this energy demand and is notably related to the socioeconomic progress of the country which is growing at a rate of 8%. The Compound Annual Growth Rate (CAGR) of power generation in India since 2005 is 5.2% while there was a peak shortage of 12.7% (over 15 GW) and average Transmission and Distribution (T&D) loss of 27.2% recorded during 2009–2010 [7]. Unfortunately, over 400 million people do not have access to electricity and nearly 84,740 un-electrified villages (14.3%) in the country, calling for intensive decentralized and efficient power generation [8]. The Integrated Energy Policy (IEPR 2006) in India has envisaged more than 800,000 MW (Megawatts) by 2032 which is 5 times the existing power generation capacity [9]. The scarce fossil fuel based centralized capacity addition is expected to be further expensive, inefficient,

polluting and unsustainable. Though mega hydro projects share 23% of the generation capacity, further addition would mean increased environmental disturbance. Nuclear energy is vital but hazardous for environment and national security. Renewable sources contribute only 10% to the nation's power basket where coal is the dominant source. Currently India is ranked fifth in the world with 15,691.4 MW grid connected and 367.9 MW off-grid renewable energy based power capacity, hinting at a slow clean power transition compared to other developing economies like China [10]. By and large, it is imperative to boost our renewable energy based power generation capacity, especially through solar.

Although India is one of the best recipients of solar energy due to its favorable location in the solar belt (40◦S to 40◦N), a meager aggregate of 66 MWp (Megawatt peak) solar applications (80% of which are solar lanterns, home/street lighting systems and solar water pumps) are installed in the country. This includes a total of 12.28 MWp grid connected and 2.92 MWp off grid Solar Power Plants (SSPs) [11]. The National Solar Mission (NSM) launched in January 2010 has given a great boost to the solar scenario in the country. The identification of hotspots of solar potential hasten the penetration of SPV and CSP based off-grid and grid-connected SPPs, encourage decentralized power generation with the reduced transmission and distribution (T&D) losses while meeting a major part of the country's energy demand. These regions help attract investment, generate employment, abate Green-house Gas (GHG) emissions and realize a sustainable mechanism of power generation. An initial step towards achieving the goal of a 'Solar India' is to assess the solar resource potential and its variability in the country.

4. Solar Refrigeration Technology

Solar refrigeration offers a wide variety of cooling techniques powered by solar collector based thermally driven cycles and photovoltaic (PV) based electrical cooling systems. Since solar energy is time dependent, the successful utilization of all these cooling systems is to a very large degree dependent on the thermal storage tank employed. In comparison with conventional electrically driven compression systems, substantial primary energy savings can be expected from solar cooling, thus aiding in conserving energy and preserving the environment. Solar refrigeration technology engages a system where solar power is used for cooling purposes [12]. Cooling can be achieved through four basic methods: solar PV cooling, solar thermo electrical cooling, solar thermo mechanical cooling, and solar thermal cooling. The first is a PV based solar energy system, where solar energy is converted into electrical energy and used for refrigeration much like conventional methods [12]. The second one produce cool by thermoelectric processes. The third one converts the thermal energy to mechanical energy, which is utilized to produce the refrigeration effect. The fourth method utilizes a solar thermal refrigeration system, where a solar collector directly heats the refrigerant through collector tubes instead of using solar electric power [2].

5. Indian Government Policies

As discussed, the use of CSP technologies in India for the northwestern part of the country, particularly in Rajasthan and Gujarat states, has huge potential to meet its future energy needs. Considering a short time frame, development of solar power by the JNNSM would have to be implemented within the existing framework of the Electricity Act 2003. The National Tariff Policy 2006 which currently mandates the State Electricity Regulatory Commissions to fix a minimum percentage of energy purchase from renewable sources of energy would be modified to mandate that the state electricity regulators fix a percentage for purchase of solar power. Starting with 0.25% in the Phase I as the solar power purchase obligation for states would be advisable with plans to increase it to 3% by 2022. One of the options in promoting setting up of a large number of solar power projects with the consideration of minimizing the impact on tariff, is to bundle solar power along with power out of the cheaper unallocated quota of central stations and selling this bundled power to state distribution utilities at the Central Electricity Regulatory Commission of India (CERC) regulated price. The gap between average cost of power and sale price of power would be minimized. NTPC Vidyut Vyapar Nigam Ltd. (NVVN), a wholly owned subsidiary company of NTPC, will undertake the sale of the bundled power to state utilities at the rates determined as per CERC regulations and those state utilities will be entitled to use the solar part of the bundled power for meeting their renewable purchase obligations under the Electricity Act, 2003 [14]. Rajasthan state is in the advanced stage of preparedness for installation of grid Interactive solar power plants of more than 500 MW in next 2–3 years based on the progressive views adopted in past five years in respect of solar generation policy issued under Government of Rajasthan for harnessing renewable energy in Rajasthan in year 2004. Demonstration projects being set up in the state of Rajasthan under JNNSM's initiatives include a 50–100 MW Solar thermal plant with 4–6 h storage (which can meet both morning and evening peak load and double plant load factor up to 40%), a 100 MW Parabolic trough technologies based solar thermal plant, a 100–150 MW solar hybrid plant with coal, gas or bio-mass to address variability and space-constraints and a 20–50 MW Solar plant with or without storage, based on central receiver technology with molten salt/steam as working fluid and other emerging technologies [15]. The Rajasthan Solar Policy, 2010 was issued by the Government of Rajasthan, Energy Department, with one of the objectives being developing a global hub of solar power of 10,000–12,000 MW capacity in next 10–12 years to meet some of the energy requirements of Rajasthan and India. The state has sanctioned 66 MW solar power projects in compliance of the Rajasthan Electricity Regulatory Commission's orders and will promote deployment of utility grid power to be connected at 33 kV and above level which shall be procured by NVVN as per mechanism provided under JNNSM Phase-1. The Rajasthan state will develop 50 MW SPV and 50 MW solar thermal power plants by selection of developer through tariff based competitive bidding process on concept of bundling of solar power with equivalent amount of MW capacity of conventional power. The state shall promote setting up of solar power projects for direct sale to state distribution utilities

