Werner Weiss, Monika Spörk-Dür

Global Market Development
and Trends 2023
Detailed Market Figures 2022

SOLAR HEAT WORLD WIDE

Edition 2024

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

维尔纳-魏斯、莫妮卡-斯波尔克-迪尔

2023 年全球市场发展与趋势 2022 年详细市场数据

太阳能 HEAT 世界 WIDE

第 2024 版

SHC
SOLAR HEATING & COOLING PROGRAMME
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Global Market Development and Trends 2023
Detailed Market Figures 2022

2024 Edition

Werner Weiss, Monika Spörk-Dür

AEE - Institute for Sustainable Technologies
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2024 年版

维尔纳-魏斯、莫妮卡-斯波尔克-迪尔

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Country Data Contributors

We very much appreciate the long-term cooperation with all national delegates of the IEA SHC Executive Committee, Solar Heat Europe, and national experts, who provide updated solar thermal market data from 72 countries around the globe every year. All these contributors are listed in the Appendix of this report.

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我们非常感谢与国际能源机构太阳能热委员会执行委员会的所有国家代表、欧洲太阳能热委员会以及各国专家的长期合作，他们每年都会提供来自全球 72 个国家的最新太阳能热市场数据。所有这些贡献者的名单都列在本报告的附录中。

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Table of Contents

目录

1 Background

The Solar Heat Worldwide report has been published annually since 2005 within the framework of the Solar Heating and Cooling Technology Collaboration Programme (SHC TCP) of the International Energy Agency (IEA). This unique series of reports documents solar thermal energy development over the last twenty years.

The 2024 edition and past editions can be downloaded from the website, http://www.iea-shc.org/solar-heat-worldwide.

The report aims to achieve the following objectives:

1. Provide an overview of the general trends in the solar thermal industry.
2. Highlight unique applications and noteworthy projects within the sector.
3. Document the installed solar thermal capacity across key global markets.
4. Assess the contribution of solar thermal systems to energy supply and quantify the reduction in CO_2 emissions resulting from their operation.

The collector types detailed in the report are unglazed collectors, glazed flat plate collectors (FPC), evacuated tube collectors (ETC) with water as the energy carrier, and glazed and unglazed air collectors.

Photovoltaic Thermal (PVT) systems are included, as this market has grown in relevance in recent years.

Photovoltaic-generated heat systems are a pioneering technology, and this edition documents them in more detail for the first time.

1 背景介绍

自 2005 年以来，在国际能源机构（IEA）的太阳能加热和冷却技术合作计划（SHC TCP）框架内，每年都会出版《全球太阳能热能》报告。这一系列独特的报告记录了过去二十年太阳能热能的发展。

2024editionandpasteditions 可从网站 http://www.iea-shc 下载。

org/solar-heat-worldwide.

本报告旨在实现以下目标

1. 概述太阳能热利用行业的总体趋势。
2. 突出行业内独特的应用和值得关注的项目。
3. 记录全球主要市场的光热装机容量。
4. 评估太阳能热系统对能源供应的贡献，并量化其运行所减少的二氧化碳排放量。

报告中详细介绍的集热器类型包括无釉集热器、有釉平板集热器 (FPC)、以水为能源载体的真空管集热器 (ETC)，以及有釉和无釉空气集热器。

光电热能（PVT）系统也包括在内，因为近年来这一市场的相关性不断提高。

Photovoltaic-generatedheatsystems 是一项开创性技术，本版首次对其进行了更详细的记录。

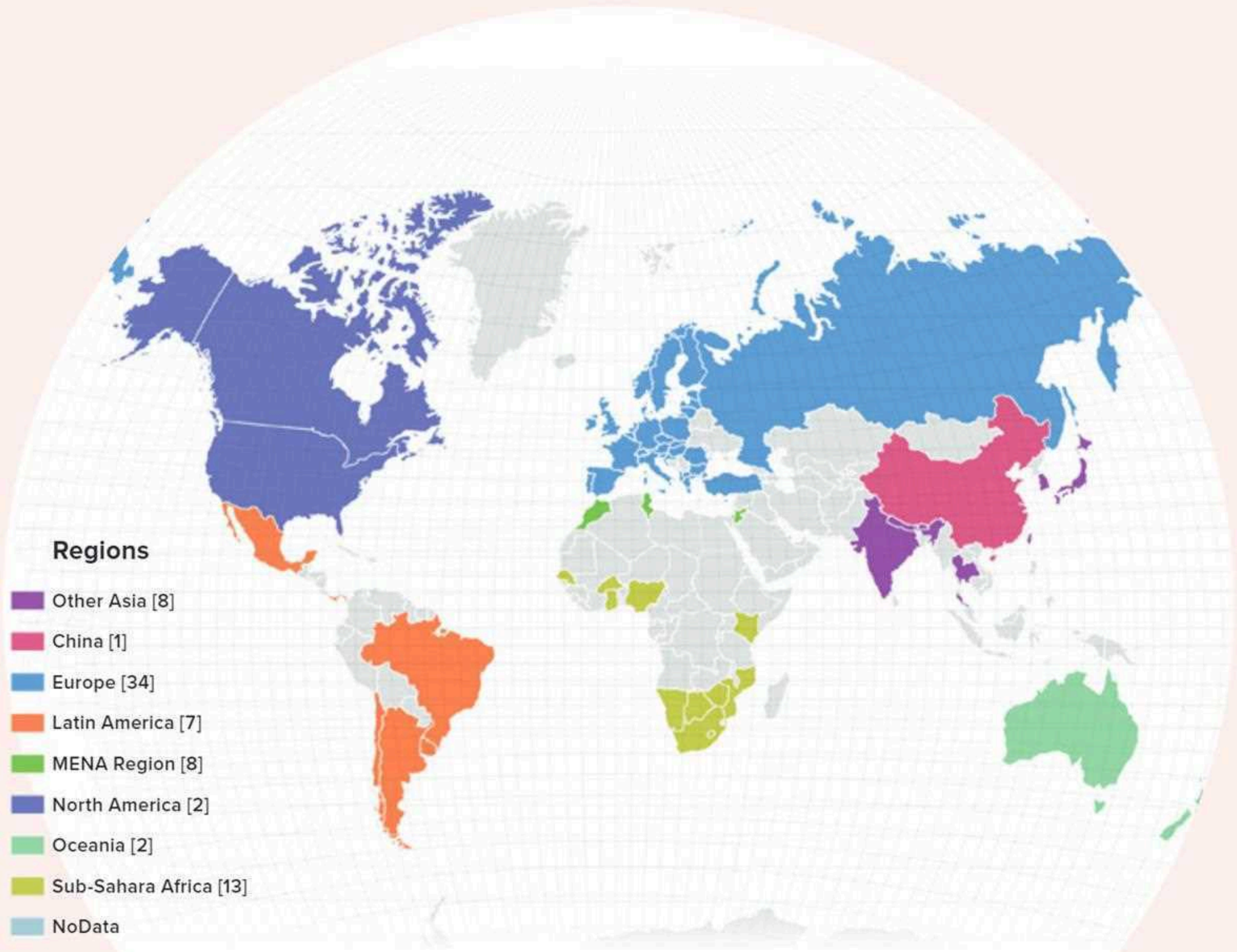

Figure 1: Countries shown in color have detailed market data. Countries shown in grey have estimated market data.
Source: Natural Earth v.4.1.0, 2020/ AEE INTEC

The report's data was collected through a survey of the national delegates of the SHC TCP Executive Committee, Solar Heat Europe, and national experts active in the field of solar thermal energy. As some of the 72 countries included in this report have very detailed statistics and others have only estimates from experts, the data was checked for plausibility based on various publications.

The collector area, also known as the installed capacity, served as the basis for estimating the contributions of solar thermal systems to the energy supply and reductions of CO_2 emissions.

The 2024 edition and past editions can be downloaded from the website,
http://www.iea-shc.org/solar-heat-worldwide.

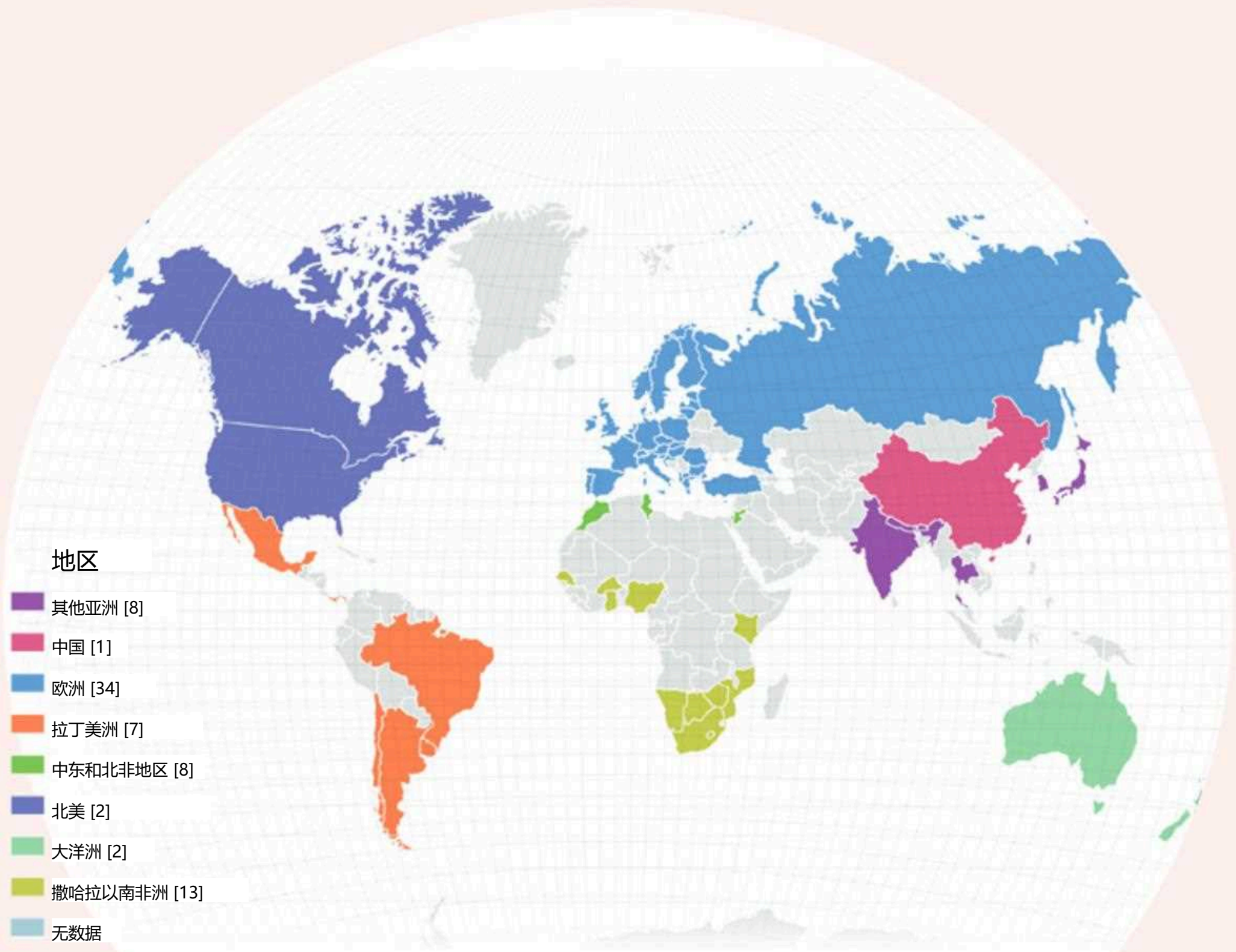

图 1：彩色显示的国家拥有详细的市场数据。
灰色显示的国家有估计的市场数据。
资料来源资料来源：Natural Earth v.4.1.0，2020/ AEE INTEC

本报告的数据是通过对 SHC TCP 执行委员会的各国代表、欧洲太阳能热利用组织以及活跃在太阳能热利用领域的各国专家进行调查而收集的。由于本报告收录的 72 个国家中，有些国家有非常详细的统计数据，有些国家只有专家的估计数据，因此我们根据各种出版物对数据的可信度进行了检查。

集热器面积也称为装机容量，是估算太阳能热系统对能源供应和减少二氧化碳排放量贡献的基础。

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http://www.iea-shc.org/solar-heat-worldwide.

2 Summary

Photo: Abora Solar, Spain

This report is divided into three sections: The first part (Chapters 3 - 5) provides an overview of the global solar thermal market in 2023, highlighting key trends and showcasing successful applications such as solar-assisted district heating, solar heat for industrial processes, hybrid photovoltaic thermal systems, and photovoltaic generated heat systems. Additionally, Chapter 5 offers insights and projections for developments expected in 2024.

The second part (Chapters 6 - 8) offers detailed market data for 2022 from 72 surveyed countries. Notably, this year's edition includes data from Nepal, a new country, in the survey. Alongside figures for installed collector area and related capacity, this section delves into the distribution of collectors across various systems and applications, as well as solar yields and emissions reduction.

The third part (Chapter 9) outlines the methodological approach, reference systems, climate and population data, literature references, and data sources used in the report.

Global solar thermal market developments in 2023

As of the end of 2023, the total operational solar thermal capacity reached 560 GW_{th}, equivalent to 800 million square meters of collector area. This means a net increase of 18 GW_{th} or 26 million square meters of collector area in 2023, or in other words, an increase in cumulative global installed capacity of 3% in 2023 compared to 2022.

The annual solar thermal energy yield of this installed capacity amounted to 456 TWh, which correlates to savings of 49.1 million tons of oil and 158.4 million tons of CO_2.

Despite the overall increase in total installed capacity, it's noteworthy that the installed capacity of 21 GW_{th} or 30 million square meters of collector area in 2023 marked a decrease from the previous year's figure of 22.7 GW_{th}. This indicates a 7% decline in the global solar thermal market compared to 2022.

Large-scale solar heating systems for district heating or residential, commercial, and public buildings

In 2023, 28 new large-scale solar heating systems (>350 kW_{th}, 500 m^2) were constructed, totaling 139 MW_{th} capacity. This brought the global count to 598 systems, with a combined capacity of 2,285 MW_{th}, corresponding to 3.3 million square meters of collector area.

2

摘要

本报告分为三个部分：第一部分（第 3-5 章）概述了 2023 年全球太阳能热利用市场，重点介绍了主要趋势，并展示了太阳能辅助区域供热、工业流程太阳能热利用、混合光伏热利用系统和光伏发电供热系统等成功应用。此外，第 5 章还对 2024 年的发展进行了深入分析和预测。

第二部分（第 6-8 章）提供了 72 个被调查国家 2022 年的详细市场数据。值得注意的是，今年的调查包括了尼泊尔这个新国家的数据。除了集热器安装面积和相关容量的数据外，本部分还深入探讨了集热器在各种系统和应用中的分布情况，以及太阳能产量和减排情况。

第三部分（第 9 章）概述了报告中使用的方法、参考系统、气候和人口数据、文献参考以及数据来源。

照片西班牙阿博拉太阳能公司

2023 年全球太阳能热利用市场发展

截至 2023 年底，全球太阳能热发电总装机容量达到 560 千兆瓦，相当于 8 亿平方米的集热器面积。这意味着 2023 年将净增 18 千兆瓦或 2600 万平方米的集热器面积，换句话说，与 2022 年相比，2023 年全球累计装机容量增加了 3%。

这些装机容量的太阳能热能年产量达 456 太瓦时，相当于节省了 4910 万吨石油和 1.584 亿吨二氧化碳。

尽管总装机容量总体上有所增加，但值得注意的是，2023 年的装机容量为 21 千兆瓦，即 3,000 万平方米的集热器面积，与上一年的 22.7 千兆瓦相比有所下降。这表明与 2022 年相比，全球太阳能热利用市场下降了 7%。

用于区域供热或住宅、商业和公共建筑的大型太阳能供热系统

2023 年，新建了 28 个大型太阳能供热系统（大于 350 千瓦，500 平方米），总容量达 139 兆瓦。这样，全球共有 598 个系统，总容量为 2285 兆瓦，相当于 330 万平方米的集热器面积。

The largest sub-sector of large-scale solar thermal heating systems is solar district heating, comprising 336 systems with 1,908 MW_{th} capacity (2.73 million square meters).

Solar heat for industrial processes (SHIP)
In 2023, at least 116 new SHIP plants with a capacity of 94 MW_{th} were installed worldwide.
This means a tripling of installed capacity compared to 2022. Even though this is a very good development, it should be noted that this corresponds to the average installed capacity in the solar process heat sector over the last seven years.

The total number of SHIP plants is approximately 1,200 systems, with a 1.4 million square meters collector area and a capacity of 951 MW_{th}.

Photovoltaic-Thermal (PVT) collectors
After experiencing steady growth averaging 9% annually between 2017 and 2020, followed by an all-time high of 13% in 2021, the trend took a sharp turn in 2022. The decline, driven by the end of subsidies for PVT in certain countries, led to market slumps of 51% in 2022 and 30% in 2023.

The newly installed capacity in 2023 was 29.5 MW_{th} and 14.5 MW_{peak}. Thus, the cumulative installed PVT collector area is 1.6 million square meters, which relates to a thermal capacity of 822 MW_{th} and an electrical capacity of 292 MW_{peak}.

Photovoltaic-generated heat systems
An emerging trend is the utilization of photovoltaic-generated heat. This can be seen in the small system sector with directly coupled "PV2Heat" systems in South Africa, where 34,000 systems of this type have been installed. In addition, with a growing number of solar combisystems providing hot water and space heating supply in residential buildings, and the two PV district heating systems built in 2023.

Market status worldwide in 2022

Photo: Savo Solar / Solar Heat Europe

While 2023 data is only available for 20 leading countries, the report includes detailed 2022 data on 72 countries.

122 million solar thermal systems were in operation at the end of 2022.

The top 5 countries by total installed capacity at the end of 2022 were again The People's Republic of China (hereinafter China), Turkey, the United States, Germany and Brazil.

However, the picture is different when comparing the data on a per capita basis.
The top 5 countries by installed capacity per 1,000 inhabitants are Barbados, Cyprus, Israel, Austria, and Greece.

In 2022 **evacuated tube collectors represented 59%** of the newly installed capacity, followed by flat plate collectors with a share of 34%.

In the global context, this breakdown is mainly driven by the dominance of the Chinese market, where around 73% of all newly installed collectors in 2022 were evacuated tube collectors, but also by the Indian market, with 95% of newly installed collectors being evacuated tubes.

Nevertheless, it is notable that the share of evacuated tube collectors worldwide decreased from about 82% in 2011 to 59% in 2022, while flat plate collectors increased their share from close to 15% to 34%.

In Europe, the situation is almost the opposite of that in China, with 72% of all solar thermal collectors installed in 2022 being flat plate collectors. In the medium term, however, the share of flat plate collectors decreased in Europe from 81% in 2011 to 72% in 2022. In contrast, Europe's share of evacuated tube collectors increased between 2011 and 2021 from 16% to 28%.

Distribution by system type
Pumped systems accounted for 61% of all newly installed systems in 2022, while 39% were thermosiphon systems.

Employment and turnover
Based on a comprehensive literature survey and data collected from detailed country reports, the number of jobs in the production, installation, and maintenance of solar thermal systems is estimated to be 345,000 worldwide in 2022.[1]

The estimated worldwide turnover of the solar thermal industry in 2022 is € 15.3 billion (US$ 16.4 billion).

[1] Background information on the methodology used can be found in the Appendix, Chapter 9.3.

大型太阳能热供暖系统中最大的分部门是太阳能区域供暖，包括 336 个系统，容量达 1908 兆瓦（273 万平方米）。

工业流程太阳能供热（SHIP）
2023 年，全球将新建至少 116 座 SHIP 发电站，装机容量为 94 兆瓦。这意味着与 2022 年相比，装机容量增加了两倍。尽管这是一个非常好的发展，但应该注意的是，这与过去七年太阳能工艺加热领域的平均装机容量相当。
SHIP 发电站总数约为 1,200 个，集热器面积达 140 万平方米，发电量为 951 兆瓦。

光伏-热（PVT）集热器
在经历了 2017 年至 2020 年平均每年 9% 的稳定增长，以及 2021 年 13% 的历史新高之后，这一趋势在 2022 年急转直下。由于某些国家停止了对光伏发电的补贴，导致 2022 年和 2023 年市场分别下滑了 51% 和 30%。
2023 年的新增装机容量分别为 29.5 兆瓦和 14.5 兆瓦。因此，光伏集热器的累计安装面积为 160 万平方米，相当于 822 兆瓦的热容量和 292 兆瓦的电容量。

光伏供热系统
一个新兴趋势是利用光伏发电产生的热量。这可以从南非直接耦合 "PV2Heat "系统的小型系统领域看出，南非已经安装了 34 000 套此类系统。此外，越来越多的太阳能组合系统为住宅楼提供热水和空间供热，2023 年还将建成两个光伏区域供热系统。

2022 年全球市场现状

照片萨沃太阳能公司/欧洲太阳能供热公司

虽然目前只有 20 个主要国家的 2023 年数据，但报告包含了 72 个国家的 2022 年详细数据。

到 2022 年底，有 1.22 亿个太阳能热系统投入使用。
到 2022 年底，总装机容量排名前五的国家仍然是中华人民共和国（以下简称 "中国"）、土耳其、美国、德国和巴西。

然而，如果按人均数据进行比较，情况则有所不同。按每千名居民的装机容量计算，排名前五位的国家分别是巴巴多斯、塞浦路斯、以色列、奥地利和希腊。
2022 年，真空管集热器占新安装容量的 59%，其次是平板集热器，占 34%。
在全球范围内，这一细分主要受中国市场主导地位的影响，在 2022 年新安装的所有集热器中，约 73% 为真空管集热器，但印度市场也是如此，95% 的新安装集热器为真空管集热器。
不过，值得注意的是，全球真空管集热器的份额从 2011 年的约 82% 下降到 2022 年的 59%，而平板集热器的份额则从接近 15%上升到 34%。
欧洲的情况几乎与中国相反，2022 年安装的所有太阳能集热器中有 72% 是平板集热器。然而，从中期来看，欧洲平板集热器的比例从 2011 年的 81% 降至 2022 年的 72%。相比之下，2011 年至 2021 年期间，欧洲的真空管集热器所占比例从 16% 增加到 28%。

按系统类型分布
2 0 2 2 年，泵送系统占所有新安装系统的 61%，而热虹吸系统占 3 9%。

就业和更替
根据全面的文献调查和从详细的国家报告中收集到的数据，预计到 2022 年，全球在太阳能热系统的生产、安装和维护方面的工作岗位数量将达到 345 000 个。
据估计，2022 年全球太阳能热利用行业的营业额将达到 153 亿欧元（164 亿美元）。

[1] 有关所用方法的背景信息，请参见附录第 9.3 章。

3 Worldwide solar thermal capacity in 2023

As shown in the figure below, the global solar thermal capacity of unglazed and glazed water collectors grew from 62 GW_{th} (89 million m^2) in 2000 to 560 GW_{th} (800 million m^2) in 2023. The corresponding annual solar thermal energy yields amounted to 51 TWh in 2000 and 456 TWh in 2023. The cumulated worldwide installed capacity increased by 3% in 2023 compared to 2022. (Figure 2).

Figure 3 shows the annual installed collector capacities and the net additions.[2] In 2023, a total capacity of 21 GW_{th}, or 30 million square meters of collector area, was installed. This means the global solar thermal market declined 7% compared to 2022.

Over the past decade, it's evident that the yearly rate of new installations has decreased by over fifty percent. Most of this development is due to the ongoing challenges in the real estate sector in China, which have persisted for several years. This became clear again in 2023, as the globally dominant Chinese market experienced a significant slump of 7.7%.

[2] The net addition is the difference between the annually installed collector capacity minus the collector capacity of those collectors that have reached their statistical lifespan of 25 years. For details in the lifespan see chapter 6.

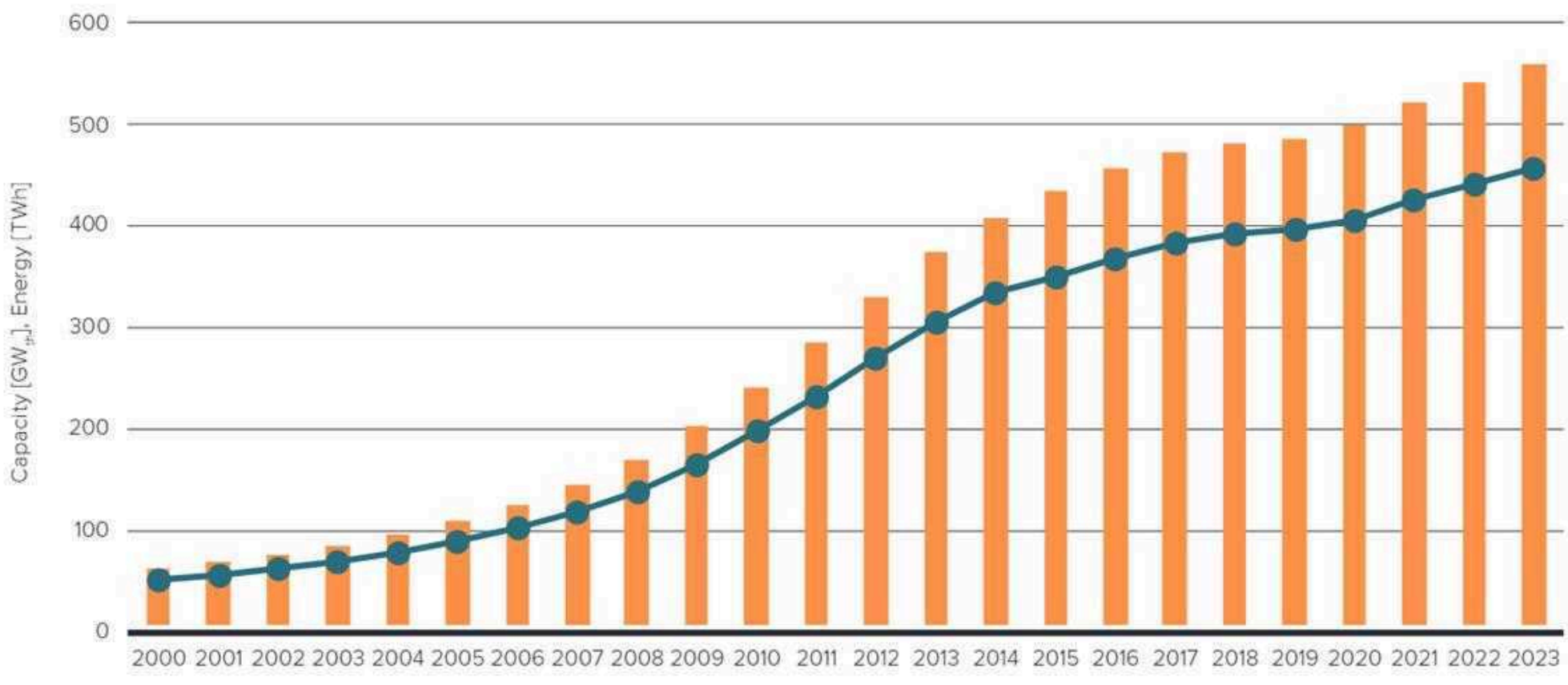

Figure 2: Global solar thermal capacity in operation and annual energy 2000-2023

3 2023 年全球太阳能热发电能力

如下图所示，全球无釉和有釉集热器的太阳能热发电能力从 2000 年的 62 千兆瓦（8900 万米）增长到 2023 年的 560 千兆瓦（8 亿米）。相应的太阳能热能年产量在 2020 年达到 51 太瓦时，2023 年达到 4 560 太瓦时。与 2022 年相比，2023 年全球装机容量增加了 3%（图 2）。(图 2）。

图 3 显示了每年已安装的集热器容量和净增容量。2023 年的总装机容量为 21 千兆瓦，即 3,000 万平方米的集热器面积。这意味着全球太阳能热利用市场与 2022 年相比下降了 7%。

在过去十年中，每年的新安装率明显下降了五成以上。造成这种情况的主要原因是中国房地产行业持续多年的挑战。这一点在 2023 年再次变得明显，因为全球占主导地位的中国市场经历了 7.7% 的大幅下滑。

[2] 净增加量是每年安装的集热器容量减去已达到 25 年统计寿命的集热器容量后的差额。有关使用寿命的详细信息，请参见第 6 章。

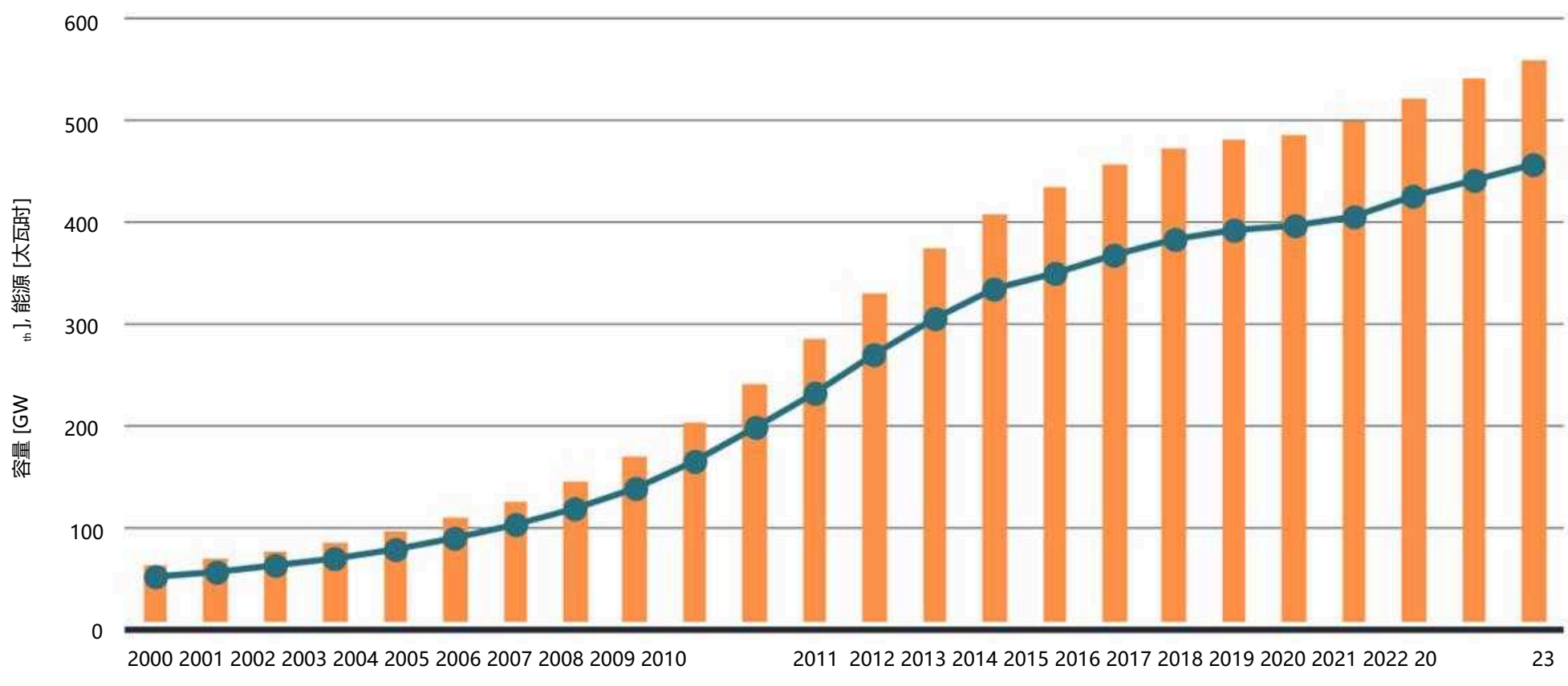

图 2：2000-2023 年全球太阳能热发电运行能力和年发电量

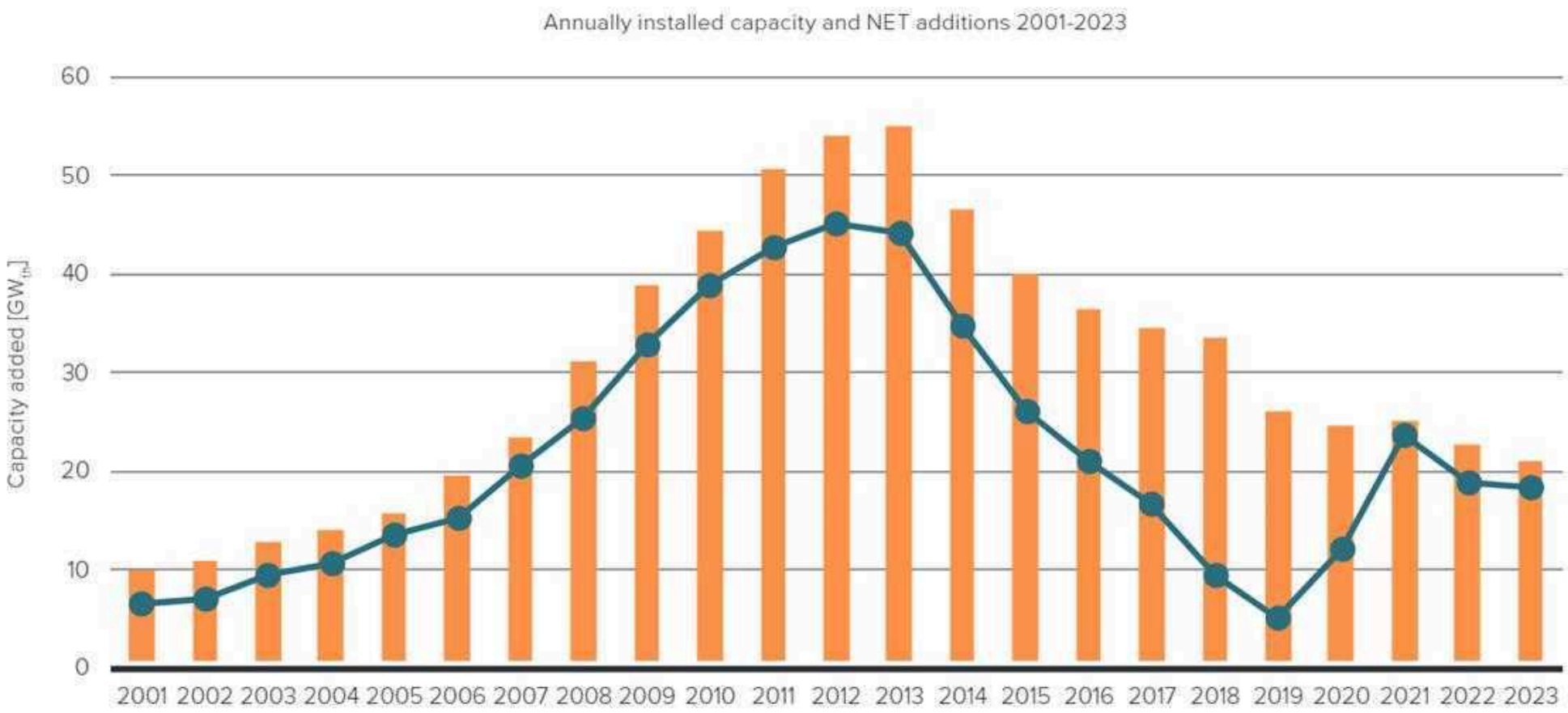

Figure 3: Annual installed collector capacity and net additions

Annually installed capacity of water collectors [GW$_{th}$]
Water collectors NET additions [GW$_{th}$]

Figure 4 illustrates the annual installed collector capacity categorized by collector type and total installed collector capacity. This clearly shows how different the various collector types have developed globally. While the market for flat plate (FPC) and unglazed collectors remained almost constant, the market for evacuated tube collectors (ETC) contracted. This is again primarily due to market developments in China and, to some extent, India, as evacuated tube collectors dominate these two countries.

Environmental effects and contribution to climate goals

In 2023, the global solar thermal energy yield from all installed systems corresponds to savings of 49.1 million tons of oil and 158.4 million tons of CO_2. This underscores the substantial contribution of this technology toward mitigating global greenhouse gas emissions.

158.4
million tons of CO_2 avoided

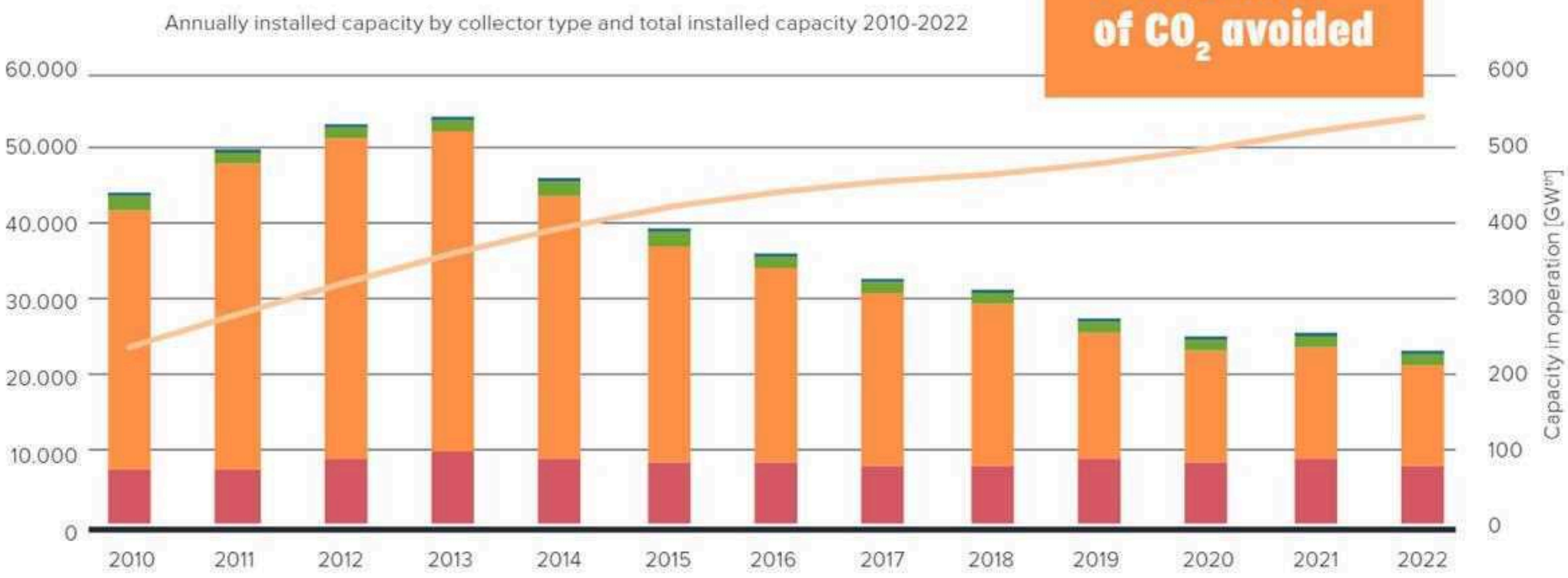

Figure 4: Annually installed capacity by collector type and total installed capacity 2010-2022

图 3：每年集热器装机容量和净增加量

图 4 显示了按集热器类型和集热器总装机容量分类的年集热器装机容量。这清楚地显示了各种集热器类型在全球范围内的发展差异。平板集热器（FPC）和无釉集热器的市场几乎保持不变，而电子集热器（E TC）的市场则有所萎缩。这主要还是由于中国的市场发展，在一定程度上也是由于印度的市场发展，因为这两个国家的集热器以真空管集热器为主。

环境影响和对气候目标的贡献

2023 年，全球所有已安装系统的太阳能热发电量相当于节约 4910 万吨石油和 1.584 亿吨二氧化碳。这凸显了该技术对减少全球温室气体排放的巨大贡献。

158.4
百万吨
避免的二氧化碳排放量

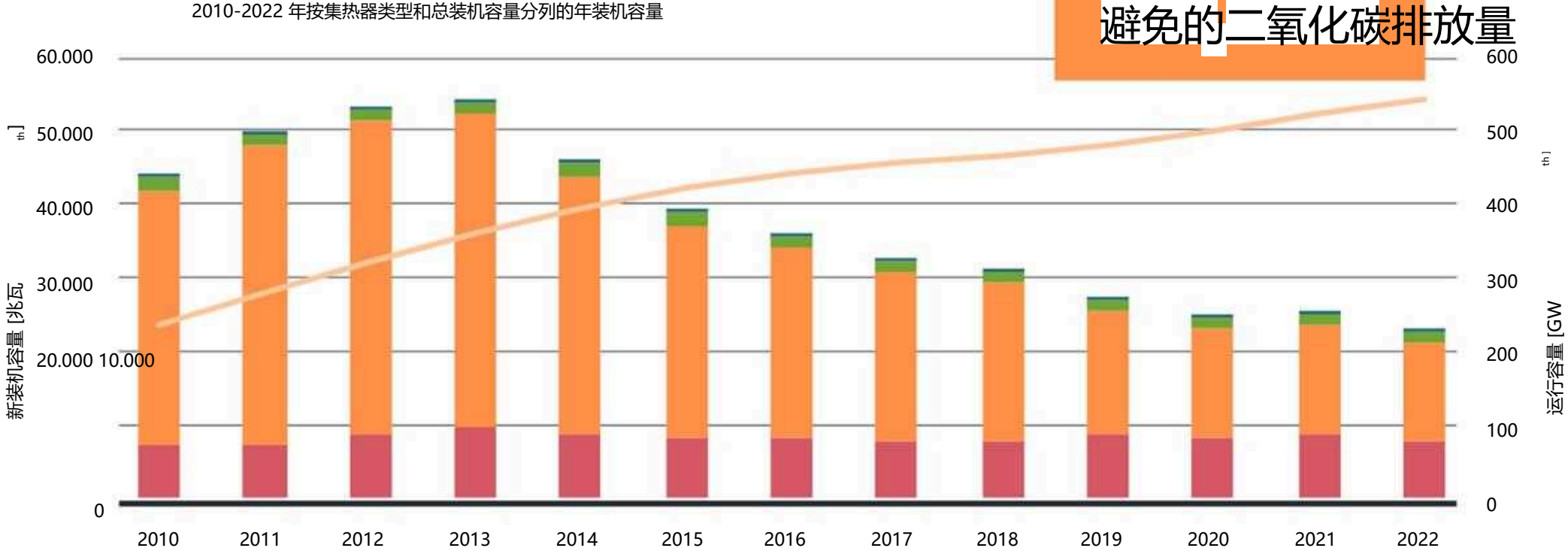

图 4：2010-2022 年按集热器类型和总装机容量分列的年装机容量

Parabolic trough collectors at Iberafrica in Kenya
Photo: Absolicon Solar Collector AB, Sweden

3.1 Solar thermal capacity in relation to the capacity of other renewable energy technologies

The cumulated solar thermal capacity in operation by the end of 2023 was 560 GW_{th}[3], which trailed behind wind power's installed capacity of 1,021 GW_{el} and photovoltaics 1,581 GW_{el} of installed capacity (Figure 5). Geothermal energy and concentrated solar (thermal) power (CSP) lag behind these three technologies in installed capacity. The total capacity of geothermal power was 15 GW_{el}. and CSP was 7 GW_{el}.

In terms of energy, solar thermal systems supplied 456 TWh of heat, whereas wind turbines supplied 2,496 TWh and photovoltaic systems 1,805 TWh of electricity.

[3] The figures for 2023 are based on the latest market data from Australia, Austria, Belgium, Bhutan, Brazil, China, Cyprus, Denmark, Germany, Greece, India, Italy, Mozambique, Poland, Portugal, South Africa, Spain, Switzerland, Turkey, United Kingdom and USA which represent about 95% of the cumulated installed capacity in operation in 2023.

