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New trends in solar thermal and photovoltaic applications

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Abstract

This paper deals with the overview of worldwide position and new application possibilities of solar thermal and photovoltaic (PV) technologies.

The worldwide situation is 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 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, as colouring, transparency and extra size of modules, application of thin film technologies and new fixation systems.

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

Keywords: New technologies, environmental issues, thermal energy use, 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 is analyzed based on the recent development shown intensively at the Solar World Congress events. The recent one will be organized by the International Solar Energy Society in Abu Dhabi, UAE during October 29 - November 2, 2017. The motto of the Congress is "Innovation for the 100% renewable energy transformation". 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 such technologies.

The main thematic questions are as follows:

1. SHC systems and components
   - Solar thermal collectors
   - Low to medium temperature thermal storage
   - Other innovative components and systems
   - Performance measurement, durability and reliability
   - Solar and heat pump systems
   - PVT systems

- Testing, standards, and certification for solar thermal technologies
- Solar ponds

2. SHC applications
   - Domestic solar water heating
   - Solar space heating and hybrid applications
   - District heating
   - Solar heat for industrial and agricultural processes
   - Solar refrigeration and solar air conditioning

3. Producing and storing renewable electricity
   - Photovoltaics: Cells, materials and components; advanced materials and concepts; design, operation and performance of PV systems; balance of system components; codes and standards; testing and certification; concentrating PV
   - Concentrating solar power technologies: solar concentration fundamentals and optical engineering, heat transfer, materials and components; solar thermal electricity systems; co-generation; solar thermochemical production of fuels and chemicals
   - Wind energy, ocean energy, hydro and other direct conversion renewables
   - Biomass energy, geothermal and other thermal renewables
   - Electrical storage technologies at Grid or utility-scale
   - Medium/high temperature thermal storage for electricity production with CSP systems

4. Renewable energy grid integration & distribution: Utilities of the future
   - Grid integration of variable renewable and energy storage systems
   - Active demand-side management
   - Smart Grids strategies including smart metering

5. Off-grid & rural energy access
   - Off-grid energy supply
   - Community micro power and hybrid systems
   - Solar cooking and clean cook stoves

6. Solar architecture and building integration
   - Integrating renewable technologies into buildings
   - Sustainable building materials and components
   - Net zero energy buildings
   - Daylighting
   - Energy storage in buildings

7. Renewable cities and community power programs
   - Urban and regional planning to maximize renewable energy
   - Policies and financial mechanisms
   - Clean transportation technologies and strategies

8. Solar resource assessment and energy meteorology
   - Renewable resource assessment and applications
   - Resource forecasting
   - Resource measurement and instrumentation

9. From laboratory to the real world: Solar energy markets, policies and initiatives that enable commercialization
   - Strategies, policies and case studies for renewable heat and electricity
   - Education and workforce development

10. Water, food, and energy nexus
    - Solar thermal desalination technology
    - Solar electrical desalination technology
    - Solar detoxification of water
    - Integrating desalination with thermal and electrical systems
    - Solar supported agriculture in desert regions

Additionally, the most recently published books serve also a basic source to the overview statements and the future vision, which are listed in the reference list.

2. Solar thermal

There are several attempts in order to improve the solar thermal technologies. Accordingly, a great number of books, publications and conference proceeding are presented to share all the available information in the field (Renewables 2015 – Global Status Report, Rethinking Energy 2015, Solar Heat Worldwide – 2015, Farkas, 2011).

The rate of development of the solar thermal applications in a long-time horizon is shown in Fig. 1 (based on Seyboth et al. 2008).

