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Extended Abstract

Analysis of the Solar Collectors Installation on a Roof of the Small Public Building in Poland, Lithuania and Spain—A Case Study †

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Abstract: A solar collector market is most European countries is at the stage of continuous development, however its expansion rate differs. It shows that much more factors than only the local solar radiation is important, including a technology progress, costs, local manufactures' engagement, an economic government support or an environmentally consciousness raising relevant to a mitigating climate change. We conducted the analysis for a public office building, with a few toilets and a social room, used by 54 people. As a primary heat source for HVAC and DHW systems an oil boiler was used, whereas solar collectors were considered as an energy source for hot water preparation. The analysis was conducted for three locations of the building: Bialystok (Poland), Cordoba (Spain) and Kaunas (Lithuania), using a simulation software delivered within the framework of VIPSKILLS project. Theoretical hot water consumption was considered as 3–7 dm^3/(day person) in compliance with national recommendations. It was found that beam solar radiation share in a total radiation balance was nearly twice higher in Cordoba than in Bialystok or Kaunas. The highest efficiency (44%) was estimated in Cordoba for solar collectors installed with the tilt angle between 45–50°. In case of Bialystok and Kaunas the efficiency was lower than in Cordoba and nearly equal 40–41% and the recommended tilt angle was in a range 30– 45°.

Keywords: solar collectors; renewable energy; DHW; efficiency

1. Introduction

The use of renewable energy plays an important role in a sustainable economic growth, and helps the policy makers to meet the increasing energy demand, as well as reduce the growth of CO_2 emissions that are primarily generated through the consumption of fossil fuels.

A solar collector market in most European countries is at the stage of continuous development, however its expansion rate differs. It shows that much more factors than only the local solar radiation is important, including a technology progress, costs, local manufactures' engagement, an economic government support or an environmentally consciousness raising relevant to a mitigating climate change. The thermal energy consumption in development countries (including energy used for water heating) has been rising since 2000 [1]. According to the Directive on the promotion of the use of energy from renewable sources [2–3], the EU countries target is to produce at least 20% of all energy from renewable energy sources by 2020. Promoting the use of renewable energy sources is one of the best solutions to meet the energy needs of protecting nature and its resources. The installation of solar thermal systems into the design of buildings can provide a sustainable and efficient energy solutions for hot water supply systems. Implementation of solar thermal systems provides numerous opportunities and benefits, including greenhouse gas emission reductions, energy security, improved energy access, grid stability and resilience, improved quality of life, and new economic development opportunities. It can also mitigate burdens on local governments and infrastructure by reducing pressure on the national power system and diminishing pollution produced by conventional energy sources [1,4].

The aim of this paper is to compare purposefulness of solar collectors installation in small offices in different countries.

2. Materials and Methods

We conducted the analysis for a public office building (Figure 1), used by 54 people. There were a few toilets and a social room with total 12 water intake points. As a heat source for HVAC and DHW systems an oil boiler was used. needs of hot water, the building uses an oil boiler. We considered 3 locations of the building: Bialystok (Poland), Cordoba (Spain) and Kaunas (Lithuania).

Figure 1. Analyzed building.

According to Spanish recommendations in offices, 3 dm^3/day person should be considered in calculations [5]. In Poland regulation from 2008 [6] shows 7 dm^3/day per person, as the valued for the energy estimation while standard [7] recommends to set specific energy needs for hot water at 0.4 kWh per person per day. In Lithuania, according to act [8] hot water consumption is taken as 5–7 dm^3/day person. We considered plate water collectors with a gross area 2.05 m^2, and coefficient of efficiency 0.784.

3. Results and Discussion

Theoretical hot water and energy consumption in the analysed building for all locations was estimated in a range from 162 dm^3/day in Spain to 378 dm^3/day in Poland and Lithuania. Based on assumption of covering all DHW needs in months with maximum solar radiation 3 solar panels were selected in Bialystok, 2 collectors in Kaunas, whereas only 1 collector is needed in Cordoba. The difference between Poland and Lithuania follows on slightly higher solar radiation in Kaunas than in Bialystok. Figure 2 shows a contribution of the beam and diffuse radiation for analyzed locations of the building. In Cordoba the beam solar radiation share in the total radiation balance was nearly twice higher than in Bialystok or Kaunas.

The highest efficiency (44%) was estimated in Cordoba for solar collectors installed with the tilt angle between 45–50°, as shown in Figure 3. In case of Bialystok and Kaunas the efficiency was lower than in Cordoba and nearly equal 40–41% and the recommended tilt angle was in a range 30–45°.