Global capacity in operation [GW_{el}], [GW_{th}] and Energy supplied [TWh_{el}], [TWh_{th}], 2023

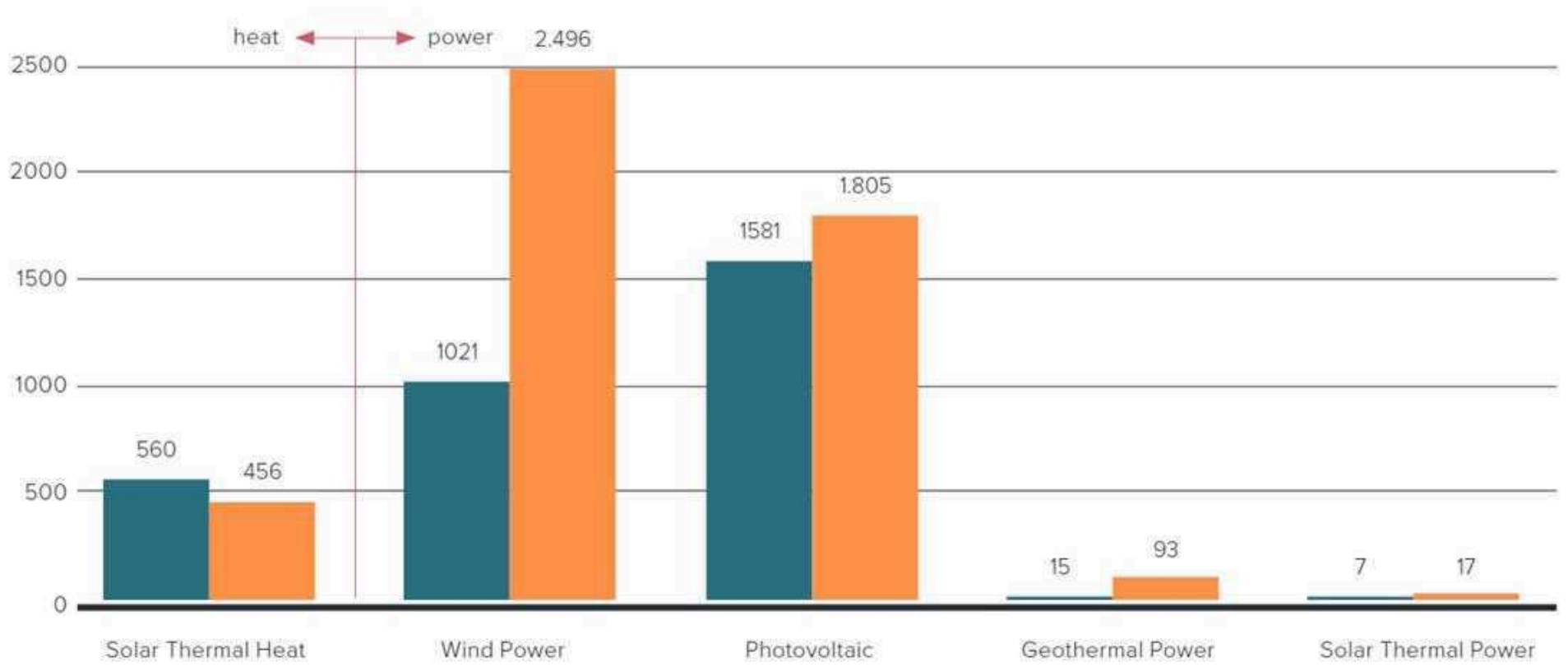

Figure 5: Global capacity in operation [GW_{el}], [GW_{th}] 2023 and annual energy yields [TWh_{el}], [TWh_{th}]
(Solar Thermal: AEE INTEC, Wind Power: Global Wind Energy Council (GWEC), Photovoltaic: IEA Solar PVPS (https://iea-pvps.org/snapshot-reports/snapshot-2024/), Geothermal Power and Solar Thermal Power: Irena Renewable Energy Capacity Statistics 2023

肯尼亚 Iberafrica 的抛物面槽式集热器
照片瑞典 Absolicon 太阳能集热器公司

3.1 相对于其他可再生能源技术的太阳能热发电能力

截至 2023 年底，累计运行的太阳能热发电装机容量为 5.6 亿千瓦，落后于风力发电 10.21 亿千瓦的装机容量和光伏发电 15.81 亿千瓦的装机容量（图 5）。地热能和聚光太阳能（热）发电（CSP）的装机容量落后于这三种技术。地热发电的总装机容量为 15 千兆瓦，CSP 为 7 千兆瓦。

在能源方面，太阳能热系统提供了 456 太瓦时的热量，而风力涡轮机提供了 2496 太瓦时的电量，光伏系统提供了 1805 太瓦时的电量。

[3] 2023 年的数据基于澳大利亚、奥地利、比利时、不丹、巴西、中国、塞浦路斯、丹麦、德国、希腊、印度、意大利、莫桑比克、波兰、葡萄牙、南非、西班牙、瑞士、土耳其、英国和美国的最新市场数据，这些国家约占 2023 年累计运行装机容量的 95%。

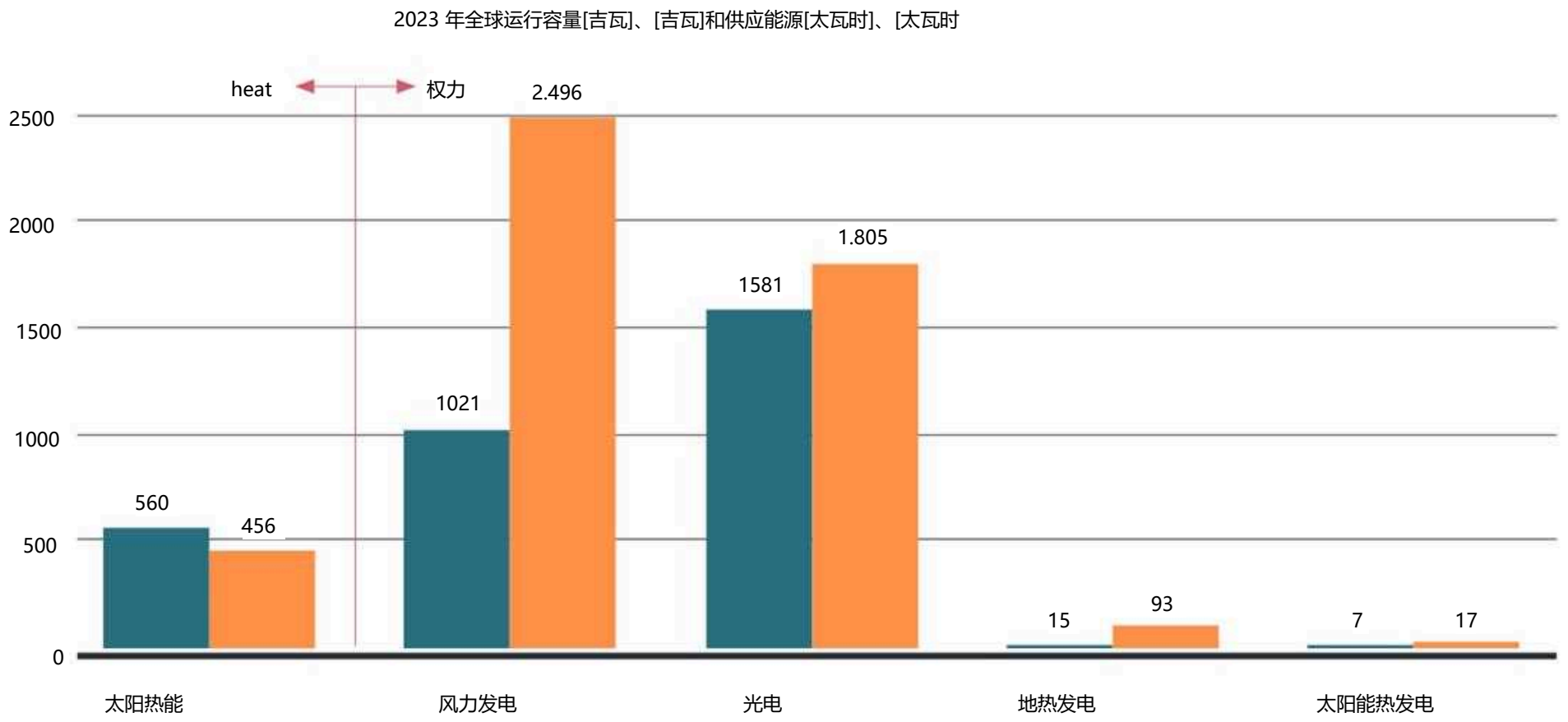

图 5：2023 年全球运行容量[吉瓦]、[吉瓦]和年发电量[太瓦时]、[太瓦时]
(太阳能热：风能：全球风能理事会 (GWEC)；光伏：国际能源机构太阳能光伏发电系统 (snapshot-reports/sapshot-2024/)光伏：IEA Solar PVPS (https://iea-pvps.org/ snapshot-reports/snapshot-2024/)，地热发电和太阳能热发电：Irena Renewable Energy Capacity Statistics 2023

4 Outlook 2024 and beyond

Even if the annual heat consumption expanded by 6% over 2017-2022 [4], the global final energy consumption for heating and cooling has remained virtually unchanged at around 50% of the total final energy consumption for many years. According to the IEA Renewables 2022 report, industrial processes are responsible for 53% of the final energy consumed for heat, while another 44% is used in buildings for space and water heating.[5] The remainder is used in agriculture, primarily for greenhouse heating.

The heating sector is dominated by fossil fuels. Apart from traditional biomass, only 13% of the global heating needs were met by modern renewables in 2022.[4] According to Eurostat, the share of renewables for heating and cooling in the European Union was 22.9% in 2021. This is twice the global share but still did not cover even a quarter of heat consumption.

The IEA Renewables Report 2023 assumes that the share of heat from renewable energy will increase by more than 40% (+12 EJ) worldwide in 2023-2028. However, this growth corresponds to only 70% of the projected global increase in total heat demand, leading to a rise in fossil fuel consumption for heat and the associated CO_2 emissions (+5%/+0.6 Gt CO_2 in annual emissions).

This means that we must significantly accelerate the implementation of renewables if we want to achieve the international targets for reducing greenhouse gas emissions on time.

This demand for renewables can only be met through the intensive utilization of solar thermal energy, modern biomass applications, geothermal energy, and carbon-free electricity.

With the building and industrial sectors consuming about 97% of the final energy consumed for heat, there is enormous potential for solar thermal to not only provide hot water and space heating but also be used for district heating in urban areas and industrial process heat.

Based on the data available, demand for large-scale solar thermal systems appears to increase in 2024. If one also considers that the development of large-scale systems for solar district heating and industrial process heat has a long lead time and that most of the policies related to renewable heat were only implemented in 2022, then it can be assumed there will be significant growth in the number of solar thermal systems in the coming years.

As mentioned above, increased demand is expected in the building and industry sectors. Solar thermal energy offers a cost-effective way to make urban district heating systems CO_2-neutral. As shown by plants already installed, solar heat can be provided at costs between 20 and 50 €/MWh under favorable conditions. This is significantly lower than the prices end customers currently pay for district heating.

The following paragraphs highlight recent developments and trends in solar district heating and solar heating for industrial processes (SHIP).

Solar heat costs range from €20 to €50/MWh

[4] Renewables 2023 – Analyses IEA, January 2024
[5] Renewables 2022: Renewable analysis and forecasts to 2027, IEA, January 2023

4 2024 年展望及以后

即使 2017-2022 年间每年的热能消耗量增长了 6%，全球用于供热和制冷的最终能源消耗多年来一直保持不变，约占最终能源消耗总量的 50%。根据国际能源机构《2022 年可再生能源》报告，工业生产过程消耗的热量占最终能源消耗的 53%，另有 44% 用于建筑物的空间和水加热。其余则用于农业，主要是温室供暖。

供暖行业以化石燃料为主。除传统的生物质能外，2022 年全球供暖需求中仅有 13% 由现代可再生能源满足。根据欧盟统计局（Eurostat）的数据，2021 年可再生能源在欧盟供热和制冷领域的比例为 22.9%。这一比例是全球的两倍，但仍无法满足四分之一的供热需求。

国际能源机构《2023 年可再生能源报告》假定，2023-2028 年全球可再生能源供热份额将增加 40% 以上（+12 EJ）。然而，这一增长仅相当于全球热能总需求预计增长量的 70%，这将导致热能化石燃料消耗量和相关二氧化碳排放量的增加（+5%/+0.6 千兆吨二氧化碳年排放量）。

这意味着，如果我们想按时实现减少温室气体排放的国际目标，就必须大大加快可再生能源的实施。

对可再生能源的需求只能通过大量利用太阳能热能、现代生物质能应用、地热能和无碳电力来满足。

建筑和工业部门消耗的热能约占最终能源消耗的 97%，因此，太阳能热不仅在提供热水和空间供暖方面具有巨大的潜力，而且还可用于城市地区的区域供暖和工业加工热。

根据现有数据，2024 年对大型太阳能热系统的需求似乎会增加。如果再考虑到开发大型太阳能区域供热和工业过程供热系统需要较长的准备时间，而且大多数与可再生能源供热相关的政策仅在 2022 年实施，那么可以推断未来几年太阳能热系统的数量将大幅增长。

如上所述，建筑和工业部门的需求预计会增加。太阳能热能为城市区域供热系统实现二氧化碳中和提供了一种经济有效的方法。正如已安装的设备所示，在有利条件下，太阳能供热的成本在 20 至 50 欧元/兆瓦时之间。这大大低于终端用户目前为区域供热支付的价格。

太阳能区域供热和工业过程太阳能供热（SHIP）的发展和趋势。

太阳能供热成本
从
20 欧元至
50 欧元/兆瓦时

[4] 2023 年可再生能源--国际能源机构的分析，2024 年 1 月
[5] 2022 年可再生能源：至 2027 年的可再生能源分析与预测》，国际能源机构，2023 年 1 月

Increasing demand for solar district heating in Europe

According to the German Steinbeis research institute Solites, in March 2024, six new solar thermal systems for district heating networks with a total collector area of 13,955 square meters (9.4 GW_{th}) went into operation in 2023. Although this is less than expected, it is because the announced federal funding program for efficient district heating networks was released with a delay. Nevertheless, the positive trend of previous years appears set to continue in 2024 and beyond. Nine systems representing a collector area of 112,000 m^2 (78 MW_{th}) are under construction or in an advanced planning stage. Another 70 systems with a collector area of 400,000 m^2 (280 MW_{th}) are under concrete discussion or construction, according to Solites.

78 MW_{th} solar district heating in the pipeline in Germany

One of these German systems is in Sonderhausen with 4.3 MW_{th} of high-vacuum flat plate collectors (6,086 m^2). This system should start operating at the end of the first half 2024. In March 2024, in the city of Leipzig, construction began on the largest solar district heating plant in Germany. It has a capacity of 41 MW_{th} (58.500 m^2). During summer, the plant is expected to supply up to 20% of Leipzig's heat demand, contributing an average of around 2% annually. The plant is scheduled to be completed by the end of 2025 and will feed heat into the city's district heating network starting in 2026.

Another large-scale solar district heating system with a collector area of 48,000 m^2 (33.6 MW_{th} capacity) is nearing completion in Groningen in the Netherlands. According to information from the installation company, this system is scheduled to be completed in June 2024.[6]

Large-scale SHIP plants in the pipeline

In 2023, 116 solar thermal systems were built and put into operation, supplying industrial processes in various sectors. A clear trend here was that the large industrial process heat systems were predominantly built with concentrating collectors that enable the provision of higher temperatures (see Chapter 5.3.1).

This trend will continue in the coming years, as shown by currently planned systems worldwide. Some of these SHIP systems are presented below.

1.5 GW_{th} for an Aluminum Refinery

By far, the largest solar thermal plant in the project planning phase is the first GW-scale plant for an aluminum refinery of the Saudi Arabian mining company Ma'aden Group. As reported in the 2023 edition of the Solar Heat Worldwide report, the system builder Glasspoint and Saudi Arabia's leading mining company signed a memorandum of understanding in 2022 to build the world's largest solar process heat plant. The plant is to be built in Ras al Khair with a capacity of 1.5 GW_{th}, corresponding to a collector area of 6 km^2. It will produce 3,000 GWh annually using parabolic trough collectors and reduce the refinery's carbon emissions by 600,000 tons annually. The average daily steam production is expected to be 14,000 tons. Construction is scheduled to start in 2024, and the first solar steam will be used to refine bauxite ore into aluminum oxide in 2026.[7]

154 MW_{th} for Chilean copper mines

Building on the good experiences that began in 2013 with the commissioning of the 38 MW_{th} system for the Gabriela Mistral copper mine in Chile's Atacama Desert, the Chilean energy supply company Gasco is planning to build three large industrial solar thermal systems for electrolysis baths in copper mines. A total of three flat-plate collector fields with a total capacity of 154 MW_{th} are planned. Two solar thermal systems with 90 MW_{th} and 23 MW_{th} for the Minera Escondida copper mine and another with 41 MW_{th} for the Spence copper mine. Commissioning is scheduled for 2025.[8]

154 MW_{th} for Chilean copper mines scheduled

First commercial Fresnel collector system in Latin America

The first commercial Fresnel collector system in Latin America is at an advanced stage of implementation. The planning for the solar process heat system for the Unilever plant in Cuernavaca, Mexico, has been completed. The steam produced is intended to be used in the factory's production of personal care products. The construction of the solar heat system with a capacity of 365 kW_{th} (521 m^2) is planned for the second half of 2024.[9]

16.4 MW_{th} malting plant in Croatia

Despite some delays in planning and constructing a solar thermal heating plant, heat pumps and a storage facility for a malting plant in Croatia are being implemented with the support of the European Innovation Fund. The solar plant consists of 23,400 m^2 (16.4 MW_{th}) of flat plate collectors in combination with a 5,000 m^3 hot water storage tank.

[6] TVP Solar, April 2024
[7] Source: https://www.glasspoint.com/projects/maaden-solar, March 2024
[8] https://solarthermalworld.org, 23 February 2024
[9] Source: Miguel Frasquet Herraiz, Solatom

欧洲对太阳能区域供热的需求不断增长

根据德国 Steinbeis 研究机构 Solites 的数据，2024 年 3 月，6 个新的用于区域供热网络的太阳能热系统在 2023 年投入使用，集热器总面积达 13 955 平方米（9.4 千兆瓦）。尽管这一数字低于预期，但这是因为已宣布的高效区域供热网络联邦资助计划被推迟发布。不过，前几年的积极趋势似乎将在 2024 年及以后继续保持。九个集热器面积达 112,000 平方米（78 兆瓦）的系统正在建设或处于后期规划阶段。据 Solites 公司称，另有 70 个集热器面积达 400,000 平方米（280 兆瓦）的系统正在具体讨论或建设中。

78 兆瓦

德国正在规划太阳能区域供热

其中一个德国系统位于 Sonderhausen，拥有 4.3 兆瓦的高真空平板集热器（6,086 平方米）。该系统将于 2024 年上半年末开始运行。2024 年 3 月，莱比锡市开始建设德国最大的太阳能区域供热厂。它的发电能力为 41 兆瓦（58 500 平方米）。在夏季，该厂预计将供应莱比锡 20% 的热量需求，年平均供热量约为 2%。该厂计划于 2025 年底竣工，并将于 2026 年开始向该市的区域供热网络供热。

另一个大型太阳能区域供热系统即将在荷兰格罗宁根完工，该系统的集热器面积为 48,000 平方米（功率为 33.6 兆瓦）。根据供热公司提供的信息，该系统计划于 2024 年 6 月完工。

正在筹建的大型 SHIP 工厂

2023 年，共有 116 个太阳能热系统建成并投入使用，为各行各业的工业流程供热。一个明显的趋势是，大型工业加工供热系统主要采用聚光集热器，这样可以提供更高的温度（见第 5.3.1 章）。

今后几年，这一趋势仍将继续，目前世界各地计划中的系统就表明了这一点。下文将介绍其中一些 SHIP 系统。

炼铝厂 1.5 千兆瓦

到目前为止，处于项目规划阶段的最大太阳能热发电厂是沙特阿拉伯矿业公司的第一座 GW 级炼铝厂。

公司 Ma'aden Group。据《全球太阳能供热》2023 年版报道，系统建造商 Glasspoint 与沙特阿拉伯领先的太阳能热电厂于 2022 年达成一项谅解，将建造世界上最大的太阳能工艺热电厂。该厂将建在海尔角，产能为 1.5 千兆瓦，相当于 6 平方公里的集热器面积。它将利用抛物槽式集热器每年生产 3,000 千兆瓦时，每年可减少炼油厂的碳排放量 600,000 吨。日均蒸汽产量预计为 1,4,0 0 0 至 n，计划于 2024 年开始使用，2026 年将首次使用太阳能蒸汽将铝土矿提炼成氧化铝。

为智利铜矿提供 154 兆瓦电力

2013 年，位于智利阿塔卡马沙漠的 Gabriela Mistral 铜矿 38 兆瓦系统投入使用，在此良好经验的基础上，智利能源供应公司 Gasco 计划为铜矿的电解槽建造三个大型工业太阳能热系统。计划总共建造三个平板集热器场，总容量为 154 兆瓦。两个太阳能热系统分别为 90 兆瓦和 23 兆瓦，用于 Minera Escondida 铜矿，另一个为 41 兆瓦，用于 Spence 铜矿。计划于 2025 年投入使用。

154 兆瓦

智利铜矿计划开采的地雷

拉丁美洲首个商用菲涅尔集电系统

拉丁美洲首个商用菲涅尔集热系统已进入后期实施阶段。墨西哥库埃纳瓦卡联合利华工厂的太阳能工艺热系统规划工作已经完成。生产出的蒸汽将用于工厂个人护理产品的生产。计划在 2024 年下半年建造容量为 365 千瓦（521 平方米）的太阳能供热系统。

克罗地亚 16.4 兆瓦麦芽加工厂

在欧洲创新基金的支持下，克罗地亚一家麦芽加工厂的太阳能供热厂、热泵和储水设施的规划和建设尽管出现了一些延误，但仍在实施之中。该太阳能供热厂由 23 400 平方米（16.4 兆瓦）的平板集热器和一个 5 000 立方米的热水储罐组成。

[6] TVP 太阳能，2024 年 4 月
[7] 资料来源：https://www.glasspoint.com/projects/maaden-solar，2024 年 3 月
[8] https://solarthermalworld.org, 2024 年 2 月 23 日
[9] 资料来源Miguel Frasquet Herraiz，Solatom 公司

5 Solar thermal market development and trends in 2023

Multi-family house solar system “Im Werk” in Uster, Switzerland
Photo: Soltop Energie AG, Switzerland

The global market development in 2023 presents a varied landscape. Despite an overall decline of 7% in the global solar thermal market, mainly due to a decline of 7.7% in China, there are notable areas of growth.
In India, also one of the world's most important markets, the market for solar thermal energy grew by 27 %.

Growing markets are emerging in Southern Africa and Latin America, with some small African markets showing significant increases. Mozambique reported a notable 40% market increase, while South Africa experienced a 12% growth. Similarly, Mexico and Brazil saw growth rates of 5% and 3% respectively.

In Europe, only a handful of countries, including the United Kingdom and Greece, saw positive market growth in 2023. The UK solar thermal market grew by an impressive 66%, and Greece experienced a 10% growth. With this, Greece is the sole European country to have sustained uninterrupted growth for many years. Meanwhile, former European market leaders like Denmark faced a 25% decline. Similarly, traditionally strong countries such as Spain saw declines of 26%, along with Germany, Poland, and Cyprus experienced decreases of 46%, 38%, and 10%, respectively. The situation is similar in Australia, where the market declined by 8% in 2023.

5 太阳热能市场开发和趋势 2023 年

瑞士乌斯特 "Im Werk "多户住宅太阳能系统
照片：瑞士 Soltop 能源股份公司

2023 年的全球市场发展呈现出多样化的格局。尽管全球太阳能热利用市场总体下降了 7%，主要原因是中国市场下降了 7.7%，但仍有显著的增长领域。

印度也是世界上最重要的市场之一，其太阳能热能市场增长了 27%。

南部非洲和拉丁美洲的市场正在不断扩大，一些小型非洲市场也出现了显著增长。据报告，莫桑比克的市场显著增长了 40%，而南非则增长了 12%。同样，墨西哥和巴西的增长率分别为 5%和 3%。

在欧洲，只有英国和希腊等少数几个国家在 2023 年实现了市场正增长。英国太阳能热利用市场增长了

令人印象深刻的是，希腊的经济增长率达到了 66%，增长了 10%。由此，希腊成为欧洲唯一一个连续多年保持不间断增长的国家。与此同时，丹麦等曾经的欧洲市场领导者却面临着 25% 的下滑。同样，西班牙等传统强国下降了 26%，德国、波兰和塞浦路斯分别下降了 46%、38% 和 10%。澳大利亚的情况也类似，2023 年的市场下降了 8%。

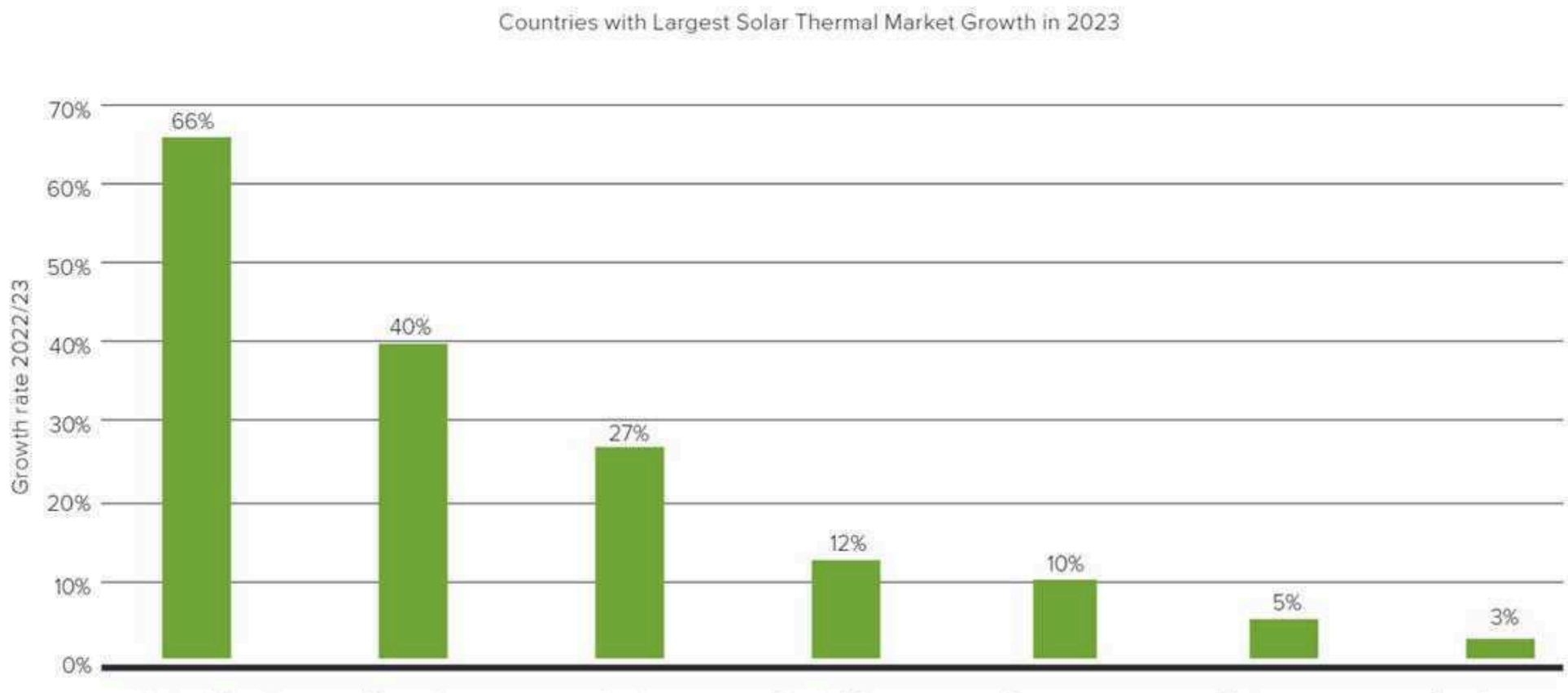

Figure 6: Reporting countries with the highest growth rates in 2023

66%
market growth in the UK in 2023

Roof-integrated solar system for hot water preparation
Photo: Velux / Solar Heat Europe

5.1 Small-scale solar thermal heating systems

Approximately 60% of the world's annual installations consist of small-scale solar water heating systems and solar combi-systems for combined hot water preparation and space heating for single-family and multi-family houses, apartment buildings, hotels, and public buildings.

However, in many parts of Europe and China, these systems face growing competition from photovoltaic systems and heat pumps, resulting in a decline in market share in recent years. The systems are predominantly pumped systems that are characterized by complex system technology.

In contrast, thermosiphon systems dominate in Asia (excluding China), Latin America, Sub-Saharan Africa, and the Mediterranean region. The market for this type of system is relatively stable and so far, has come under less price pressure from photovoltaic systems. Only in South Africa there is increasing competition from PV2Heat systems. For detailed information, see also section 5.5.

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https://task66.iea-shc.org/

图 6：2023 年增长率最高的报告国

用于制备热水的屋顶一体化太阳能系统
照片Velux / 欧洲太阳能供热公司

66%
2023 年英国市场增长情况

5.1 小型太阳能热供暖系统

全世界每年安装的设备中约有 60% 是小型太阳能热水系统和太阳能组合系统，用于为单户和多户住宅、公寓楼、酒店和公共建筑提供热水和空间供暖。

然而，在欧洲和中国的许多地区，这些系统面临着光伏系统和热泵日益激烈的竞争，导致近年来市场份额下降。这些系统主要是泵送系统，其特点是系统技术复杂。

相比之下，热虹吸系统在亚洲（不包括中国）、拉丁美洲、撒哈拉以南非洲和地中海地区占主导地位。这类系统的市场相对稳定，到目前为止，受到光伏系统的价格压力较小。只有在南非，PV2Heat 系统的竞争日益激烈。详情另见第 5.5 节。

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https://task66.iea-shc.org/

Photo: GREENoneTEC Solarindustrie GmbH, Austria

5.2 Large-scale solar thermal heating systems

Since the early 1980s, several large-scale solar thermal systems have been operational in Scandinavian countries and Central Europe, serving local or district heating networks and installed on large residential, commercial, and public buildings.

Since 2010, Denmark has been the dominant player in the large-scale system market and for nearly a decade in solar district heating. However, a significant shift in energy technology policy and funding conditions led to the collapse of the Danish solar district heating market in 2020. Subsequently, since 2020, Denmark has only seen the construction of three new plants and the extension of three existing ones. Compared to the very large systems built in previous years, it is remarkable, that one of the new systems added in 2023 was relatively small, with a collector area of only 2,000 m^2 (1.4 MW_{th}). Consequently, Denmark has slipped from first to fourth place among newly installed large-scale plants.

In 2023, China reported installing five new district heating systems with a collector area of 147,206 m^2 (103 MW_{th}) and 16 other large-scale systems with a 33,734 m^2 (23.7 MW_{th}) collector area. In addition to China and Denmark, new plants were commissioned in Germany and Austria in 2023. In Germany, six solar district heating systems were installed with a collector area of 13,955 m^2, and there are nine systems with a collector area of 112,000 m^2 under construction or in the planning phase and 70 further systems in the pipeline.

In 2023, Austria reported two expansions of existing large-scale district heating systems. The newly installed collector area totaled 2,173 m^2 (1.5 MW_{th}); The total collector area of these district heating systems is now 1,954 m^2 (1.4 MW_{th}) and 6,807 m^2 (4.8 MW_{th}).

By the end of 2023, 598 large-scale solar thermal systems (>350 kW_{th}, 500 m^2) were operating worldwide. Their total installed capacity equaled 2.3 GW_{th}, corresponding to a 3.3 million square meters collector area.

照片：奥地利 GREENoneTEC 太阳能工业有限公司

5.2 大型太阳能热供暖系统

自 20 世纪 80 年代初以来，斯堪的纳维亚国家和中欧国家已经安装了一些大型太阳能供热系统，为当地或区域供热网络服务，并安装在大型住宅、商业和公共建筑上。

自 2010 年以来，丹麦一直是大型系统市场的主导者，近十年来在太阳能区域供热方面也是如此。然而，能源技术政策和资金条件的重大转变导致丹麦太阳能区域供热市场在 2020 年崩溃。此后，自 2020 年以来，丹麦仅新建了三座电厂，扩建了三座现有电厂。与前几年建造的大型系统相比，2023 年新增的一个系统规模相对较小，只有 2 0 0 0 平方米（1.4 兆瓦）。因此，在新安装的大型发电厂中，丹麦从第一位滑落到第四位。

2023 年，中国报告安装了 5 个新的区域供热系统，集热器面积为 147 206 平方米（103 兆瓦），以及 16 个其他大型系统，集热器面积为 33 734 平方米（23.7 兆瓦）。除中国和丹麦外，德国和奥地利的新工厂也将于 2023 年投入使用。在德国，安装了 6 个太阳能区域供热系统，集热器面积达 13 955 平方米，还有 9 个系统正在建设或处于规划阶段，集热器面积达 112 000 平方米，另有 70 个系统正在筹备中。

2023 年，奥地利对现有的大型区域供热系统进行了两次扩建。新安装的集热器面积共计 2,173 平方米（1.5 兆瓦）；这些区域供热系统的集热器总面积目前分别为 1,954 平方米（1.4 兆瓦）和 6,807 平方米（4.8 兆瓦）。

到 2023 年底，全球将有 598 个大型太阳能热发电站（> 3 5 0 k W，5 0 0 m ²）投入使用。它们的总装机容量相当于 2.3 GW，相当于 330 万平方米的集热器面积。

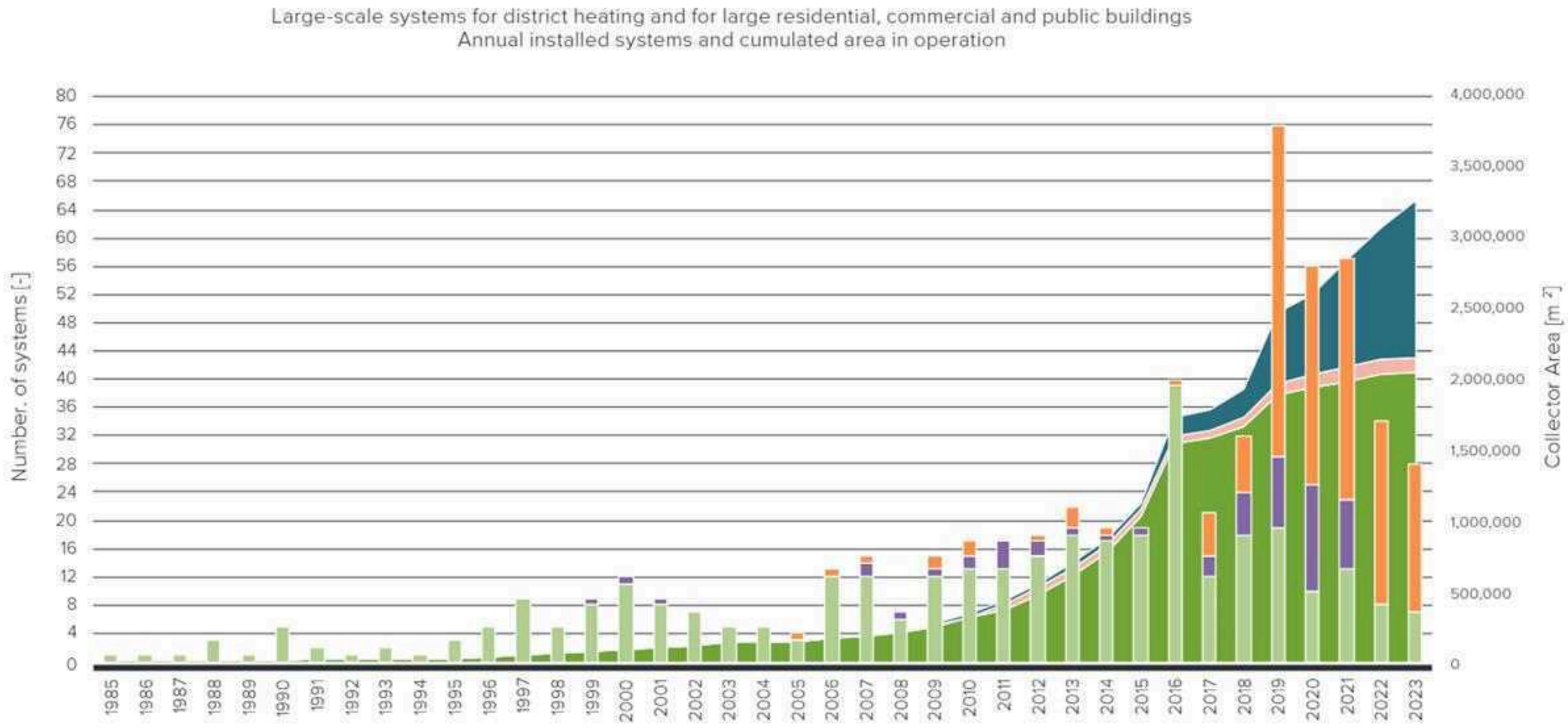

Figure 7: Large-scale systems for solar district heating and large residential, commercial, and public buildings worldwide – annual installations and cumulated area in operation in 2023

Data sources: Daniel Trier - PlanEnergi, DK, Jan-Olof Dalenbäck - Chalmers University of Technology, SE, Sabine Putz - IEA SHC Task 55, AT, Bärbel Epp - solrico.com/, DE, AEE INTEC, AT, Janusz Starościk – SPIUG, PL, Zheng Ruicheng, China Academy of Building Research, CHN.

- Cumulated collector area in operation in Europe [m²]
- Cumulated collector area in operation in China [m²]
- Number of systems installed in "Other countries" [m²]
- Cumulated collector area in operation "Other countries" [m²]
- Number of systems installed in Europe [-]
- Number of systems installed in China [-]

* **Other countries:**
MENA countries: Dubai, Jordan, Kuwait, Morocco, Saudi Arabia, Tunisia, UAE
Latin America: Brazil, Colombia, Mexico
Other Asia: Cambodia, Japan, Kyrgyzstan, India, Russia, South Korea, Thailand, Turkey
Plus: Australia, Canada, South Africa, USA

5.2.1
Solar district heating (SDH) systems

The largest sub-sector of large-scale solar thermal heating systems is solar district heating. By the end of 2023, 336 large-scale solar district heating systems (>350 kW_{th}, 500 m^2) with an installed capacity of 1,908 MW_{th} (2.73 million square meters) were reported in operation.

As shown in Figure 8, Denmark leads in this market segment, boasting the highest number of systems and installed area. Alongside Denmark (124 systems) and China (72 systems), several other countries have a growing interest in this plant type. Solar district heating systems present a compelling opportunity to decarbonize the heat sector in neighborhoods and entire cities.

Countries to note are Germany (56 systems, some with seasonal storage), Sweden (23 systems), Austria (20 systems), Poland and France (with 8 systems each). Outside China and Europe, solar district heating systems are installed in Saudi Arabia, Japan, Kyrgyzstan, Russia (Other Asia), the USA, Canada, and South Africa.

336 Solar district heating systems with 1.9 GW_{th} in operation

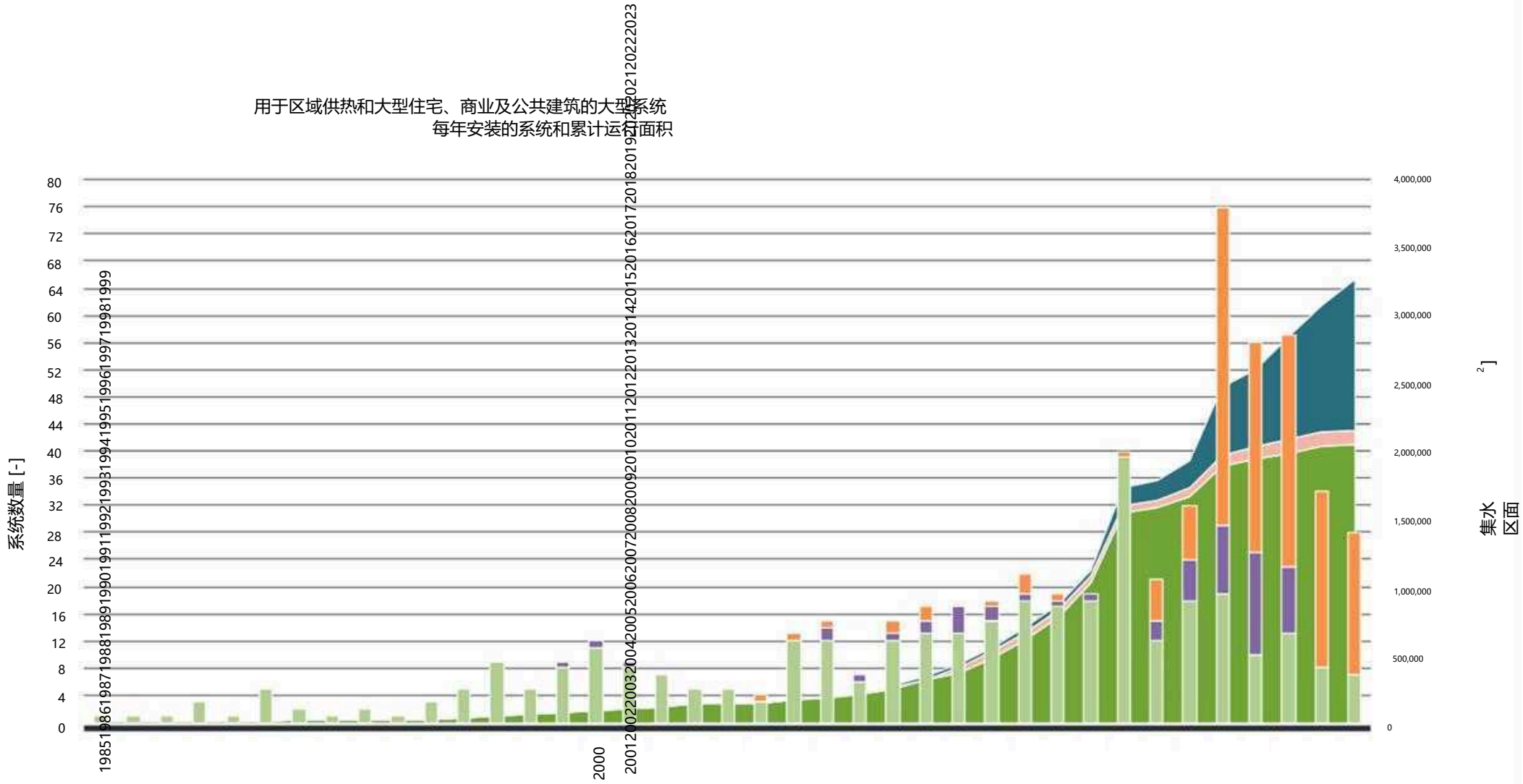

图 7：全球用于太阳能区域供热和大型住宅、商业及公共建筑的大型系统 - 2023 年的年安装量和累计运行面积

数据来源Daniel Trier - PlanEnergi，丹麦；Jan-Olof Dalenbäck - Chalmers 科技大学，瑞典；Sabine Putz - IEA SHC Task 55，奥地利；Bärbel Epp - solrico.com/，德国；AEE INTEC，奥地利；Janusz Starościk - SPIUG，波兰；Zheng Ruicheng，中国建筑科学研究院，中国。

* 其他国家：
中东和北非国家迪拜、约旦、科威特、摩洛哥、沙特阿拉伯、突尼斯、阿联酋 拉丁美洲：巴西、哥伦比亚、墨西哥 其他亚洲国家柬埔寨、日本、吉尔吉斯斯坦、印度、俄罗斯、韩国、泰国、土耳其 此外还有澳大利亚、加拿大、南非、美国

5.2.1 太阳能区域供热（SDH）系统

大型太阳能热供暖系统中最大的子行业是太阳能区域供暖。
据报道，到 2023 年底，有 336 个大型太阳能区域供热系统（大于 350 千瓦，500 平方米）投入使用，装机容量达 1908 兆瓦（273 万平方米）。

如图 8 所示，丹麦在这一市场领域处于领先地位，拥有最多的系统和安装面积。除丹麦（124 个系统）和中国（72 个系统）外，其他几个国家对这种设备类型的兴趣也日益浓厚。太阳能区域供热系统为社区和整个城市的供热部门去碳化提供了一个引人注目的机会。

值得注意的国家有德国（56 个系统，其中一些带有季节性储能）、瑞典（23 个系统）、奥地利（20 个系统）、波兰和法国（各 8 个系统）。除中国和欧洲外，沙特阿拉伯、日本、吉尔吉斯斯坦、俄罗斯（其他亚洲国家）、美国、加拿大和南非也安装了太阳能区域供热系统。

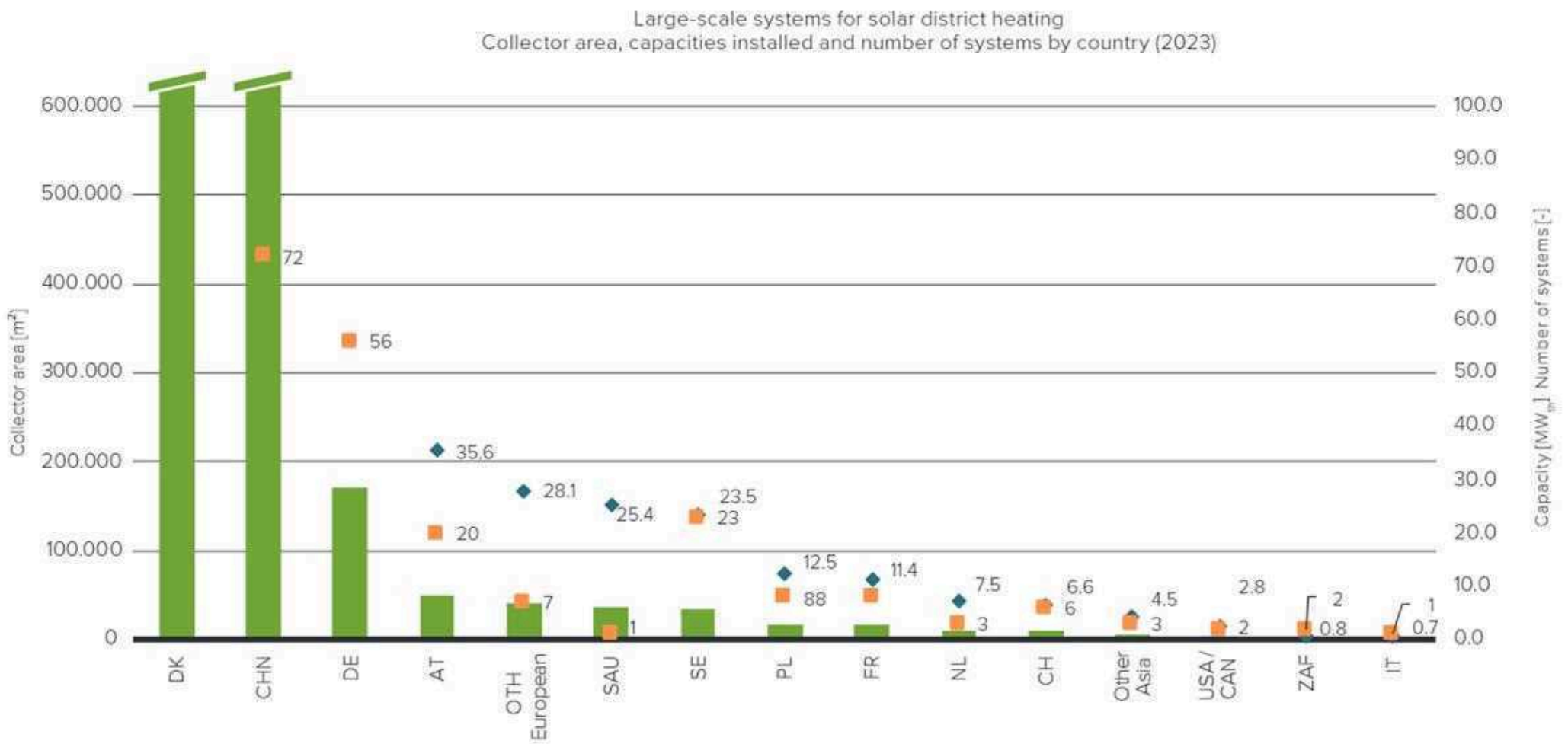

Figure 8: Large-scale systems for solar district heating – capacities and collector area installed and number of systems by the end of 2023

Data sources: Daniel Trier - PlanEnergi, DK, Jan-Olof Dalenbäck - Chalmers University of Technology, SE, Sabine Putz - IEA SHC Task 55, AT, Bärbel Epp - solrico.com, DE

Table 1 lists the 20 largest solar district heating systems. By far, the largest system is in the Danish city of Silkeborg, built in 2016. It has a collector area of almost 157,000 m², corresponding to a capacity of 110 MW_{th}. The second largest plant, with 65 MW_{th}, is in China.