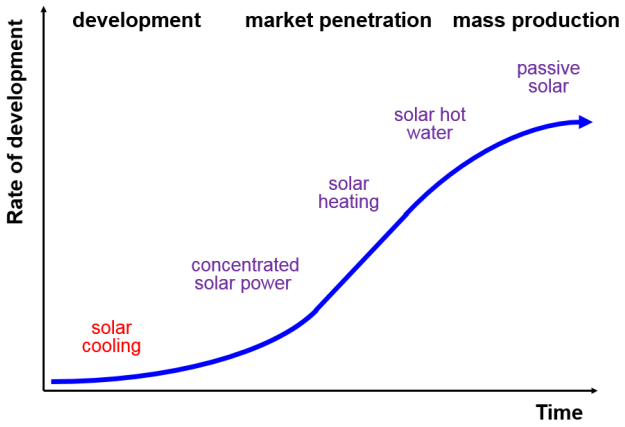

Fig. 1: Development of solar thermal applications in a long-term time horizon

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 with 71%, following by Europe with about 11% and USA/Canada with about 4% as shown in Fig. 2 (Weiss et al., 2017).

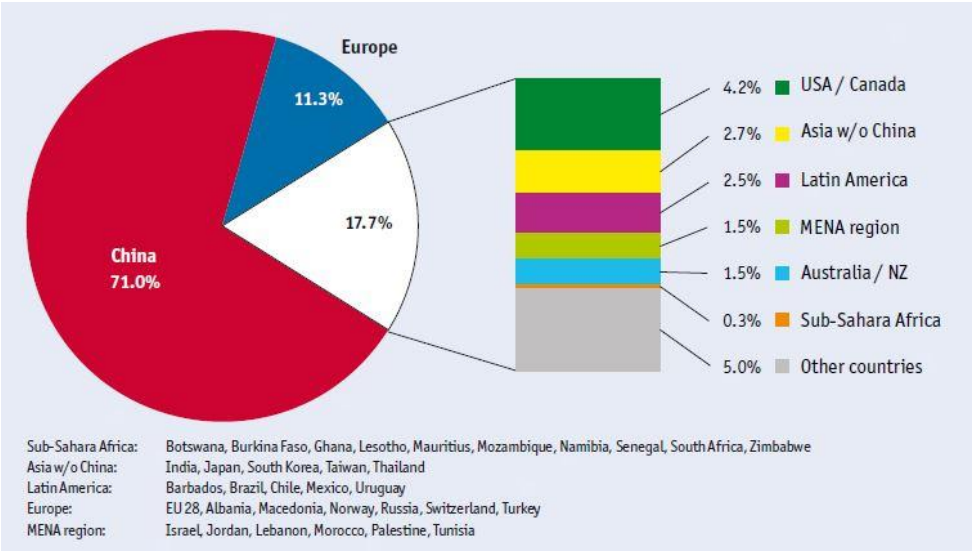

Fig. 2: Share of the solar thermal capacity by the end of 2015

In the period of 2000-2016 the global solar thermal capacity of glazed and unglazed water collectors in operation grew from 62 GWth (89 million m2) to 456 GWth (652 million m^2) in 2016. The corresponding annual solar thermal energy yields amounted from 51 TWh to 375 TWh as can be seen in Fig. 3 (Weiss et al., 2017).

Fig. 3: Global solar thermal capacity in operation and energy yield for the period of 2000-2016

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 architecture

In the coming period several trials are to be performed to increase significantly the building oriented solar applications, so lowering the energy consumption in buildings and/or find new solutions for providing energy resources from renewable energies.

The solar thermal vision for 2030 in Europe, especially to the building industry, is projected by European Renewable Heating and Cooling Technology Platform (RHC-ETP):

New buildings:

100% solar heated buildings will be the standard.

Existing buildings:

50% solar heated will be the most effective way to refurbish the building stock,

The new building components will be:

- the entire roof is covered by solar collectors and solar photovoltaic modules,
- the faced is used to harvest solar energy,
- seasonal heat storage,
- active heating system,
- compact units for solar heating and cooling,
- very well insulated.

The existing building components will be:

- renovation with multi-function modules for roof and facade,
- insulation and solar collector,
- seasonal heat storage,
- solar assisted cooling,
- around 70% heat demand is covered by solar thermal energy,
- remaining heat demand will be covered with other type of renewables.