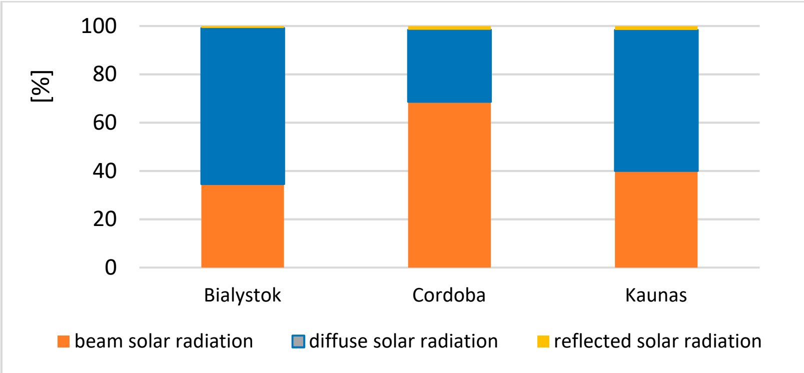
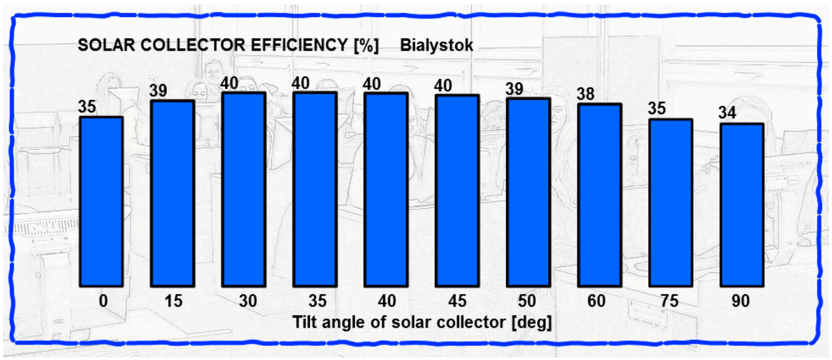
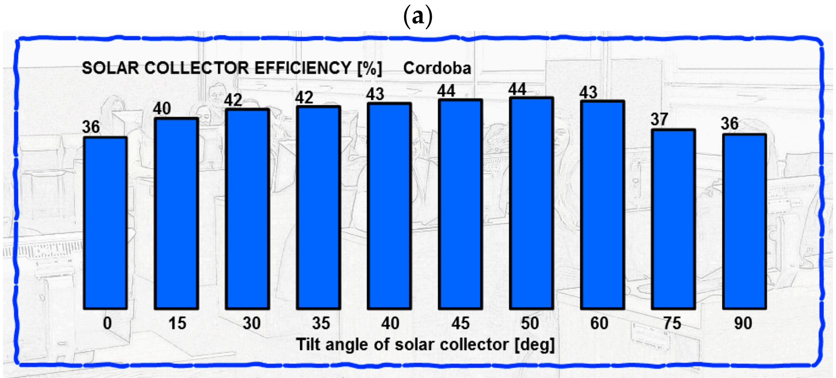


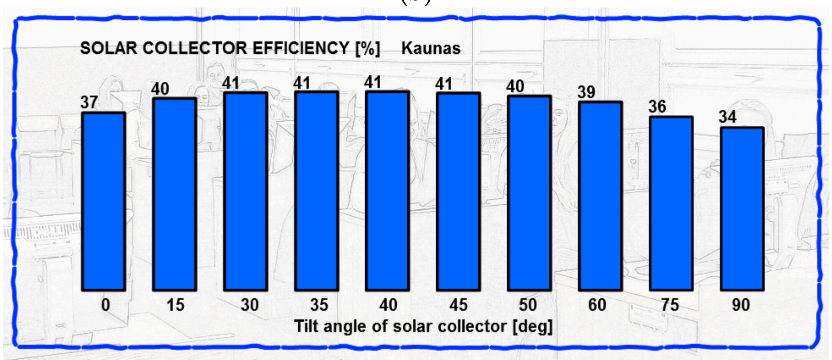
Figure 2. Contribution of beam and diffuse radiation in a total balance.



(**a**)



(**b**)



(**c**)

Figure 3. Efficiency of solar collectors in Bialystok (**a**), Cordoba (**b**) and Kaunas (**c**) in dependence on the tilt angle—drawn upon VIPSKILLS tools [9].

4. Conclusions

The results of our research leads showed a significantly different share of the beam and diffusion radiation in Spain and East Europe. Efficiency of solar collectors system was 3–4% higher in Cordoba than Białystok and Kaunas. The optimal tilt angle in Cordoba was found between 45–

50°, whereas in Bialystok and Kaunas the recommended tilt angle was in a range 30–45°. The lowest savings were estimated in Spain, as a result of much lower hot water demand, according to national recommendations and higher network water temperature.

Author Contributions: D.A.K. conceived the analysis. R.B. and D.A.K. prepared introduction part. M.Ż. delivered e-lab tool for analysis. D.A.K., M.Ż. and A.R. participated in simulations and calculation, as well as data analysis and making conclusions. D.A.K wrote the paper.

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Conflicts of Interest: The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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