The table also clearly shows the dominance of these two countries in terms of the number of largest solar district heating systems. Eleven of the 20 largest plants are in Denmark and seven are in China.

Table 1: The twenty largest solar district heating systems

Installation	SDH Project	Country	Installed Collector Area m²	Installed Capacity MW_{th}
2016	Silkeborg	Denmark	156,694	110
2016	Inner Mongolia	China	93,000	65
2015	Vojens stage 2	Denmark	52,492	37
2023	Longzi, Tibet	China	45036	32
2014	Dronninglund	Denmark	37,573	26
2023	Lazi, Tibet	China	36,700	26
2011	Rhiad	Saudi Arabia	36,305	25
2015	Gram stage 2	Denmark	34,851	24
2019	Zhongba, Tibet	China	34,650	24
2023	Dingri, Tibet	China	34250	24
2019	Ringe	Denmark	31,224	22
2023	Seni, Tibet	China	28356	20
2016	Brønderslev	Denmark	26,929	19
2018	Aabybro	Denmark	26,195	18
2019	Sæby, stage 2	Denmark	25,313	18
2019	Hadsten	Denmark	24,517	17
2016	Aalestrup	Denmark	24,129	17
2018	Langkasi, Tibet	China	22,275	16
2019	Salaspils	Latvia	21,672	15
2015	Hjallerup	Denmark	21,546	15

Sources: PlanEnergi, Solarthermalworld.org, Bärbel Epp, China Academy of Building Research

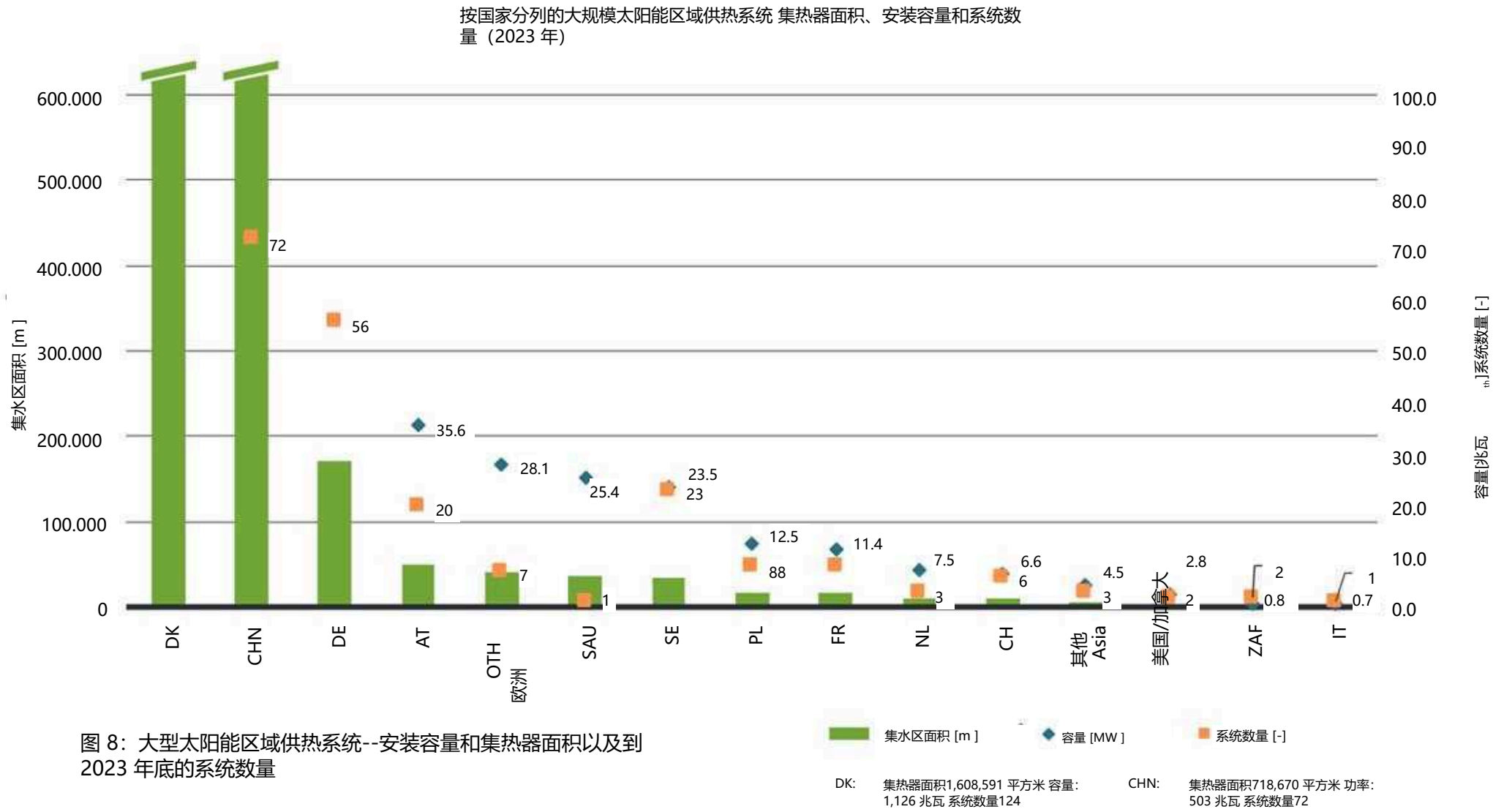

图 8：大型太阳能区域供热系统--安装容量和集热器面积以及到 2023 年底的系统数量

数据来源Daniel Trier - PlanEnergi，丹麦；Jan-Olof Dalenbäck - Chalmers 科技大学，瑞典；Sabine Putz - IEA SHC Task 55，奥地利；Bärbel Epp - solrico.com，德国

表 1 列出了 20 个最大的太阳能区域供热系统。到目前为止，最大的系统位于丹麦城市 Silkeborg，建于 2016 年。该系统的集热器面积近 15.7 万平方米，相当于 110 兆瓦的发电能力。

第二大发电厂位于中国，功率为 65 兆瓦。

该表还清楚地显示了这两个国家在最大的太阳能区域供热系统数量方面的优势。最大的 20 个工厂中有 11 个在丹麦，7 个在中国。

表 1：二十个最大的太阳能区域供热系统

安装	SDH 项目	国家	已安装的收集器面积 平方米	装机容量 MW
2016	锡尔克堡	丹麦	156,694	110
2016	内蒙古	中国	93,000	65
2015	Vojens 第 2 赛段	丹麦	52,492	37
2023	西藏隆子	中国	45036	32
2014	德龙宁伦	丹麦	37,573	26
2023	西藏拉孜	中国	36,700	26
2011	Rhiad	沙特阿拉伯	36,305	25
2015	克级 2	丹麦	34,851	24
2019	西藏仲巴	中国	34,650	24
2023	西藏定日	中国	34250	24
2019	Ringe	丹麦	31,224	22
2023	西藏森尼	中国	28356	20
2016	布兰德斯列夫	丹麦	26,929	19
2018	Aabybro	丹麦	26,195	18
2019	沙比，第 2 阶段	丹麦	25,313	18
2019	哈斯滕	丹麦	24,517	17
2016	Aalestrup	丹麦	24,129	17
2018	西藏郎卡寺	中国	22,275	16
2019	萨拉斯皮尔斯	拉脱维亚	21,672	15
2015	希亚勒鲁普	丹麦	21,546	15

资料来源PlanEnergi, Solarthermalworld.org, Bärbel Epp, 中国建筑科学研究院

Solar district heating plant in Søllested, Denmark, consists of 4,700 m² double glazed flat plate collectors
Photo: SavoSolar / Solar Heat Europe

5.2.2
Large-scale systems for buildings in the residential, public and commercial sector

Beyond solar district heating, another significant market segment in the large-scale sector involves solar applications for residential, commercial, and public buildings. By the end of 2023, 262 large-scale solar thermal systems (>350 kW_{th}, 500 m^2) were providing heat to these buildings globally. The total installed capacity of these systems is 377 MW_{th} (538,216 m^2).

China leads this market segment with 114 installed systems and a capacity of 275 MW_{th}, followed by Turkey with 18 systems and an installed capacity of 14.2 MW_{th}. Latin America ranks third with 16 systems and an installed capacity of approximately 12 MW_{th}.

Moreover, alongside European countries like Greece, France, Austria, Switzerland, Poland, and Spain, an increasing number of large-scale systems are being constructed in Latin America (Brazil and Mexico), the MENA region (Dubai, Jordan, Kuwait, United Arab Emirates), and Other Asia (Cambodia, India, Thailand). These systems are commonly installed in hospitals, hotels, and sports centers.

Solar thermal system for an apartment building in Zurich, Switzerland
Photo: Soltop Energie AG, Switzerland

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Learn more about current research results and international cooperation on the topic of solar district heating: https://task68.iea-shc.org/

丹麦 Søllested 的太阳能区域供热厂由 4,700 平方米的双层玻璃平板集热器组成
照片SavoSolar / 欧洲太阳能供热公司

5.2.2 用于住宅、公共和商业建筑的大型系统

除了太阳能区域供热，大规模领域的另一个重要细分市场涉及住宅、商业和公共建筑的太阳能应用。到 2023 年底，全球有 262 个大型太阳能热系统（大于 350 千瓦，500 平方米）为这些建筑供热。这些系统的总装机容量为 377 兆瓦（538,216 平方米）。

中国在这一细分市场中处于领先地位，安装了 114 套系统，装机容量为 275 兆瓦；其次是土耳其，安装了 18 套系统，装机容量为 14.2 兆瓦。拉丁美洲位居第三，安装了 16 套系统，装机容量约为 12 兆瓦。

此外，除希腊、法国、奥地利、瑞士、波兰和西班牙等欧洲国家外，拉丁美洲（巴西和墨西哥）、中东和北非地区（迪拜、约旦、科威特、阿拉伯联合酋长国）以及其他亚洲国家（柬埔寨、印度和泰国）也正在建造越来越多的大型系统。这些系统通常安装在医院、酒店和体育中心。

瑞士苏黎世一栋公寓楼的太阳能热系统
照片：瑞士 Soltop 能源股份公司

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太阳能区域供暖： https://task68.iea-shc.org/

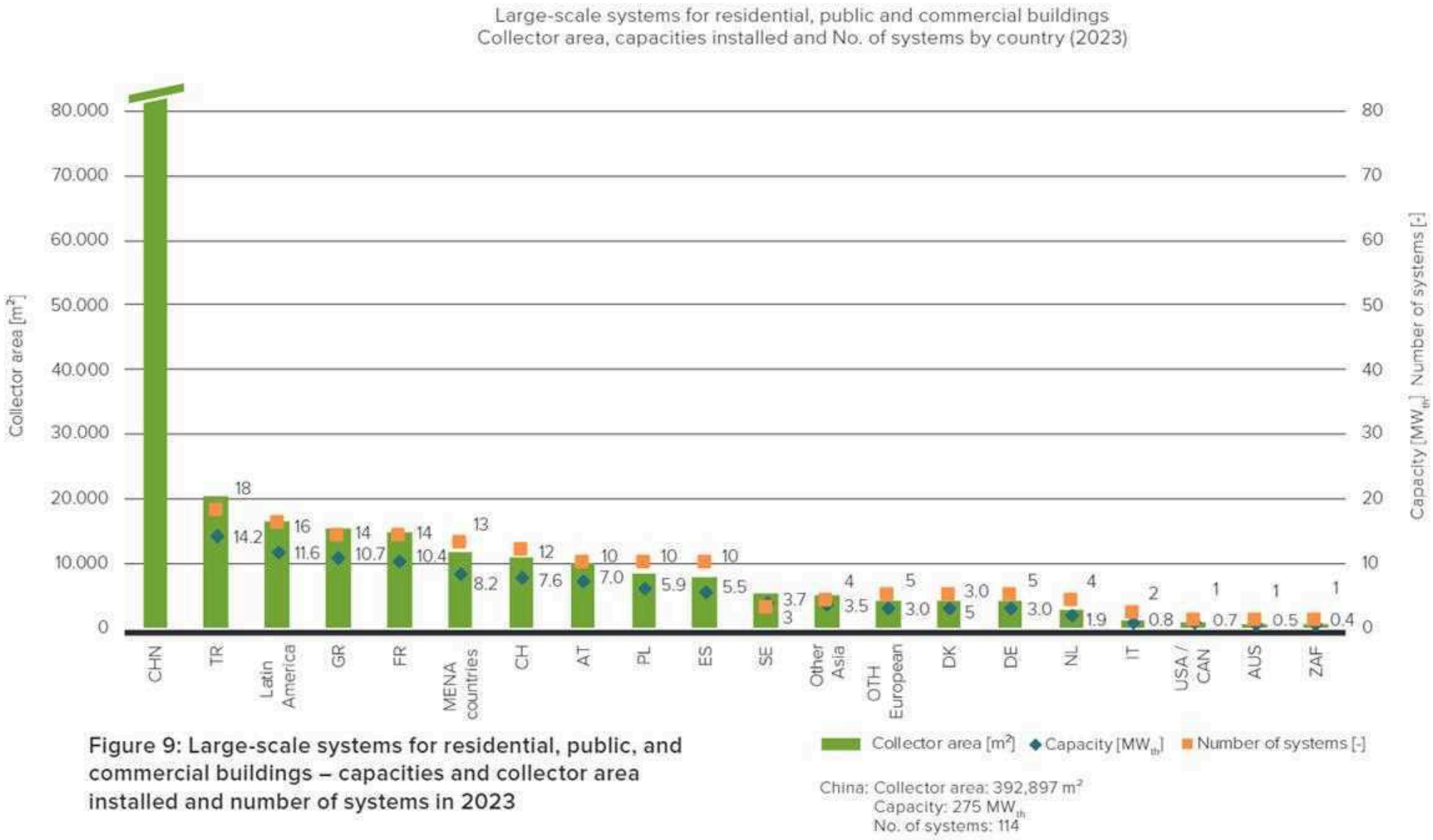

Figure 9: Large-scale systems for residential, public, and commercial buildings – capacities and collector area installed and number of systems in 2023

5.3 Solar heat for industrial processes

According to the IEA analysis, industrial accounts for two-thirds of industrial energy demand and almost one-fifth of global energy consumption.[10] It also constitutes most of the direct industrial CO_2 emitted yearly, as most industrial heat still originates from fossil-fuel combustion. At the same time, many companies have clear targets for reducing greenhouse gas emissions.

The challenge in decarbonizing industry is that industrial heat covers a wide range of temperature levels for different processes and end applications.

Electrification can be a solution for certain high-temperature industrial processes, such as steel production. For industrial low-temperature process heat up to 400°C, solar thermal systems are an excellent option. More than a thousand systems operating across various industry sectors worldwide impressively demonstrate this.
Depending on the temperature level of the needed heat, different types of solar thermal collectors are used, from air collectors, flat plate, and evacuated tube collectors for temperatures up to 100 °C to concentrating solar thermal collectors, such as Scheffler dishes, Fresnel collectors and parabolic troughs for temperatures up to 400 °C.

According to a study published by the German agency solrico[11] in March 2024 and the SHIP database, the number of SHIP systems in operation totals at least 1,209 systems with 1.359 million square meters collector area related to a capacity of 951 MW_{th}.

Although the market for solar thermal systems for industrial processes (SHIP) fluctuates in the number of systems installed per year and the annual installed capacity, it is a relatively stable market. Between 2017 and 2023, approximately 100 new SHIP systems with an average capacity of 1.1 MW_{th} each were commissioned each year.

Parabolic trough collectors for one of the breweries of the Carlsberg Group in Salonika, Greece
Photo: Absolicon

[10] https://www.iea.org/commentaries/clean-and-efficient-heat-for-industry
[11] https://solarthermalworld.org/news/the-netherlands-and-spain-drive-ship-market-2023/

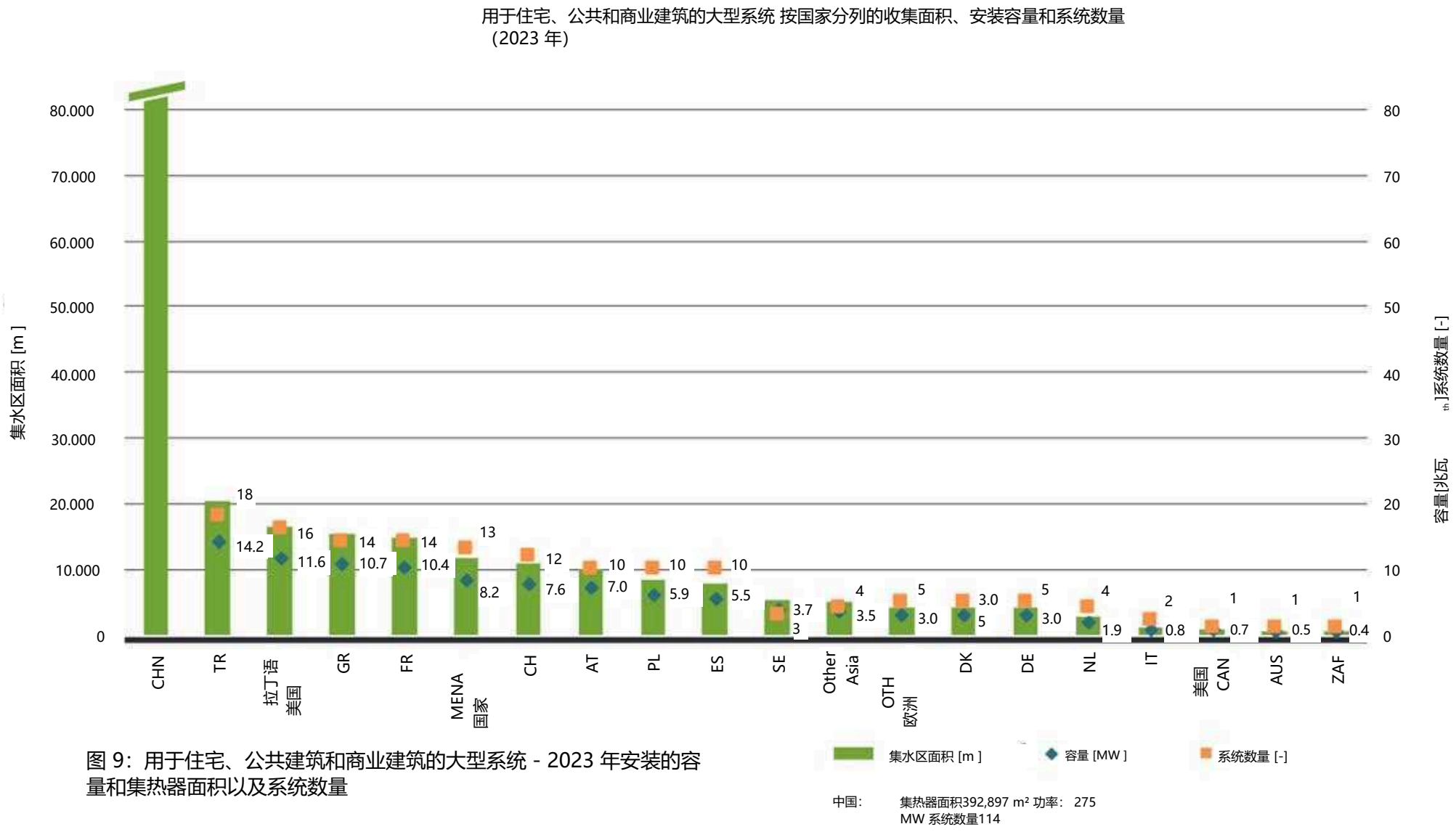

图 9：用于住宅、公共建筑和商业建筑的大型系统 - 2023 年安装的容量和集热器面积以及系统数量

5.3 用于工业加工的太阳热能

根据国际能源机构的分析，工业占工业能源需求的三分之二，几乎占全球能源消耗的五分之一。由于大部分工业用热仍然来自化石燃料燃烧，因此它也构成了每年直接排放的大部分工业二氧化碳。同时，许多公司都有减少温室气体排放的明确目标。

工业脱碳所面临的挑战是，工业用热的温度范围很广，适用于不同的工艺和最终应用。

电气化可作为某些高温工业流程（如钢铁生产）的解决方案。对于温度不超过 400°C 的工业低温工艺加热，太阳能热系统是一个极佳的选择。全球各行各业运行的一千多套系统有力地证明了这一点。

根据所需热量的温度水平，可使用不同类型的太阳能集热器，从温度不超过 100 °C 的空气集热器、平板集热器和真空管集热器，到温度不超过 400 °C 的聚光型太阳能集热器，如谢弗勒盘、菲涅尔集热器和抛物面槽。

根据德国 solricoin 机构 2024 年 3 月发布的研究报告和 SHIP 数据库

希腊萨洛尼卡嘉士伯集团一家啤酒厂的抛物槽式集热器

照片Absolicon

运行中的 SHIP 系统总数至少有 1,209 个，集电面积达 135.9 万平方米，发电能力为 951 兆瓦。

尽管工业流程太阳能热系统（SHIP）市场每年安装的系统数量和年装机容量有所波动，但这是一个相对稳定的市场。2017 年至 2023 年期间，每年约有 100 个新的 SHIP 系统投入使用，平均每个系统的装机容量为 1.1 兆瓦。

[10] https://www.iea.org/commentaries/clean-and-efficient-heat-for-industry
[11] https://solarthermalworld.org/news/the-netherlands-and-spaindrive-ship-market-2023/

	2017	2018	2019	2020	2021	2022	2023	Annual average
No. of commissioned SHIP systems	107	99	86	85	73	116	116	97
Newly installed capacity [MW_{th}]	153	39	251	93	36	31	94	100
Average capacity/system [MW_{th}]	1,43	0,39	2,92	1,09	0,49	0,27	0,81	1,1

Table 2: Development of commissioned SHIP systems over the past seven years
Source: Solrico with additions from AEE INTEC

The analysis of the top 3 countries in terms of the number of installed systems and installed capacity also shows how diverse the SHIP market is. Mexico is ahead of Germany and the Netherlands in the total number of systems installed. In terms of the installed capacity of SHIP systems, the picture is entirely different, with Oman in first place, followed by China and Spain. For details, see Figure 13.

5.3.1.
New trends in solar process heat in 2023

In 2023, at least 116 new SHIP systems with a capacity of 94 MW_{th} were installed worldwide, according to the solrico study mentioned above. One hundred five of these newly installed systems (total collector area 133,000 m^2, 93 MW_{th}) are also documented in detail in the SHIP database.[12]

Two factors were particularly noteworthy in 2023. Even if the total number of documented solar process heat systems has not increased, it is remarkable that after two years with relatively small systems, the average system size has more than tripled compared to the systems installed in 2022. The second change in the market concerns the types of collectors used. In previous years, flat-plate collectors were primarily utilized for industrial applications. However, by 2023, **concentrating collectors** became the predominant choice, especially in larger systems. From the beginning of 2023 to March 2024, a total of 11 solar systems for industrial process heat with concentrating collectors with a total installed capacity of 120 MW_{th} were installed. It is worth noting that most of **the systems were installed in breweries**. In addition, an extraordinary plant was completed for the tourism industry in China in the first quarter of 2024.

Some of these systems are presented in more detail below.

Solar Snow for the Handan Bay Water World in China

A 80 MW_{th} solar plant for the Handan Bay Water World resort in the province of Hebei opens a new dimension. The 114,000 m^2 parabolic trough collector system provides heat to a thermal oil loop. Forty percent of the solar heat supplies an ice and snowmaking system for an indoor ski slope, as well as the hotel's HVAC and hot water systems and the indoor swimming pool.

An 80 MW_{th} parabolic trough collector system supplies snow for an indoor ski hall, as well as heating and cooling at the Handan Bay Water World in China
Photo: Inner Mongolia Xuchen Energy Co., Ltd

Breweries point the way

With four solar industrial process heat plants built in 2023, the brewing industry is pointing the way to a sustainable future for the food and beverage industry.

What Heineken, one of the world's largest brewery groups, began in 2013 at the Gösser Brewery in Austria has been impressively continued. At the Göss plant, the brewing process was converted from steam to hot water supply with the help of a 1 MW_{th} flat-plate collector system. The brewery group has now opted for concentrating collector systems to reach higher temperatures at their Spanish breweries in Sevilla and Valencia.

With a 30 MW_{th} parabolic trough collector system, now the largest solar industrial heating system in Europe, Heineken is setting new standards in the field of solar process heat in Sevilla. The parabolic troughs generate pressurized water at 210°C. To compensate for the fluctuations in production and demand, a thermal storage consisting of eight stratified, pressurized steel tanks with a total volume of 800 m^3 completes the system. The expected annual solar yield is 35,000 MWh, with heat being available for 15 to 20 Euro/MWh.

	2017	2018	2019	2020	2021	2022	2023	年平均
已投入使用的 SHIP 系统数量	107	99	86	85	73	116	116	97
新装机容量 [兆瓦]	153	39	251	93	36	31	94	100
平均容量/系统 [MW]	1,43	0,39	2,92	1,09	0,49	0,27	0,81	1,1

表 2：过去 7 年委托 SHIP 系统的发展情况
资料来源来源：Solrico，AEE INTEC 增补

对安装系统数量和装机容量排名前三位的国家的分析还显示了 SHIP 市场的多样性

在已安装的系统总数方面，墨西哥超过了德国和荷兰。就 SHIP 系统的安装容量而言，情况则完全不同，阿曼位居第一，中国和西班牙紧随其后。详见图 13。

5.3.1. 2023 年太阳能工艺加热的新趋势

根据上述 solrico 公司的研究，2023 年全球至少安装了 116 个新的 SHIP 系统，功率为 94 兆瓦。在这些新安装的系统中，有 15 个（总面积为 1 3 3 0 0 平方米，功率为 93 兆瓦）在 SHIP 数据库中有详细记录。

2023 年有两个因素特别值得注意。即使记录在案的太阳能工艺加热系统总数没有增加，但值得注意的是，在系统规模相对较小的两年后，系统的平均规模与 2022 年安装的系统相比增加了两倍多。市场的第二个变化涉及所使用的集热器类型。前几年，平板集热器主要用于工业应用。然而，到 2023 年，聚光集热器成为主要选择，尤其是在大型系统中。从 2023 年初到 2024 年 3 月，共安装了 11 套用于工业加工供热的聚光集热器太阳能系统，总装机容量为 120 兆瓦。值得注意的是，这些系统大多安装在酿酒厂。此外，在 2024 年第一季度，还为中国旅游业建成了一座特殊的发电厂。

下文将详细介绍其中一些系统。

中国邯郸湾水世界的 80 兆瓦抛物面槽式集热系统为室内滑雪馆供雪、供热和制冷 照片：内蒙古旭宸能源有限公司

中国邯郸湾水世界的太阳能雪

为邯郸市邯郸湾水上世界建造的 80 兆瓦太阳能发电站开创了新局面。11.4 万平方米的抛物面槽式集热系统为导热油回路提供热量。40% 的太阳能热量用于室内滑雪场的制冰和造雪系统，以及酒店的暖通空调系统、热水系统和室内游泳池。

啤酒厂指明方向

酿造业将在 2023 年建成四座太阳能工业加工热电厂，为食品和饮料行业的可持续未来指明了方向。

喜力（Heineken）是世界上最大的啤酒酿造集团之一，它于 2013 年在奥地利的戈瑟（Gösser）啤酒厂开始实施的节能项目一直在持续进行，令人印象深刻。在 Göss 工厂，借助 1 兆瓦平板集热系统，酿造工艺从蒸汽转换为热水供应。现在，该酿酒集团已选择在其位于塞维利亚和巴伦西亚的西班牙酿酒厂使用聚光集热系统，以达到更高的温度。

凭借目前欧洲最大的太阳能工业加热系统--30 兆瓦抛物面槽式集热系统，喜力公司在塞维利亚为太阳能工艺加热领域设立了新标准。抛物面槽能产生 210°C 的加压水。为了补偿生产和需求的波动，该系统还配备了一个由八个总容积为 800 立方米的加压钢罐组成的蓄热系统。预计年太阳能发电量为 35,000 兆瓦时，供热价格为 15 至 20 欧元/兆瓦时。

By switching to renewable heat, the brewery can reduce its gas consumption by more than 60% and reduce its carbon footprint by almost 7,000 tons of CO_2 equivalent per year.
What is also interesting about this project, built by the AZTEQ group, is that the heat supply is handled via a thermal power purchase agreement (TPA). The energy service provider Engie España operates the plant and supplies heat at a fixed price. At the end of the 20-year term of the agreement, ownership of the solar thermal plant is transferred to Heineken.

A section of Europe's largest solar industrial heat plant, with a capacity of 30 MW_{th}, was installed by Engie in cooperation with Azteq-Solarlite Spain at the Heineken brewery in Sevilla, Spain
Photo: Wolfgang Gruber-Glatzl, AEE INTEC

Another Heineken SHIP system, equipped with 6,000 m² of linear **Fresnel collectors**, began operation in March 2024 in Valencia, Spain. The solar field consists of 182 modules with a peak output of 4.2 MW_{th} and covers 10% of the brewery's steam needs. In addition, its 1.5 MWh storage allows it to operate in transition periods and store part of the energy generated on weekends.

This system also sets new standards, as it is the world's largest solar thermal system with Fresnel collectors.[13] The brewery also signed a steam purchase agreement with the turnkey supplier.

Two further solar process heat systems for breweries were built in 2023 in Bari, Italy, for Birra Peroni, and in Salonika, Greece, for the Carlsberg Group by the Swedish company Absolicon. Both systems, with a thermal capacity of 660 kW_{th}, supply the pasteurization process of the breweries.

660 m² parabolic trough collectors for the Brewery Birra Peroni in Bari, Italy
Photo: Absolicon, Sweden

Drying of spent grain from breweries

In connection with the solar thermal boom in breweries, two solar process heat systems with 7 MW_{th} air collectors should not go unmentioned. The Spanish animal feed specialist L. Pernía uses the Solar Wall air collector systems at its two locations in Sevilla and Madrid to dry spent grain from breweries, which is processed into animal feed.

3.9 MW_{th} parabolic trough collector system supplies drying ovens

A parabolic trough collector system with 5,540 m² of collector area (3.9 MW_{th}) and a heat storage supplies an Avery Dennison plant in Turnhout, Belgium, with solar-generated process heat. Avery Dennison is a global leader in self-adhesive materials and technologies. The products are used, among other things, in the automotive industry, construction, medical technology, and personal care. The solar field generates heat at temperatures of approximately 280°C. This is used for the partial solar operation of the drying ovens in the production lines for coating adhesive tapes. An annual yield of up to 2.7 GWh of thermal energy is expected, saving 2.3 GWh of gas annually.

3.9 MW_{th} Parabolic trough collector system at the company Avery Dennison in Turnhout, Belgium
Photo: Avery Dennison

[12] http://ship-plants.info/ data retrieved by 31st March 2024
[13] https://www.theheinekencompany.com/newsroom/heineken-and-csin-open-worlds-largest-solar-thermal-plant-with-innovative-fresnel-technology-for-industrial-use-in-spain/

通过改用可再生能源供热，啤酒厂每年可减少 60% 以上的天然气消耗，并减少近 7000 吨二氧化碳当量的碳足迹。

这个由 AZTEQ 集团建造的项目还有一个有趣之处，即热能供应是通过热能购买协议（TPA）进行的。能源服务供应商 Engie España 负责运营发电厂，并以固定价格供应热量。在 20 年的协议期结束后，太阳能热电厂的所有权将移交给喜力公司。

Engie 与 Azteq-Solarlite Spain 合作，在西班牙塞维利亚喜力啤酒厂安装了欧洲最大的太阳能工业热电厂的一部分，发电能力为 30 兆瓦。

照片Wolfgang Gruber-Glatzl，AEE INTEC

另一个喜力 SHIP 系统配备了 6000 米长的线性菲涅尔集热器，于 2024 年 3 月在西班牙巴伦西亚开始运行。该太阳能发电场由 182 个模块组成，峰值输出功率为 4.2 兆瓦，可满足啤酒厂 10% 的蒸汽需求。此外，其 1.5 兆瓦时的储能装置使其能够在过渡时期运行，并在周末储存所产生的部分能量。

酿酒厂还与交钥匙供应商签订了团队采购协议。

2023 年，瑞典 Absolicon 公司又在意大利巴里的 Birra Peroni 和希腊萨洛尼卡的嘉士伯集团建造了两套用于酿酒厂的太阳能工艺加热系统。两套系统的热容量均为 660 千瓦，用于啤酒厂的巴氏杀菌工艺。

为意大利巴里的 Birra Peroni 啤酒厂建造 660 平方米抛物面槽式集热器

照片瑞典 Absolicon

啤酒厂废谷物的干燥

与酿酒厂的太阳能热利用热潮相关联，两套配备 7 兆瓦空气集热器的太阳能工艺热系统也不容忽视。西班牙动物饲料专业公司 L. Pernía 在塞维利亚和马德里的两家工厂使用太阳能墙空气集热器系统干燥酿酒厂的废谷物，这些废谷物被加工成动物饲料。

3.9 兆瓦抛物面槽式集热系统为烘干炉供电

一套抛物面槽式集热系统的集热面积达 5,540 平方米（3.9 兆瓦），并配有一个储热装置，为比利时特恩霍特的艾利丹尼森工厂提供太阳能产生的工艺热。Avery Dennison 公司是一家研发太阳能技术的公司。其产品主要用于汽车工业、建筑、医疗技术和个人护理等领域。太阳能场产生的热量温度约为 280°C。这些热量用于胶带涂布生产线干燥箱的部分太阳能操作。预计每年可产生高达 2.7 千兆瓦时的热能，每年可节省 2.3 千兆瓦时的天然气。

比利时特恩霍特艾利丹尼森公司的 3.9 兆瓦抛物面槽式集电系统

照片艾利丹尼森

[12] http://ship-plants.info/ 2024 年 3 月 31 日前检索的数据

[13] https://www.theheinekencompany.com/newsroom/heinekenand-csin-open-worlds-largest-solar-thermal-plant-with-innovativefresnel-technology-for-industrial-use-in-spain/

5.3.2.
Distribution of solar process heat systems across processes, countries, and sectors

As mentioned above, out of the 1,209 documented systems with a size of at least 50 m^2 collector area or 35 kW_{th}, 615 systems are detailed (collector area, installed capacity, and the type of application and collector) in a SHIP database. This database is an online portal operated by AEE INTEC in Austria.[14] These 615 SHIP systems account for a total collector area of 1,325,853 m^2 and a thermal capacity of 823 MW_{th}.[15] Only the data of these 615 SHIP systems are presented in the following figures. The data includes installed systems through March 2024.

The following figures are dominated by the world's largest solar process heat application in Oman, commissioned in 2017 and continuously expanded. The plant's current thermal capacity is 330 MW_{th}, accounting for 40% of the total installed thermal capacity of the 615 documented solar process heat applications worldwide. The figures include the new and second largest system at Handan Bay Water World, with 79.8 MW_{th}. Arguably, a unique application of SHIP. The third largest system is a greenhouse project in Australia with a capacity of 36 MW_{th}. In fourth place is the Heineken brewery in Sevilla, commissioned in 2023, with a capacity of 30.3 MW_{th}. A copper mine in Chile with a thermal capacity of 27.5 MW_{th}, once the largest system, is now fifth in the SHIP ranking.

Together, these five plants make up 61% of the total installed thermal capacity.

Figure 10 shows the distribution of the 615 systems in terms of size. The five systems mentioned above exceed 21 MW_{th} of thermal capacity (30,000 m^2), 85 systems have installed capacities between 0.7 MW_{th} and 21 MW_{th} (1,000 m^2 - 29,999 m^2) of thermal capacity, 79 systems have installed capacities between 0.35 and 0.7 MW_{th} (500 – 999 m^2), and 446 systems are below 0.35 MW_{th} (<500 m^2).

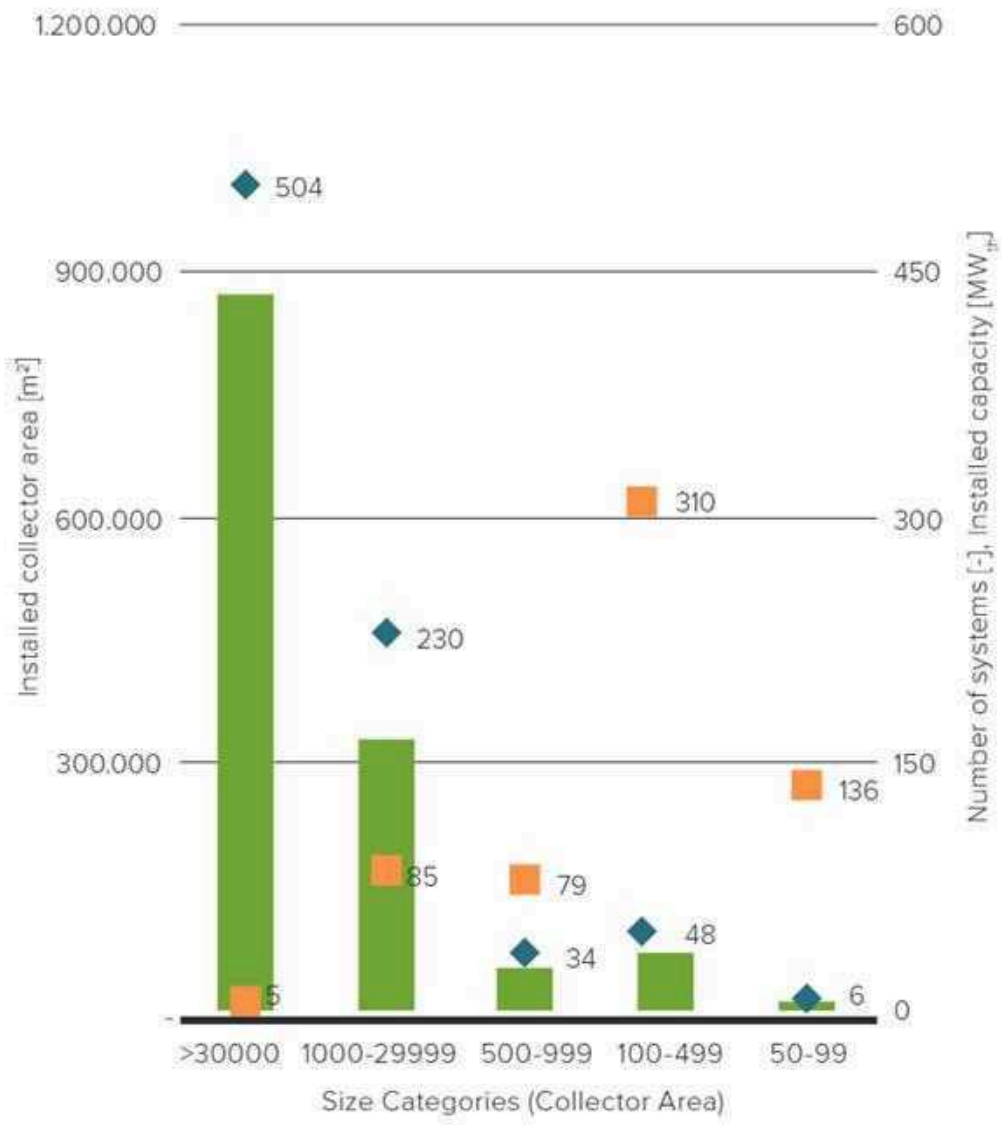

Figure 10: Global solar process heat applications in operation the end of March 2024 by number, capacity, and collector area
Source: SHIP database

The process heat systems by collector technology are presented in Figure 11. The majority of the systems use flat plate collectors to produce solar process heat, followed by parabolic trough collectors and evacuated tube collectors.