Thus, nowadays it is strongly focusing to the development and design aspects of building integrated solar collectors. The literature review confirms that solar collectors appreciated not only by their thermal efficiency and the entire energetic performance, but also according to their aesthetic considerations. In Fig. 4 a new type of shell-structured solar collector is shown, which is a proper combination of the traditional and new type of construction materials. During the investigation the temperature distribution on the collector surface was validated by an infrared camera recording (Farkas, Fekete, 2017; Kendrick, 2009).

Fig. 4: The layout of a shell-structured solar collector

Concerning to the passive solar applications, it can be stated that:

- several trials are to be performed to increase significantly the building oriented solar applications,
- especially in Europe 100% solar heated buildings will be the standard by 2030.

4. 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.

The solar photovoltaic global capacity (reaching 303 GW_{pv} in 2016) and the annual additions worldwide are indicated in Fig. 5 for the period 2006-2016 (Renewables 2017). In 2016, the increased amount of 75 GW_{pv} is equivalent to the production of 31,000 modules every hour.

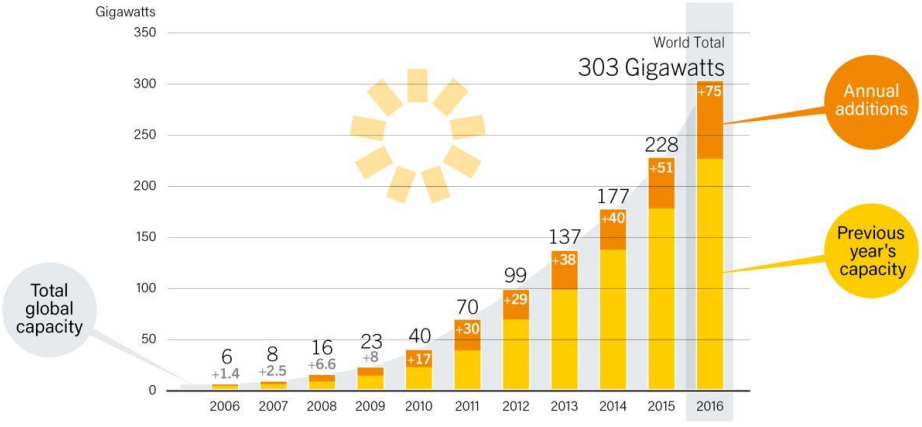

Fig. 5: The solar PV global capacity and the annual additions for the period 2006-2016

Just making a comparison of the different total renewable energy capacities in operation and their produced energy in 2016 is shown in Fig. 6, along with their the growth rate of for the period of 2010-2016 (Fig. 7). From the referred figures it can be easily justified the increasing importance of the solar photovoltaic technology (Weiss et al., 2017).

