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Recent achievements in solar thermal and photovoltaic energy applications

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Abstract

This paper deals with the overview of the recent worldwide achievements and applications concerning to the solar thermal and photovoltaic (PV) technologies. Both, the technical and environmental issues are to be presented and discussed.

The worldwide situation is mainly analysed based on the recent development shown intensively at the Solar World Congresses organized by the International Solar Energy Society, and also by the ISES-Europe Unit. Moreover, the most recently published books in this topic served also a basic source to the overview statements.

The main area of solar thermal energy use covers the solar domestic hot water systems, the combined systems, the large-scale systems, the swimming pool collectors, the solar district heating systems, the process heat and the solar thermal assisted cooling systems.

The most important standpoints of the PV manufacturing and applications are as: increasing trend in energy mix, decreasing cell and module prices, cell efficiency does not increase so fast, competition between different technologies, multi-Gigawatts applications, widening feed-in tariff system. Due to the growing market demand of solar photovoltaic applications, several new issues came to the light, transparency and extra size of modules, application of new technologies.

Examples are shown for both solar thermal and photovoltaic application possibilities.

Keywords: New solar technologies, environmental issues, thermal energy, third generation PV, passive solar

1. Introduction

Generally saying, within the use of solar energy the solar thermal field identified at a lower innovation potential however their application shows large varieties. Especially the production of electricity from solar thermal is a preferred solution.

In spite of the recent economic situation all over the world, a significant yearly increase of photovoltaic module production and their installation were performed in last couple of year period. However, it can be observed sensitivity of the market change on the photovoltaic industry, the PV technologies still show increasingly high priority.

The worldwide situation can be analysed based on the recent development discussed intensively at the Solar World Congress events. The last one was organized by the International Solar Energy Society in Santiago, Chile during November 4-7, 2019. Within the congress beside the technical-scientific topics several forums are organized to talk on local, national and international problems of energy politics which are responsible for the wider dissemination of such technologies.

The main thematic groups were as follows:

- Solar Heating and Cooling Technologies
- Solar Heating and Cooling Applications
- Solar and Renewable Electricity
- Energy Storage for Heat and Electricity
- Solar Energy Markets and Policies

- Energy Systems and Sector Coupling
- Off-Grid & Rural Energy Access
- Solar Architecture and Building Integration
- Education and Training
- Clean Water Technologies
- Special Themes:
  - Renewable energy cities
  - Renewable energy for mobility
  - Community power programs
  - Sustainable practices in the mining industry
  - History of solar energy

The most recent solar meeting, e.g. EuroSun 2020, the 13th International Conference on Solar Energy for Buildings and Industry will be organised by the International Solar Energy Society (ISES), the Cyprus University of Technology and the University of West Attica in Athens during September 1-4, 2020 in Athens, Greece.

EuroSun 2020 will focus on all aspects or solar energy (heat and electricity), and how solar energy combines with other technologies (i.e. storage) and will be connected with different sectors (i.e., transportation, industry, buildings) as well as communities.

The conference programme will include distinguished keynote speakers in plenary sessions, specialists' meetings in breakout sessions and poster exhibitions.

This conference will give a chance to the researchers, developers and industrial and governmental actors to continue moving the world towards 100% renewable energy program.

The main thematic topics at the EuroSun 2020 will be as follows:

- Solar Buildings
- Solar Assisted District Heating and Cooling
- Solar Heat for Industrial Processes
- Domestic Hot Water and Space Heating
- PV and PVT Systems for Buildings and Industry
- Solar Thermal Collectors and Solar Loop Components
- Thermal Storage
- Testing & Certification
- Solar Resource and Energy Meteorology
- Solar Education
- Renewable Energy Strategies, Policies, Scientists for Future
- Renewable Energy Solutions for Isolated Systems (i.e. Islands)
- Renewable Energy Systems and Spatial Energy Planning

Additionally, the abovementioned international conferences and their published Proceedings, the most recently issued yearbooks, and also the easily accessible web pages serve basic sources to the overview statements and the future vision, which are listed in the reference list. That materials were also used in the course to set of this paper.

2. Solar thermal

There are several attempts in order to improve the different solar thermal technologies. Focusing on the recent technical and market situation a great number of publications were presented to share all the available information in the field. In this study some of them are referred as Renewables 2019 – Global Status Report; Solar Heat Worldwide – 2019 and Farkas, 2017.

Focusing the solar heat energy worldwide several comments can be drawn. The most important ones are as follows:

In the share of the total installed capacity in operation (including the glazed and unglazed water and air collectors) China is taking leading position now with 75,3%, which is going on a longer period. China is followed by Europe with about 8,1% and USA/Canada with about 2% as shown in Fig. 1 (Weiss and Spörk-Dür, M., 2019).