Parabolic trough collectors have solidified their dominance in installed capacity and average system size. Three of the five largest SHIP systems use parabolic trough collectors. The average size of the 72 documented plants is 6.7 MW_{th}, showing the trend towards large systems that operate at higher temperatures.

[14] http://ship-plants.info/ data retrieved by 31st March 2024
[15] According to an agreement within the IEA SHC Task 64/IV, the conversion of m^2 collector area into kW_{th} is also done for concentrating solar thermal systems with a factor of 0.7. Only the Mirrah system in Oman was converted with a lower factor due to the special glass house construction.

Lactosol is the largest SHIP plant in France. It combines a 10.4 MW_{th} solar thermal flat-plate collector field with a 3,000 m^3 water tank to supply hot air to the spray drying tower of a whey-powder facility of Lactoserum France.
Project: Newheat
Photo: IMAGESinAIR Productions

5.3.2. 太阳能工艺加热系统在不同工艺、国家和部门的分布情况

如上所述，在集热器面积至少为 50 平方米或功率至少为 35 千瓦的 1 209 个记录在案的系统中，有 615 个系统的详细情况（集热器面积、装机容量以及应用和集热器类型）已载入 SHIP 数据库。该数据库是由奥地利 AEE INTEC 运营的在线门户网站。这 615 个 SHIP 系统的集热器总面积为 1,325,853 平方米，热容量为 823 兆瓦。这些数据包括截至 2024 年 3 月的已安装系统。

以下数据主要来自位于阿曼的世界上最大的太阳能工艺热应用项目，该项目于 2017 年投入使用并不断扩大。该电站目前的热容量为 330 兆瓦，占全球 615 个记录在案的太阳能工艺热应用总装机容量的 40%。其中包括邯郸海湾水世界新建的第二大系统（79.8 兆瓦）。可以说，这是 SHIP 的独特应用。第三大系统是澳大利亚的一个温室项目，功率为 36 兆瓦。第四大系统是位于塞维利亚的喜力啤酒厂，将于 2023 年投入使用，发电量为 30.3 兆瓦。智利的一个铜矿热发电量为 27.5 兆瓦，曾经是最大的系统，现在在 SHIP 排名中位居第五。

这五家发电厂共占总热能装机容量的 61%。

图 10 显示了 615 个系统的规模分布。上述五个系统的热容量超过 21 兆瓦（30,000 平方米），85 个系统的热容量在 0.7 兆瓦至 21 兆瓦（1,000 平方米至 29,999 平方米）之间，79 个系统的热容量在 0.35 兆瓦至 0.7 兆瓦（500 平方米至 999 平方米）之间，446 个系统的热容量低于 0.35 兆瓦（小于 500 平方米）。

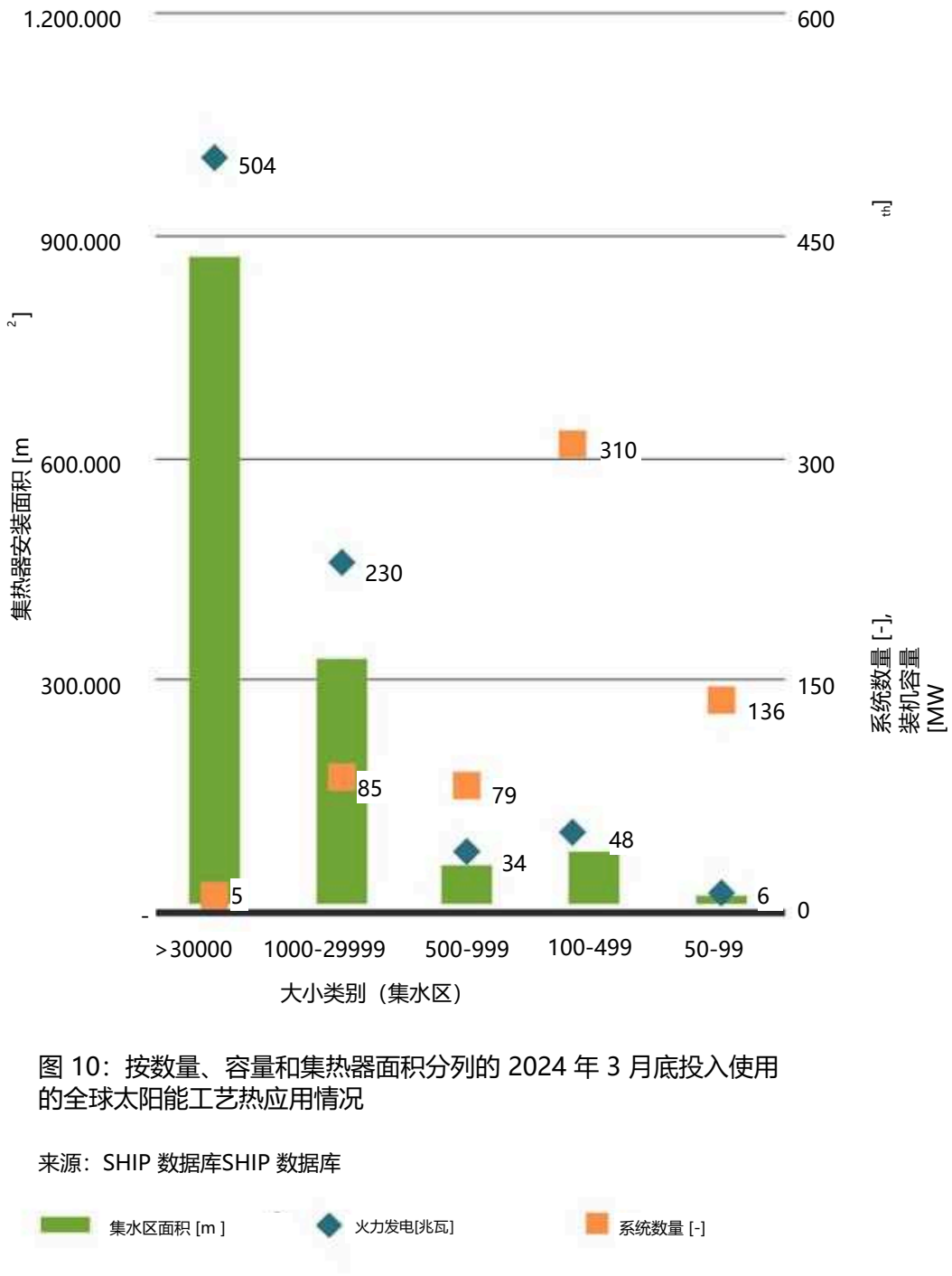

图 10：按数量、容量和集热器面积分列的 2024 年 3 月底投入使用的全球太阳能工艺热应用情况

来源：SHIP 数据库SHIP 数据库

按集热器技术划分的工艺热系统见图 11。大多数系统使用平板集热器生产太阳能工艺热，其次是抛物槽集热器和真空管集热器。

抛物面槽式集热器巩固了其在装机容量和平均系统规模方面的主导地位。五个最大的 SHIP 系统中有三个使用抛物面槽式集热器。72 个记录在案的发电厂的平均规模为 6.7 兆瓦，显示了在更高温度下运行的大型系统的发展趋势。

Lactosol 是法国最大的 SHIP 工厂。它将一个 10.4 兆瓦的太阳能平板集热场与一个 3,000 立方米的水箱相结合，为法国 Lactoserum 公司乳清粉设备的喷雾干燥塔提供热空气。项目：新热力公司

照片：IMAGESinAIR 制作公司

[14] http://ship-plants.info/ 2024 年 3 月 31 日前检索的数据

[15] 根据国际能源机构 SHC 任务 64/IV 中的一项协议，聚光太阳能热系统的集热器面积按 0.7 的系数转换为千瓦。只有阿曼的 Mirrah 系统由于采用了特殊的玻璃房结构，因此转换系数较低。

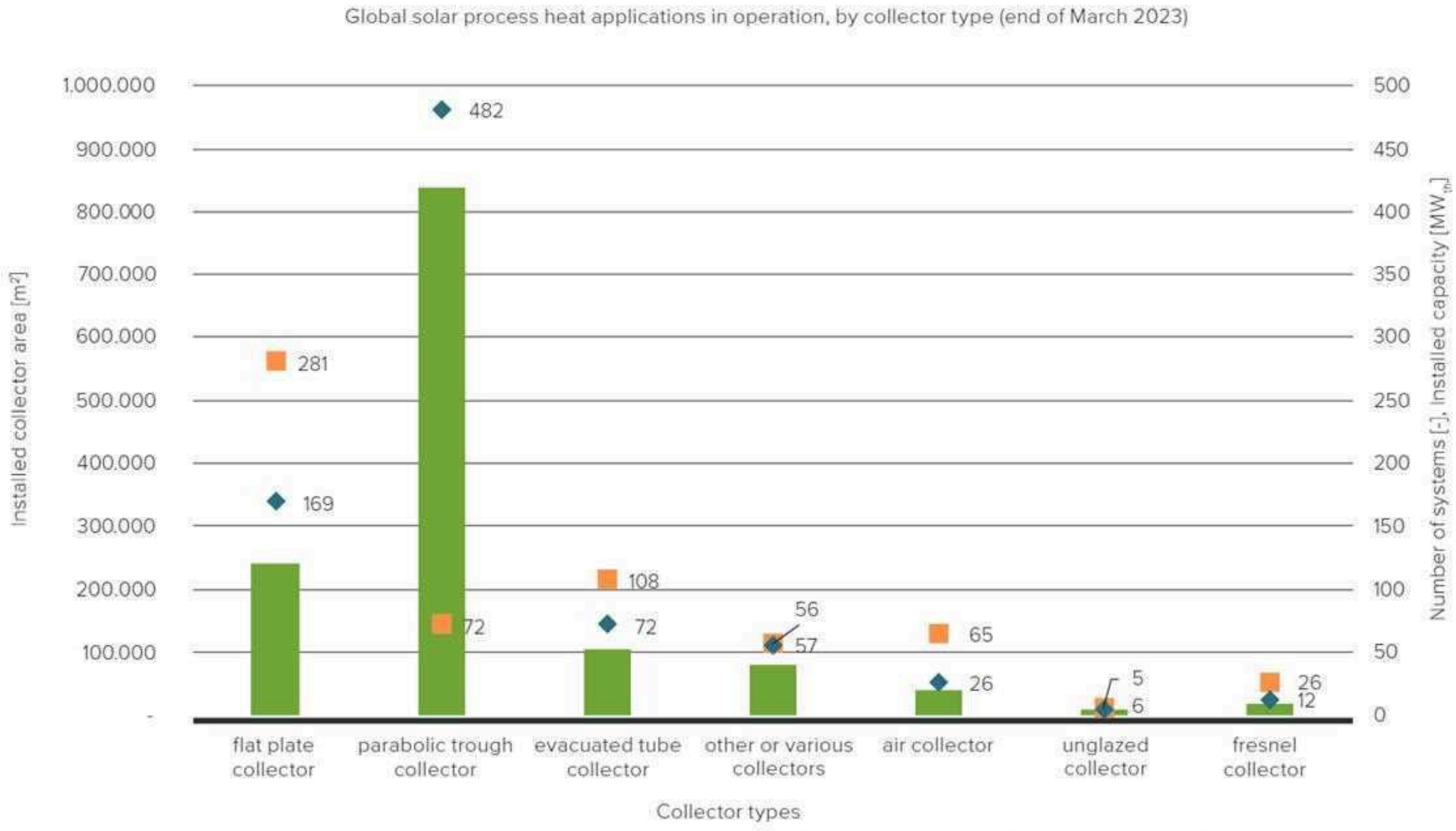

Figure 11: Global solar process heat applications in operation in March 2024 by collector type

Source: SHIP database

Figure 12 shows the industry sectors of the 615 documented systems. The food and beverage sectors continue to grow and is the dominant sector in terms of number of installed systems. This sector accounts for 199 systems with an average size of 1,083 m² and an installed thermal capacity of 151 MW$_{th}$.

In contrast, the mining sector includes two of the five largest SHIP systems and thus is the dominant sector in terms of installed thermal capacity. However, its share has decreased from 59% to 47%, while the share of food and beverage has increased from 13% to 18%.

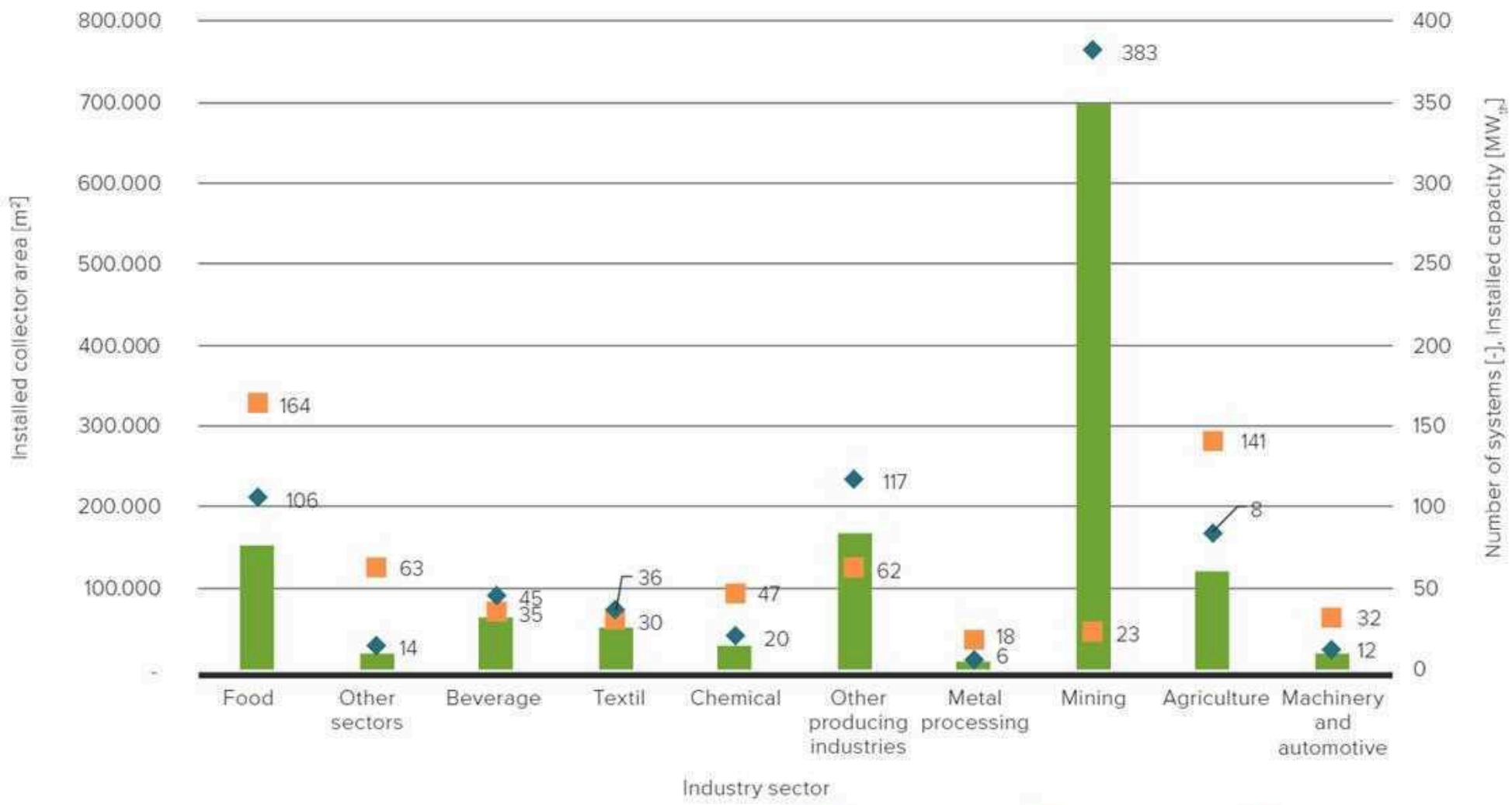

Figure 12: Global solar process heat applications in operation at the end of March 2024 by industry sector

Source: SHIP database

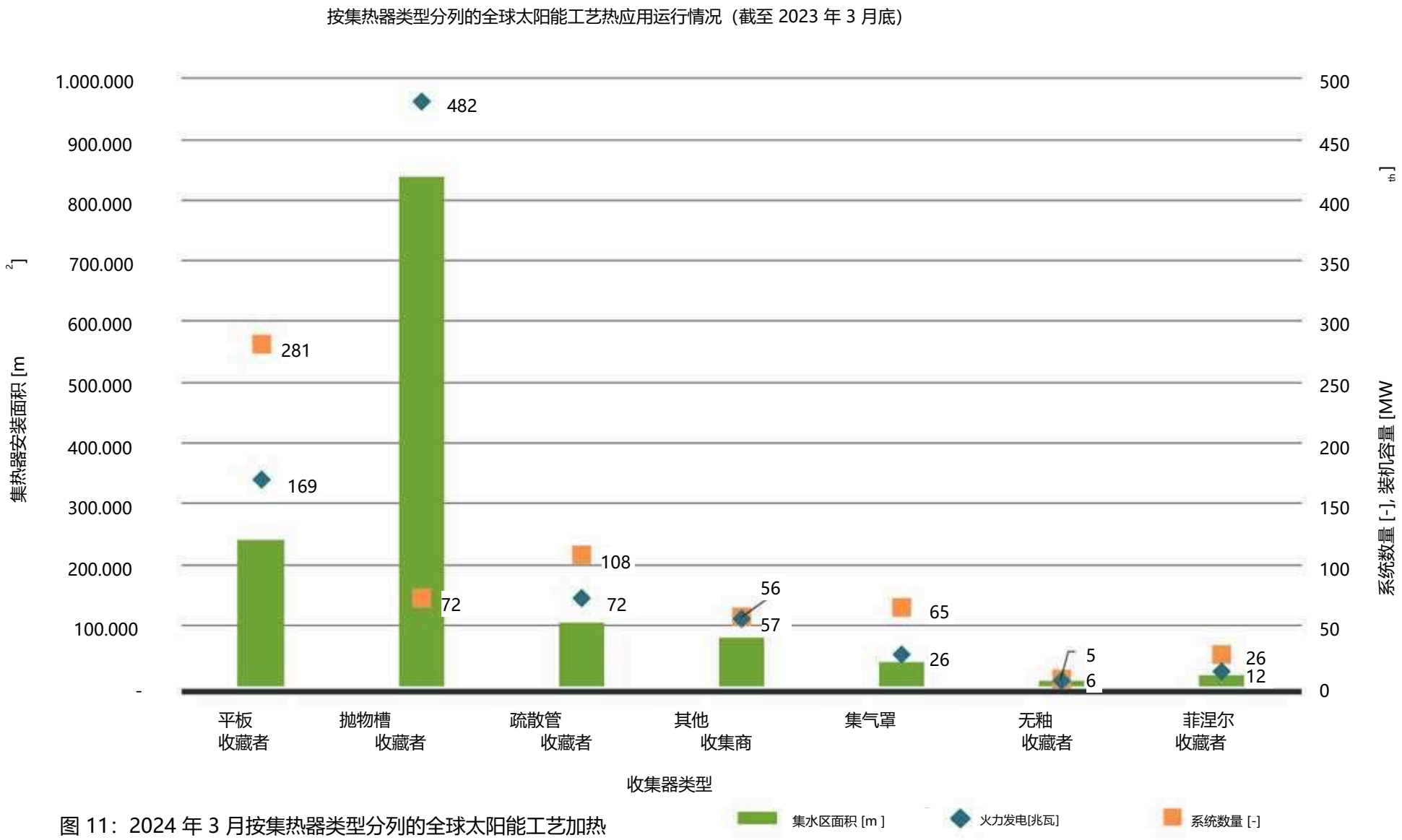

图 11：2024 年 3 月按集热器类型分列的全球太阳能工艺加热应用情况

来源：SHIP 数据库SHIP 数据库

图 12 显示了 615 个记录在案的系统所处的行业领域。食品和饮料行业继续增长，在已安装系统的数量方面占主导地位。该行业共有 199 个系统，平均面积为 1,083 平方米，热装机容量为 151 兆瓦。

相比之下，采矿业包括五个最大的 SHIP 系统中的两个，因此在热装机容量方面占主导地位。不过，其所占份额已从 59% 下降到 47%，而食品和饮料所占份额则从 13% 上升到 18%。

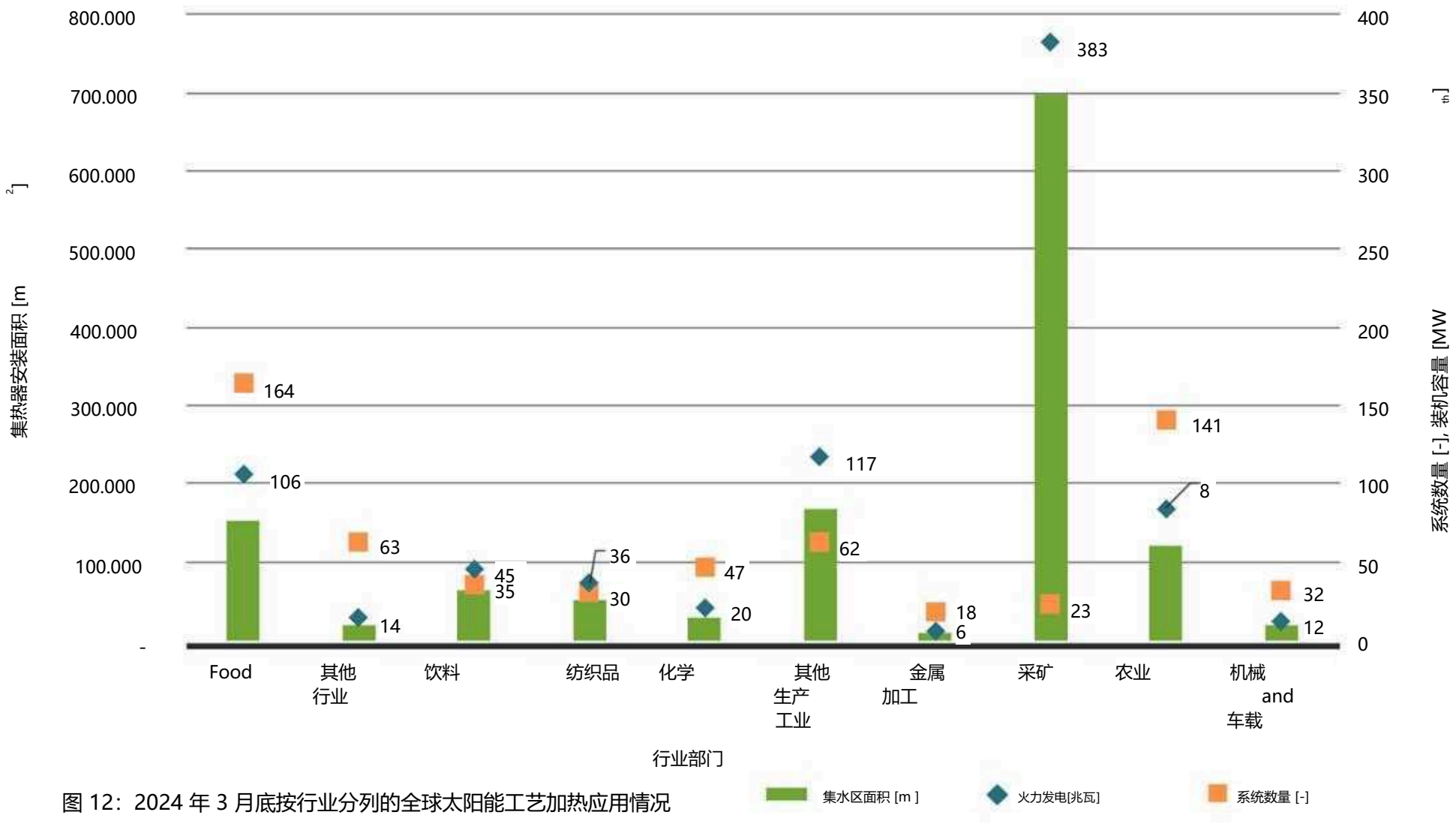

图 12：2024 年 3 月底按行业分列的全球太阳能工艺加热应用情况

来源：SHIP 数据库SHIP 数据库

Figure 13 presents the globally installed solar process heat systems by country. Mexico has achieved 119 installed SHIP systems with a thermal capacity of 21 MW_{th} and leads when it comes to the number of installations.
The order looks different if it is related to the installed capacity. Oman leads in terms of installed thermal capacity (342 MW_{th}) with the two systems at the Amal Oilfield (Miraah and Amal II). China ranks second in this category with 55 systems and an installed capacity of 153 MW_{th}. However, it should be noted that according to information from the China Academy of Building Research, significantly more solar process heat systems have been built since 2021. Unfortunately, the China Academy of Building Research could not provide detailed data on the individual systems, so they could not be included in these figures.
The leading countries in Europe in terms of installed capacity in the SHIP segment are Spain (59 MW_{th}), the Netherlands (29 MW_{th}) and France (28 MW_{th}). The USA and Chile are also among the top 10 countries with 28 MW_{th} of installed capacity each.

Industrial process heating systems developed enormous momentum in Europe in 2023. In this year alone, 77 new systems were installed (+90%). This corresponds to an increase in area by 110,183 m^2 and in thermal capacity of 77.1 MW_{th} (+792%) compared to 2022.

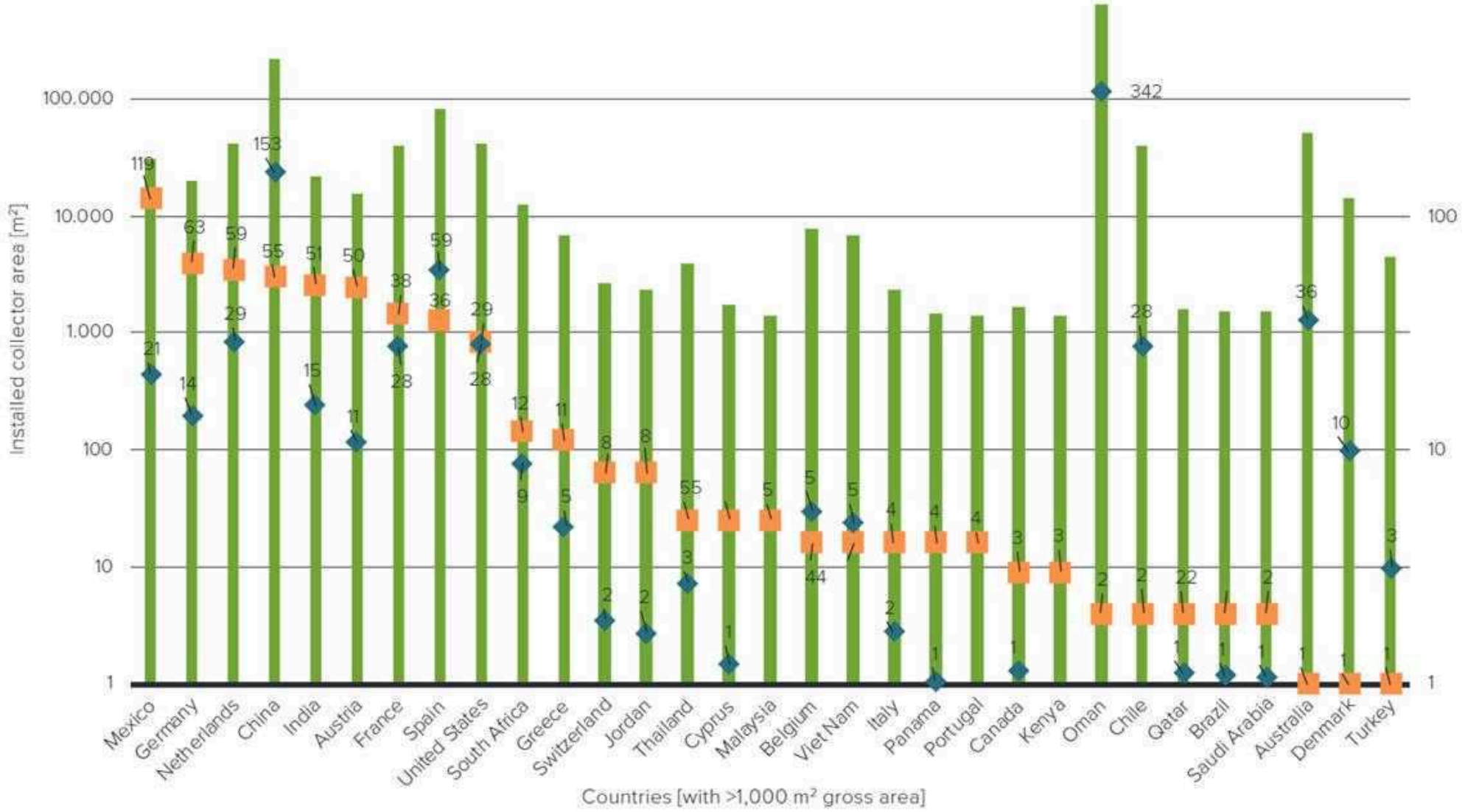

Figure 13: Global solar process heat applications in operation by country in March 2024
Source: SHIP database

Only countries with at least 0.7 MW_{th} (1,000 m^2 collector area) are shown in Figure 13 (593 of 615 systems accounting for >99% of installed thermal capacity).

Table 3 documents all SHIP systems with a collector area larger than 5,000 m^2 corresponding to 3.5 MW_{th}.

LEARN MORE

Learn more about current IEA SHC research results and international cooperation at:
Solar Process Heat: https://task64.iea-shc.org/
Solar Energy in Industrial Water & Wastewater: https://task62.iea-shc.org/

EU Projects: https://friendship-project.eu http://www.inship.eu/ http://ship2fair-h2020.eu/ www.indheap.eu

图 13 按国家列出了全球已安装的太阳能工艺加热系统。墨西哥已安装了 119 套 SHIP 系统，热容量达 21 兆瓦，在安装数量上遥遥领先。

如果按装机容量排序，则情况有所不同。阿曼凭借阿迈勒油田的两个系统（Miraah 和阿迈勒 II），在热能装机容量方面遥遥领先（342 兆瓦）。中国位居第二，有 55 个系统，装机容量为 153 兆瓦。不过，需要指出的是，根据中国建筑科学研究院的信息，自 2021 年以来，中国建造的太阳能工艺加热系统数量大幅增加。遗憾的是，中国建筑科学研究院无法

欧洲各国提供了有关单个系统的详细数据，因此这些数据无法包括在内。就 SHIP 部分的装机容量而言，欧洲的主要国家是西班牙（59 兆瓦）、荷兰（29 兆瓦）和法国（28 兆瓦）。美国和智利也跻身前 10 强，装机容量各为 28 兆瓦。2023 年，"梧桐 "工艺加热系统在欧洲发展势头迅猛。仅在这一年，就安装了 77 套新系统（+90%）。与 2022 年相比，面积增加了 110,183 平方米，热容量增加了 77.1 兆瓦（+792%）。

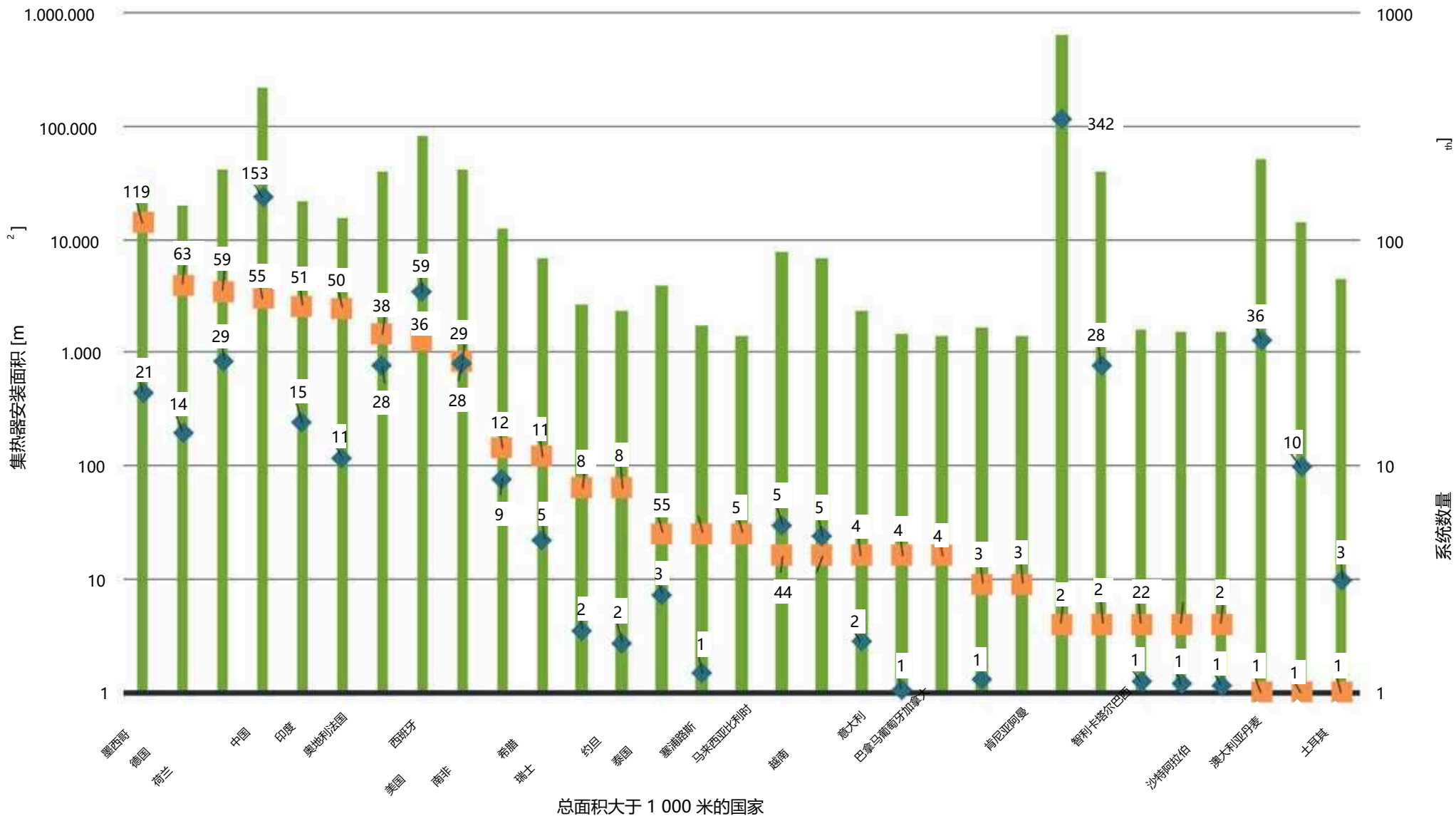

图 13：2024 年 3 月按国家分列的全球太阳能工艺热应用运行情况

来源：SHIP 数据库SHIP 数据库

图 13 只显示了至少拥有 0.7 兆瓦（1,000 平方米集热器面积）的国家（615 个系统中的 593 个系统占热能装机容量的 99%以上）。

表 3 列出了所有集热器面积大于 5000 平方米（相当于 3.5 兆瓦）的 SHIP 系统。

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了解更多有关国际能源署目前的 SHC 研究成果和国际合作的信息，请访问
太阳能工艺热： https://task64.iea-shc.org/
太阳能在工业用水和废水处理中的应用：https://task62.iea-shc.org/

欧盟项目： https://friendship-project.eu http://www.inship.eu/ http://ship2fair-h2020.eu/ www.indheap.eu

Table 3: Solar Heat for Industrial Processes (SHIP) plants > 5000 m²

Country	Site	Commissioned	Installed capacity [MW_{th}]	Collector size [m^2]
Oman	Miraah Oman, Amal	2017	330	622,080
China	Handan Bay	2024	80	114,000
Australia	Sundrop Farms, Port Augusta	2014	36	51,505
Spain	Heineken Brewery Seville	2023	30	43,414
Chile	Codelco Gabriela Mistral Mine	2013	28	39,300
Oman	Amal II	2020	12	17,280
France	Lactoserum Milk powder, Verdun	2023	11	15,317
France	Maltery, Issoudun	2021	9	13,243
China	Daly Textile, Hanghzhou	2007	9	13,000
Spain	Solarwall Madrid	2023	7	10,000
Spain	Solarwall Seville	2023	7	10,000
China	Ruyi Textile, Shandong	2015	7	9,903
USA	Prestage Foods St. Pauls, North Carolina	2012	5	7,804
China	Jiangsu Printing and Dyeing	2011	5	7460
Mexico	La Parerena Copper Mine	2016	4	6,270
Turkey	Packaging Business, Izmir	2021	4	6,000
Spain	Heineken, Quart de Poblet, Solatom, Valencia	2024	4	6,000
China	Jiangsu Jiashengyuan Agricultural Development, Sunrain	2023	4	6,000
China	Jingshi East Road Jinan	2011	4	5,750
Belgium	Avery Dennison, Turnhout	2023	4	5,540
China	Jinan, Shanddong, pre-heating of industrial boiler	2010	4	5,184
USA	Frito Lay, Arizona	2008	3.5	5,068
Vietnam	Prime Asia Leather, Ba Ria-Vung Tau	2018	3.5	5,018

Source: ship-plants.info

In addition to the more traditional industrial sectors that use thermal solar systems highlighted above, is horticulture. Solar thermal plants are being used to heat greenhouses for flower and vegetable cultivation. The following table provides an overview of the top 10 systems with collector areas larger than 50 m² between 2013 and 2020.

Table 4: Overview of the 10 largest solar thermal systems for flower and vegetable cultivation

Country	Site	Commissioned	Installed capacity [MW_{th}]	Collector size [m^2]	Storage tank [m^3]
Australia	Port Augusta	2014	36.05	51,505	-
Netherlands	Nibbixwoud	2020	10.5	15,000	1,450
Netherlands	Mol Freesia	2020	11	15,000	-
Denmark	Østervang Varpelev	2015	9.89	14,112	4,800
Netherlands	Heerhugowaard	2019	6.51	9,300	1,300
Netherlands	Tesselaar Freesias	2019	6	9,300	-
South Africa	Krugersdorp	2015	6.40	9,135	2,100
China	Tibet	2020	3.5	5,000	n.a.
Uganda	Kampala	2017	3.23	4,614	900
Ethiopia	Arerti	2020	2.91	4,170	1,400

Source: Bosman Van Zaal, G2 Energy, Solar Payback SHIP Supplier Survey 2020, AEE INTEC

表 3：面积大于 5000 平方米的工业加工太阳能供热（SHIP）工厂

国家	Site	受委托	装机容量 [MW]	收集器尺寸 [m²]
Oman	米拉赫-阿曼，阿迈勒	2017	330	622,080
中国	邯郸湾	2024	80	114,000
澳大利亚	奥古斯塔港 Sundrop 农场	2014	36	51,505
西班牙	塞维利亚喜力啤酒厂	2023	30	43,414
智利	Codelco 加布里埃拉米斯特拉尔矿	2013	28	39,300
Oman	阿迈勒 II	2020	12	17,280
法国	凡尔登奶粉	2023	11	15,317
法国	马尔特里，伊苏敦	2021	9	13,243
中国	杭州达利纺织有限公司	2007	9	13,000
西班牙	马德里太阳能墙	2023	7	10,000
西班牙	塞维利亚太阳能墙	2023	7	10,000
中国	山东如意纺织	2015	7	9,903
USA	Prestage Foods 北卡罗来纳州圣保罗市	2012	5	7,804
中国	江苏印染	2011	5	7460
墨西哥	拉帕雷纳铜矿	2016	4	6,270
土耳其	包装业务，伊兹密尔	2021	4	6,000
西班牙	喜力、夸特-德-波布莱特、索拉托姆，巴伦西亚	2024	4	6,000
中国	江苏嘉盛源农业发展有限公司，太阳雨	2023	4	6,000
中国	济南经十东路	2011	4	5,750
比利时	艾利丹尼森，特恩霍特	2023	4	5,540
中国	济南，山东，预热工业锅炉	2010	4	5,184
USA	亚利桑那州 Frito Lay	2008	3.5	5,068
越南	Prime Asia Leather, Ba Ria-Vung Tau	2018	3.5	5,018

来源： ship-plants.info

除了上述使用太阳能热系统的传统工业部门外，园艺业也在使用太阳能热系统。

太阳热能设备正被用于加热温室，以进行低温和蔬菜栽培。下表概述了 2013 至 2020 年间集热器面积大于 50 平方米的 10 大系统。

表 4：用于花卉和蔬菜种植的 10 大太阳能光热系统概览

国家	Site	受委托	装机容量 [MW]	收集器尺寸 [m²]	储存罐 [m³]
澳大利亚	奥古斯塔港	2014	36.05	51,505	-
荷兰	Nibbixwoud	2020	10.5	15,000	1,450
荷兰	小苍兰	2020	11	15,000	-
丹麦	Østervang Varpelev	2015	9.89	14,112	4,800
荷兰	Heerhugowaard	2019	6.51	9,300	1,300
荷兰	苔丝拉尔小苍兰	2019	6	9,300	-
南非	克鲁格斯多普	2015	6.40	9,135	2,100
中国	西藏	2020	3.5	5,000	n.a.
乌干达	坎帕拉	2017	3.23	4,614	900
埃塞俄比亚	Arerti	2020	2.91	4,170	1,400

资料来源Bosman Van Zaal，G2 Energy，《2020 年太阳能投资回报率 SHIP 供应商调查》，AEE INTEC

Domestic hot water and swimming pool system with 2,082 m² PVT in Barcelona, Spain
Photo: Abora Solar, Spain

5.4 PVT – Photovoltaic Thermal Systems

Photovoltaic-Thermal collectors (PVT) are hybrid solar panels that generate both electricity (photovoltaic) and heat (thermal) from sunlight. These collectors integrate photovoltaic cells, which convert sunlight into electricity, with a thermal absorber to capture heat energy, thus reaching higher yields per area. This is particularly important if the available roof area is limited and integrated solar energy concepts are needed to achieve a climate-neutral energy supply for consumers, such as in residential and commercial buildings.

