BPU11 CONGRESS International Physics Conference of the Balkan Physical Union 28 August – 1September 2022, Belgrade, Serbia

Solar Thermal Heating and Cooling Systems: Technical Aspects, Their Current and Future State

Daniela Halili[1,a)], Urim Buzra[2,b)], Driada Mitrushi[2,c)], Pëllumb Berberi[2,d)]
[1]Department of physics, Faculty of Natural Science, "Aleksandër Xhuvani" University, Elbasan, Albania
[2]Department of Engineering Physics, Faculty of Engineering Mathematics and Engineering Physics, Polytechnic University of Tirana, Tirana, Albania.
[a)]Corresponding author: topciudaniela@yahoo.com
[b]

ABSTRACT

Electricity is essential for human life, but growing demands for energy, high cost, limited fossil fuel resources, environmental pollution, and global warming through the greenhouse effect are the reason why renewable energy, over about three recent decades, are seen as cost-effective and environmentally sustainable energy sources. Solar heating and cooling systems are replacing the use of electricity or gas almost all over the world in order to have a high standard of living for all users of solar energy or other renewable energies. The overview aims to present the technical aspects of solar heating and cooling systems, economical methods and ways of production, use and energy conservation, their current states, and scientific developments to improve their use in the future. A particular analysis is dedicated to the actual state of these systems in Albania.

Keywords: Solar collectors, solar energy, heating and cooling solar systems

INTRODUCTION

- Conventional energy is based on sources such as oil, coal and natural gas. Grow of global energy demand (nearly 40% by 2050)[1], climate change, greenhouse gas emissions, depletion of conventional energy sources and uncertainty for various reasons are leading to the widespread use of renewable resources and the rapid development of related technologies. Solar energy is the cleanest and most abundant energy among green sources available.
- Solar power is energy that come from the sun and then is converted into thermal or electrical energy. Related technologies can use this energy for different applications, such as generating electricity, providing light, heating water for domestic, commercial, or industrial use, etc. These technologies are technically well-proven, with numerous systems installed around the world over the last few decades [2].
- The goal of the work is to present a global overview of the solar thermal heating and cooling systems: assessment of the state of the art of a broad portfolio of low-carbon energy technologies, market and industry potential, their share in different end-use applications, and their benefits, growth, investment, and deployment. In addition, a particular description is dedicated to the state of solar thermal heating and cooling systems in Albania.

SOLAR THERMAL HEATING AND COOLING, THEIR CURRENT AND FUTURE STATE WORLDWIDE

Almost 50 % of total final energy consume heating demands are mainly covered by fossil fuels using conventional technology and cooling demands by individual electric chillers. By the end of 2019, it accounted for about 2,000 solar (thermal) cooling systems worldwide [7]; but most of them can be considered customized, early-stage systems. It is estimated that renewable heating and cooling will almost reach a 30 % share of total heat consumption by 2020 and more than 50 % of the EU heat demand by 2030 [8]. The choice of solar thermal collector generally depends on the application and the required temperature. Solar heating and cooling technologies collect thermal energy from the sun and use this heat to provide hot water, space heating, cooling, and pool heating for residential, commercial, and industrial applications. Today solar thermal collectors are the most common way to cover hot water loads in buildings. These systems are typically installed in single-family houses and use large buffer storages of about 800-2000 liters and a solar thermal collector field of 10-20 m². Most of them employ the physical phenomena of sorption, either absorption or adsorption [9]. By the end of 2020, hybrid – or solar photovoltaic thermal (PV-T) technologies provided 635 MWth of thermal capacity (and 232 MW of electric power capacity) for space and water heating. In addition, 566 MWth of concentrating solar thermal capacity provided hot water or steam for industrial and commercial customers at year's end. Around 1 GWth of air collectors for drying and space heating was in operation in 2019. The global solar thermal market continued a gradual decline in 2020, with an estimated 25.2 GWth of capacity added worldwide, down 3.6% from 26.1 GWth in 2019. The total operating capacity for glazed (flat plate and vacuum tube) and unglazed collectors (used mainly for heating swimming pools) reached an estimated 501 GWth by year's end, up 5% from 478 GWth in 2019(Fig 2).. China and Germany took the lead. Solar water heating collectors' global capacity, [10] from Denmark in solar district heating, thanks to policy support in both countries.