with the target of developing a maximum capacity of 100 MW for Phase-1 (up to 2013) and an additional 250 MW for Phase-2 (2014–2017). The Government of Gujarat has allotted 716 MW of solar power capacity, of which 351 MW is from solar thermal technology, to 34 national and international project developers against the capacity of 500 MW mentioned above. Investment of over INR 120,000 million would be coming into the state in the next few years and estimates indicate that the 716 MW of solar power would generate 1250 Million Units of green energy annually [16].

6. Prospects

The present research article highlighted the potential of solar energy of India and its application in cooling systems. The solar hot spots of India were also identified, with clearly identifying the power scenario. The government must think for the policy for the solar assisted cooling system to have more and more utilization of solar energy instead of commercial fossil fuels and electricity.

References

[1] Z.F. Li, K. Sumathy, Technological development in the solar absorption air-conditioning systems, Renewable and Sustainable Energy Reviews 4 (2000) 267-293.

[2] N. Kalkan, E.A. Young, A. Celiktas, Solar thermal air conditioning technology reducing the footprint of solar thermal air conditioning, Renewable and Sustainable Energy Reviews 16 (2012) 6352-6383.

[3] B. Choudhury, P.K. Chatterjee, J.P. Sarkar, Review paper on solar-powered air-conditioning through adsorption route, Renewable and Sustainable Energy Reviews 14 (2010) 2189-2195

[4] C. Vac, S. Sana, F. Arion, Renewable energy market in Romania, Bulletin UASVM Horticulture 68(2) (2011) 237-240

[5] European Bank for Reconstruction and Development (EBRD), Renewable Energy Resource Assessment, Romania, 2010.

[6] /http://powermin.nic.in/JSP_SERVLETS/internal.jsp Retrieved: 12.02S; 2013.

[7] Renewables Global Status Report 2010 update, Renewable energy policy network for the 21st century (REN21), REN21 Secretariat, Paris, Viewed on December 15 2010 http://www.ren21.net/Portals/97/documents/GSR/REN21 GSR 2010 full revised%20Sept2010.pdf.

[8] Progress Report on Village Electrification, Central Electricity Authority, Government of India, Viewed on December 15 2010 http://www.cea.nic.in/god/dpd/village electrification.pdf.

[9] Report of the Expert Committee, Integrated Energy Policy, Planning Commission, Government of India, Viewed on December 15 2010 http://www.planningcommission.gov.in/reports/genrep/rep intengy.pdf.

[10] TERI Energy Data Directory & Yearbook. New Delhi: TERI Press; 2010.
[11] Delhi International Renewable Energy Conference, Ministry of New and Renewable Energy, Government of India, Viewed on December 16 2010 http://www.direc2010.gov.in/solar.html.
[12] L.A. Chidambaram, A.S. Ramana, G. Kamaraj, R. Velraj, Review of solar cooling methods and thermal storage options, Renewable and Sustainable Energy Reviews 15 (2011) 3220-3228.
[13] R. Saidur H. Masjuki, M. Mahlia, C. Tan, J. Ooi at al. Performance investigation of a solar powered thermoelectric refrigerator, International Journal of Mechanical and Materials Engineering 3 (2008) 7-16
[14] GoR. Rajasthan Solar Policy. Government of Rajasthan – Energy Department; 2010, <http://www.indiaenvironmentportal.org.in/files/Solar% 20Policy%20 2010.pdf> [accessed .10.10].
[15] GoG. Solar Power Policy. Government of Gujarat - Energy and Petrochemicals Department; 2009, <http://gidb.org/downloads/solarp.pdf> [accessed 14.10.10].
[16] GEDA. Capacity allotment for solar power project development in Gujarat. Gujarat Energy Development Agency; 2009, <http://www.geda.org.in/pdf/solar allotment webnote.pdf> [accessed 14.10.10].