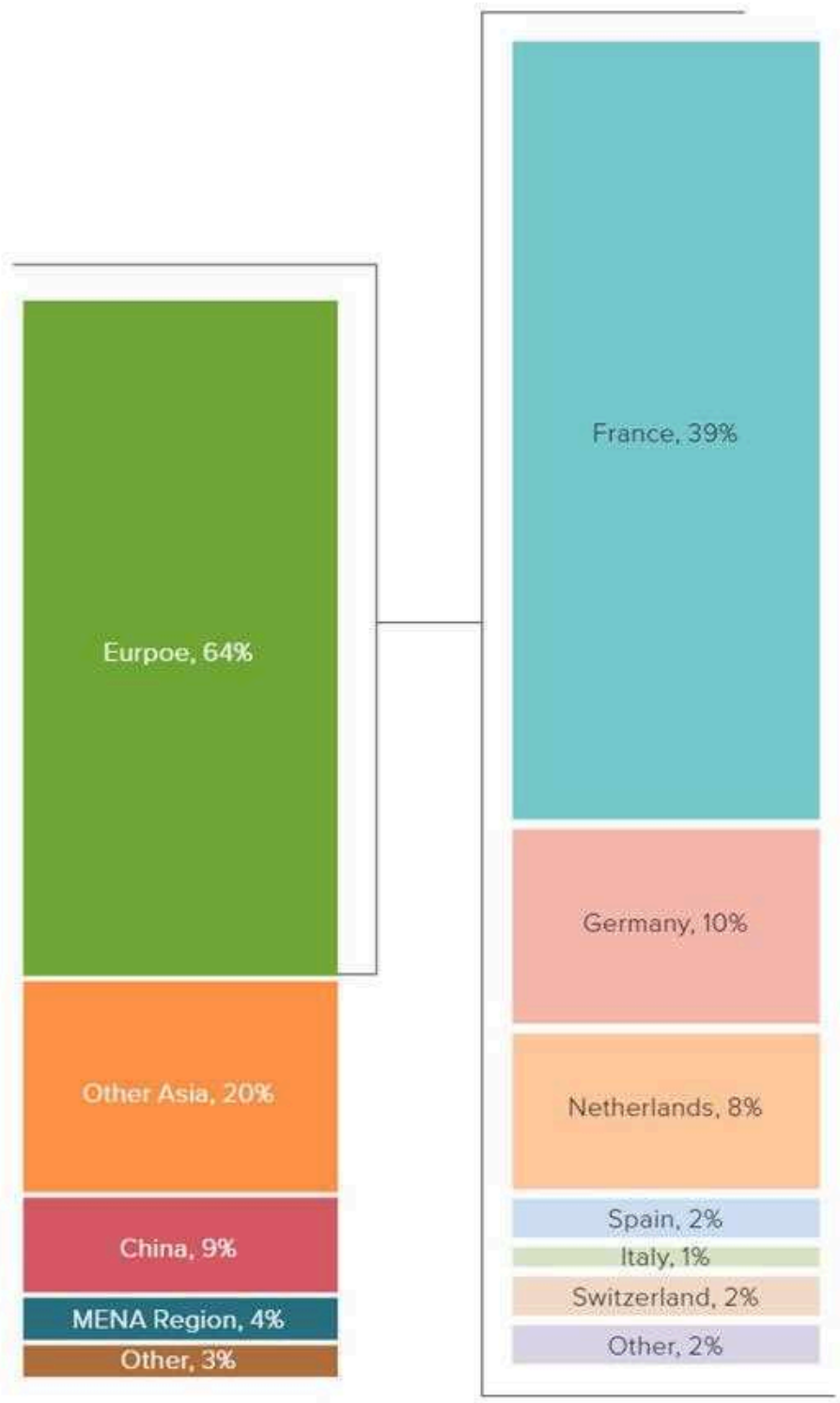


Figure 14: Distribution of the total installed collector area by economic region in 2023
Source: AEE INTEC

西班牙巴塞罗那 2,082 平方米 PVT 生活热水和游泳池系统

照片西班牙阿博拉太阳能公司

5.4 PVT - 光电热系统

光伏-热能集热器（PVT）是一种混合太阳能电池板，既能利用太阳光发电（光伏），又能利用太阳光发热（热能）。这些集热器将把太阳光转化为电能的光伏电池与捕捉热能的热能吸收器集成在一起，因此单位面积产量更高。如果可利用的屋顶面积有限，需要采用综合太阳能概念为消费者（如住宅和商业建筑）提供气候中立的能源供应，这一点尤为重要。

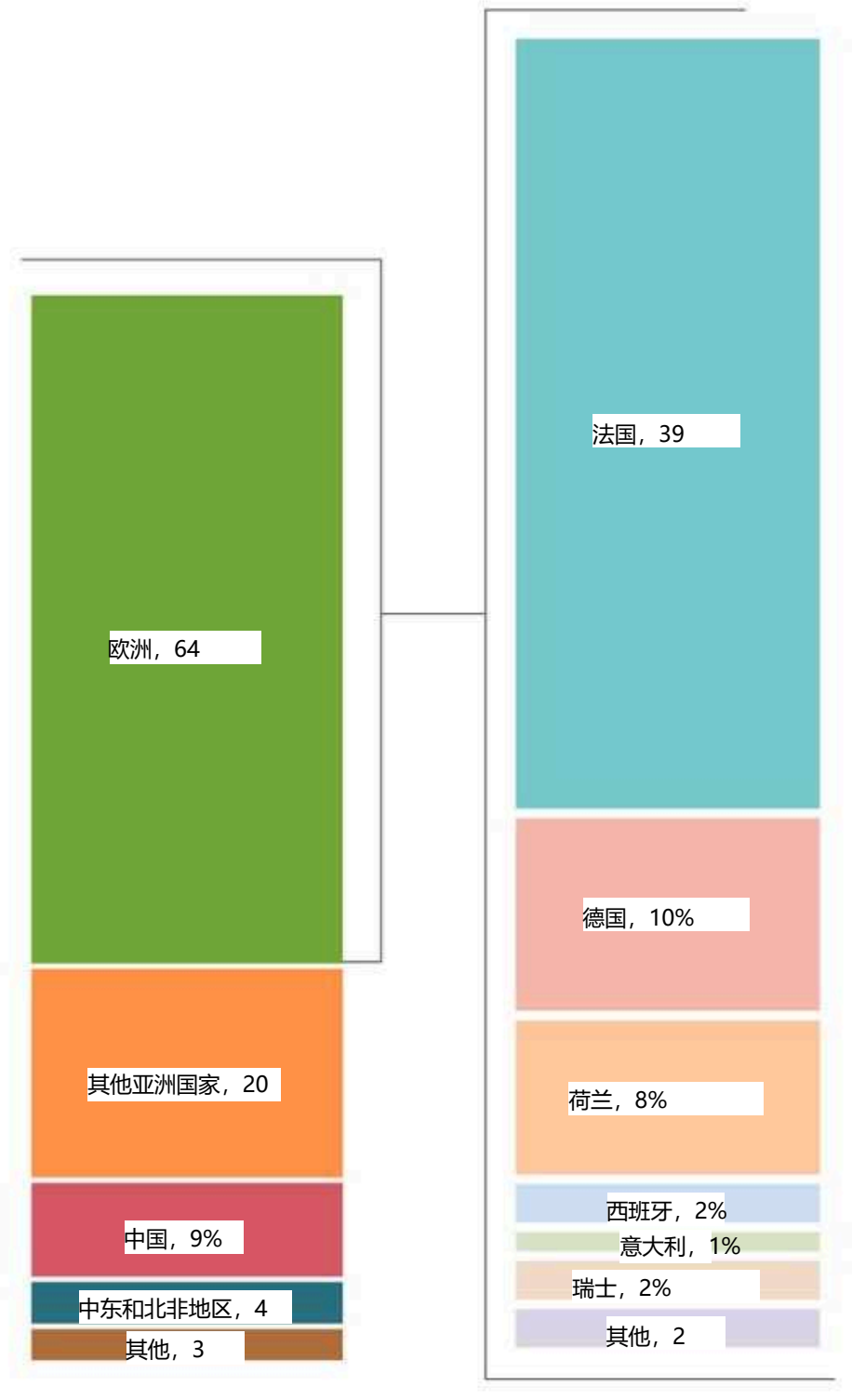


图 14：2023 年各经济区集热器总安装面积分布图

来源：AEE INTECAEE INTEC

The technology is more complex than just a PV or a solar thermal collector but provides additional significant advantages. The PV production can be slightly higher if the collectors operate at temperatures below that of PV-only modules. Depending on the type of PVT collectors, the produced temperature ranges from about -20°C up to +150°C and serves a wide range of applications. The solar thermal energy generated by PVT systems offers significant flexibility in the system design. The energy can be stored in many ways, including onsite tanks, aquifers, ground strata, and pit storage systems. It can be used directly for hot water, space heating, or a secondary system such as a heat source (heat pumps). Cooling (radiative and convective) can also be provided directly during the night using the PVT collector's thermal absorber or indirectly through a machine driven by the PV electricity.

General market overview

In 2023, the total installed PVT collector area was 1,589,553 m^2 (822 MW_{th}, 292 MW_{peak}). The vast majority of this collector area was installed in Europe (1,011,212 m^2) followed by Other Asia (318,329 m^2) and China (146,926 m^2), which together accounted for 822 MW_{th}, 292 MW_{peak} of the total installed capacity. The remaining installed collector area was shared between the MENA countries (Egypt, Israel, and Iraq (70,130 m^2), Sub-Sahara African countries (Ghana, Lesotho, and South Africa (22,926 m^2), United States and Canada (11,133 m^2), Australia (3,576 m^2), Latin America (766 m^2), and others (4,555 m^2).

In the European Market, France is the market leader with an installed collector area of 616,551 m^2 followed by Germany with 162,549 m^2 and the Netherlands with 127,303 m^2. In Spain, Italy, and Switzerland, collector areas range between 25,915 m^2 and 34,192 m^2. In the remaining European countries, collector areas of at least 23,664 m^2 were reported.

With a global share of 63% of installed thermal capacity, uncovered PVT water collectors were the dominating PVT technology, followed by air PVT collectors with 33% and covered PVT water collectors with 4%. Evacuated tube collectors and concentrators play only a minor role in the total numbers. Table 5 shows the cumulated installed collector area by PVT collector type at the end of 2023.

1.6 million m² PVT collector area installed worldwide

PVT system (240 collectors, 617 m^2, 390 kW_{th}, 17 kW_{el}) installed at the British Library in Central London, UK. Annual CO_2 savings of 58 tons
Photo: Naked Energy Ltd, UK

该技术比单纯的光伏或光热集热器更为复杂，但却具有更多显著优势。如果集热器的工作温度低于纯光伏组件的工作温度，则光伏发电量会稍高一些。根据 PVT 集热器的不同类型，其产生的温度范围从 -20°C 到 +150°C 不等，应用范围十分广泛。光伏热发电系统产生的太阳热能为系统设计提供了极大的灵活性。能量可以通过多种方式储存，包括现场储罐、含水层、地层和坑式储存系统。它可以直接用于热水、空间加热或热源（热泵）等辅助系统。夜间还可利用光伏集热器的热吸收器直接提供冷却（辐射冷却和对流冷却），或通过光伏发电驱动的机器间接提供冷却。

在欧洲市场，法国的集热器安装面积为 616 551 平方米，居于首位；其次是德国的 162 549 平方米和荷兰的 127 303 平方米。西班牙、意大利和瑞士的集热器面积介于 25,915 平方米和 34,192 平方米之间。其余欧洲国家的采集面积至少为 23,664 平方米。

在全球 63% 的热能装机容量中，无遮挡光伏热管水集热器是最主要的光伏热管技术，其次是空气光伏热管集热器（33%）和有遮挡光伏热管水集热器（4%）。蒸发管式集热器和聚光器在总数中只占很小的比例。表 5 显示了 2023 年底按 PVT 集热器类型划分的累计安装集热器面积。

市场概况

2023 年，光伏发电集热器总安装面积为 1,589,553 平方米（822 兆瓦，292 兆瓦）。其中绝大部分集热器安装在欧洲（1,011,212 m²），其次是其他亚洲（318,329 m²）和中国（146,926 m²），共占总装机容量的 822 兆瓦和 292 兆瓦。其余已安装的集热器面积由中东和北非国家（埃及、以色列和伊拉克（70,130 平方米））、撒哈拉以南非洲国家（加纳、莱索托和南非（22,926 平方米））、美国和加拿大（11,133 平方米）、澳大利亚（3,576 平方米）、拉丁美洲（766 平方米）和其他国家（4,555 平方米）共享。

1.6 百万米
PVT 收集器
安装面积
全球

光伏发电系统（240 个集热器，617 平方米，390 千瓦，17 千瓦）安装在英国伦敦市中心的大英图书馆。每年可节约 58 吨二氧化碳
照片英国裸体能源有限公司

Table 5: Cumulated collector area by PVT collector type at the end of 2023

Country	Water Collectors [m²]			Air Collectors [m²]	Concentrators [m²]	TOTAL [m²]
	uncovered	covered	evacuated tube			
Albania	364	30	0	0	0	394
Argentine	129	0	0	0	0	129
Australia	3,477	0	0	99	0	3,576
Austria	1,929	2,710	0	0	0	4,639
Belgium	4,177	0	32	290	15	4,515
Brazil	26	0	0	0	0	26
Bulgaria	1,017	43	0	0	0	1,060
Canada	393	32	7	0	0	432
Chile	213	113	0	0	10	337
China	177,721	1,034	0	0	171	178,926
Croatia	907	125	0	0	0	1,032
Cyprus	0	0	3	0	0	3
Czech Republic	0	4	0	0	0	4
Denmark	117	54	0	0	0	171
Dubai	43	9	0	0	0	52
Ecuador	0	138	0	0	0	139
Egypt	0	0	0	0	21	21
Finland	312	0	0	0	0	312
France	67,024	1,952	0	547,575	0	616,551
Germany	154,900	6,939	3	512	195	162,549
Ghana	22,000	0	0	0	0	22,000
Greece	0	16	0	0	0	16
Guadeloupe	0	4	0	0	0	4
Hungary	525	53	0	0	0	578
India	0	801	0	0	255	1,056
Iraq	0	30	0	0	0	30
Israel	70,054	0	0	0	0	70,054
Italy	18,091	2,696	0	0	0	20,787
Korea, South	280,814	0	0	0	0	280,814
Kosovo	176	14	0	0	0	190
Lebanon	25	0	0	0	0	25
Lesotho	0	48	0	0	0	48
Luxembourg	709	0	0	145	0	854
Macedonia	1,358	199	0	0	0	1,557
Maldives	0	0	0	0	21	21
Martinique	0	63	0	0	0	63
Netherlands	113,654	11,794	33	0	1,822	127,303
Norway	646	0	0	0	0	646
Pakistan	0	7	0	0	0	7
Paraguey	0	0	0	0	51	51
Peru	0	16	0	0	0	16
Poland	1,313	61	0	0	0	1,374
Portugal	335	338	0	0	0	672
Romania	46	4	0	0	0	50
Russia	0	50	0	0	0	50
Singapur	875	0	0	0	0	875
Slovakia	0	250	0	0	0	250
Slovenia	130	15	0	0	0	144
South Africa	0	79	32	0	767	878
Spain	1,552	32,640	0	0	0	34,192
Sweden	1,200	20	0	0	31	1,251
Sri Lanka	3,461	44	0	0	0	3,505
Switzerland	22,257	128	0	3,530	0	25,915
Turkey	0	25	0	0	30	55
United Kingdom	1,440	1,539	640	348	135	4,102
United States	10,676	20	7	0	0	10,702
Uruguay	0	2	0	0	0	2
Other	1,274	3,250	16	0	15	4,555
Total	**965,358**	**67,385**	**773**	**552,499**	**3,538**	**1,589,553**

Source: AEE INTEC

表 5：2023 年底按 PVT 集热器类型分列的累计集热器面积

国家	集水井 [m]			空气收集器 [m]	浓缩器 [m]	总计 [m]
	露袒	掩盖	疏散管			
阿尔巴尼亚	364	30	0	0	0	394
阿根廷	129	0	0	0	0	129
澳大利亚	3,477	0	0	99	0	3,576
奥地利	1,929	2,710	0	0	0	4,639
比利时	4,177	0	32	290	15	4,515
巴西	26	0	0	0	0	26
保加利亚	1,017	43	0	0	0	1,060
加拿大	393	32	7	0	0	432
智利	213	113	0	0	10	337
中国	177,721	1,034	0	0	171	178,926
克罗地亚	907	125	0	0	0	1,032
塞浦路斯	0	0	3	0	0	3
捷克共和国	0	4	0	0	0	4
丹麦	117	54	0	0	0	171
迪拜	43	9	0	0	0	52
厄瓜多尔	0	138	0	0	0	139
埃及	0	0	0	0	21	21
芬兰	312	0	0	0	0	312
法国	67,024	1,952	0	547,575	0	616,551
德国	154,900	6,939	3	512	195	162,549
加纳	22,000	0	0	0	0	22,000
希腊	0	16	0	0	0	16
瓜德罗普岛	0	4	0	0	0	4
匈牙利	525	53	0	0	0	578
印度	0	801	0	0	255	1,056
Iraq	0	30	0	0	0	30
以色列	70,054	0	0	0	0	70,054
意大利	18,091	2,696	0	0	0	20,787
韩国	280,814	0	0	0	0	280,814
科索沃	176	14	0	0	0	190
黎巴嫩	25	0	0	0	0	25
莱索托	0	48	0	0	0	48
卢森堡	709	0	0	145	0	854
马其顿	1,358	199	0	0	0	1,557
马尔代夫	0	0	0	0	21	21
马提尼克岛	0	63	0	0	0	63
荷兰	113,654	11,794	33	0	1,822	127,303
挪威	646	0	0	0	0	646
巴基斯坦	0	7	0	0	0	7
Paraguey	0	0	0	0	51	51
Peru	0	16	0	0	0	16
波兰	1,313	61	0	0	0	1,374
葡萄牙	335	338	0	0	0	672
罗马尼亚	46	4	0	0	0	50
俄罗斯	0	50	0	0	0	50
辛格普尔	875	0	0	0	0	875
斯洛伐克	0	250	0	0	0	250
斯洛文尼亚	130	15	0	0	0	144
南非	0	79	32	0	767	878
西班牙	1,552	32,640	0	0	0	34,192
瑞典	1,200	20	0	0	31	1,251
斯里兰卡	3,461	44	0	0	0	3,505
瑞士	22,257	128	0	3,530	0	25,915
土耳其	0	25	0	0	30	55
英国	1,440	1,539	640	348	135	4,102
美国	10,676	20	7	0	0	10,702
乌拉圭	0	2	0	0	0	2
其他	1,274	3,250	16	0	15	4,555
总计	965,358	67,385	773	552,499	3,538	1,589,553

来源：AEE INTECAEE INTEC

Table 6: Total installed PVT capacity in 2023 divided into thermal and electrical power

Country	Water Collectors						Air Collectors		Concentrators		TOTAL	
	uncovered		covered		evacuated tube							
	[kW_{th}]	[kW_{peak}]	[kW_{th}]	kW_{peak}]	[kW_{th}]	[kW_{peak}]	[kW_{th}]	[kW_{peak}]	[kW_{th}]	[kW_{peak}]	[kW_{th}]	[kW_{peak}]
Albania	185	88	15	5	0	0	0	0	0	0	200	93
Argentine	0	0	0	0	0	0	0	0	0	0	0	0
Australia	1,781	656	0	0	0	0	54	17	0	0	1,835	673
Austria	968	416	1,372	469	0	0	0	0	0	0	2,340	885
Belgium	2,115	948	0	0	16	4	141	46	9	2	2,281	1,000
Brazil	13	5	0	0	0	0	0	0	0	0	13	5
Bulgaria	513	238	19	7	0	0	0	0	0	0	531	245
Canada	200	110	14	6	3	1	0	0	0	0	216	116
Chile	105	37	52	21	0	0	0	0	6	1	162	59
China	89,866	32,207	452	180	0	0	0	0	98	20	90,416	32,407
Croatia	506	172	54	22	0	0	0	0	0	0	560	194
Cyprus	0	0	0	0	1	0	0	0	0	0	1	0
Czech Republic	0	0	2	1	0	0	0	0	0	0	2	1
Dubai	59	21	30	9	0	0	0	0	0	0	89	30
Denmark	23	8	5	1	0	0	0	0	0	0	28	10
Ecuador	0	0	67	24	0	0	0	0	0	0	67	24
Egypt	0	0	0	0	0	0	0	0	12	2	12	2
Finland	0	0	0	0	0	0	0	0	0	0	0	0
France	34,701	14,083	1,029	330	0	0	271,352	88,288	0	0	307,081	102,701
Germany	77,048	30,124	3,562	1,189	1	0	263	87	109	22	80,983	31,423
Ghana	11,958	4,140	0	0	0	0	0	0	0	0	11,958	4,140
Greece	0	0	7	3	0	0	0	0	0	0	7	3
Guadeloupe	0	0	2	1	0	0	0	0	0	0	2	1
Hungary	257	90	24	10	0	0	0	0	0	0	282	100
India	0	0	410	135	0	0	0	0	146	30	557	164
Iraq	28,212	9,110	13	5	0	0	0	0	0	0	28,225	9,115
Israel	34,566	12,368	0	0	0	0	0	0	0	0	34,566	12,368
Italy	9,009	3,618	1,280	501	0	0	0	0	0	0	10,289	4,119
Korea, South	137,599	47,828	0	0	0	0	0	0	0	0	137,599	47,828
Kosovo	90	49	8	2	0	0	0	0	0	0	98	51
Lebanon	0	0	0	0	0	0	0	0	0	0	0	0
Lesotho	0	0	21	8	0	0	0	0	0	0	21	8
Luxembourg	349	129	0	0	0	0	71	23	0	0	419	152
Macedonia	701	321	100	35	0	0	0	0	0	0	802	356
Maldives	0	0	0	0	0	0	0	0	12	2	12	2
Martinique	0	0	34	10	0	0	0	0	0	0	34	10
Netherlands	58,827	24,160	5,441	2,031	14	4	0	0	1,046	213	65,328	26,407
Norway	349	121	0	0	0	0	0	0	0	0	349	121
Pakistan	0	0	3	1	0	0	0	0	0	0	3	1
Paraguey	0	0	0	0	0	0	0	0	30	6	30	6
Peru	0	0	7	3	0	0	0	0	0	0	7	3
Poland	672	329	30	10	0	0	0	0	0	0	702	340
Portugal	168	62	159	58	0	0	0	0	0	0	326	119
Romania	24	13	2	1	0	0	0	0	0	0	26	14
Russia	0	0	22	9	0	0	0	0	0	0	22	9
Singapur	462	166	0	0	0	0	0	0	0	0	462	166
Slovakia	0	0	108	43	0	0	0	0	0	0	108	43
Slovenia	68	31	8	2	0	0	0	0	0	0	75	33
South Africa	0	0	34	14	16	4	0	0	441	90	491	108
Spain	775	284	16,714	5,630	0	0	0	0	0	0	17,489	5,914
Sweden	682	228	11	3	0	0	0	0	18	4	710	235
Sri Lanka	1,760	903	21	8	0	0	0	0	0	0	1,781	911
Switzerland	11,264	5,054	63	21	0	0	1,806	576	0	0	13,134	5,651
Turkey	0	0	11	4	0	0	0	0	15	3	26	8
United Kingdom	722	307	819	268	273	72	170	55	66	15	2,050	717
United States	5,449	2,160	11	3	3	1	0	0	0	0	5,462	2,164
Uruguay	0	0	1	0	0	0	0	0	0	0	1	0
Other	651	294	1,496	617	7	2	0	0	7	2	2,161	914
Total	**512,696**	**190,880**	**33,531**	**11,699**	**333**	**88**	**273,856**	**89,092**	**2,014**	**412**	**822,430**	**292,172**

Source: AEE INTEC

As shown in the table, PVT collectors' total cumulative thermal capacity by the end of 2023 was 822 MW_{th}, and the PV power was 292 MW_{peak}.

表 6：2023 年光伏发电总装机容量，按热能和电力分列

国家	水收集器						空气收集器		浓缩器		总计	
	露袒		掩盖		疏散管							
	[kW]	[kW]	[kW]	kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]
阿尔巴尼亚	185	88	15	5	0	0	0	0	0	0	200	93
阿根廷	0	0	0	0	0	0	0	0	0	0	0	0
澳大利亚	1,781	656	0	0	0	0	54	17	0	0	1,835	673
奥地利	968	416	1,372	469	0	0	0	0	0	0	2,340	885
比利时	2,115	948	0	0	16	4	141	46	9	2	2,281	1,000
巴西	13	5	0	0	0	0	0	0	0	0	13	5
保加利亚	513	238	19	7	0	0	0	0	0	0	531	245
加拿大	200	110	14	6	3	1	0	0	0	0	216	116
智利	105	37	52	21	0	0	0	0	6	1	162	59
中国	89,866	32,207	452	180	0	0	0	0	98	20	90,416	32,407
克罗地亚	506	172	54	22	0	0	0	0	0	0	560	194
塞浦路斯	0	0	0	0	1	0	0	0	0	0	1	0
捷克共和国	0	0	2	1	0	0	0	0	0	0	2	1
迪拜	59	21	30	9	0	0	0	0	0	0	89	30
丹麦	23	8	5	1	0	0	0	0	0	0	28	10
厄瓜多尔	0	0	67	24	0	0	0	0	0	0	67	24
埃及	0	0	0	0	0	0	0	0	12	2	12	2
芬兰	0	0	0	0	0	0	0	0	0	0	0	0
法国	34,701	14,083	1,029	330	0	0	271,352	88,288	0	0	307,081	102,701
德国	77,048	30,124	3,562	1,189	1	0	263	87	109	22	80,983	31,423
加纳	11,958	4,140	0	0	0	0	0	0	0	0	11,958	4,140
希腊	0	0	7	3	0	0	0	0	0	0	7	3
瓜德罗普岛	0	0	2	1	0	0	0	0	0	0	2	1
匈牙利	257	90	24	10	0	0	0	0	0	0	282	100
印度	0	0	410	135	0	0	0	0	146	30	557	164
Iraq	28,212	9,110	13	5	0	0	0	0	0	0	28,225	9,115
以色列	34,566	12,368	0	0	0	0	0	0	0	0	34,566	12,368
意大利	9,009	3,618	1,280	501	0	0	0	0	0	0	10,289	4,119
韩国，南朝鲜 137,599 47,828 0 0 0 0 0 0 137,599 47,828 科索沃												
	90	49	8	2	0	0	0	0	0	0	98	51
黎巴嫩	0	0	0	0	0	0	0	0	0	0	0	0
莱索托	0	0	21	8	0	0	0	0	0	0	21	8
卢森堡	349	129	0	0	0	0	71	23	0	0	419	152
马其顿	701	321	100	35	0	0	0	0	0	0	802	356
马尔代夫	0	0	0	0	0	0	0	0	12	2	12	2
马提尼克岛	0	0	34	10	0	0	0	0	0	0	34	10
荷兰	58,827	24,160	5,441	2,031	14	4	0	0	1,046	213	65,328	26,407
挪威	349	121	0	0	0	0	0	0	0	0	349	121
巴基斯坦	0	0	3	1	0	0	0	0	0	0	3	1
Paraguey	0	0	0	0	0	0	0	0	30	6	30	6
Peru	0	0	7	3	0	0	0	0	0	0	7	3
波兰	672	329	30	10	0	0	0	0	0	0	702	340
葡萄牙	168	62	159	58	0	0	0	0	0	0	326	119
罗马尼亚	24	13	2	1	0	0	0	0	0	0	26	14
俄罗斯	0	0	22	9	0	0	0	0	0	0	22	9
辛格普尔	462	166	0	0	0	0	0	0	0	0	462	166
斯洛伐克	0	0	108	43	0	0	0	0	0	0	108	43
斯洛文尼亚	68	31	8	2	0	0	0	0	0	0	75	33
南非	0	0	34	14	16	4	0	0	441	90	491	108
西班牙	775	284	16,714	5,630	0	0	0	0	0	0	17,489	5,914
瑞典	682	228	11	3	0	0	0	0	18	4	710	235
斯里兰卡	1,760	903	21	8	0	0	0	0	0	0	1,781	911
瑞士	11,264	5,054	63	21	0	0	1,806	576	0	0	13,134	5,651
土耳其	0	0	11	4	0	0	0	0	15	3	26	8
英国	722	307	819	268	273	72	170	55	66	15	2,050	717
美国	5,449	2,160	11	3	3	1	0	0	0	0	5,462	2,164
乌拉圭	0	0	1	0	0	0	0	0	0	0	1	0
其他	651	294	1,496	617	7	2	0	0	7	2	2,161	914
总计	512,696	190,880	33,531	11,699	333	88	273,856	89,092	2,014	412	822,430	292,172

来源：AEE INTECAEE INTEC

如表所示，到 2023 年底，PVT 集热器的累计总热容量为 822 兆瓦，光伏发电量为 292 兆瓦。

Market development of PVT collectors between 2017 and 2023

Based on the market data provided by 46 PVT manufacturers, the market experienced robust growth of 9% on average between 2017 and 2020. In 2021, it reached its highest value at +13%, but in 2022, it faced challenges leading to a significant decline of 37%. Unfortunately, this trend continued in 2023. The newly installed capacity in 2023 amounted to 29.5 MWt_h and 14,5 MW_{peak}. This is a decrease of 30.4% compared to the installed thermal capacity in 2022.

In 2023, the global PVT market shrank by 30%

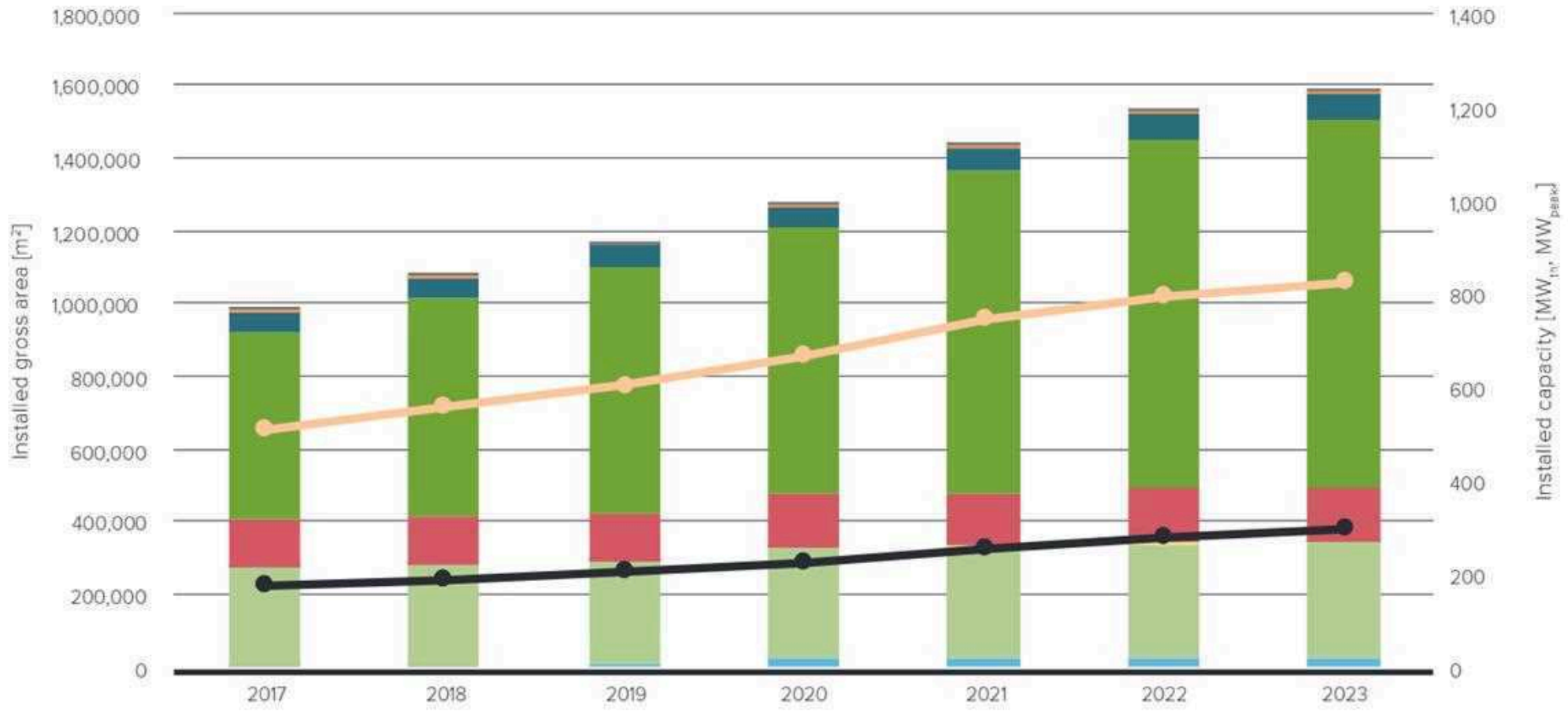


Figure 15: Global market development of PVT collectors from 2017 to 2023
Source: AEE INTEC

100 PVT solar panels at the town hall Offenbach an der Queich, Germany, operate in combination with a 50 kW heat pump
Photo: Consolar Solare Energiesysteme GmbH, Germany

2017 年至 2023 年 PVT 集热器的市场发展情况

根据 46 家光伏 T 制造商提供的市场数据，2017 年至 2020 年间，市场平均增长率为 9%。2021 年，市场达到最高值 +13%，但在 2022 年，市场面临挑战，大幅下滑 37%。不幸的是，这一趋势在 2023 年仍将继续。2023 年的新增装机容量为 29.5 兆瓦和 14.5 兆瓦。与 2022 年的热装机容量相比，下降了 30.4%。

2023 年全球 PVT 市场缩减了 30%

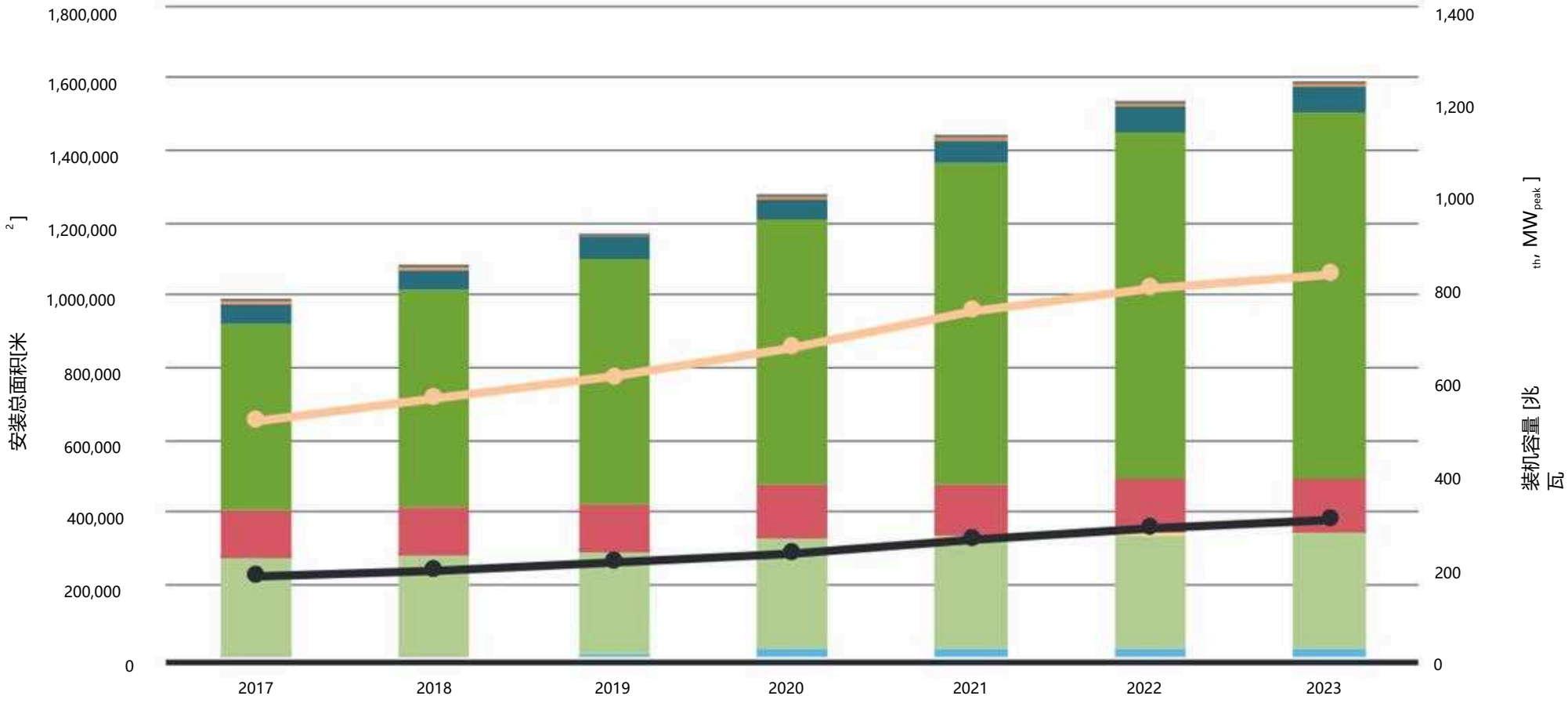


图 15：2017 年至 2023 年全球 PVT 集热器市场发展情况
来源：AEE INTECAEE INTEC

德国 Offenbach an der Queich 市政厅的 100 块 PVT 太阳能电池板与 50 千瓦热泵结合使用

照片德国 Consolar Solare Energiesysteme GmbH 公司

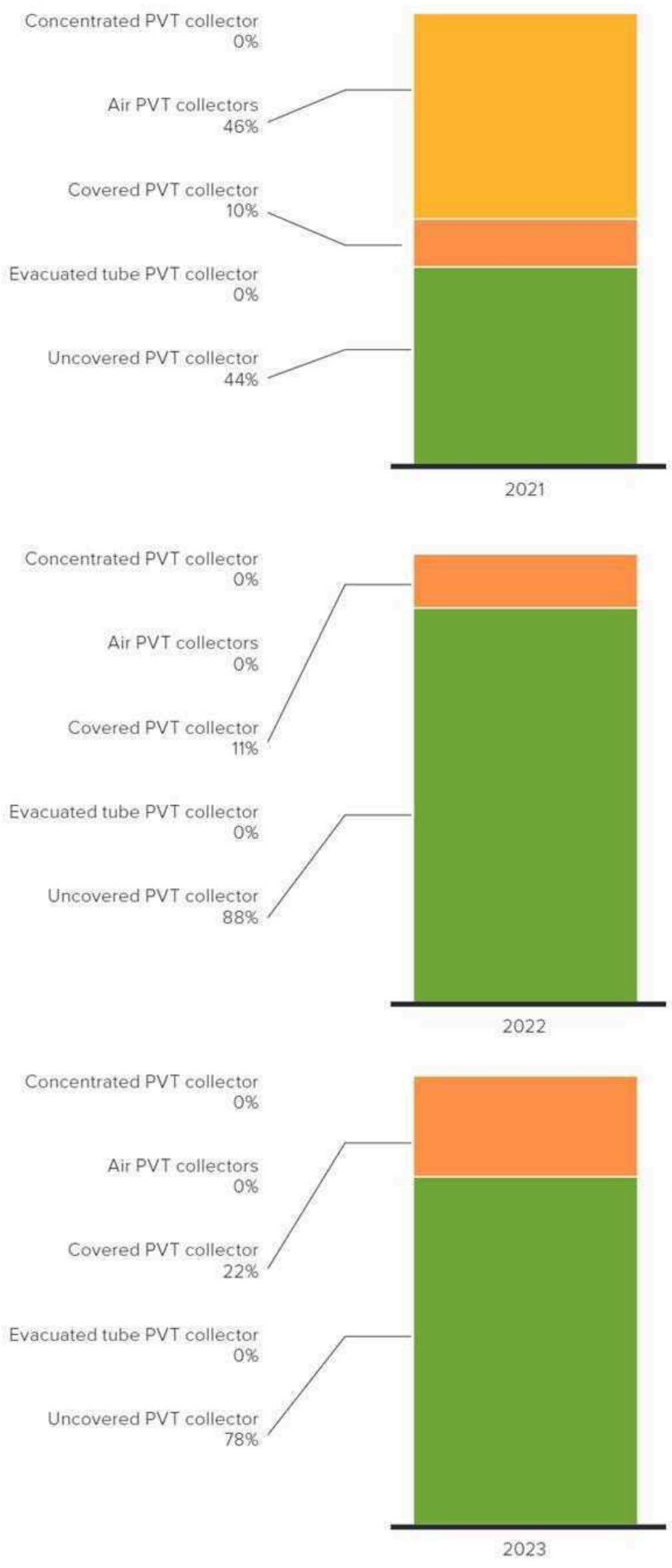


Figure 16: Distribution of newly installed PVT collector area worldwide by collector type from 2021 to 2023
Source: AEE INTEC

Market development in 2023

As mentioned above and shown in Figure 15, global interest in PVT systems grew steadily between 2017 and 2021. However, in 2022, the PVT market was negatively affected by declining or discontinued subsidies in some countries. At the same time, the demand for photovoltaic systems increased significantly worldwide due to large-scale subsidies and support measures.

Some PVT manufacturers responded to the increased demand for PV technologies by focusing mainly on the PV market. However, PVT was not able to capitalize on the PV momentum in every country. As a result, strong, previously dominant markets like France came to a near halt while smaller markets continued to grow.[16]

The significant global marked decline started in 2022, mainly due to the downturn in the French market. Changes in the French funding scheme led to the Air PVT collector market collapse in 2022 (-90%) and continued in 2023 (-16%). Other traditionally strong PVT markets in Europe, Germany (-22%), and the Netherlands (-59%) also reported market declines in 2023.

On the positive side, there were European countries with growing PVT markets. Spain reported a growth of +34% (7,832 m^2), and Belgium 20% (1,018 m^2). However, the increase in these countries could not compensate for the overall market slumps.

The fact that France suffered a major market decline in Air PVT collectors in 2022 is also reflected in the breakdown of the different PVT collector types in 2021, as shown in Figure 16. Air PVT collectors were the dominant collector type in 2021 at 45.5%, ahead of uncovered PVT collectors at 44.2%. In 2023, the market share of uncovered PVT collectors decreased slightly from 87% to 78 %, while covered PVT collectors increased by 10%. Air PVT collectors, evacuated tube PVT, and concentrated PVT have almost disappeared from the market.

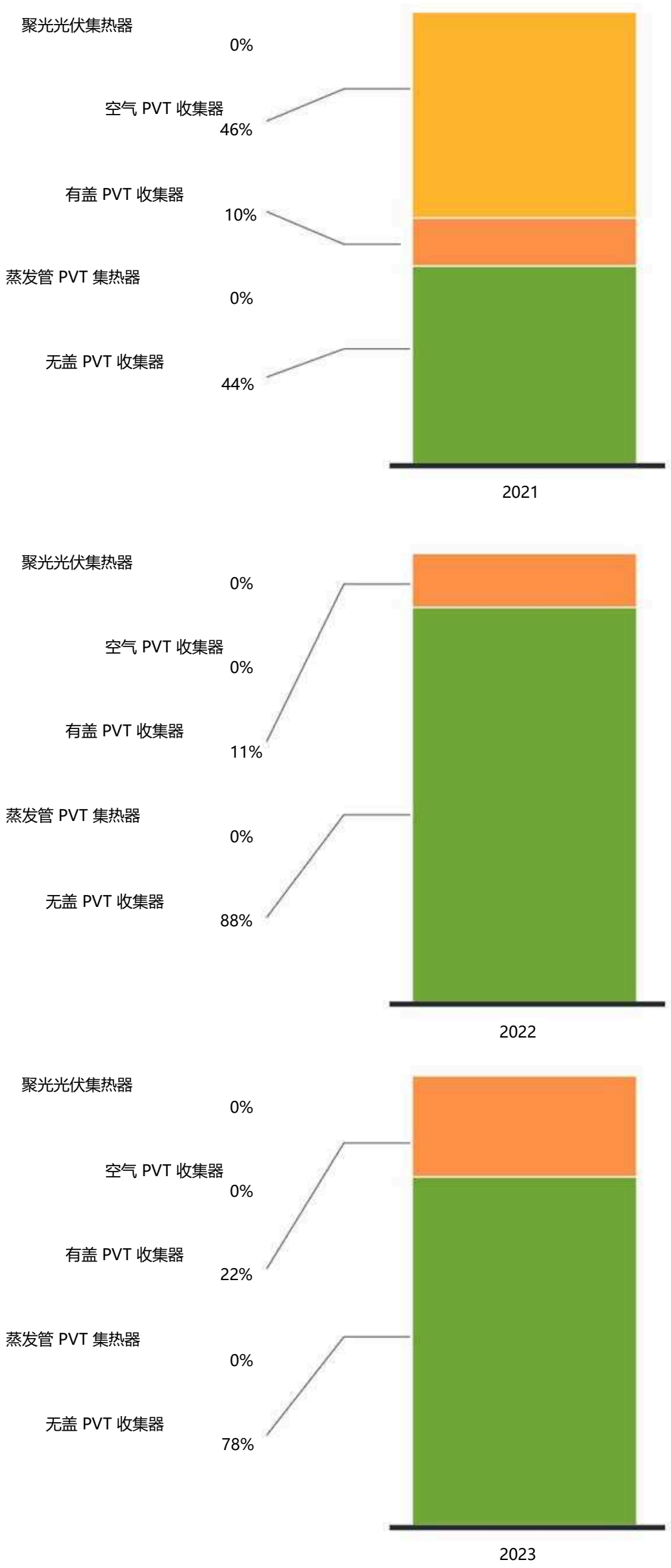
[16] The 2023 PVT data are based on feedback from 28 PVT collector manufactures and PVT system suppliers from 12 different countries.