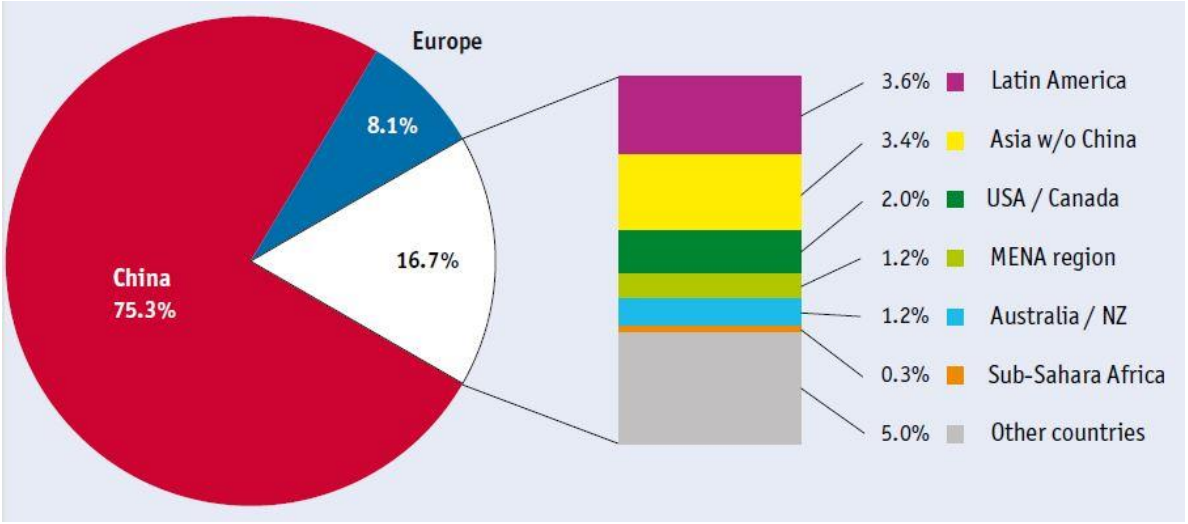

Fig. 1: Share of the solar thermal capacity by the end of 2017

The cumulated solar thermal capacity in operation by end of 2018 was 480 GWth (which equivalent with about 686 million square meters of collector area) compared to the year 2000 the installed capacity grew by a factor of 7.7.

The corresponding annual solar thermal energy yield in 2018 amounted to 396 TWh, which correlates to savings of 42.6 million tons of oil and 137.5 million tons of CO_2 (Fig. 2).

Fig. 2: Global solar thermal capacity in operation and energy yield for the period of 2000-2018

Although the global solar thermal market fell by 3.9% in 2018, there are positive growth figures in the case of the top 20 countries. Fig. 3 shows the date for the most determining 10 countries.

It is worth to mention that the Megawatt-scale solar district heating systems and the solar heating and cooling applications in the commercial and in the industrial sectors played an important role in increasing the growth in recent years. Consequently, several large-sale projects have been initiated and successfully implemented all through the world in 2018.

Nevertheless, it is a rather important fact to be mentioned that the Megawatt-scale plants still represent only about 1% of the overall global installed capacity.

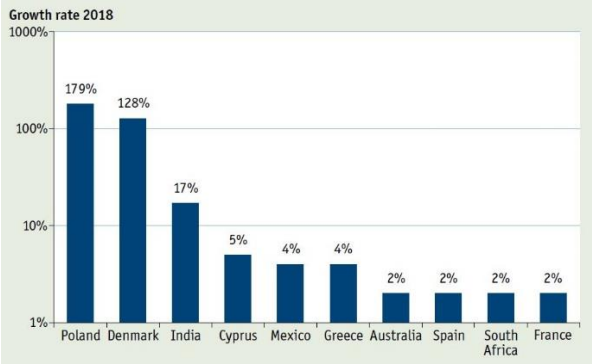

Fig. 3: Solar thermal market growth rates in the top countries in 2018

The positive trend of solar thermal energy use discussed before, according to the recent estimation has continued in 2019, as well.

It has been observed a strange fact that the traditional mass markets for small-scale solar water heating systems for single-family houses are under market pressure from heat pumps and PV systems. The PV/T systems are also in the market.

The main issues of the use of solar thermal energy especially in Europe can be summarized along with the statements as:

- mainly solar domestic hot water systems are in use,
- growing share of combined systems,
- growing number of collective (large) systems,
- plastic absorber for swimming pool collectors,
- several solar district heating systems,
- some pilot plants for process heat,
- about 200 pilot plants for solar thermal assisted cooling system.