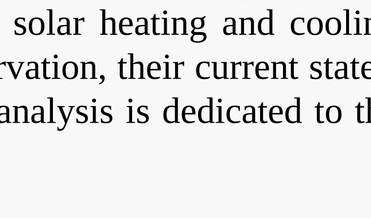

***Figure 1** Main renewable energy resources of the earth [1]*

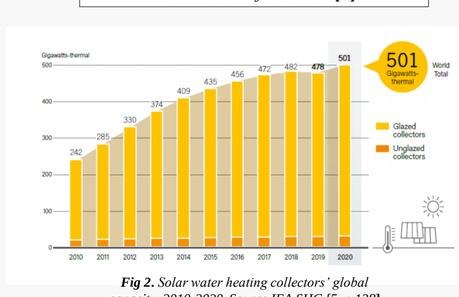

***Fig 2.** Solar water heating collectors' global capacity, 2010-2020. Source IEA SHC [5, p.138]*

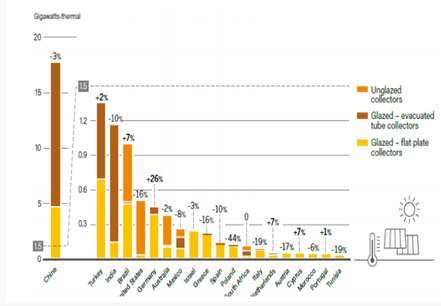

***Fig 3.** Solar water heating collector addition, top 20 countries for capacity added in 2020 [5, p. 139]*

In addition, a new generation of manufacturers of innovative concentrating collectors unveiled the first demonstration or commercial projects. The leading countries for new glazed and unglazed installations in 2020 were again China, Turkey, India, Brazil, the United States, Germany, and Australia. (See Figure 3) China dominated the market, accounting for 71% of new global sales, followed by Turkey and India (5% each). The top 20 countries accounted for an estimated 96% of the worldwide market in 2020.[11]

SOLAR COLLECTORS

RENEWABLE ENERGIES

Renewable energies are energy sources that are continually replenished by nature and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun, or from other natural movements and mechanisms of the environment Renewable energy does not include energy resources derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources [3]. Renewable energy technologies turn these natural energy sources into usable forms of energy—electricity, heat, and fuels. Figure 1 illustrates the world potential of renewable energy sources to provide over 3000 times the current global energy needs. [2,3]

TECHNICAL ASPECTS

SOLAR AIR COOLING SYSTEMS

Solar air-conditioning systems have provoked great interest over the last years especially on countries with high temperatures. Demands on energy for air-conditioning are growing faster than any other consumption, (nowadays nearly 20% of the total electricity in buildings worldwide is required for cooling) [4]. India, China and Indonesia are the countries that contribute to more than half of the annual growth rates. Nowadays India e.g.. consumes 30% of total energy consumption in buildings for space cooling which goes 60% of the summer peak load [5]. While in other countries, the peak load through space cooling can be more than 70% on hot days [4].. There are two ways to assure solar air-conditioning: by driving a vapor compression air-conditioner using solar photovoltaic cells for electricity production or by driving a thermal chiller using solar thermal heat.

SOLAR AIR HEATING SYSTEMS

Solar air heating systems use solar energy to heat air directly. They are primarily used for heating buildings, including ventilation, and also for crop drying [6]. Solar air heating technology is actually under-utilized. Covid-19 requirements for fresh air in buildings have brought an increase in the energy demand and CO2 emissions too, so solar heating systems are a smart solution. Most solar air heating collectors are wall-mounted in order to take advantage of the lower winter sun angles and for eliminating snow accumulation. Storage of heat in order to have it when it is necessary is the best solution, but this would increase the cost. Solar air heating collectors can be built integrated and usually help to bring down about 20 –30% of the conventional energy used. These applications can connect to existing or new ventilators and pass via the ventilation system into the building.