2023 年的市场发展

如上文所述和图 15 所示，2017 年至 2021 年期间，全球对光伏发电系统的兴趣稳步增长。然而，在 2022 年，由于一些国家的补贴减少或停止，光伏技术市场受到了负面影响。与此同时，由于大规模的补贴和支持措施，全球对光伏系统的需求大幅增加。

一些 PVT 制造商为应对光伏技术需求的增长，主要关注光伏市场。然而，PVT 并不能利用每个国家的光伏发展势头。因此，像法国这样强大的、以前占主导地位的市场几乎停滞不前，而较小的市场则继续增长。

全球显著下滑始于 2022 年，主要是由于法国市场的低迷。法国资助计划的变化导致空气 PVT 集热器市场在 2022 年崩溃（-90%），并持续到 2023 年（-16%）。欧洲其他传统强势的 PVT 市场，德国（-22%）和荷兰（-59%）在 2022 年也出现了市场下滑。



2023.

从积极的方面来看，一些欧洲国家的光伏发电市场也在增长。西班牙增长了 34%（7832 平方米），比利时增长了 20%（1018 平方米）。然而，这些国家的增长并不能弥补整体市场的下滑。

如图 16 所示，2021 年不同 PVT 集热器类型的细分也反映了 2022 年法国空气 PVT 集热器市场大幅下滑的事实。2021 年，空气式 PVT 集热器占主导地位，达到 45.5%，超过无遮挡式 PVT 集热器的 44.2%。2023 年，无盖 PVT 集热器的市场份额略有下降，从 87% 降至 78%，而有盖 PVT 集热器则增加了 10%。空气式 PVT 集热器、真空管式 PVT 和聚光式 PVT 在市场上几乎销声匿迹。

[16] 2023 年 PVT 数据基于来自 12 个不同国家的 28 家 PVT 集热器制造商和 PVT 系统供应商的反馈。

图 16：2021 年至 2023 年按集热器类型划分的全球光伏发电集热器新安装面积分布图
来源：AEE INTECAEE INTEC

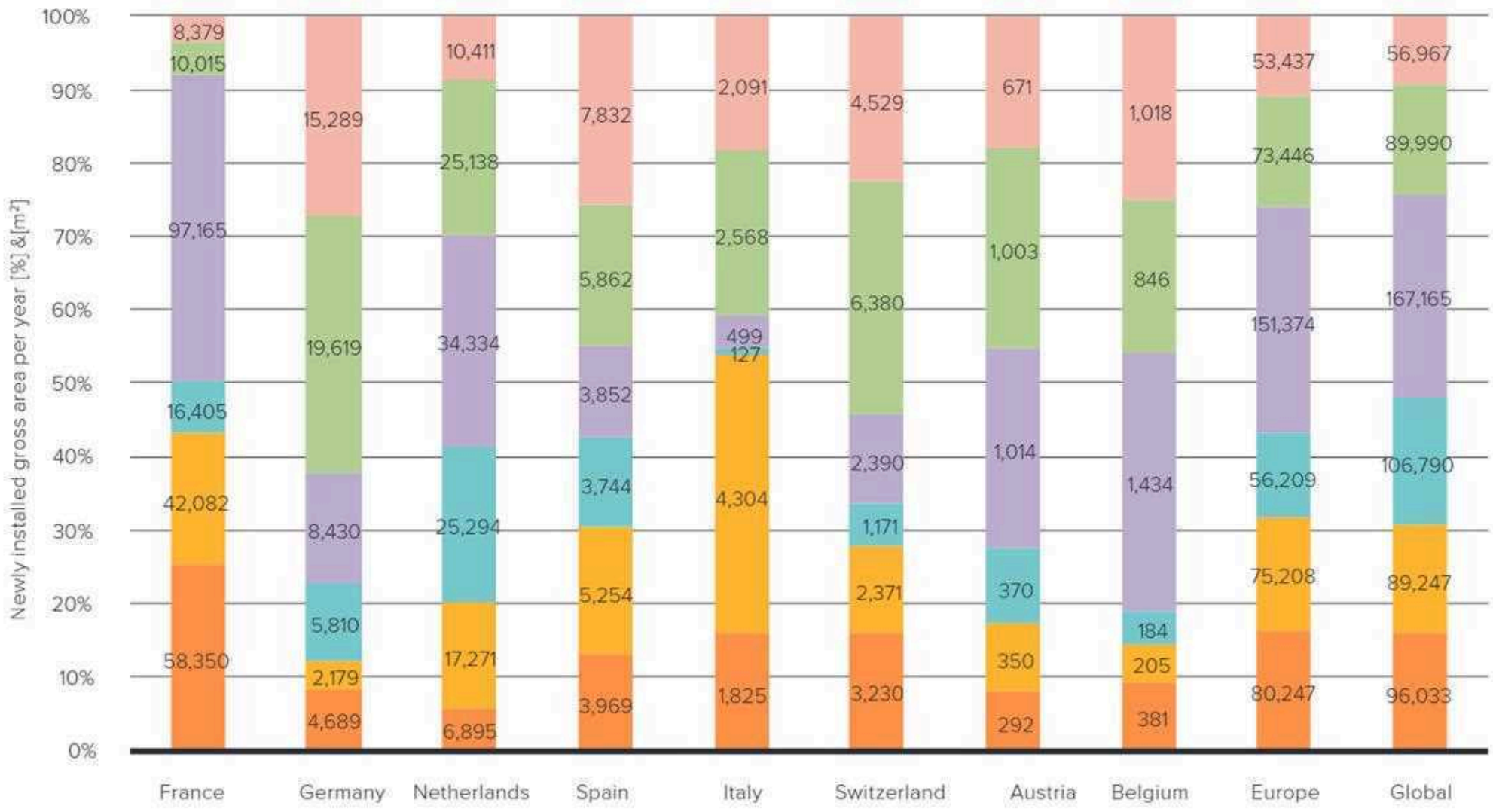


Figure 17: Newly installed PVT collector area in selected countries from 2018 to 2023 Source: AEE INTEC

5.5
Photovoltaic generated heat - PGH

In its Renewables 2023 report, the International Energy Agency expects global heat consumption in the building sector to stagnate over the period 2023-2028.[17]

Modern uses of renewable energy sources for space and water heating, as well as for cooking, are projected to expand nearly 40% in the meantime, raising the share of renewables in the building sector's heat consumption from 15% in 2023 to 21% in 2028, and displacing 5.7 EJ of fossil fuel consumption by 2028.

According to the IEA report mentioned above, renewable electricity will be the fastest-growing renewable heat source in buildings between 2023 and 2028. Its use will expand by two-thirds globally (+2.2 EJ) and contribute almost 40% of the sectoral increase in renewable heat consumption. This means that in the building sector, too, the electrification of the heating sector will take the largest share in the transition from traditional fossil fuel-based heating systems to renewable heating technologies.

PV2Heat systems installed in South Africa
Photo: Bongani Xakaza, SANEDI, South Africa

This shift is driven by various factors, including efforts to reduce greenhouse gas emissions, improve energy efficiency, and increase the integration of renewable energy sources into the heating sector.
However, challenges to widespread electrification of the heat sector remain, including the need for sufficient renewable energy generation capacity and grid infrastructure upgrades to support increased electricity demand.

LEARN MORE

Learn more about application of PVT collectors at:
https://task60.iea-shc.org/

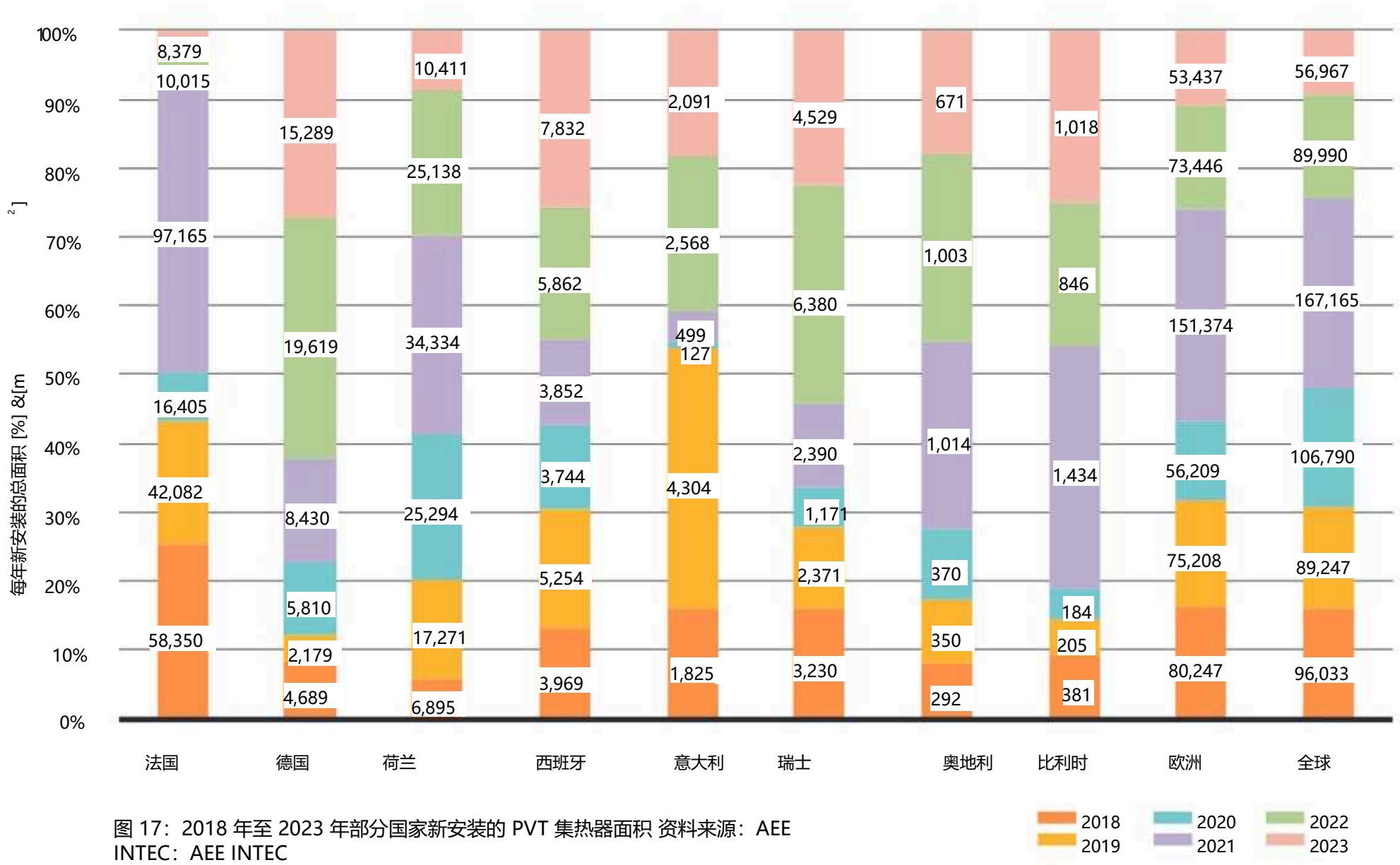


图 17：2018 年至 2023 年部分国家新安装的 PVT 集热器面积 资料来源：AEE INTEC：AEE INTEC

5.5 光伏产生的热量 - PGH

国际能源机构在其《2023 年可再生能源报告》中预计，2023-2028 年期间，全球建筑行业的热消耗量将停滞不前。

与此同时，可再生能源在空间和水加热以及烹饪方面的现代用途预计将扩大近 40%，使可再生能源在建筑部门热量消耗中所占的比例从 2023 年的 15%提高到 2028 年的 21%，到 2028 年可替代 5.7 亿焦耳的化石燃料消耗。

根据上述 IE A 报告，2023 年至 2028 年期间，可再生能源电力将成为建筑物中增长最快的可再生能源热源。在全球范围内，可再生电力的使用量将增加三分之二（+2.2 EJ），并占可再生热能消耗部门增长量的近 40%。这意味着在建筑领域，供热部门的电气化也将在从传统化石燃料供热系统向可再生供热技术过渡的过程中占据最大份额。

在南非安装 PV2Heat 系统
照片Bongani Xakaza，南非 SANEDI

推动这一转变的因素有很多，包括努力减少温室气体排放、提高能源效率以及将更多可再生能源纳入供热部门。

然而，供热行业广泛电气化仍面临挑战，包括需要足够的可再生能源发电能力和电网基础设施升级，以支持增加的电力需求。

LEARN MORE

了解有关 PVT 集热器应用的更多信息，请访问
https://task60.iea-shc.org/

In addition to these factors, the discussion about the electrification of the heating sector is also about questioning renewable heating technologies such as biomass, geothermal energy, and solar thermal energy and replacing them with photovoltaics (PV). While PV panels are primarily associated with generating electricity for various applications, including powering homes and businesses, they can also be utilized for heating purposes through electrification. Electric heating technologies, such as heat pumps or electric resistance heaters, can efficiently convert the electricity generated by PV panels into heat for space heating, water heating, or industrial processes. This Photovoltaic Generated Heat (PGH) discussion is being driven above all by the significant and ongoing price reductions in photovoltaics, which put traditional renewable heating technologies under economic pressure.

When photovoltaic solar collectors were >100 USD/Watt, solar thermal hot water was the vanguard technology for households to utilize their own solar resources. This has led to a large installed base of solar thermal systems. In 2024, a residential photovoltaic system can be installed for <1 USD/Watt in most markets. This dramatic cost reduction has made PV-driven electric hot water options viable. In fact, a directly connected "PV2Heat" system may now represent the most affordable and reliable option in some markets. In high PV penetration markets, several emerging solutions are being brought to market to increase the solar electricity consumed in water heating, space heating, and even district heating.

Examples of PGH system concepts and installations are presented below.

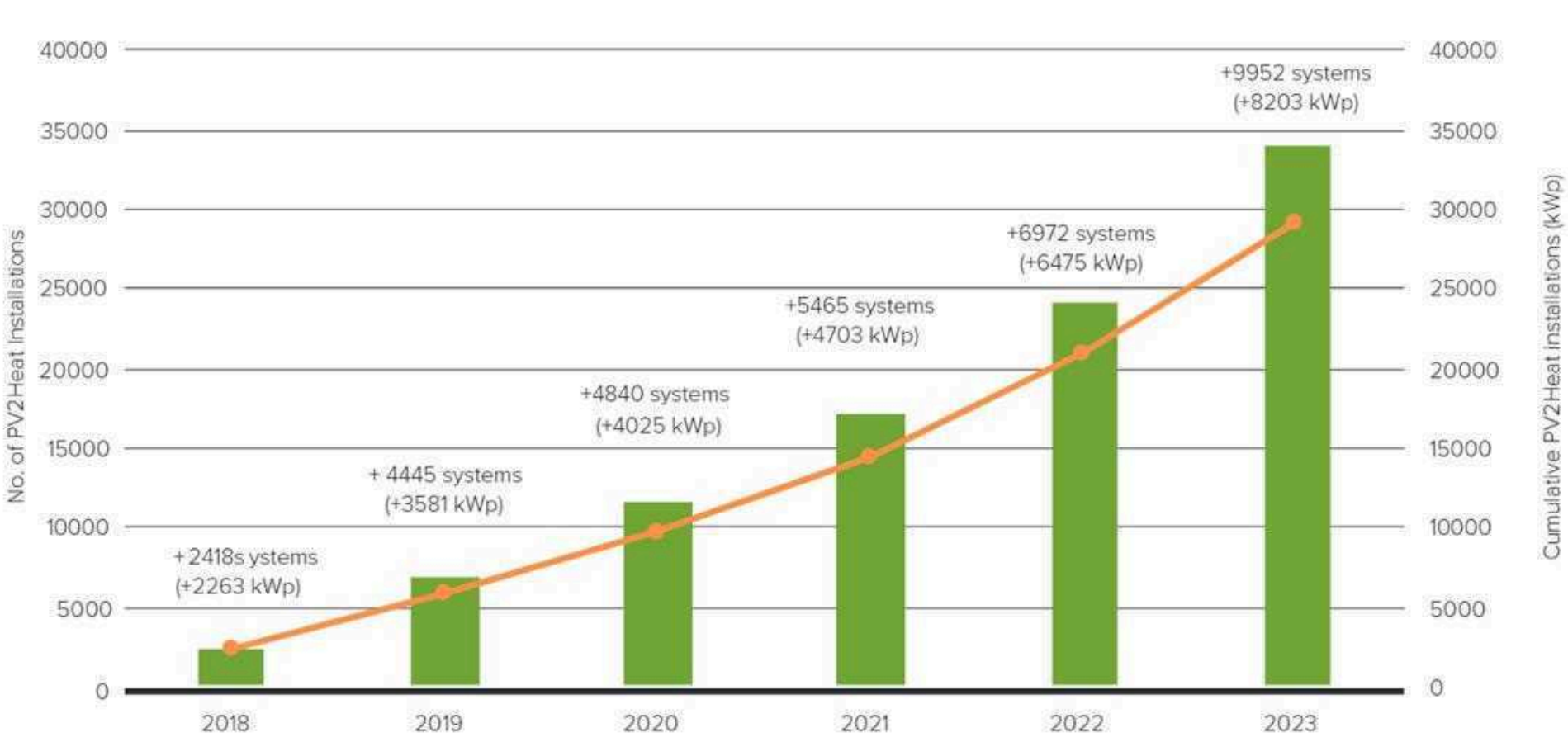


Figure 18: PV2Heat Market development in South Africa between 2018 and 2023
Source: Lavhe Maluleke, Stellenbosch University, South Africa

5.5.1. Direct Coupled "PV2Heat" Technologies

So-called "PV2Heat" systems couple the direct current (DC) from rooftop PV panels directly to a DC resistance heating element in the hot water tank (i.e., no inverter and minimal intermediary electronics). In areas with unreliable grid service, high connection costs, or low up-front capital, "PV2Heat" systems represent an ideal hot water technology.

PV2Heat systems are increasingly offered at a lower cost than solar thermal thermosyphon systems. In addition to cost benefits, this type of system also has the advantage that hot water storage tanks no longer need to be installed on the roof and do not have any stagnation or frost issues.

As presented for the first time in the 2021 edition of the Solar Heat Worldwide report, a considerable and growing market has developed in recent years, particularly in some countries in southern Africa. As shown in Figure 18, by the end of 2023, 34,000 "PV2Heat" systems had been installed in South Africa.

[17] Renewables 2023 – Analyses IEA, January 2024

除了这些因素之外，关于供热行业电气化的讨论还涉及到对生物质能、地热能和太阳热能等可再生供热技术的质疑，以及用光伏技术取而代之。虽然光伏电池板主要用于发电，包括为家庭和企业供电，但也可以通过电气化用于供暖。电加热技术，如热泵或电阻加热器，可以有效地将光伏电池板产生的电能转化为热能，用于空间加热、水加热或工业生产。光伏发电供热（PGH）的讨论主要是由于光伏发电的价格持续大幅下降，这给传统的可再生供热技术带来了经济压力。

当光伏太阳能集热器的价格超过 100 美元/瓦时，太阳能热能热水成为家庭利用自身太阳能资源的先锋技术。因此，太阳能热系统的安装量很大。2024 年，在大多数市场上，住宅光伏系统的安装成本将低于 1 美元/瓦。成本的大幅降低使光伏发电驱动的电热水方案变得可行。事实上，在某些市场，直接连接的 "PV2Heat "系统可能是最经济、最可靠的选择。在光伏发电渗透率较高的市场中，一些新兴的解决方案正在推向市场，以增加太阳能电力在热水、空间供热甚至区域供热中的消耗。

下文介绍了 PGH 系统的概念和安装实例。

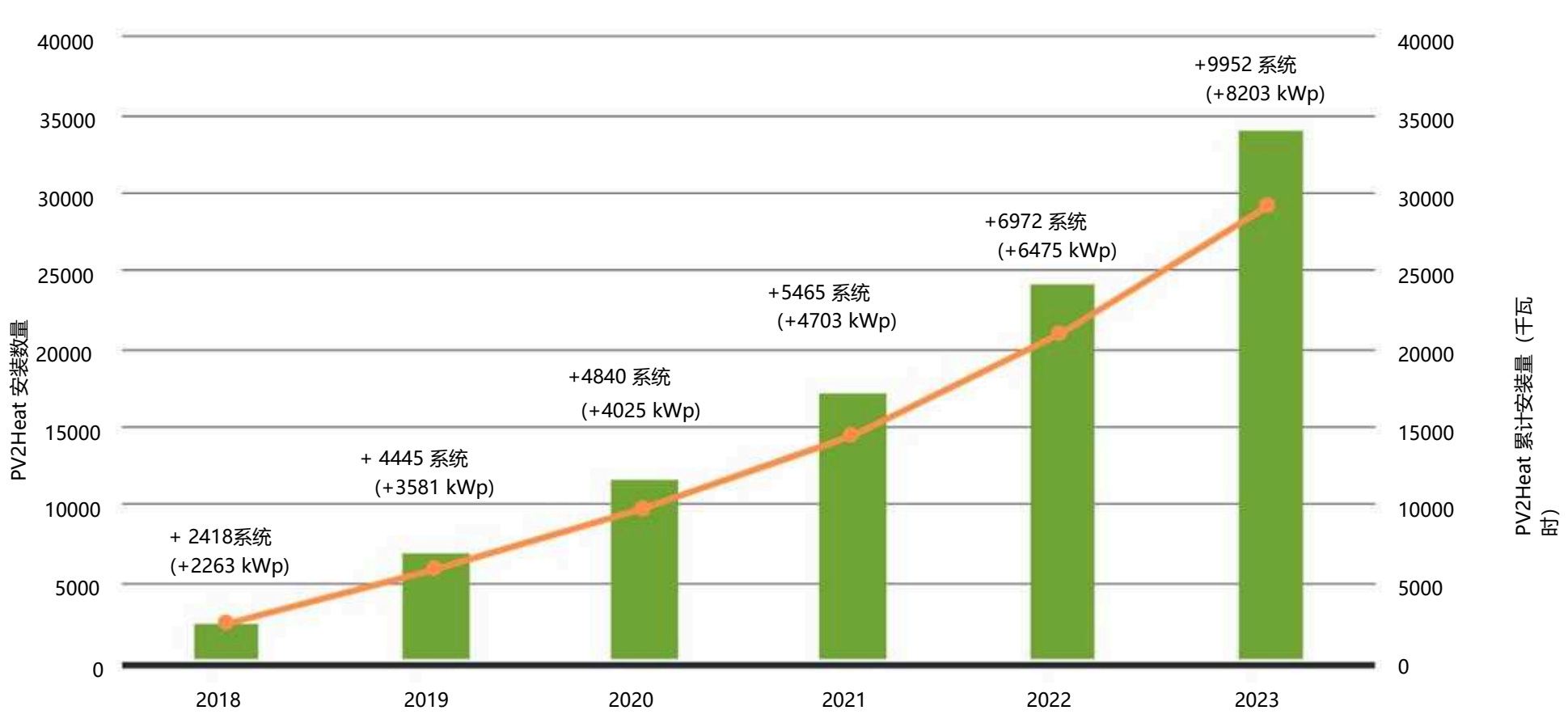


图 18：2018 至 2023 年南非 PV2Heat 市场发展情况

资料来源南非斯泰伦博斯大学 Lavhe Maluleke

5.5.1. 直接耦合 "PV2Heat "技术

所谓的 "PV2Heat "系统是将屋顶光伏电池板的直流电（DC）直接与热水箱中的直流电阻加热元件相连接（即不需要逆变器和最少的中间电子设备）。在电网服务不可靠、连接成本高或前期投资低的地区，"PV2Heat "系统是一种理想的热水技术。

PV2Heat 系统的成本越来越低于太阳能热泵系统。除了成本优势外，这种系统还有一个优点，即热水储存罐不再需要安装在屋顶上，也不会出现任何积水或结霜问题。

正如 2021 年版《全球太阳能供热》报告首次介绍的那样，近年来，特别是在南部非洲的一些国家，已经形成了一个相当大且不断增长的市场。如图 18 所示，到 2023 年底，南非已安装了 34 000 套 "PV2Heat "系统。

[17] 2023 年可再生能源--国际能源机构的分析，2024 年 1 月

A 144 kWpeak photovoltaic system supplies the multi-family house with electricity, hot water, and space heating[18]
Photo: Markus Ursprung, Switzerland

5.5.2.
Partially Coupled PV Hot Water Technologies

Partially coupled systems are particularly interesting in markets with high levels of installed PV on the electrical grid (e.g., a pronounced 'duck' curve). This has led to a dramatic reduction in the export value of generated PV electricity. Australia is a leader in PV penetration, with >1kWe installed capacity per person in 2024. Pure electric water heaters represent one-third of the Australian hot water market. The humble hot water storage tank in these systems can easily store ~10kWh of energy, and emerging products can unlock the value of this energy storage through PV self-consumption schemes that optimize usage patterns and real-time pricing and work together with other grid-connected systems.

Another option is PV diverters, which ensure excess PV electricity is routed to thermal loads when PV generation exceeds the house's other energy requirements. These devices have been developed predominantly by manufacturers in the United Kingdom.

5.5.3.
Solar Combisystem powered by PV

A solar combisystem, is a type of solar thermal system that integrates solar energy for both space heating and domestic hot water (DHW) production in residential or commercial buildings. This type of system still has a significant market share, particularly in some central and northern European countries. It combines solar thermal collectors with other components, such as a hot water storage tank, backup heating source (e.g., a boiler or electric heater), and control systems to provide space heating and DHW throughout the year.

A solar combisystem powered by PV instead of thermal collectors has a few examples in Germany and Switzerland where it provides 100% of the building's heat supply.

The following picture shows a multi-family house in Switzerland with a building-integrated 144 kW_{peak} photovoltaic system. The PV electricity is used to heat a 100 m^3 hot water tank with a diameter of four meters and a height of 12 meters. The water in the well-insulated tank is heated to 95°C in summer using electric heating elements. This hot water supplies the multi-party and communal house with hot water all year and space heating in winter.

5.5.4.
PV district heating in Germany

A new solar heating concept for municipalities in Germany is to use photovoltaic systems with heat pumps to supply municipalities with district heating from the sun instead of the traditional solar thermal systems used for district heating.

In September 2023, a ground-mounted photovoltaic system with a capacity of 125 MW was commissioned in the German municipality of Bundorf.
1.5 MW of the PV plant is directly connected to the neighboring heating center of the district heating network. There, a 400 kW electric boiler and a 200 kW air heat pump process the solar power into heat. Solar power will generate approximately 54% of the heat demand for an initial 30 connected buildings throughout the year. A few more buildings will be connected in the coming years.

A 75 m^3 buffer storage tank ensures the balance between daytime and nighttime heating demands and reserves for rainy days. In cases where this capacity falls short of meeting the district heating grid's winter requirements, a 200 kW wood-chip boiler can step in.

According to the Bundorf plant's general contractor, further projects using the PV-heat pump-biomass concept are in progress.[19]

125 MW_{peak} PV system in Bundorf, Germany, uses part of the solar power to supply the district heating network
Photo: MaxSolar, Germany

144 kWpeak 光伏系统为多户住宅提供电力、热水和空间供暖

照片马库斯-乌斯普龙，瑞士

5.5.2.
部分耦合光伏热水技术

部分耦合系统在电网光伏装机水平较高（如明显的 "鸭子 "曲线）的市场中尤其引人注目。这导致光伏发电的出口价值急剧下降。澳大利亚在光伏发电渗透率方面处于领先地位，到 2024 年，人均光伏发电装机容量将超过 1 千瓦。纯电热水器占澳大利亚热水市场的三分之一。这些系统中不起眼的热水存储罐可以轻松存储约 10kWh 的能量，新兴产品可以通过光伏自消费计划释放这种能量存储的价值，该计划可以优化使用模式和实时定价，并与其他并网系统协同工作。

另一种选择是光伏分流器，当光伏发电量超过房屋的其他能源需求时，可确保将多余的光伏电力输送到热负荷。这些装置主要由英国制造商开发。

5.5.3.
光伏供电的太阳能组合系统

太阳能组合系统是一种太阳能热系统，它将太阳能用于住宅或商业建筑的空间供暖和生活热水生产。这种系统仍然占有很大的市场份额，尤其是在一些中欧和北欧国家。它将太阳能集热器与热水储罐、备用热源（如锅炉或电加热器）和控制系统等其他组件结合在一起，全年提供空间供暖和生活热水。

在德国和瑞士，有一些以光伏发电取代集热装置的太阳能组合系统的实例，该系统可为建筑提供 100% 的热能。

下图显示的是瑞士的一栋多户住宅，该住宅安装了 144 千瓦的建筑一体化光伏系统。光伏发电用于加热一个直径 4 米、高 12 米、容积 100 立方米的热水箱。在夏季，隔热性能良好的水箱中的水通过电加热元件被加热到 95°C。这些热水全年为多方和公共住宅提供热水，冬季为空间供暖。

5.5.4.
德国光伏区域供热

德国市政当局采用的一种新的太阳能供热概念是，利用光伏系统和热泵为市政当局提供来自太阳的区域供热，而不是用于区域供热的传统太阳能热系统。

2023 年 9 月，一个容量为 125 兆瓦的地面光伏系统在德国邦多夫市投入使用。

1.5 兆瓦的光伏电站直接连接到邻近的区域供热网络供热中心。在那里，一台 400 千瓦的电锅炉和一台 200 千瓦的空气热泵将太阳能转化为热能。太阳能发电将满足最初连接的 30 座建筑全年约 54% 的供热需求。在未来几年内，还将有更多的建筑接入。

75 立方米的缓冲储水箱可确保白天和夜间供热需求之间的平衡，并为雨天提供储备。如果该容量无法满足区域供热网的冬季需求，则可使用 200 千瓦的木屑锅炉。

据本多夫电厂的总承包商称，采用光伏-热泵-生物质概念的更多项目正在进行中。

德国本多夫 125 兆瓦光伏系统利用部分太阳能为区域供热网络供电

照片德国 MaxSolar

A second German example of the solar electrification of district heating systems was built in Altensteig Wart. Heat for the hybrid district heating system is provided by an 800 kW biomass boiler, a 375 kW heat pump, and a 100 kW combined heat and power (CHP) unit. In summer, the heat pump is supplied with power by a 70 kW_{peak} photovoltaic system. As the PV system cannot provide all of the electricity during the heating period, the electricity is generated by the CHP plant.[20]

While these two PV-powered district heating systems may still be relatively small in capacity, they represent innovative approaches to how sector coupling could revolutionize the electrification of the heating sector.

5.6 Solar air conditioning and cooling

Small and medium-sized applications

The global market for cooling and refrigeration will continue to grow, particularly in the Global South, and by 2050, 37% of the total electricity demand growth will be for air conditioning.[21] Thus, there is enormous potential for cooling systems that use solar energy, both solar thermal and PV-driven solar cooling and air conditioning systems, as presented, for example, in the GIZ 2022 technical, economic analysis for PV-powered air-conditioning in buildings of 13 developing countries[22], GIZ 2017 feasibility study for social housing buildings in Mexico[23], and RCREEE/UNDP 2015 study on commercial buildings/ applications in the Arab region[24].

A central argument for solar thermal-driven systems is that they consume less conventional energy (up to a factor of five[25]) and use natural refrigerants, such as water and ammonia. In Europe, their application is also pushed by the European F-gas Regulation No. 573/2024[26] to establish the total elimination of hydrofluorocarbons by 2050. Another driver for solar cooling technology is its potential to reduce peak electricity demand, particularly in countries with significant cooling needs and grid constraints. Today, for example, 30% of India's total energy consumption in buildings is used for space cooling, and it reaches 60% of the summer peak load, which is already stretching the capacity of the Indian national electricity supply.[27] In other countries, like the USA, the peak load through air conditioning reaches >70% on hot days.

There are mature cooling technologies grabbing the attention of the OECD and developing countries because cooling demand will continue to grow over the next decades, and national electric grids need protection against overloads. Solar sorption cooling applications are particularly adapted for medium to large-size units (100 kW to several MWs). For several years now, China has been promoting a voluntary policy to develop such green sorption devices. And in 2019, Germany changed its incentives scheme for both vapor compression and sorption-based technologies to only support chillers and air conditioners that use natural refrigerants (sorption chillers 5 kW to 600 kW) in combination with a minimum required performance.[28]

Heat from 294 m² of flat plate CPC (Compound Parabolic Collector) solar collectors drive a 70 kW water/LiBr absorption chiller for air-conditioning at the CERMI center in Praia, Cape Verde, since 2013
Photo: JER

Solar thermal cooling is still a niche market, with over 2,000 systems deployed globally as of 2023. Due to changing distribution channels and B2B sales of the sorption chillers, tracking newly installed solar-driven systems is difficult and can only be estimated. Small units with a capacity lower than 20 kW are getting more compact (thus cheaper upfront costs) and targeting the mass markets. Medium to large-scale projects, 30 kW to 2,000 kW, are dominated by engineered systems. Of the small and medium

[18] www.synergieplus.ch
[19] Source: Personal communication with AGFW and Maxsolar
[20] Sources: AGFW and Stadtwerke Altensteig, Germany
[21] https://www.iea.org/futureofcooling/
[22] https://www.green-cooling-initiative.org/fileadmin/user_upload/220607_Proklima_Solar_AC_med.pdf
[23] http://task53.iea-shc.org/Data/Sites/53/media/events/meeting-09/workshop/09-jakob_results-from-feasibility-studies-of-solar-cooling-systems-in-mexico-and-the-arab-region.pdf
[24] https://www.solarthermalworld.org/sites/default/files/story/2016-04-05/solar_cooling_in_arab_region_0.pdf
[25] http://task53.iea-shc.org/Data/Sites/1/publications/IEA-SHC-Task53-C3-Final-Report.pdf
[26] https://eur-lex.europa.eu/eli/reg/2024/573/oj
[27] Low energy cooling and ventilation in indian residences, https://doi.org/10.1080/23744731.2018.1522144
[28] https://www.bafa.de/DE/Energie/Energieeffizienz/Klima_Kaeltetechnik/klima_kaeltetechnik_node.html

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德国在 Altensteig Wart 建立了第二个太阳能电气化区域供热系统的实例。该混合区域供热系统的热量由一台 800 千瓦的生物质锅炉、一台 375 千瓦的热泵和一台 100 千瓦的热电联产（CHP）装置提供。夏季，热泵由 70 千瓦的光伏系统供电。由于光伏系统无法在供暖期间提供全部电力，因此由热电联产装置发电。

虽然这两个由光伏发电供电的区域供热系统的容量可能仍然相对较小，但它们代表了部门耦合如何彻底改变供热部门电气化的创新方法。

5.6 太阳能空调和制冷

中小型应用

全球制冷和冷藏市场将继续增长，特别是在全球南部地区，到 2050 年，电力总需求增长的 37% 将用于空调。因此，利用太阳能的冷却系统潜力巨大，包括太阳能热和光伏驱动的太阳能冷却和空调系统，例如，德国国际合作机构（GIZ）2022 年对 13 个发展中国家建筑物光伏空调的技术和经济分析、德国国际合作机构（GIZ）2017 年对墨西哥社会住房建筑的可行性研究，以及 RCREEE/UNDP 2015 年对阿拉伯地区商业建筑/应用的研究。

太阳热能驱动系统的一个主要论点是，它们消耗的常规能源较少（最多五倍），并且使用天然制冷剂，如水和氨。在欧洲，欧洲第 573/2024 号含氟温室气体法规也推动了它们的应用，该法规规定到 2050 年完全消除氢氟碳化合物。太阳能冷却技术的另一个驱动力是其减少高峰电力需求的潜力，特别是在冷却需求巨大且电网紧张的国家。例如，目前印度建筑物总能耗的 30% 用于空间冷却，达到夏季高峰负荷的 60%，这已经使印度国家电网的能力捉襟见肘。

电力供应。在美国等其他国家，高温天空调的峰值负荷高达 70%以上。

经合组织和发展中国家都在关注成熟的冷却技术，因为未来几十年冷却需求将持续增长，而且国家电网需要防止过载。太阳能吸附冷却技术尤其适用于大中型机组（100 千瓦至数百万瓦）。几年来，中国一直在推广一项自愿政策，以开发此类绿色吸附装置。2019 年，德国改变了对蒸汽压缩和吸附式技术的激励计划，仅支持使用天然制冷剂的冷水机组和空调（吸附式冷水机组 5 千瓦至 600 千瓦），并规定了最低性能要求。

自 2013 年起，294 平方米的平板 CPC（复合抛物面集热器）太阳能集热器产生的热量为佛得角普拉亚的 CERMI 中心的 70 千瓦水/溴吸收式制冷机提供热量，用于空调系统。
照片JER

太阳能热制冷仍然是一个利基市场，截至 2023 年，全球部署了 2,000 多个系统。由于吸附式制冷机的分销渠道和 B2B 销售不断变化，很难跟踪新安装的太阳能驱动系统，只能进行估算。功率小于 20 千瓦的小型设备越来越紧凑（因此前期成本更低），并以大众市场为目标。30 千瓦至 2000 千瓦的中大型项目则以工程系统为主。在中小型

[18] www.synergieplus.ch
[19] 资料来源：与 AGFW 和 Maxsolar 的个人通信：与 AGFW 和 Maxsolar 的个人通信
[20] 资料来源：AGFW 和 Stadtwerke Altensteig，德国：资料来源：德国 AGFW 和 Stadtwerke Altensteig。
[21] https://www.iea.org/futureofcooling/
[22] https://www.green-cooling-initiative.org/fileadmin/user_upload/220607_Proklima_Solar_AC_med.pdf
[23] http://task53.iea-shc.org/Data/Sites/53/media/events/meeting-09/workshop/09-jakob_results-from-feasibility-studies-of-solar-coolingsystems-in-mexico-and-the-arab-region.pdf
[24] https://www.solarthermalworld.org/sites/default/files/story/2016-04-05/solar_cooling_in_arab_region_0.pdf
[25] http://task53.iea-shc.org/Data/Sites/1/publications/IEA-SHC-Task53-C3-Final-Report.pdf
[26] https://eur-lex.europa.eu/eli/reg/2024/573/oj
[27] 印度住宅的低能耗制冷和通风，https://doi.org/10.1080/23744731.2018.1522144
[28] https://www.bafa.de/DE/Energie/Energieeffizienz/Klima_Kaeltetechnik/klima_kaeltetechnik_node.html

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capacity (<350 kW) solar cooling systems worldwide, 70% are installed in Europe. According to a survey carried out in early 2019 by solrico for REN21[29], only a few new solar cooling systems in the small and medium range were installed in 2018, mainly in Italy and Germany.

However, awareness of small to medium-scale solar thermal-driven systems is rising. There are several international initiatives (e.g., Global Cooling Pledge, MI IC7, K-CEP, IEA SHC Programme), research projects (e.g., SunBeltChiller[30], FRIENDSHIP[31], SHIP2FAIR[32], HyCool[33], sol.e.h.[2 34], Zeosol[35]) and commercial solar thermal cooling projects (e.g., China, the USA, Mexico, Mali, Uganda, Nigeria, Morocco, Egypt, Jordan, Dubai, Greece, Spain, Austria, Netherlands, Ukraine, India, and Thailand). This is also reflected in the development and activities of small-capacity components and system manufacturers/suppliers targeting the high-volume market segment of cooling and air conditioning devices, i.e., 2.5 kW to 25 kW. A market and sales uptake can be observed at the manufacturing level, with an increase in sales of almost 15% last year.[36] Most of the cooling systems sold are powered by solar thermal systems. Some systems are configured for use with a backup heat supply (e.g., district heating); others are configured with a thermal energy storage system. The global market for low-capacity cooling and air conditioning systems is focused on exporting to Asia, the Middle East, African countries, North and South America, and the EU.

Solar Cooling with a cooling capacity larger than 350 kW

Solar cooling using thermal absorption chillers with a cooling capacity larger than 350 kW/100 RT[37] has improved significantly in performance and decreased in cost. In addition, there have been significant improvements in the performance of large flat plate collectors at temperatures up to 120 °C. This increase in performance, combined with an economy of scale, makes solar cooling applications cost-competitive for large office buildings, hotels, hospitals, and commercial/industrial applications.

The advantage of solar energy for cooling is that the supply, solar radiation, is available when the demand, cooling, is at its peak. In other words, cooling is needed when the sun is shining, which means during peak demand. Solar cooling saves money by avoiding purchasing electricity at its highest cost. Plus, solar thermal energy is an easy way to store the solar heat and shift it for cooling demands in the evenings and nights while keeping the remaining energy for morning cooling.

The electricity a solar cooling system needs to run pumps and a cooling tower is relatively low. Depending on the climate, it may give Energy Efficiency Ratios (kW_{th}/kW_{el}) of 20 to 40 in systems with optimized variable speed-driven auxiliaries. Thus, the electric demand for air conditioning in a building is cut by more than 80% compared to conventional HVAC equipment. Even though the technical and economic conditions for solar cooling and air conditioning have improved significantly, this remains a challenging market, as reflected in the comparatively low number of solar cooling systems built in recent years.

The world's largest solar cooling system with a cooling capacity of 3.5 MW for a packaging factory is in Izmir, Turkey.[38] The plant was commissioned at the end of 2021 and formally inaugurated in June 2022. The installation covers two solar thermal collector fields with a total capacity of 2.5 MW_{th} (5,000 m^2). The solar system supplies heat to two double-effect lithium bromide absorption chillers with a cooling capacity of 1.4 MW and 2.1 MW, respectively, to match the size of the associated solar collector fields. The installed double-effect absorption chillers can achieve a COP of up to 1.40.

In 2022, three larger solar cooling systems with a 972 kW cooling capacity were commissioned. Their total collector capacity is 1.86 MW_{th}, corresponding to a 2,660 m^2 collector area.

[29] Not published internal communication
[30] https://forum.iea-shc.org/Data/Sites/1/publications/2023-12-Task65-Sunbelt-Chiller.pdf
[31] https://friendship-project.eu/ship-200-300/
[32] http://ship2fair-h2020.eu/demo-2-bodegas-roda
[33] Jakob, Uli; Kiedaisch, Falko (2019) Analysis of a solar hybrid cooling system for industrial applications, ISES SWC 2019-SHC 2019, doi:10.18086/swc.2019.55.07.
[34] Neyer, Daniel; et al. (2019) Solar Heating and Cooling in hot and humid climates – sol.e.h.^{2} Project Introduction, ISES SWC 2019-SHC 2019, paper ID 10400.
[35] Roumpedakis, Tryfon; et al. (2019) Performance results of a solar adsorption cooling and heating unit, ISES SWC 2019-SHC 2019, paper ID 11465
[36] Internal IEA SHC Task 65 communication
[37] Ton of refrigeration is a unit of power used in North America to describe the capacity of heat extraction in industrial air conditioning and refrigeration equipment.
[38] Lokurlu, Ahmet; Ramesh, Akshay (2022) Parabolic Trough Collector (PTC) system for combined cooling and heating supply for a factory building in Turkey. EuroSun 2022, paper ID 1558.