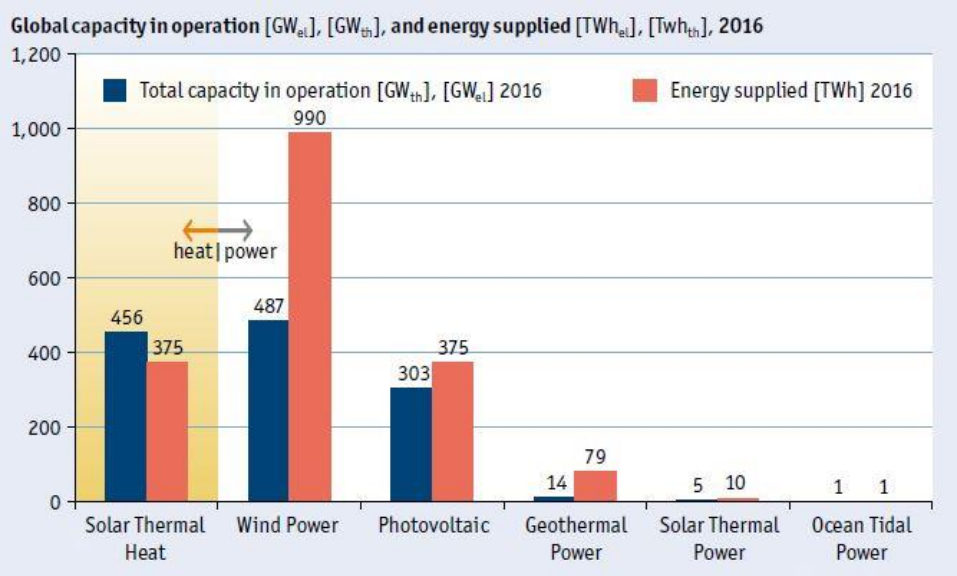

Fig. 6: The total renewable capacity and energy produced in 2016

Fig. 7: The growth rate of different renewables for the period of 2010-2016

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,
- strong competition between the crystalline and the thin film technologies,
- 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 growing market demand of the solar photovoltaic applications several new specific issues came to the light. These factors include new type of modules along with their colouring and extra size, wide range application of thin film technologies, colouring of the modules, transparency of the modules, extra size of modules and new type of fixation systems.

3.1. Transparent PV applications

The attractiveness of the applications is increased with the use of the different colours of modules. A possible colour of the planned semi-shade cells (Suntech, 2015) can be seen in Fig. 8. The main features of the Suntech modules are the standard framed unit with a tempered front glass and the durable clear polymer substrate. The module has got 50% transparency, so it can be used to increase natural light behind the module along with providing energy production and surely some shading.

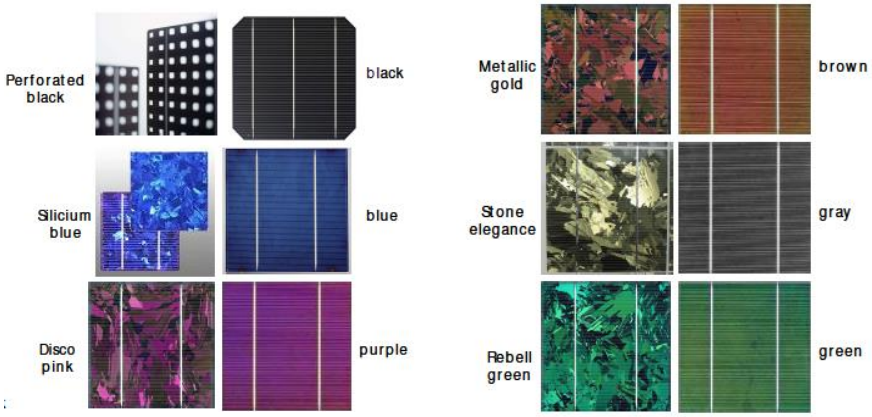

Fig. 8: Suntech glass PV colours

The most recently installed transparent PV applications is shown in Fig. 9. The system consists of 2x10 modules along with the total nominal power of 3,3 kWp.

Fig. 9: Suntech glass PV colours

3.2. New type of fixation system

Several cases when the roof of an existing building covered with a special plastic cover in order to keep it water tight. In cause some difficulty in the fixation of the support for the modules. For such a purpose, for example, it can be used the solution of Tectum flat roof system (Fig. 10.a), which has a feature of quick installation, lightweight (~12 kg/m^2) and high yields. It provides an intelligent, well-engineered, easy installation and simple maintenance solution (Tectum, 2015).

In Fig. 10 b. another type of fast fixation system is shown which provide a very fast installation procedure. Such solution allows a tilt angel at around 10-15 degrees.

Fig. 10.a. Tectum flat roof PV system

Fig. 10.b. Flat fixation of PV module installation, NVS (2014)

5. Conclusion

This paper gives an overview of the solar energy application fields worldwide. It discusses the solar thermal and the solar photovoltaic issues along with an attention to solar architectural questions. The new trends and technologies are also analysed and providing information on the solutions methods and approaches. Several examples are also given.

6. Acknowledgements

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