SOLAR THERMAL HEATING AND COOLING IN ALBANIA

In Albania, a typical solar water heating (SWH) system with a collector area of 3-4 m2 , a 150- 200 liter water tank, and a minimum operational lifetime of 15 years costs approximately USD 1000, including installation. With 50% annual efficiency, such a system could provide up to 2640 kWh/year in mountainous regions and up to 3 600 kWh/year on the coastline. An average household of four persons requires between 2 500 kWh and 3 000 kWh for hot water annually. [12, 13] The solar water system could fully supply this demand for seven to eight months of the year, especially in the summer season, and may require minimal backup in colder months. According to a market study undertaken by UNDP/GEF, close to 8000 public buildings, including hospitals, schools, dormitories, and others, have the potential to install SWH systems for various sanitary hot water needs. Estimated solar thermal installations in Albania amounted to 176000 m2 of solar water heating capacity, equivalent to 123 MW of nominal thermal capacity, by the end of 2015 (UNDP, 2017), the most recent official documentation of the installed capacities. Of this installed capacity, 90% are flat-plate collector systems, while 10% are evacuated, tube collectors.

CONCLUSIONS

Demand for renewables grew by 3% in 2020 and will increase across all key sectors –power, heating, industry, and transport – in 2021. The power sector leads the way, with its demand for renewables on course to expand by more than 8%, to reach 8300 TWh. Renewables are set to provide more than half of the increase in global electricity supply in 2021. An estimated 25.2 GWth of new solar thermal capacity was added in 2020, increasing the global total 5% to around 501 GWth. China again led in new solar thermal installations, followed by Turkey, India, Brazil, and the United States.

Albania has made significant economic progress during the past three decades, moving from a low-income economy to a middle-income EU member state, with a gross domestic product (GDP) per capital from 200 USD in 1991 to 5 353 USD in 2019.

REFERENCES

1.http://www.irenPerspectives for the Energy Transition, https://iea.blob.core.windows.net/assets/d9090f84-fd5a-464b-976a-99c7905c9c57/PerspectivesfortheEnergyTransition-TheRoleofEnergyEfficiency.pdf,p19
2.Renewable electricity generation and economic growth nexus in developing countries: An ARDL approach, A Azam , M Rafiq , M Shafique, J Yuan, Economic Research-Ekonomska Istraživanja, (2021), DOI: 10.1080/1331677X.2020.1865180,
3. IEA Global Energy Review 2021 Assessing the effects of economic recoveries on global energy demand and CO2 emissions in 2021, International Energy Agency, Website: www.iea.org]
4. OECD/IEA 2018
5. Patwardhan et al. 2012
6. 2015 Renewable Energy Resources Third edition by John Twidell and Tony Weir,110-112
7. IEA SHC 2020
8. [0010] Technology Map of the European Strategic Energy Technology Plan (SET-Plan). Technology Descriptions, doi: 10.2790/99812 (online),Luxembourg: Publications Office of the European Union, 2014, © European Union, 2014
9. Solar Systems for Heating and Cooling of Buildings, H-M Henning, J Döll, Energy Procedia · December 2012, DOI: 10.1016/j.egypro.2012.11.073
10. 2010-2020. Source IEA SHC [5, p.138
11. REN 21 Renewable energy policy network for the 21st century. https://www.ren21.net/wp content/uploads/2019/05/GSR2021_Full_Report.pdf, accessed on line 01 03 2022.
12. Influence aerosols in near atmosphere in the city of Tirana on ground budget of solar energy, U Buzra, D Halili, D Mitrushi, V Muda, E Serdari, I Berdufi, P Berberi, The 10th International Physics Conference of the Balkan Physical Union (BPU-10), Sofia, Bulgaria, 26 - 30 August 2018.
13. Regional Distribution of Life Cycle Cost of Hot Water Produced by a Solar Collectors In Albania, D
Halili, P. Berberi, V. LAME-MUDA, 9th International Physics Conference of the Balkan Physical Union, 24-27 August 2015, İstanbul University, İstanbul / Turkey;