全球太阳能制冷系统容量（<350 千瓦）中，70% 安装在欧洲。根据 solrico 于 2019 年初为 REN21 开展的一项调查，2018 年仅安装了少数新的中小型太阳能冷却系统，主要集中在意大利和德国。

不过，人们对中小型太阳能热驱动系统的认识正在提高。有一些国际倡议（例如，全球冷却承诺、MI IC7、K-CEP、IEA SHC 方案）、研究项目（例如，SunBeltChiller、FRIENDSHIP、SHIP2FAIR、HyCool、sol.e.h²、Zeosol）和商业太阳能热制冷项目（例如，中国、美国、墨西哥、马里、乌干达、尼日利亚、摩洛哥、埃及、约旦、迪拜、希腊、西班牙、奥地利、荷兰、乌克兰、印度和泰国）。这也反映在小容量组件和系统制造商/供应商针对制冷和空调设备的大容量细分市场（即 2.5 千瓦至 25 千瓦）的发展和活动中。从生产层面可以看到市场和销售的增长，去年的销售额增长了近 15%。大部分销售的冷却系统都由太阳能热系统提供动力。一些系统配置有备用热源（如区域供热），另一些系统配置有热能储存系统。全球低容量制冷和空调系统市场主要集中在向亚洲、中东、非洲国家、北美、南美和欧盟出口。

冷却能力大于 350 千瓦的太阳能冷却器

使用冷却能力大于 350 kW/100 RT 的热吸收冷却器进行太阳能冷却，在性能上有了显著改善，在成本上也有所下降。此外，大型平板集热器在温度高达 120 °C 时的性能也有显著提高。性能的提高加上规模经济，使得太阳能冷却应用在大型办公楼、酒店、医院和商业/工业应用中具有成本竞争力。

太阳能制冷的优势在于，当制冷需求达到峰值时，就可以获得太阳能辐射供应。换句话说，在阳光普照时需要制冷也就是在用电高峰期。太阳能制冷可以避免以最高成本购买电力，从而节省资金。此外，太阳能热能是一种储存太阳能热量的简便方法，可将其用于晚上和夜间的制冷需求，而将剩余能量用于早晨的制冷。

太阳能冷却系统运行水泵和冷却塔所需的电力相对较低。根据不同的气候条件，在配有优化变速驱动辅助设备的系统中，能效比（千瓦/千瓦）可达到 20 至 40。因此，与传统的暖通空调设备相比，建筑空调的电力需求可减少 80% 以上。尽管太阳能制冷和空调的技术和经济条件已经有了显著改善，但这仍然是一个充满挑战的市场，近年来建造的太阳能制冷系统数量相对较少就反映了这一点。

世界上最大的太阳能冷却系统位于土耳其伊兹密尔，冷却能力为 3.5 兆瓦，用于一家包装厂。该厂于 2021 年底投入使用，并于 2022 年 6 月正式落成。该装置包括两个太阳能集热场，总容量为 2.5 兆瓦（5,000 平方米）。太阳能系统向两台双效溴化锂吸收式制冷机供热，制冷量分别为 1.4 兆瓦和 2.1 兆瓦，与相关太阳能集热场的大小相匹配。安装的双效吸收式制冷机的 COP 可高达 1.40。

2022 年，三个较大的太阳能冷却系统投入使用，冷却能力为 972 千瓦。它们的总集热器容量为 1.86 兆瓦，相当于 2,660 平方米的集热器面积。

[29] 未公布内部交流
[30] https://forum.iea-shc.org/Data/Sites/1/publications/2023-12-Task65-Sunbelt-Chiller.pdf
[31] https://friendship-project.eu/ship-200-300/
[32] http://ship2fair-h2020.eu/demo-2-bodegas-roda
[33] Jakob, Uli; Kiedaisch, Falko (2019)《工业应用太阳能混合冷却系统分析》，ISES SWC 2019-SHC 2019，doi:10.18086/swc.2019.55.07。

[34] Neyer, Daniel; et al. (2019)《湿热气候下的太阳能供暖和制冷--sol.e.h.² 项目介绍》，ISES SWC 2019-SHC 2019，论文编号 10400。

[35] Roumpedakis, Tryfon; et al. (2019) Performance results of a solar adsorption cooling and heating unit, ISES SWC 2019-SHC 2019, paper ID 11465
[36] 国际能源机构第 65 项任务的内部交流
[37] 制冷吨是北美地区用来描述工业空调和制冷设备热量提取能力的功率单位。

[38] Lokurlu, Ahmet; Ramesh, Akshay (2022) 抛物线槽式集热器（PTC）系统，用于为土耳其的一座工厂大楼提供冷热联供。EuroSun 2022，论文编号 1558。

Table 7: Large-scale solar cooling systems installed between 2008 and 2022

Country	Site	Commissioned	Installed capacity [kW_{th}]	Collector size [m^2]	Collector type	Cooling capacity [kW_{cold}]
Spain	Barcelona	2022	560	800	Fresnel	260
Spain	Barcelona	2022	252	360	Fresnel	12
Italy	Padova	2022	1,050	1,500	Evacuated tube	700
Turkey	Izmir	2021	2,500	6,000	Parabolic trough	3,500
Austria	Graz	2020	2,450	3,500	Flat plate	660
UAE	Dubai	2020	496	708	Flat plate	n.a.
Switzerland	Zurich	2019	800	1,143	Evacuated tube	600
Singapore	Mandai Depot	2018	2,308	3,297	Evacuated tube	850
Italy	Borgoricco	2018	1,046	1,494	Evacuated tube	700
Italy	Laives	2018	n.a.	n.a.	Evacuated tube	176
Jordan	Japan Tobacco International factory	2018	700	1,254	Fresnel	n.a.
Singapore	IKEA Alexandra	2017	1,730	2,472	Flat plate	880
Nicaragua	Hospital Militar Escuela, Dr. Alejandro Dávila Bolaños	2017	3,115	4,450	Flat plate	1,023
India	Office, Gujarat State Electricity Corporation	2017	1,102	1,575	Evacuated tube	528
India	Swiss Embassy, New Delhi	2017	630	441	Parabolic trough	210
China	Tianjin Zhongbei	2015	n.a.	n.a.	Evacuated tubes	698
Arizona, USA	Desert Mountain High School Scottsdale	2014	3,407	4,865	Flat plate	1,750
Cape Verde	CERMI Praia	2013	164	294	Flat plate Compound Parabolic Collector	70
Johannesburg, South Africa	MTN Headquarter	2014	272	484	Fresnel	330
China	Dezhou Institute	2014	n.a.	720	Parabolic trough	n.a.
India	Honeywell Technology Solutions Lab Pvt. Hyderabad	2013	n.a.	820	Parabolic trough	350
United Arab Emirates	Sheikh Zayed Desert Learning Center	2012	794	1,134	Flat plate	352
Kingston, Jamaica	Digicel	2012	687	982	Flat plate	600
India	National Institute of Solar Energy Gurugram	2011	n.a.	288	Parabolic trough	100
Singapore	United World College	2011	2,710	3,872	Flat plate	1,500
Qatar, Doha	Showcase football stadium	2010	700	1,408	Fresnel	n.a
Istanbul, Turkey	Metro shopping center	2009	840	1,200	Evacuated tube	n.a.
Spain, Sevilla	Sevilla University, Escuela Superior de Ingenieros	2009		352	Fresnel	n.a.
India	Mahindra Vehicle Manufacturers Ltd. Pune	2008	n.a.	1,152	Dish	315
Lisbon, Portugal	CGD Lisbon	2008	1,105	1,579	Flat plate	585
Rome, Italy	Metro Cash & Carry	2008	2,100	3,000	Flat plate	700

Sources: Blackdot Energy, Industrial Solar, Ritter XL Solar, SOLID Solar Energy Systems, SOLRICO, Vicot Solar Energy, Cosmosolar, SOLITERM Group, R2M Solution Srl., IEA SHC Task 65

表 7：2008 年至 2022 年安装的大型太阳能制冷系统

国家	Site	受委托	已安装能力 [kW]	收藏家 size [m²]	收藏家 type	冷却能力 [kW]
西班牙	巴塞罗那	2022	560	800	菲涅尔	260
西班牙	巴塞罗那	2022	252	360	菲涅尔	12
意大利	帕多瓦	2022	1,050	1,500	抽真空管	700
土耳其	伊兹密尔	2021	2,500	6,000	抛物槽	3,500
奥地利	Graz	2020	2,450	3,500	平板	660
UAE	迪拜	2020	496	708	平板	n.a.
瑞士	苏黎世	2019	800	1,143	抽真空管	600
新加坡	曼代车厂	2018	2,308	3,297	抽真空管	850
意大利	Borgoricco	2018	1,046	1,494	抽真空管	700
意大利	莱维斯	2018	n.a.	n.a.	抽真空管	176
约旦	日本烟草国际工厂	2018	700	1,254	菲涅尔	n.a.
新加坡	宜家亚历山德拉	2017	1,730	2,472	平板	880
尼加拉瓜	军事学校医院，亚历杭德罗-达维拉-博拉尼奥斯博士	2017	3,115	4,450	平板	1,023
印度	古吉拉特邦电力公司办公室	2017	1,102	1,575	抽真空管	528
印度	瑞士驻新大使馆德里	2017	630	441	抛物槽	210
中国	天津中北	2015	n.a.	n.a.	抽真空管	698
美国亚利桑那州	斯科茨代尔沙漠山高中 Desert Mountain High School Scottsdale	2014	3,407	4,865	平板	1,750
佛得角	普拉亚 CERMI	2013	164	294	平板 化合物 抛物线 收藏家	70
约翰内斯堡、南非	MTN 总部	2014	272	484	菲涅尔	330
中国	德州学院	2014	n.a.	720	抛物槽	n.a.
印度	霍尼韦尔技术解决方案实验室海得拉巴分公司	2013	n.a.	820	抛物槽	350
阿拉伯联合酋长国阿联酋	谢赫-扎耶德沙漠学习中心	2012	794	1,134	平板	352
金斯敦牙买加	Digicel	2012	687	982	平板	600
印度	古鲁格拉姆国家太阳能研究所	2011	n.a.	288	抛物槽	100
新加坡	世界联合学院	2011	2,710	3,872	平板	1,500
卡塔尔，多哈	足球展示大球场	2010	700	1,408	菲涅尔	n.a
土耳其伊斯坦布尔	麦德龙购物中心	2009	840	1,200	抽真空管	n.a.
西班牙，塞维利亚	塞维利亚大学、高级学校工程师	2009		352	菲涅尔	n.a.
印度	马辛德拉车辆制造有限公司浦那	2008	n.a.	1,152	Dish	315
葡萄牙里斯本	里斯本 CGD	2008	1,105	1,579	平板	585
意大利罗马	麦德龙现购自运	2008	2,100	3,000	平板	700

资料来源Blackdot Energy、Industrial Solar、Ritter XL Solar、SOLID Solar Energy Systems、SOLRICO、Vicot Solar Energy、Cosmosolar、SOLITERM Group、R2M Solution Srl.、IEA SHC Task 65。

Solar Refrigeration for the process industry

Solar thermal collectors and sorption chillers can also provide cold energy for process refrigeration at industrial sites. From the technical perspective, the main challenge is the lower temperatures often required by refrigeration processes, which can be close to 0 °C or even negative. In turn, this reflects a higher temperature needed for the chiller to drive the sorption process. Medium temperature collectors such as Fresnel, parabolic troughs, and vacuum collectors can be employed to meet such high activation temperatures. Alternatively, hybrid chillers have been tested in combination with solar thermal[39], connecting an electric chiller and a sorption chiller in series. In this way, the sorption device cools down the condenser of the electric chiller, thus increasing its efficiency without the need for the sorption chiller to reach very low temperatures.

According to the EU HyCool project, energy demand for process refrigeration is some 4% of industry's final energy demand end-use in 2015 in EU28 (100 TWh/y). Cold energy is required at temperatures 0 to 15 °C (2%), 1% is required at -30 to 0 °C, and 1% at below -30 °C. Space cooling at industrial sites uses another 1% of industry's final energy demand.

A newly launched EU-HEU-funded project called RE-WITCH[40] will demonstrate advanced thermally-driven industrial cooling technologies in four industrial applications (brewery, food, biodiesel, and machinery industry). This includes hybrid systems based on adsorption and absorption processes (different sizes from 40 to 400 kW cooling capacity) driven by an optimized mix of low-grade waste heat and renewable sources (innovative high vacuum flat plate solar collector fields). Another approach for hospitals, such as containerized solutions using natural refrigerant chillers and photovoltaics, is being pursued in the EU-funded project SophiA.[41] A three-stage refrigeration cascade with natural refrigerants (propane, CO_2, and ethane) reliably ensures the three required temperature levels. The most spacious room inside the container is cooled down to +5°C. Lockable shelves on the wall allow the storage of medicines and food products. The freezer chamber at –30°C is accessible only through the refrigerated room. Besides the storage possibility, there are two deep freezer boxes that can cool down to -70°C. Everything is powered by the PV panels installed on the roof of the containers.

The potential for solar thermal cooling and industrial applications was investigated in the SunBeltChiller project[42], using a newly developed GIS tool to amalgamate geographical data in a manner conducive to ascertaining localized reference conditions for solar cooling systems within Sunbelt regions. Moreover, this methodology can be adapted to generate insights into potential deployment sites and the feasibility of specific solar cooling systems. Supplementing this approach with data such as population density, industrial areas, and purchasing power (GDP) lays the groundwork for prospective market studies focusing on particular products or technologies. Consequently, prospective sites can be pinpointed, and economic variables can be factored into identifying current and future markets, as shown on the following map.

1 MW Solar cooling system at the Hospital Militar Escuela in Managua, Nicaragua
Photo: SOLID Solar Energy Systems

LEARN MORE

Learn more about Solar Cooling for the Sunbelt Regions at:
https://task65.iea-shc.org/

加工工业的太阳能制冷

太阳能集热器和吸附式制冷机也可以为工业现场的工艺制冷提供冷能。从技术角度来看，主要的挑战在于制冷过程通常需要较低的温度，可能接近 0 °C 甚至是负温度。反过来，这也反映出冷却器需要更高的温度来驱动吸附过程。中温集热器（如菲涅尔集热器、抛物面槽集热器和真空集热器）可用于满足如此高的活化温度。另外，还测试了与太阳能热结合的混合冷却器，将电动冷却器和吸附冷却器串联起来。通过这种方式，吸附装置可以冷却电制冷器的冷凝器，从而提高其效率，而不需要吸附制冷器达到很低的温度。

根据欧盟 HyCool 项目的数据，2015 年欧盟 28 国的工艺制冷能源需求约占工业最终能源需求的 4%（100 太瓦时/年）。0 至 15 °C（2%）需要冷能，-30 至 0 °C（1%）需要冷能，-30 °C以下（1%）需要冷能。工业场所的空间冷却也占工业最终能源需求的 1%。

新近启动的由欧盟-欧洲联盟资助的名为 RE-WITCH 的项目将在四个工业应用领域（酿酒、食品、生物柴油和机械行业）展示先进的工业热制冷技术。

这包括基于吸附和吸收过程的混合系统（冷却能力从 40 千瓦到 400 千瓦不等），由低品位废热和可再生能源（创新型高真空平板太阳能集热器领域）的优化组合驱动。欧盟资助的项目 SophiA 正在研究针对医院的另一种方法，例如使用天然制冷剂冷却器和光伏的集装箱式解决方案。使用天然制冷剂（丙烷、一氧化碳和乙烷）的三级制冷级联可可靠地确保三个所需的温度水平。集装箱内最宽敞的房间温度可降至 +5°C。墙壁上的可上锁货架可以存放药品和食品。只有通过冷藏室才能进入零下 30 摄氏度的冷冻室。除了可以存放物品外，还有两个深冷冻箱，可以将温度降至 -70°C。一切都由安装在集装箱屋顶上的光伏板供电。

在 SunBeltChiller 项目中对太阳能热制冷和工业应用的潜力进行了调查，利用新开发的 地理信息系统工具，以有利于在 Sunbelt 地区内为太阳能制冷系统提供本地化参考条件的方式合并地理数据。此外，这种方法还可用于深入了解潜在的部署地点和特定太阳能冷却系统的可行性。通过人口密度、工业区和购买力（GDP）等数据对该方法进行补充，可为针对特定产品或技术的前瞻性市场研究奠定基础。因此，如下图所示，可以精确定位预期地点，并在确定当前和未来市场时考虑经济变量。

尼加拉瓜马那瓜军事学校医院 1 兆瓦太阳能冷却系统
照片：SOLID 太阳能系统

LEARN MORE

了解有关阳光带地区太阳能制冷的更多信息，请访问
https://task65.iea-shc.org/

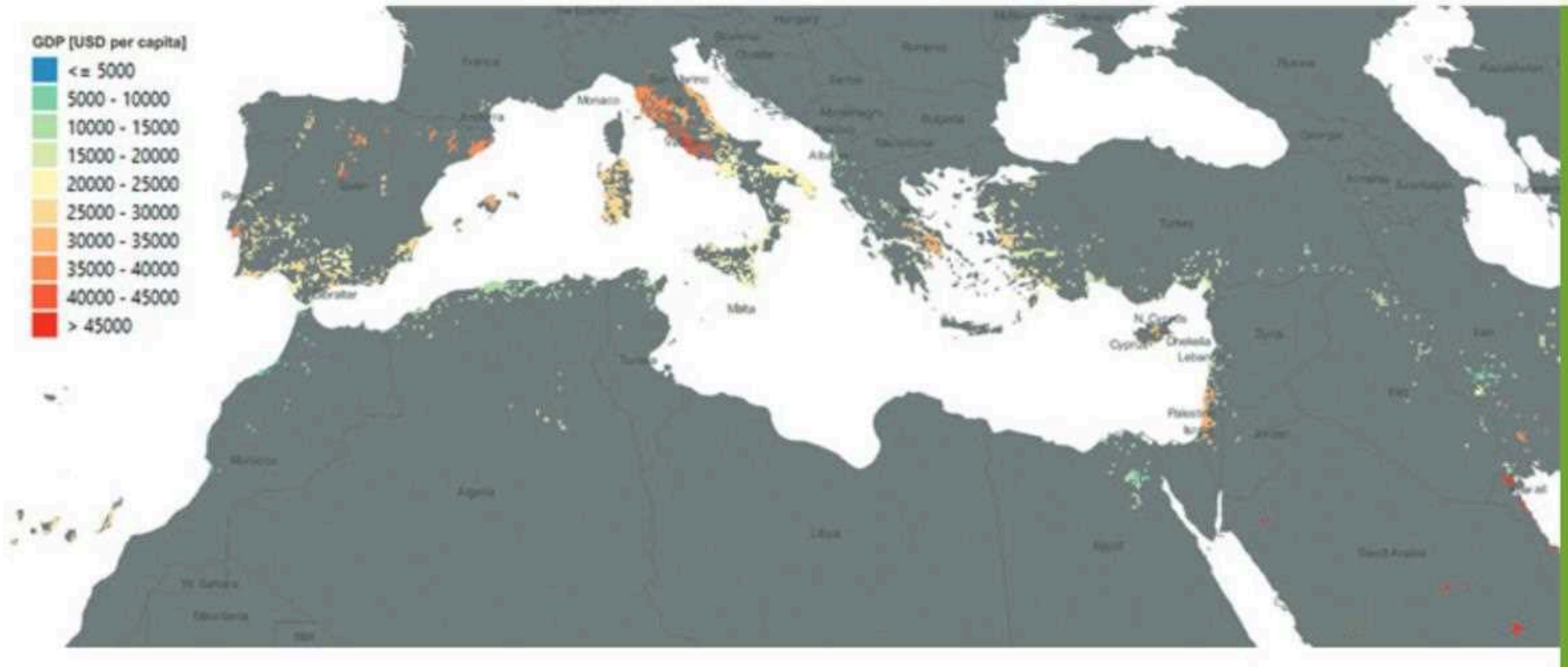

Figure 19: World map cut-out identifying the potential for the SunBeltChiller for industrial purposes (e.g., process cold) in the Mediterranean region (conducted on a 10 km raster grid, considering the Gross Domestic Product (GDP) levels)
Source: ZAE Bayern, 2023

Trends and outlook

The demand for cooling and refrigeration will continue its rapid growth, particularly in the Global South (several hundred million AC units are estimated to be sold annually by 2050[43]). This means there is a huge potential for cooling systems that use solar energy, such as thermal and photovoltaic (PV) systems.

Therefore, current and future product development focuses on compact, small-scale solar air conditioning units with air-cooled absorption and adsorption chillers and small-scale and large multi-stage desiccant systems with solar thermal collectors or desiccant-coated components. In addition, the development and market launch of x.N stage chillers (half, single, 1.N, double, triple) with new, medium temperature collectors and thermally driven heat pump systems for heating and cooling, also in hybrid operation with vapor compression chillers. Not to forget the future market penetration of small PV-driven components with new heat pumps/chillers using natural refrigerants like propane.[44]

Table 7 shows the trend regarding medium to large-scale solar cooling. In the past 15 years, very few large installations were realized each year. A change in this trend is not foreseeable at present. Despite the potential presented in many studies, exploiting it will not be possible until system prices and complexity are significantly reduced.

On the other hand, the most recently signed Global Cooling Pledge at the COP28 conference[45] shows that cooling is a very serious and important global issue. According to the Global Cooling Watch 2023 report[46], cooling-related emissions could be reduced by over 60% compared to normal operations by 2050 while expanding access to cooling to 3.5 billion people. Combined with a decarbonized power grid, emissions reductions could be up to 96%.

5.7. Solar air heating systems

Solar air heating systems are designed to heat air directly for applications requiring warm air. They are primarily used to heat buildings, including ventilation air, and to process and dry crops. Solar air heating is currently an under-utilized solar technology. Triggered by the COVID-19 requirements to increase fresh air in buildings, energy demand and CO_2 emissions have increased. Solar heating this fresh air is an excellent solution to minimize increased energy demand.

Space heating consumes more energy than hot water in most buildings. In colder climates, space heating is usually the largest consumer of energy in a building. As it is the air in buildings that is heated, air collectors are ideally suited to heat this air directly without heat exchangers. Most solar air collectors for heating

[39] https://hycool-project.eu
[40] https://ieecp.org/projects/re-witch/
[41] https://sophia4africa.eu/de/
[42] https://task65.iea-shc.org/Data/Sites/1/publications/IEA-SHC-Task65-DA1--Climatic-Conditions-and-Applications.pdf
[43] https://www.iea.org/futureofcooling/
[44] Jakob, U. (2023) Solar Cooling for emerging markets. Keynote ISES Solar World Congress 2023, New Delhi, India
[45] https://www.cop28.com/en/global-cooling-pledge-for-cop28
[46] https://www.unep.org/resources/global-cooling-watch-2023

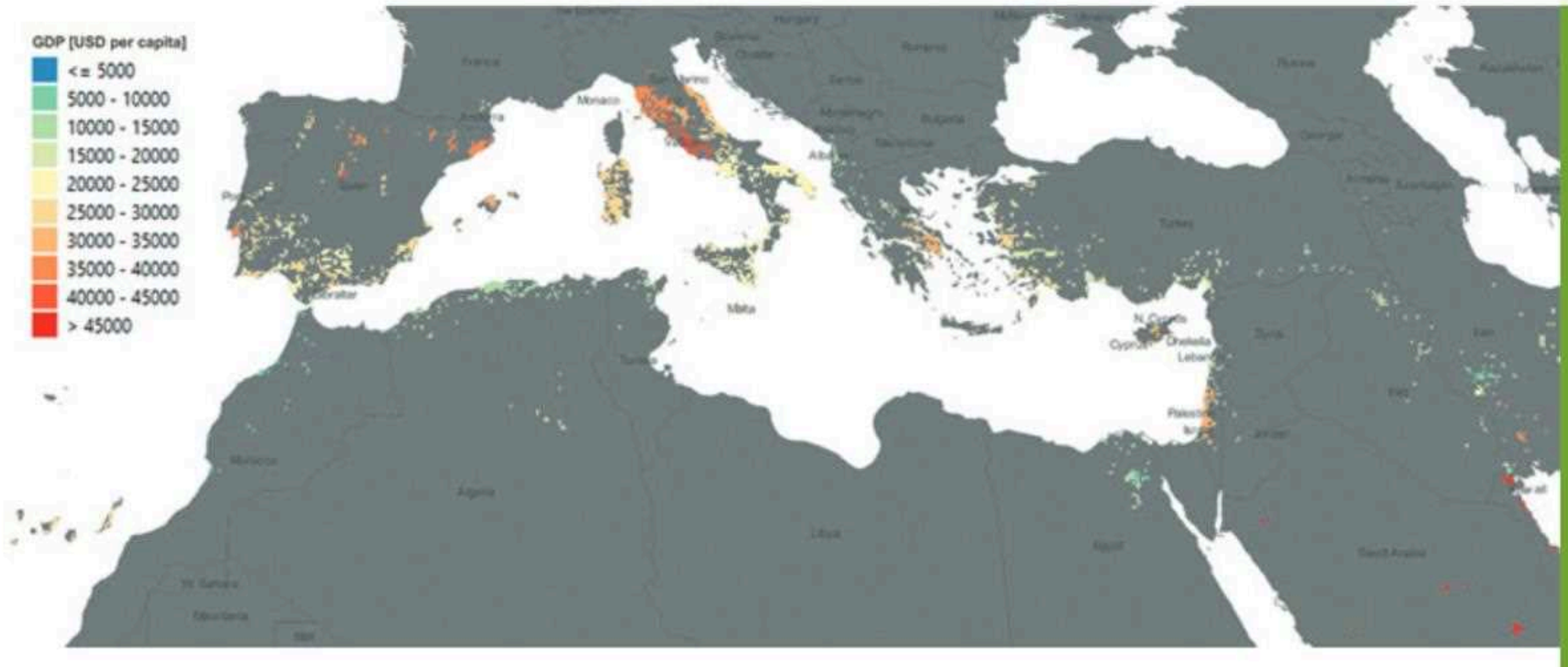

图 19：确定 SunBeltChiller 在地中海地区用于工业用途（例如冷加工）的潜力的世界地图剖面图（在 10 千米栅格上进行，考虑到国内生产总值（GDP）水平）
资料来源ZAE Bayern, 2023

趋势与展望

冷却和制冷需求将继续快速增长，尤其是在全球南部地区（预计到 2050 年，每年将售出数亿台空调设备）。这意味着利用太阳能的冷却系统，如热能和光伏（PV）系统，有着巨大的发展潜力。

因此，当前和未来的产品开发重点是带有空气冷却吸收和吸附冷却器的紧凑型、小型太阳能空调设备，以及带有太阳能集热器或干燥剂涂层组件的小型和大型多级干燥剂系统。此外，x.N 级冷却器（半、单、1.N、双、三）与新型中温集热器和用于加热和冷却的热驱动热泵系统的开发和市场投放，也与蒸汽压缩冷却器混合运行。此外，使用丙烷等天然制冷剂的新型热泵/冷却器也将在未来进入小型光伏驱动组件市场。

表 7 显示了大中型太阳能制冷的发展趋势。在过去的 15 年中，每年都只有极少数的大型装置得以实现。目前还无法预见这一趋势的改变。尽管许多研究都显示了太阳能制冷的潜力，但在系统价格和复杂性大幅降低之前，利用太阳能制冷是不可能的。

另一方面，最近在 COP28 会议上签署的《全球降温承诺》表明，降温是一个非常严肃和重要的全球性问题。根据《2023 年全球冷却观察》报告，到 2050 年，与冷却相关的排放可比正常运行时减少 60% 以上，同时使 35 亿人获得冷却。与去碳化电网相结合，减排量可高达 96%。

5.7. 太阳能空气加热系统

太阳能空气加热系统的设计目的是直接加热空气，用于需要暖空气的场合。它们主要用于加热建筑物，包括通风空气，以及加工和干燥农作物。太阳能空气加热目前是一种利用率较低的太阳能技术。由于 COVID-19 要求增加建筑物内的新鲜空气，能源需求和二氧化碳排放量都有所增加。太阳能加热新鲜空气是将增加的能源需求降至最低的绝佳解决方案。

在大多数建筑物中，空间供暖比热水消耗更多的能源。在寒冷的气候条件下，空间供暖通常是建筑物中最大的能源消耗。由于加热的是建筑物中的空气，因此空气集热器非常适合直接加热空气，而无需热交换器。大多数用于供暖的太阳能空气集热器

[39] https://hycool-project.eu
[40] https://ieecp.org/projects/re-witch/
[41] https://sophia4africa.eu/de/
[42] https://task65.iea-shc.org/Data/Sites/1/publications/IEA-SHC-Task65-DA1--Climatic-Conditions-and-Applications.pdf
[43] https://www.iea.org/futureofcooling/
[44] Jakob, U.（2023 年）新兴市场的太阳能制冷。2023 年 ISES 太阳能世界大会主题演讲，印度新德里
[45] https://www.cop28.com/en/global-cooling-pledge-for-cop28
[46] https://www.unep.org/resources/global-cooling-watch-2023

Solar air heating systems on the mechanical room penthouses at the Canary Commons, a condo community in Toronto, Canada
Photo: SolarWall Conserval Engineering Inc.

buildings are wall-mounted to take advantage of the lower winter sun angles and eliminate snow accumulation on roof-mounted systems. When heat is not needed during the summer, the panels are generally left dormant, as stagnation temperature is not usually an issue.

Solar air heating systems can be building integrated and typically reduce 20 to 30% of the conventional energy used to heat a building. The air is generally taken off the top of the wall, and the heated or pre-heated fresh air is then connected to existing or new fans and ducted into the building via the ventilation system.

Process applications are different as they operate all year or during the harvest season, allowing the panels to be roof-mounted to capture the higher sun angles.

Solar air heaters in agriculture are primarily for drying applications requiring low temperatures.

For the past 30 years, solar air heating systems have been used worldwide by schools, municipalities, military, agricultural, commercial, and industrial entities, and residential buildings.

Heat storage is possible, but most solar air systems do not include storage to minimize costs.

The following table lists the countries with more than 10,000 m^2 of solar air collectors.

Table 8: Largest solar air collector markets - total installed air collector areas in 2022

Country	Air Collectors [m^2]		Total [m^2]	Installed capacity [MW_{th}]
	unglazed	glazed		
Canada	440,069	60,539	500,608	350
Australia	250,000	10,000	261,000	182
Japan		208,378	208,378	146
United States	129,595	72,000	202,595	142
China	41,639	46,000	87,639	61
United Kingdom	24,800		24,800	17
Denmark	4,300	18,000	22,300	16
Germany		17,920	17,920	13
Turkey	13,570		13,570	10
India		12,400	12,400	9
France (mainland)	10,858	1,100	11,958	8

By the end of 2022, 954 MW_{th} (1.36 million square meters) of glazed and unglazed air collectors were installed worldwide. The annual worldwide market in 2022 was in the range of 60 MW_{th} (85,735 m^2).

Using solar air collectors for space heating is not common in Europe. In North America, however, building-integrated solar air collectors are the most popular form of solar thermal systems in the commercial, industrial, and institutional markets due to their low cost and architectural integration into buildings. Architects can be creative in integrating solar air heaters into building facades.

Canada leads
solar air collector market with 350 MW_{th}

加拿大多伦多公寓社区 Canary Commons 机房顶楼的太阳能空气加热系统

照片：SolarWall Conserval Engineering Inc：SolarWall Conserval 工程公司

建筑采用壁式安装，以利用冬季较低的日照角度，并消除屋顶安装系统的积雪。夏季不需要热量时，电池板通常处于休眠状态，因为停滞温度通常不是问题。

太阳能空气加热系统可以与建筑融为一体，通常可减少 20% 至 30% 的传统供暖能源。空气一般从墙壁顶部抽出，然后将加热或预热的新鲜空气连接到现有或新的风机上，通过通风系统导入建筑物。

加工应用则不同，因为它们全年或在收获季节都在运行，因此可以将电池板安装在屋顶上，以获取较高的日照角度。

农业领域的太阳能空气加热器主要用于需要低温的干燥应用。

在过去的 30 年里，太阳能空气加热系统已在世界各地的学校、市政当局、军队、农业、商业和工业实体以及住宅建筑中得到广泛应用。

蓄热是可能的，但大多数太阳能空气系统不包括蓄热，以尽量降低成本。

下表列出了太阳能空气集热器面积超过 10 000 平方米的国家。

表 8：最大的太阳能空气集热器市场 - 2022 年安装的空气集热器总面积

国家	空气收集器 [平方米]		总计 [m²]	已安装能力 [MW]
	无釉	黄釉		
加拿大	440,069	60,539	500,608	350
澳大利亚	250,000	10,000	261,000	182
日本		208,378	208,378	146
联合国家	129,595	72,000	202,595	142
中国	41,639	46,000	87,639	61
联合王国	24,800		24,800	17
丹麦	4,300	18,000	22,300	16
德国		17,920	17,920	13
土耳其	13,570		13,570	10
印度		12,400	12,400	9
法国 (大陆)	10,858	1,100	11,958	8

截至 2022 年底，全球共安装了 954 兆瓦（136 万平方米）有釉和无釉空气集热器。2022 年的全球年市场规模在 60 兆瓦（85,735 平方米）左右。

将太阳能空气集热器用于空间供热在欧洲并不常见。然而，在北美洲，建筑一体化太阳能空气集热器是商业、工业和机构市场上最受欢迎的太阳能热利用系统形式，因为其成本低，可与建筑融为一体。建筑师可以创造性地将太阳能空气加热器融入建筑外墙。

加拿大导致太阳能集热器市场与 350 兆瓦

6 Detailed global market data and country statistics in 2022

At the Rothaus brewery in Germany, almost 1,000 m² of vacuum tube collectors supply the bottle washing machines with heat
Photo: Rothaus brewery, Germany

The following chapters of the report provide detailed solar thermal market figures for the year 2022 and country figures for 72 countries.

Background of the 2022 data

The figures in the following chapters represent the collector area in operation in 2022, not the cumulated collector area installed in a country, meaning that system lifetimes are considered. To determine the collector area and operation capacity, official country reports on the lifetime were used, or, if such reports were not available, a 25-year lifetime for a system was calculated. The collector area in operation was then calculated using a linear equation. For China, the methodology of the Chinese Solar Thermal Industry Federation (CSTIF) was used until 2018. According to the CSTIF approach, the operation lifetime was ten years. From 2019 on, an increased lifetime is used to calculate the cumulated collector area, accounting

6 报告以下各章提供了 2022 年太阳能热利用市场的详细数据以及 72 个国家的数据。

详细

2022 年全球市场数据和国家统计

在德国的 Rothaus 啤酒厂，近 1,000 平方米的真空管集热器为洗瓶机提供热量
照片德国 Rothaus 啤酒厂

2022 年数据的背景

以下各章中的数字代表的是 2022 年运行中的集热器面积，而不是一个国家累计安装的集热器面积，这意味着系统寿命被考虑在内

为确定集热器面积和运行能力，使用了有关使用寿命的官方国家报告，如果没有此类报告，则计算出系统的 25 年使用寿命。然后使用线性方程计算运行中的集热器面积。中国在 2018 年之前采用中国太阳能热利用产业联盟（CSTIF）的方法。根据 CSTIF 的方法，运行寿命为 10 年。从 2019 年起，计算累计集热器面积时将使用更长的使用寿命，即

for the fact that the share of large systems in China has increased over the past few years. According to this approach, a lifetime of 13 years is used for 2021, increasing to 14 years in 2022. For Germany, a lifetime of 25 years was used in accordance with accumulated market statistic figures for Germany published by BSW.[47]

The analysis further distinguishes between different types of solar thermal collectors: unglazed water collectors, glazed water collectors including flat plate collectors (FPC) and evacuated tube collectors (ETC), and unglazed and glazed air collectors. Concentrating collectors are not within the scope of this report.

6.1 General market overview of the total installed capacity in operation

Installation of Sunpad systems in Cairo, Egypt
Photo: GREENoneTEC Solarindustrie GmbH, Austria

By the end of 2022, an installed capacity of 542.7 GW_{th}, corresponding to a total of 775 million m^2 of collector area, was in operation worldwide.

The vast majority of the total capacity in operation was installed in China (396.4 GW_{th}) and Europe (63.2 GW_{th}), which accounted for 84.7% of the total installed capacity. The remaining installed capacity was shared between the United States and Canada (19.3 GW_{th}), Latin America and Caribbean (20.6 GW_{th}), Other Asia (18.5 GW_{th}), the MENA countries Israel, Jordan, Lebanon, Morocco, the Palestinian Territories and Tunisia (8.1 GW_{th}), Australia and New Zealand (6.8 GW_{th}), and the Sub-Sahara African countries Botswana, Burkina Faso, Cape Verde, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa and Zimbabwe (2.6 GW_{th}). The market volume of "all other countries" is estimated to be 5% of the total installations, excluding China (7.3 GW_{th}).

[47] Bundesverband Solarwirtschaft e.V.
[48] Middle East and North Africa

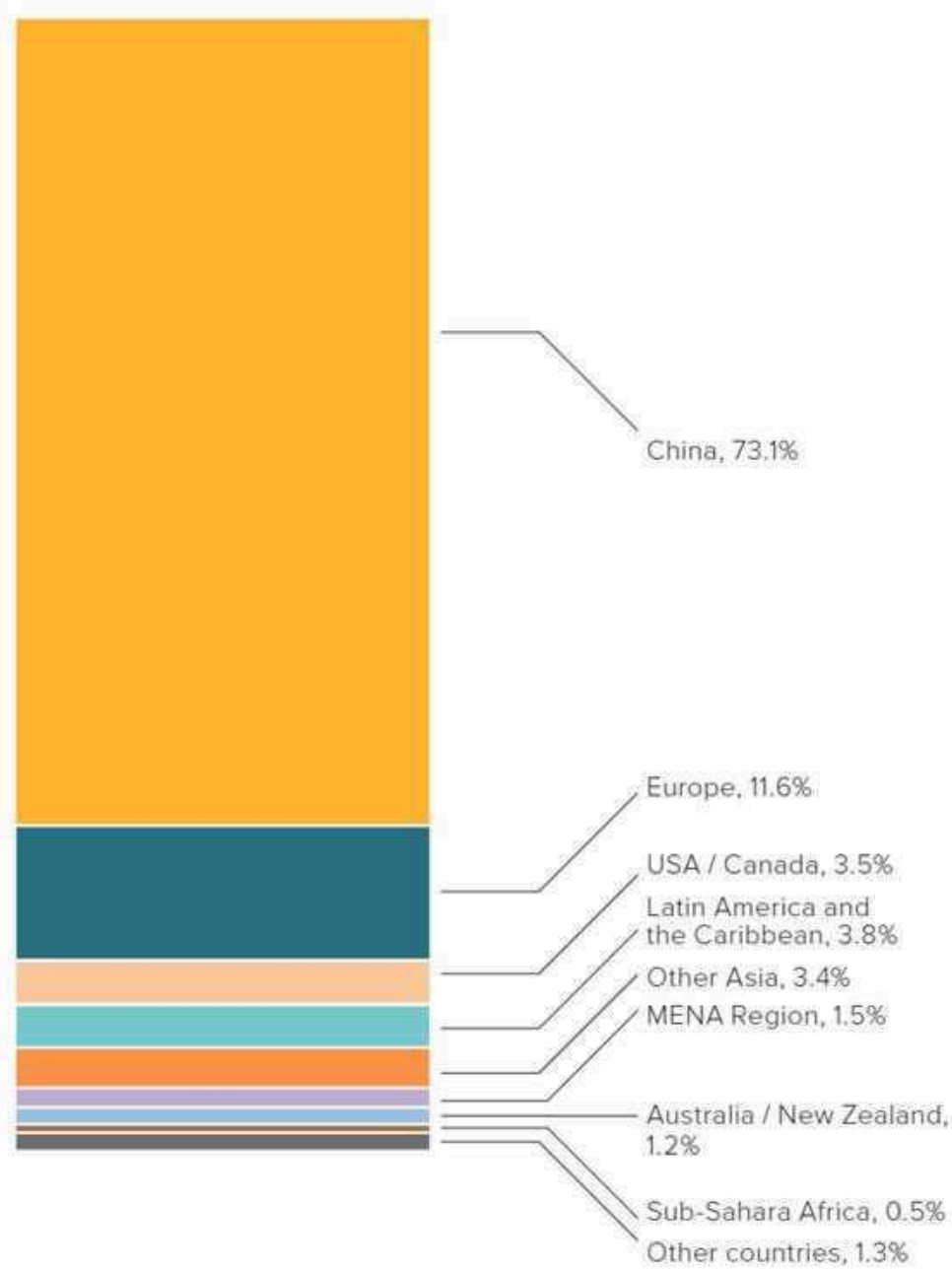

Figure 20: Share of the total installed capacity in operation (glazed and unglazed water and air collectors) by economic region in 2022

Sub-Sahara Africa: Botswana, Burkina Faso, Cape Verde, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Other Asia: Bhutan, India, Japan, Nepal, South Korea, Chinese Taipei, Thailand
Latin America and Caribbean: Argentina, Barbados, Brazil, Chile, Mexico, Panama, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

因为在过去几年中，大型系统在中国所占的比例有所上升。根据这一方法，2021 年的使用寿命为 13 年，2022 年增至 14 年。在德国，根据 BSW 公布的德国累积市场统计数据，采用了 25 年的使用寿命。

分析进一步区分了不同类型的太阳能集热器：无釉水集热器、有釉水集热器（包括平板集热器 (FPC) 和真空管集热器 (ETC)）以及无釉和有釉空气集热器。聚光集热器不在本报告讨论范围之内。

6.1 运行中的总装机容量市场概况

在埃及开罗安装遮阳板系统
照片：奥地利 GREENoneTEC 太阳能工业有限公司

截至 2022 年底，全球已投入运行的装机容量为 542.7 千兆瓦，相当于 7.75 亿平方米的集热器面积。

总装机容量的绝大部分安装在中国（396.4 千兆瓦）和欧洲（63.2 千兆瓦），占总装机容量的 84.7%。其余装机容量分布在美国和加拿大（19.3 千兆瓦）、拉丁美洲和加勒比海地区（20.6 千兆瓦）、其他亚洲地区（18.5 千兆瓦）、中东和北非国家以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土和突尼斯（8.1 千兆瓦）、澳大利亚和新西兰（8.1 千兆瓦）。1 GW），澳大利亚和新西兰（6.8 GW），以及撒哈拉以南非洲国家博茨瓦纳、布基纳法索、佛得角、加纳、肯尼亚、莱索托、毛里求斯、莫桑比克、纳米比亚、尼日利亚、塞内加尔、南非和津巴布韦（2.6 GW）。所有其他国家 "的市场容量估计占总安装量的 5%，不包括中国（7.3 千兆瓦）。

[47] Bundesverband Solarwirtschaft e.V.
[48] 中东和北非

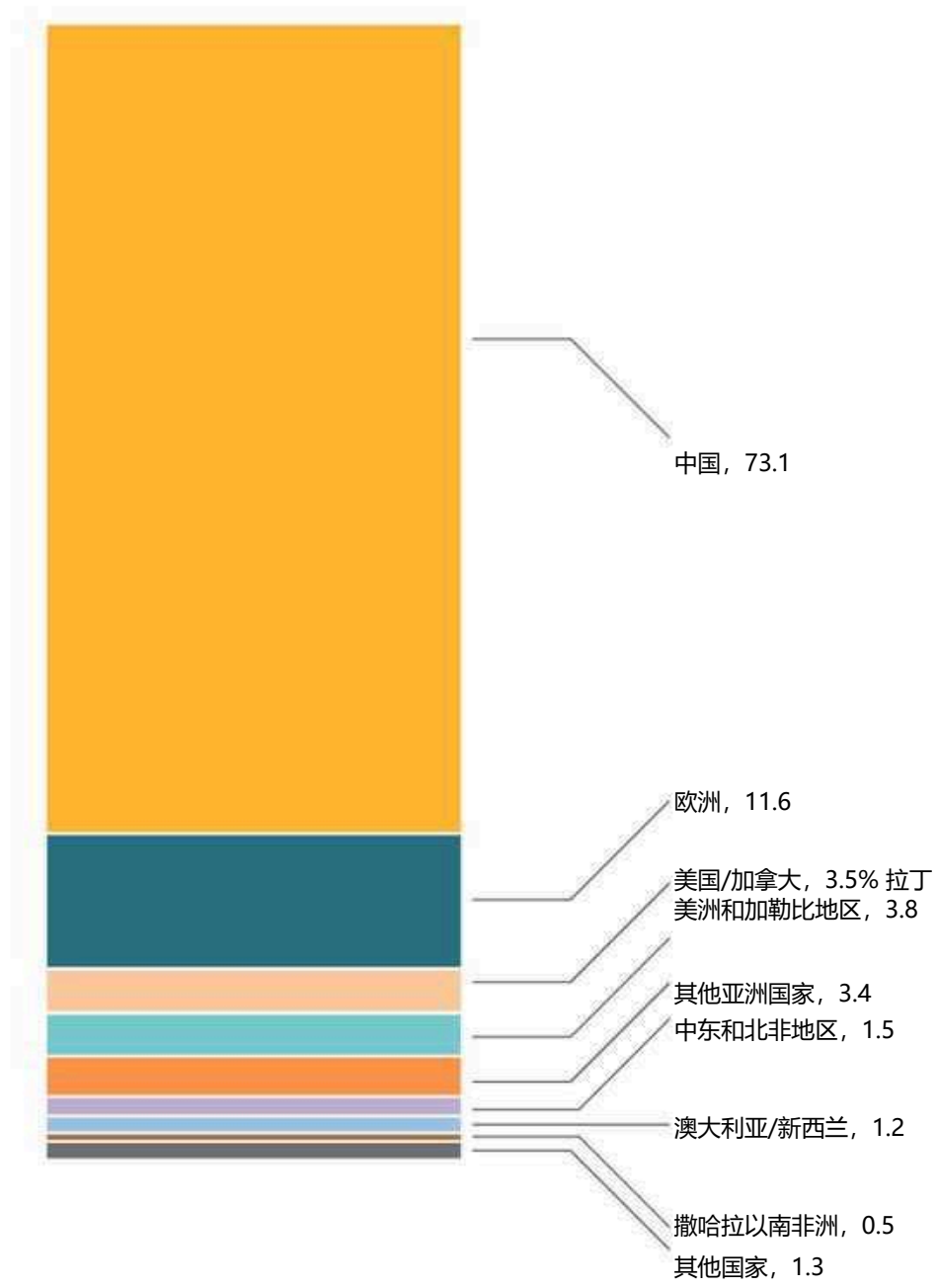

图 20：运行中的总装机容量所占比例（有玻璃和无玻璃的水和空气集热器）

2022 年按经济区域划分

Table 9: Total capacity in operation in 2022 [MW_{th}]