3. Solar photovoltaic

In spite of the recent economic situation all over the world a significant yearly increase of photovoltaic module production and their installation were performed in last couple of year period. However, it can be observed sensitivity of the market change on the photovoltaic industry, the PV technologies still show increasingly high priority.

In 2018, the solar photovoltaic global capacity reached 505 GWpv along with the annual additions of 100 GWpv, as can be seen in Fig. 4 showing the capacity increase for the period of 2008-2018 (Renewables 2019). It is equivalent to the production of about 40 thousand modules every hour. In 2019 it is estimated about 20% capacity addition.

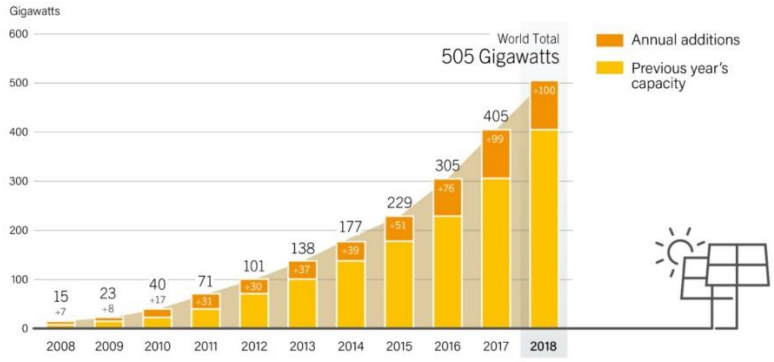

Fig. 4: The solar PV global capacity and the annual additions for the period 2006-2018

The Fig. 5 shows the share the solar photovoltaic global capacity in 5 top countries (China, United States, Japan, Germany and India) compared to the rest of world.

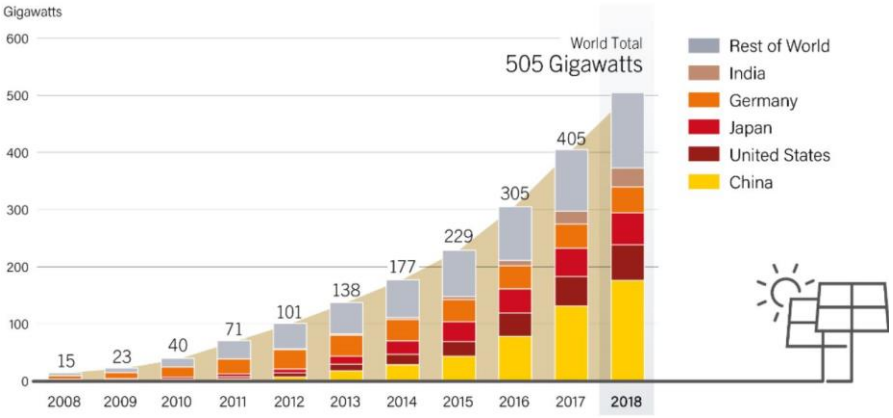

Fig. 5: The solar PV global capacity and the annual additions for the period 2006-2018 in top countries

In 2018 in China the annual solar photovoltaic market was declined more than 15% relative to 2017, because of the significant subsidy reductions by the central government. In spite of this fact still China is dominating in the PV productions and installations.

Just making a comparison of the different total renewable energy capacities in operation and their produced energy in 2018 is shown in Fig. 6, along with their growth rate of for the period of 2010-2018 (Fig. 7). From the referred figures it can be easily justified the increasing importance of the solar photovoltaic technology (Weiss et al., 2019).

It is an important break point in comparison of the field of solar thermal and photovoltaics is that in 2018 the PV overtook the solar thermal in the term of installed global capacity.

Concerning to the 2% growth rate of solar thermal, it is significantly less than the leading photovoltaic and the wind technologies.

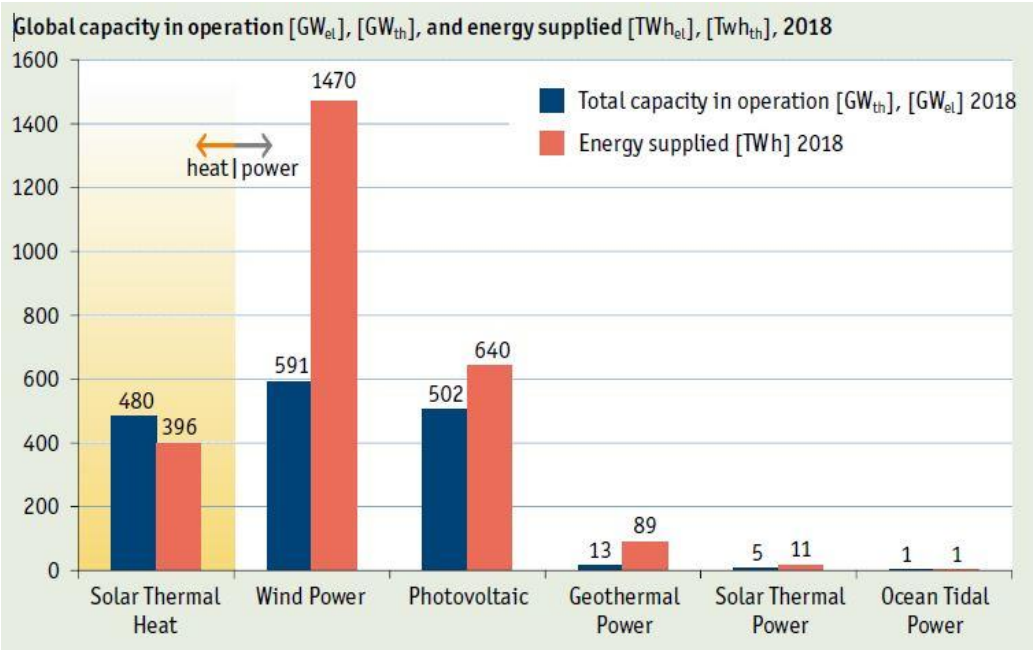

Fig. 6: The total renewable capacity and energy produced in 2018

Fig. 7: The growth rate of different renewables for the period of 2010-2018

The most important standpoints, which are characterising and influencing the PV manufacturing and applications industry could be summarized as follows:

- - 20-30% of the part of renewables in the energy mix,
- at around 30-40% yearly decrease of the PV cell and module prises,
- the cell efficiency in market products does not increase in a great extent as expected,
- multi-Gigawatts applications are getting into the practice,
- widening the feed-in tariff system in several countries in worldwide,
- presence of the Chinese PV products in worldwide and especially in the European Union market.

Due to the extensive growing market demand of the solar photovoltaic applications several new issues came to the light. Among the others, such factors include the wide range of cell manufacturing technologies, colouring, transparency and extra size and concentrated type of modules along with the new type of fixation systems, as well.

Concerning to the third generation of PV cells several schemes have been suggested to increase the efficiency of PV cells above the limit of a single bandgap device. The new technologies are aiming at to reduce the losses due to the non-absorption of sub-bandgap photons and the thermalisation of above bandgap photons.

Recently, it is worth to mention the organic and perovskite type of solar cells for which several significant

scientific research and industrial investments were performed in the last couple of years as can be seen in Fig. 8 (Fraunhofer ISE, 2019). In June 2018, perovskites solar cells have reached efficiencies of 27,3% in laboratory environment.

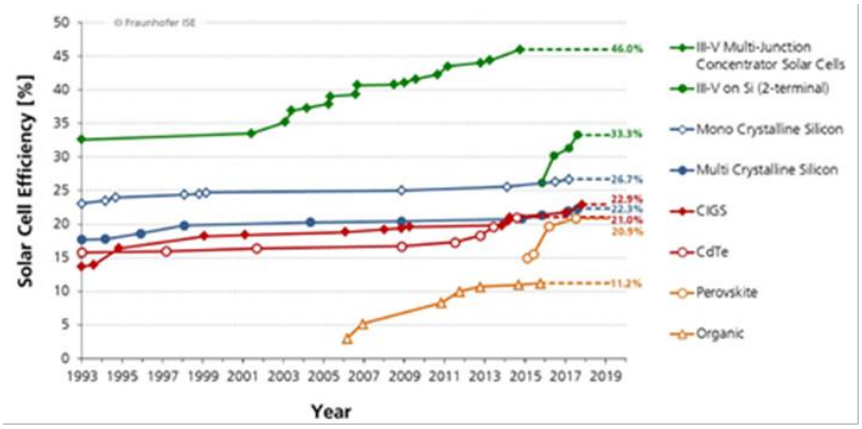

Fig. 8: The growth rate of different renewables for the period of 2010-2018

4. Conclusion

This paper gives an overview of both the solar thermal and photovoltaic energy applications fields worldwide. It discusses the technical developments, the market situation and also the future trends. The new technologies are also analysed and providing information on the solutions methods and approaches. Several examples are also given.

5. Acknowledgements

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