Country/Region/Economy	Water Collectors [MW_{th}]			Air Collectors [MW_{th}]		TOTAL [MW_{th}]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		220.7	10.0			231
Argentina	70.7	95.9	186.5	0.0	0.3	353
Australia	4,133.5	2,328.2	184,1		7.0	6,653
Austria	120.0	3,048.1	56.8		5.2	3,230
Barbados+		180.7				181
Belgium		434.0	105.0			539
Bhutan		0.6				0.6
Botswana++		12.1	2.0			14
Brazil	6,468.7	8,876.7	188.8			15,534
Bulgaria		150.5	4.1			155
Burkina Faso+		2.3	1.0			3
Canada	488.3	48.3	36.7	308.0	42.4	924
Cape Verde+++		1.8				2
Chile	45.9	226.2	38.0		0.2	310
China		51,166.5	345.165.0	29.1	32.2	396,393
Croatia		192.8	9.3			202
Cyprus	1.5	601.6	16.5			620
Czech Republic	297.5	345.0	112.8			755
Denmark	14.4	1,249.3	6.4	3.0	12.6	1,286
Estonia		10.3	5.9			16
Finland	8.3	39.4	14.6			62
France (mainland)	47.4	1,475.7	133.7	7.6	0.8	1,665
France (overseas)		828.5	30.5			859
Germany	292.8	13,678.0	1.832.9		12.5	15,816
Ghana++		3.6	1.8			5
Greece		3,779.4	16.0			3,795
Hungary	12.8	205.6	55.9	2.4	1.6	278
India	0.0	2,918.6	10,562.8	0.0	8.7	13,490
Ireland		202.1	89.7			292
Israel++	27.3	3,533.9				3,561
Italy	30.7	3,237.2	498.3	0.1		3,766
Japan		1,854.1	23.9		145.9	2,024
Jordan*	4.2	687.7	190.5			882
Kenya++		222.8	111.4			334
Latvia		27.7	2.4			30
Lebanon		284.3	352.1			636
Lesotho		1.7	2.9			5
Lithuania		7.3	10.5			18
Luxembourg		46.3	6.2			52
Malta		43.1	10.6			54
Mauritius**		93.0				93
Mexico	1,309.7	1,504.4	1,338.8	0.5	6.3	4,160
Morocco++		726.6				727
Mozambique	0.1	0.0	2.9			3
Namibia	1.1	41.8	1.0			44
Nepal++++		21.0	189.0			210
Netherlands	47.2	350.4	66.0			464
New Zealand***	4.9	100.1	6.8			112
Nigeria+		1.3	7.5	0.0	1.2	10
North Macedonia		57.3	44.2		0.0	102
Norway	1.3	25.4	3.2	0.1	2.9	33
Palestinian Territories		1,386.6				1,387
Panama		0.5				0.5
Poland		2,032.6	351.4			2,384
Portugal	1.5	1,058.8	22.8			1,083
Romania	0.2	105.3	80.2	0.6		186
Russia	0.1	58.8	2.9	0.0	0.1	62
Senegal+		3.3	3.6	0.0	0.8	8
Slovakia	0.7	125.3	19.8			146
Slovenia		89.6	16.6		0.0	106
South Africa	1,014.8	525.4	409.9			1,950
South Korea		1,040.4	312.0	0.9	0.2	1,354
Spain	116.0	3,203.9	178.8	10.2	1.6	3,511
Sweden	119.7	182.7	50.8			353
Switzerland	114.8	977.7	103.3			1,196
Chinese Taipei+	1.4	1,175.9	93.3			1,271
Thailand****		110.3				110
Tunisia		827.7	49.1			877
Turkey		11,476.9	7,665.7	11.1		19,154
United Kingdom	76.2	397.5	181.3	17.4		672
United States	16,028.6	2,092.0	123.8	90.0	50.4	18,385
Uruguay	0.4	77.2	4.6			82
Zimbabwe		15.3	68.7			84
All other countries (5% solar thermal world market excluding China)	1,626.4	4,262.5	1,384.6	23.8	15.8	7,313
TOTAL	32,529	136,416	372,858	505	349	542,657

Note: If no data is given: no reliable database for this collector type is available

* Total capacity in operation refers to the year 2014
** Total capacity in operation refers to the year 2015
*** Total capacity in operation refers to the year 2009
**** Total capacity in operation refers to the year 2016
\+ Total capacity in operation refers to the year 2020
++ Calculated based on 0% growth 2022
+++ Total capacity in operation refers to the year 2021
++++ New in ed. 2024

表 9：2022 年运行的总容量 [兆瓦]

国家/地区/经济	集水井 [MW]			空气收集器 [MW]		总计 [MW]
	无釉	FPC	ETC	无釉	黄釉	
阿尔巴尼亚		220.7	10.0			231
阿根廷	70.7	95.9	186.5	0.0	0.3	353
澳大利亚	4,133.5	2,328.2	184,1		7.0	6,653
奥地利	120.0	3,048.1	56.8		5.2	3,230
巴巴多斯+		180.7				181
比利时		434.0	105.0			539
不丹		0.6				0.6
博茨瓦纳++		12.1	2.0			14
巴西	6,468.7	8,876.7	188.8			15,534
保加利亚		150.5	4.1			155
布基纳法索+		2.3	1.0			3
加拿大	488.3	48.3	36.7	308.0	42.4	924
佛得角+++		1.8				2
智利	45.9	226.2	38.0		0.2	310
中国		51,166.5	345.165.0	29.1	32.2	396,393
克罗地亚		192.8	9.3			202
塞浦路斯	1.5	601.6	16.5			620
捷克共和国	297.5	345.0	112.8			755
丹麦	14.4	1,249.3	6.4	3.0	12.6	1,286
爱沙尼亚		10.3	5.9			16
芬兰	8.3	39.4	14.6			62
法国（本土）	47.4	1,475.7	133.7	7.6	0.8	1,665
法国（海外）		828.5	30.5			859
德国	292.8	13,678.0	1.832.9		12.5	15,816
加纳++		3.6	1.8			5
希腊		3,779.4	16.0			3,795
匈牙利	12.8	205.6	55.9	2.4	1.6	278
印度	0.0	2,918.6	10,562.8	0.0	8.7	13,490
爱尔兰		202.1	89.7			292
以色列++	27.3	3,533.9				3,561
意大利	30.7	3,237.2	498.3	0.1		3,766
日本		1,854.1	23.9		145.9	2,024
约旦*	4.2	687.7	190.5			882
肯尼亚++++。		222.8	111.4			334
拉脱维亚		27.7	2.4			30
黎巴嫩		284.3	352.1			636
莱索托		1.7	2.9			5
立陶宛		7.3	10.5			18
卢森堡		46.3	6.2			52
马耳他		43.1	10.6			54
毛里求斯**		93.0				93
墨西哥	1,309.7	1,504.4	1,338.8	0.5	6.3	4,160
摩洛哥++		726.6				727
莫桑比克	0.1	0.0	2.9			3
纳米比亚	1.1	41.8	1.0			44
尼泊尔++++		21.0	189.0			210
荷兰	47.2	350.4	66.0			464
新西兰***	4.9	100.1	6.8			112
尼日利亚+		1.3	7.5	0.0	1.2	10
北马其顿		57.3	44.2		0.0	102
挪威	1.3	25.4	3.2	0.1	2.9	33
巴勒斯坦领土		1,386.6				1,387
巴拿马		0.5				0.5
波兰		2,032.6	351.4			2,384
葡萄牙	1.5	1,058.8	22.8			1,083
罗马尼亚	0.2	105.3	80.2	0.6		186
俄罗斯	0.1	58.8	2.9	0.0	0.1	62
塞内加尔+		3.3	3.6	0.0	0.8	8
斯洛伐克	0.7	125.3	19.8			146
斯洛文尼亚		89.6	16.6		0.0	106
南非	1,014.8	525.4	409.9			1,950
韩国		1,040.4	312.0	0.9	0.2	1,354
西班牙	116.0	3,203.9	178.8	10.2	1.6	3,511
瑞典	119.7	182.7	50.8			353
瑞士	114.8	977.7	103.3			1,196
中国台北+	1.4	1,175.9	93.3			1,271
泰国****		110.3				110
突尼斯		827.7	49.1			877
土耳其		11,476.9	7,665.7	11.1		19,154
英国	76.2	397.5	181.3	17.4		672
美国	16,028.6	2,092.0	123.8	90.0	50.4	18,385
乌拉圭	0.4	77.2	4.6			82
津巴布韦		15.3	68.7			84
所有其他国家（全球 5%的太阳能热利用市场，不包括中国）	1,626.4	4,262.5	1,384.6	23.8	15.8	7,313
总计	32,529	136,416	372,858	505	349	542,657

注：如果没有给出数据：没有关于该集热器类型的可靠数据库 * 运行中的总容量指 2014 年 ** 运行中的总容量指 2015 年 *** 运行中的总容量指 2009 年 **** 运行中的总容量指 2016 年

\+ 运行中的总容量指 2020 年

++ 按 0% 增长率计算 2022 年运行中的总容量指 2021 年 ++++ 新编 2024

Table 10: Total installed collector area in operation in 2022 [m²]

Country/Region/Economy	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		315,223	14,262			329,485
Argentina	101,031	136,988	266,427	60	474	504,979
Australia	5,905,000	3,326,000	263,000		10,000	9,504,000
Austria	171,445	4,354,358	81,213		7,458	4,614,474
Barbados+		258,192				258,192
Belgium		620,000	150,000			770,000
Bhutan		824				824
Botswana++		17,251	2,824			20,075
Brazil	9,240,937	12,681,068	269,716			22,191,721
Bulgaria		214,938	5,850			220,788
Burkina Faso+		3,282	1,399			4,681
Canada	697,545	68,996	52,459	440,069	60,539	1,319,608
Cape Verde+++		2,613				2,613
Chile	65,550	323,148	54,305		300	443,303
China		73,095,000	493,092,921	41,639	46,000	566,275,560
Croatia		275,393	13,308			288,701
Cyprus	2,213	859,430	23,567			885,210
Czech Republic	425,000	492,844	161,162			1,079,006
Denmark	20,500	1,784,756	9,197	4,300	18,000	1,836,753
Estonia		14,743	8,360			23,103
Finland	11,800	56,298	20,788			88,886
France (mainland)	67,756	2,108,161	190,939	10,858	1,100	2,378,814
France (overseas)		1,183,629	43,588			1,227,217
Germany	418,245	19,540,064	2,618,388		17,920	22,594,617
Ghana++		5,170	2,508			7,678
Greece		5,399,200	22,800			5,422,000
Hungary	18,300	293,749	79,850	3,418	2,300	397,617
India	0	4,169,361	15,089,718	0	12,400	19,271,479
Ireland		288,748	128,127			416,875
Israel++	39,000	5,048,434				5,087,434
Italy	43,800	4,624,511	711,855	120		5,380,286
Japan		2,648,684	34,074		208,378	2,891,136
Jordan*	5,940	982,482	272,084			1,260,506
Kenya++		318,348	159,174			477,521
Latvia		39,572	3,490			43,062
Lebanon		406,122	502,949			909,071
Lesotho		2,371	4,101			6,472
Lithuania		10,441	15,050			25,491
Luxembourg		66,080	8,900			74,980
Malta		61,624	15,087			76,711
Mauritius**		132,793				132,793
Mexico	1,870,933	2,149,187	1,912,587	752	9,061	5,942,520
Morocco++		1,038,000				1,038,000
Mozambique	136	48	4,129			4,313
Namibia	1,560	59,713	1,395			62,669
Nepal++++		30,000	270,000			300,000
Netherlands	67,440	500,570	94,350			662,360
New Zealand***	7,025	142,975	9,644			159,645
Nigeria+		1,866	10,782	0	1,670	14,318
North Macedonia		81,907	63,129		32	145,068
Norway	1,849	36,349	4,577	200	4,106	47,082
Palestinian Territories		1,980,900				1,980,900
Panama		665				665
Poland		2,903,730	501,960			
Portugal	2,130	1,512,502	32,553			1,547,185
Romania	340	150,479	114,590	800		266,209
Russia	137	83,950	4,184	2	144	88,417
Senegal+		4,741	5,083	0	1,203	11,027
Slovakia	1,000	178,940	28,270			208,210
Slovenia		128,000	23,670		10	151,680
South Africa	1,449,753	750,504	585,628			2,785,885
South Korea		1,486,336	445,760	1,300	300	1,933,696
Spain	165,736	4,577,051	255,463	14,550	2,250	5,015,050
Sweden	171,000	260,937	72,578			504,515
Switzerland	164,000	1,396,700	147,500			1,708,200
Chinese Taipei+	1,937	1,679,874	133,244			1,815,055
Thailand****		157,536				157,536
Tunisia		1,182,497	70,104			1,252,601
Turkey		16,395,608	10,950,989	15,815		27,362,412
United Kingdom	108,850	567,846	258,931	24,800		960,427
United States	22,897,975	2,988,552	176,914	128,578	72,000	26,264,019
Uruguay	509	110,308	6,614			117,431
Zimbabwe		21,848	98,188			120,036
All other countries (5% of world market excluding China)	2,323,493	6,089,264	1,978,070	33,980	22,613	10,447,420
TOTAL	46,469,866	194,880,272	532,654,326	721,241	498,258	775,223,963

Note: If no data is given, no reliable database for this collector type is available

* Total capacity in operation refers to the year 2014
** Total capacity in operation refers to the year 2015
*** Total capacity in operation refers to the year 2009
**** Total capacity in operation refers to the year 2016
\+ Total capacity in operation refers to the year 2020
++ Calculated based on 0% growth 2022
+++ Total capacity in operation refers to the year 2021
++++ New in ed. 2024

表 10：2022 年投入使用的已安装集热器总面积[平方米]

国家/地区/经济	集水池 [平方米]			空气收集器 [平方米]		总计 [m²]
	无釉	FPC	ETC	无釉	黄釉	
阿尔巴尼亚		315,223	14,262			329,485
阿根廷	101,031	136,988	266,427	60	474	504,979
澳大利亚	5,905,000	3,326,000	263,000		10,000	9,504,000
奥地利	171,445	4,354,358	81,213		7,458	4,614,474
巴巴多斯+		258,192				258,192
比利时		620,000	150,000			770,000
不丹		824				824
博茨瓦纳++		17,251	2,824			20,075
巴西	9,240,937	12,681,068	269,716			22,191,721
保加利亚		214,938	5,850			220,788
布基纳法索+		3,282	1,399			4,681
加拿大	697,545	68,996	52,459	440,069	60,539	1,319,608
佛得角+++		2,613				2,613
智利	65,550	323,148	54,305		300	443,303
中国		73,095,000	493,092,921	41,639	46,000	566,275,560
克罗地亚		275,393	13,308			288,701
塞浦路斯	2,213	859,430	23,567			885,210
捷克共和国	425,000	492,844	161,162			1,079,006
丹麦	20,500	1,784,756	9,197	4,300	18,000	1,836,753
爱沙尼亚		14,743	8,360			23,103
芬兰	11,800	56,298	20,788			88,886
法国（本土）	67,756	2,108,161	190,939	10,858	1,100	2,378,814
法国（海外）		1,183,629	43,588			1,227,217
德国	418,245	19,540,064	2,618,388		17,920	22,594,617
加纳++		5,170	2,508			7,678
希腊		5,399,200	22,800			5,422,000
匈牙利	18,300	293,749	79,850	3,418	2,300	397,617
印度	0	4,169,361	15,089,718	0	12,400	19,271,479
爱尔兰		288,748	128,127			416,875
以色列++	39,000	5,048,434				5,087,434
意大利	43,800	4,624,511	711,855	120		5,380,286
日本		2,648,684	34,074		208,378	2,891,136
约旦*	5,940	982,482	272,084			1,260,506
肯尼亚++++。		318,348	159,174			477,521
拉脱维亚		39,572	3,490			43,062
黎巴嫩		406,122	502,949			909,071
莱索托		2,371	4,101			6,472
立陶宛		10,441	15,050			25,491
卢森堡		66,080	8,900			74,980
马耳他		61,624	15,087			76,711
毛里求斯**		132,793				132,793
墨西哥	1,870,933	2,149,187	1,912,587	752	9,061	5,942,520
摩洛哥++		1,038,000				1,038,000
莫桑比克	136	48	4,129			4,313
纳米比亚	1,560	59,713	1,395			62,669
尼泊尔++++		30,000	270,000			300,000
荷兰	67,440	500,570	94,350			662,360
新西兰***	7,025	142,975	9,644			159,645
尼日利亚+		1,866	10,782	0	1,670	14,318
北马其顿		81,907	63,129		32	145,068
挪威	1,849	36,349	4,577	200	4,106	47,082
巴勒斯坦领土		1,980,900				1,980,900
巴拿马		665				665
波兰		2,903,730	501,960			
葡萄牙	2,130	1,512,502	32,553			1,547,185
罗马尼亚	340	150,479	114,590	800		266,209
俄罗斯	137	83,950	4,184	2	144	88,417
塞内加尔+		4,741	5,083	0	1,203	11,027
斯洛伐克	1,000	178,940	28,270			208,210
斯洛文尼亚		128,000	23,670		10	151,680
南非	1,449,753	750,504	585,628			2,785,885
韩国		1,486,336	445,760	1,300	300	1,933,696
西班牙	165,736	4,577,051	255,463	14,550	2,250	5,015,050
瑞典	171,000	260,937	72,578			504,515
瑞士	164,000	1,396,700	147,500			1,708,200
中国台北+	1,937	1,679,874	133,244			1,815,055
泰国****		157,536				157,536
突尼斯		1,182,497	70,104			1,252,601
土耳其		16,395,608	10,950,989	15,815		27,362,412
英国	108,850	567,846	258,931	24,800		960,427
美国	22,897,975	2,988,552	176,914	128,578	72,000	26,264,019
乌拉圭	509	110,308	6,614			117,431
津巴布韦		21,848	98,188			120,036
所有其他国家（占世界市场的 5%，不包括中国）	2,323,493	6,089,264	1,978,070	33,980	22,613	10,447,420
总计	46,469,866	194,880,272	532,654,326	721,241	498,258	775,223,963

注：如果没有给出数据，则表示没有该类型集热器的可靠数据库 * 运行中的总容量指 2014 年 ** 运行中的总容量指 2015 年 *** 运行中的总容量指 2009 年 **** 运行中的总容量指 2016 年

\+ 运行中的总容量指 2020 年
++ 按 0% 增长率计算 2022 年
运行中的总容量指 2021 年 ++++ 新编 2024

The total installed capacity in operation in 2022 was divided into flat plate collectors (FPC): 136.4 GW_{th} (194.8 million m^2), evacuated tube collectors (ETC): 372.8 GW_{th} (532.7 million m^2), unglazed water collectors: 32.5 GW_{th} (46.5 million m^2), and glazed and unglazed air collectors: 0.9 GW_{th} (1.2 million m^2).

With a global share of 68.7%, evacuated tube collectors were the predominant solar thermal collector technology, followed by flat plate collectors at 25.1% and unglazed water collectors at 6.0% (Figure 21). Air collectors play only a minor role in the total numbers.

In Europe, the second largest market after China, flat plate collectors were the dominant collector type in 2022 (Figure 22). Europe's share of evacuated tube collectors was 18.7%.

Installation of a ground-mounted solar thermal hot water system in Bhutan
Photo: Rudi Moschik, AEE INTEC

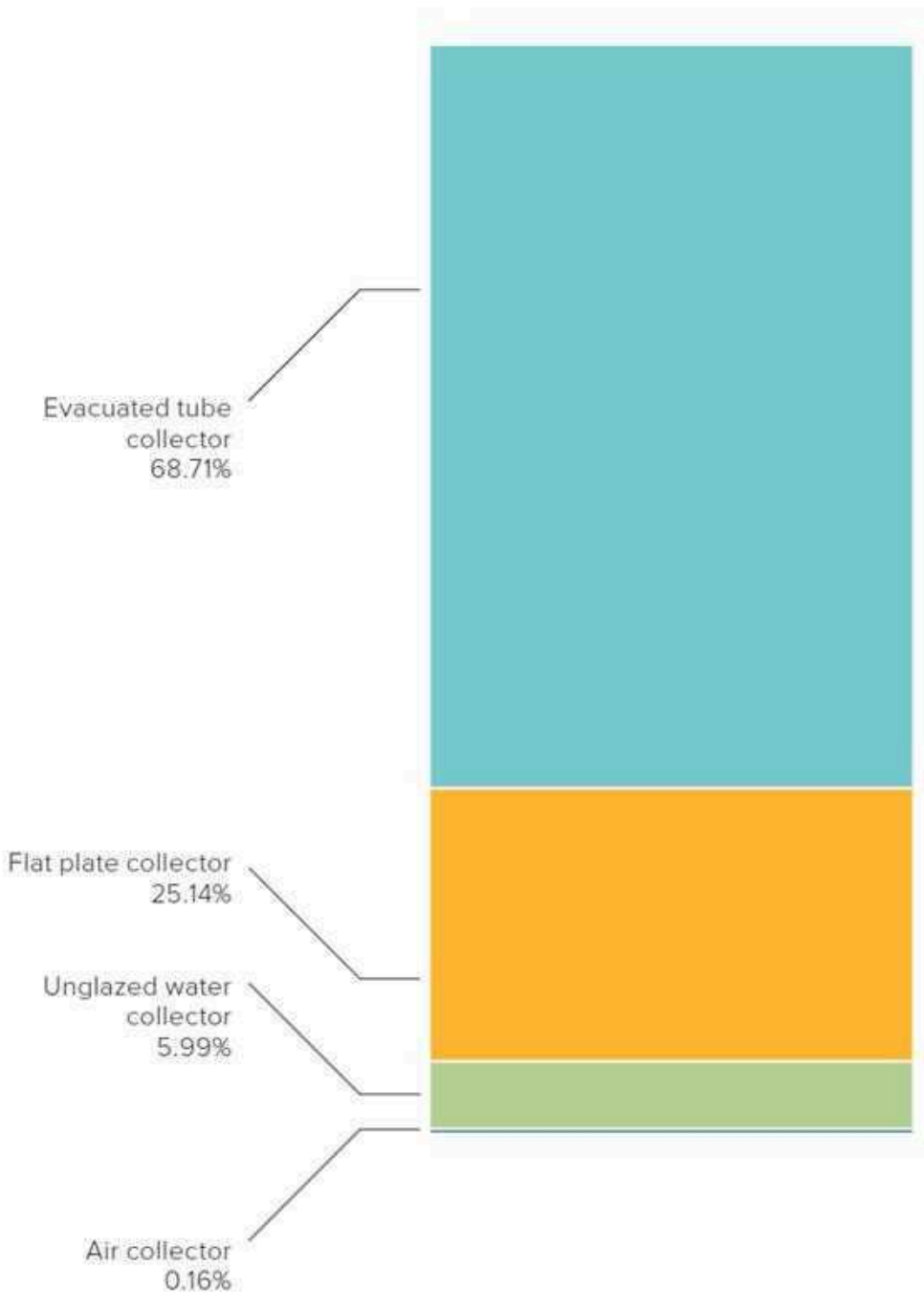

Figure 21: Distribution of the total installed capacity in operation by collector type in 2022 – WORLD

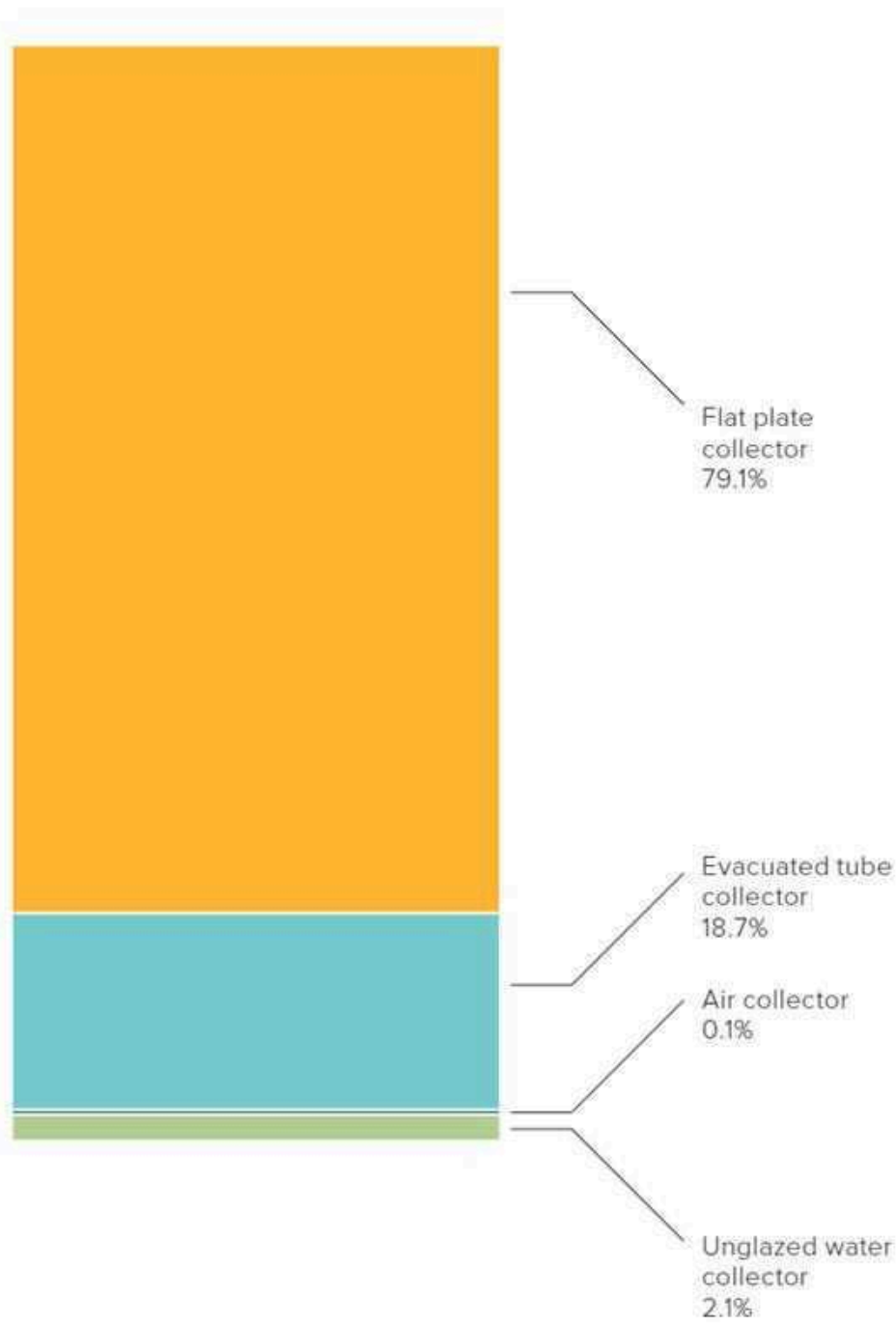

Figure 22: Distribution of the total installed capacity in operation by collector type in 2022 – EUROPE
EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom

2022 年投入运行的总装机容量分为平板集热器 (FPC)3.728 亿千瓦（5.327 亿米）、无釉水收集器：1.364 亿千瓦（1.948 亿米）、真空管收集器（ETC）：3.728 亿千瓦（5.327 亿米）：372.8吉瓦（5.327亿米），无釉水集热器：32.5吉瓦（4650万米），有釉和无釉空气集热器：0.9吉瓦（120万米）。

真空管集热器在全球所占份额为 68.7%，是最主要的太阳能集热技术，其次是平板集热器（25.1%）和无釉水集热器（6.0%）（图 21）。空气集热器在总数中所占比例很小。

在仅次于中国的第二大市场欧洲，平板集热器是 2022 年的主要集热器类型（图 22）。欧洲的真空管集热器份额为 18.7%。

在不丹安装地面太阳能热水系统

照片Rudi Moschik，AEE INTEC

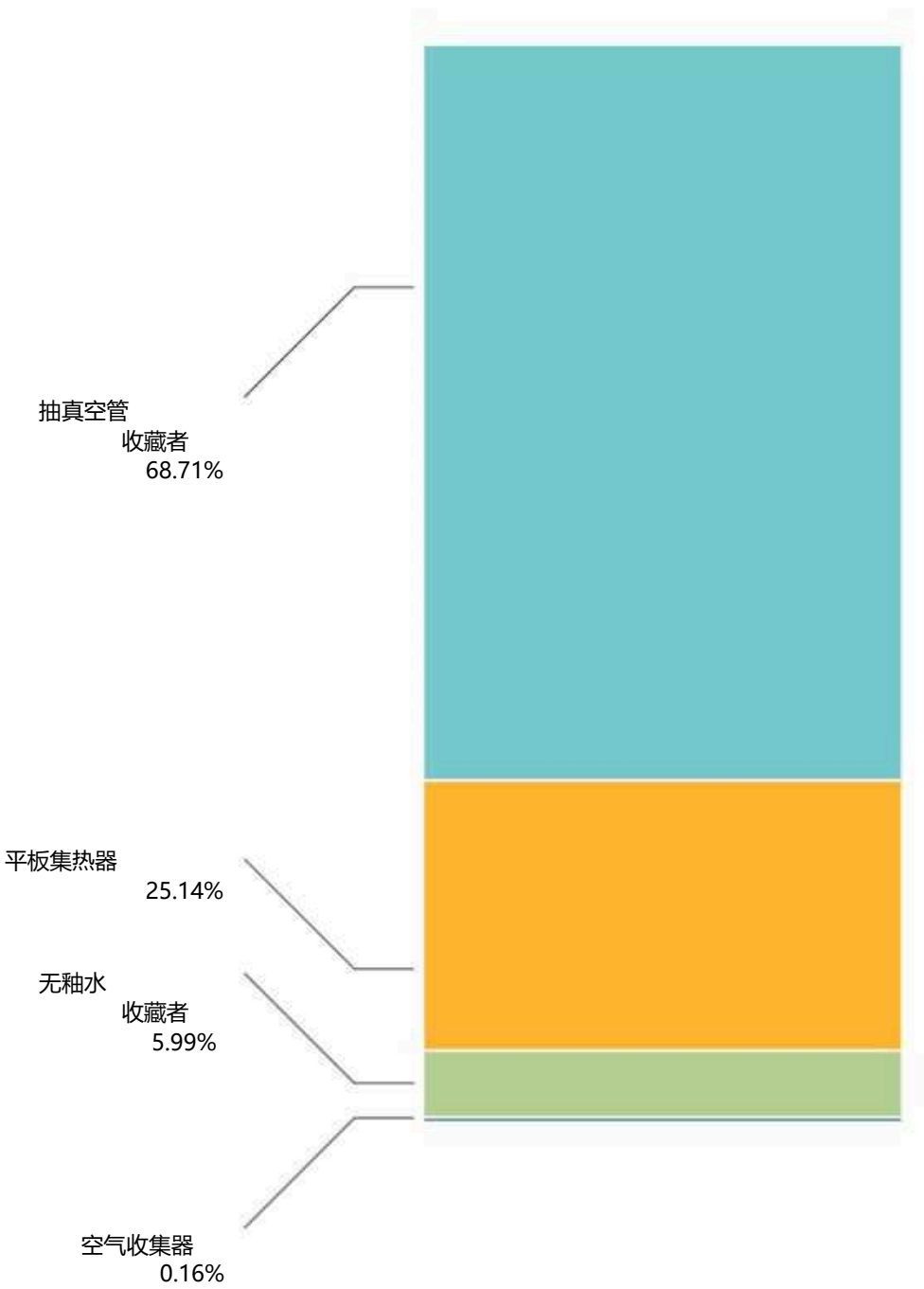

图 21：2022 年按集热器类型分列的在运总装机容量分布 - 世界

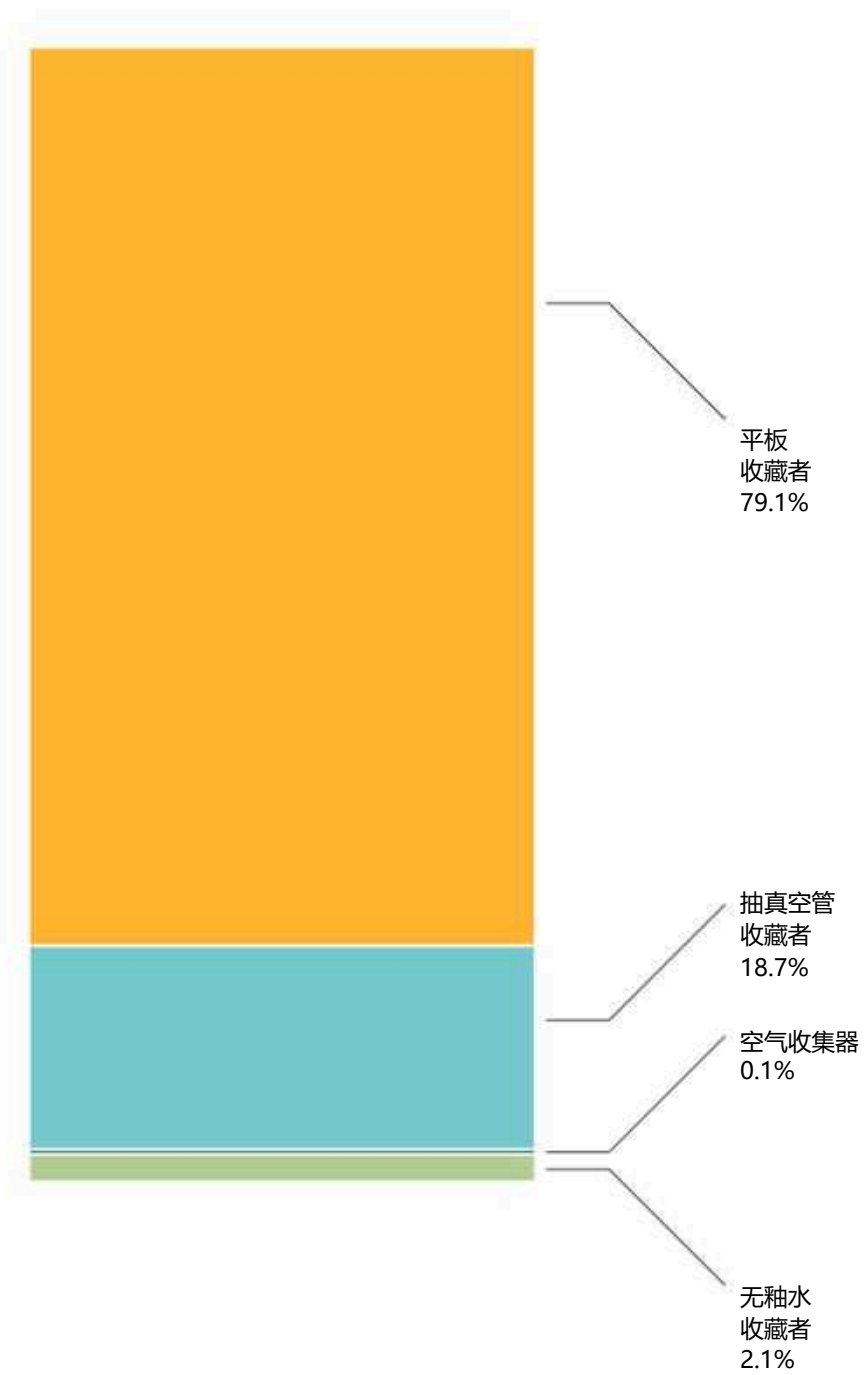

图 22：2022 年按集热器类型分列的在运总装机容量分布 - 欧洲

欧盟 27 国、阿尔巴尼亚、北马其顿、挪威、俄罗斯、瑞士、土耳其、英国

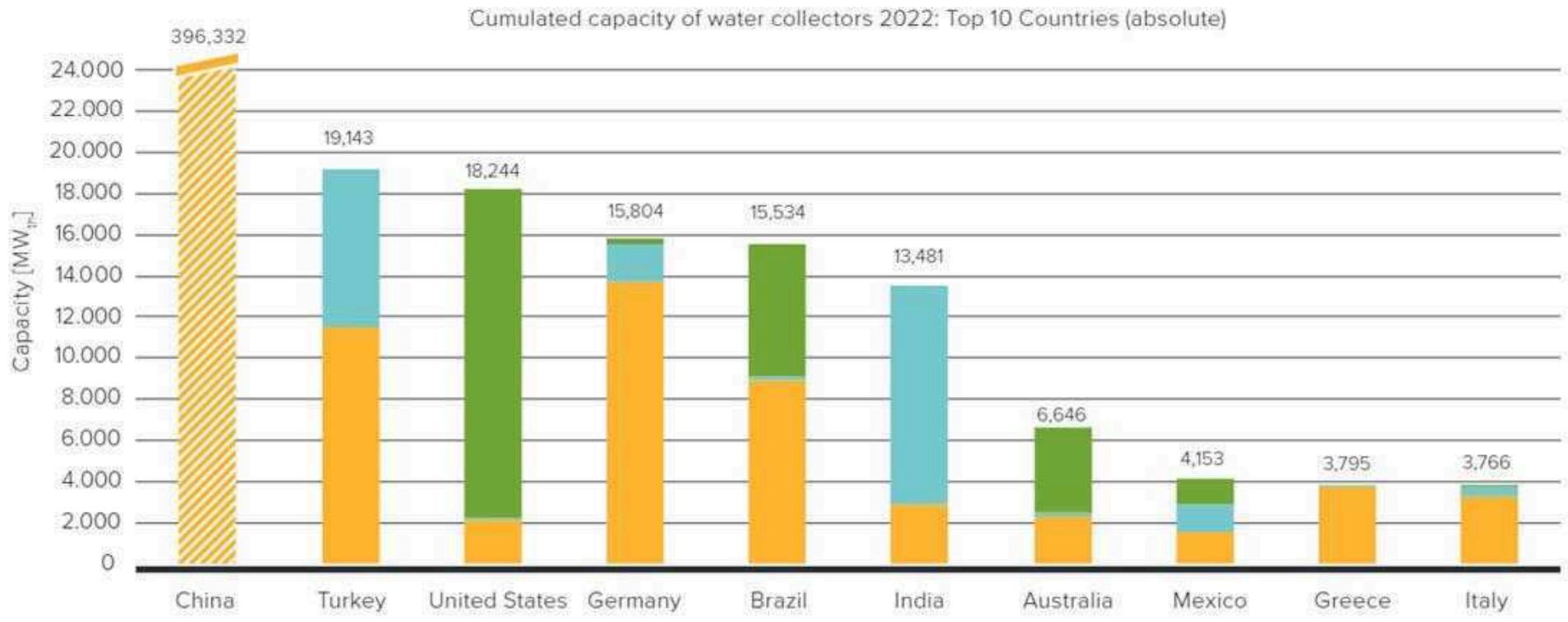

Figure 23: Top 10 countries of cumulated water collector installations in 2022 (absolute figures in MW_{th})

Compared to the year 2021, the rankings remain the same. China remained the world leader in total capacity and a market dominated by evacuated tube collectors. The United States held its third position due to its high number of installed unglazed water collectors. Besides the United States, only Australia and, to some extent, Brazil have large numbers of unglazed water collectors installed. In the large European markets, Germany, Austria, and Greece, flat plate collectors were the dominant collector technology. In Turkey, there has been a strong trend toward evacuated tube collector technology over the past several years.

The top 10 countries with the highest market penetration per capita are shown in Figure 24. The leading countries in cumulated glazed and unglazed water collector capacity in operation in 2022 per 1,000 inhabitants were Barbados (597 kW_{th}/1,000 inhabitants), Cyprus (478 kW_{th}/1,000 inhabitants), Israel (391 kW_{th}/1,000 inhabitants), Austria (362 kW_{th}/1,000 inhabitants), Greece (360 kW_{th}/1,000 inhabitants), China (281 kW_{th}/1,000 inhabitants), the Palestinian Territories (268 kW_{th}/1,000 inhabitants), France (overseas) (254 kW_{th}/1000 inhabitants) Australia (254 kW_{th}/1,000 inhabitants), and Turkey (231 kW_{th}/1,000 inhabitants).

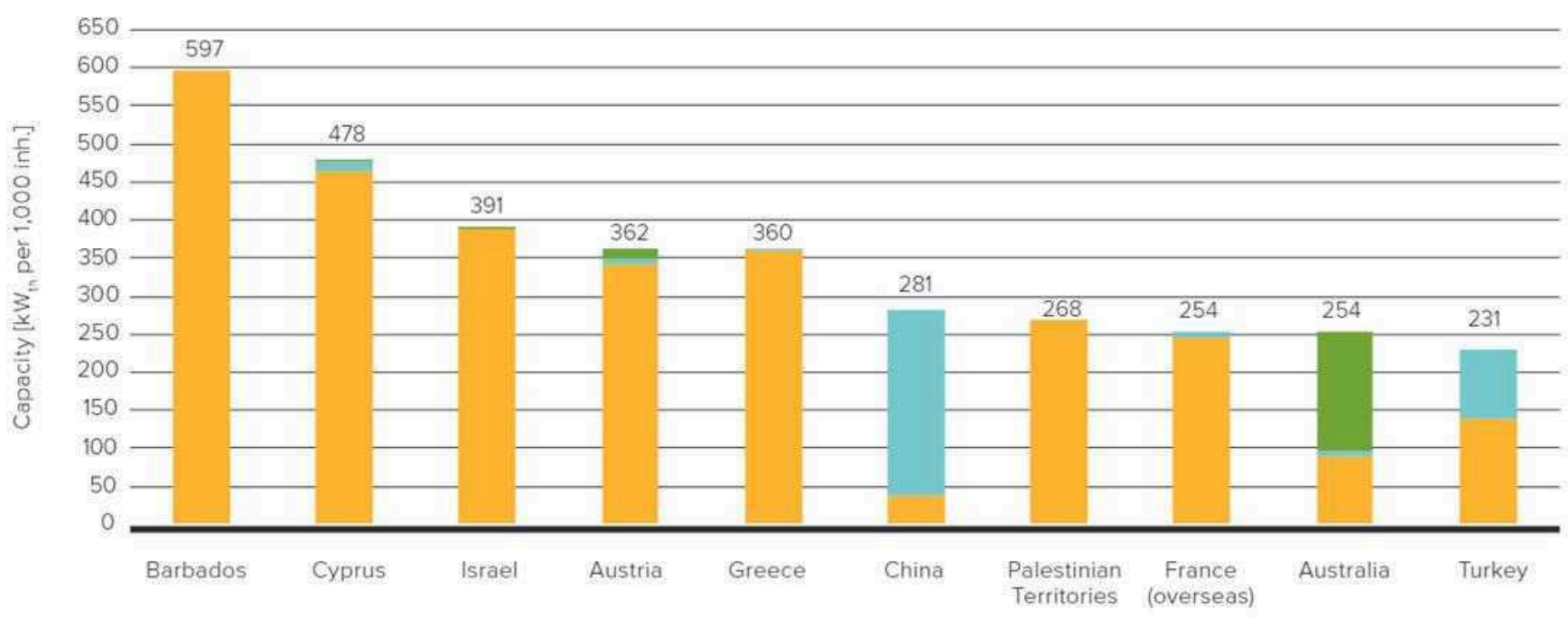

Figure 24: Top 10 countries by cumulated water collector installations per 1,000 inhabitants in 2022 (relative figures in kW_{th})

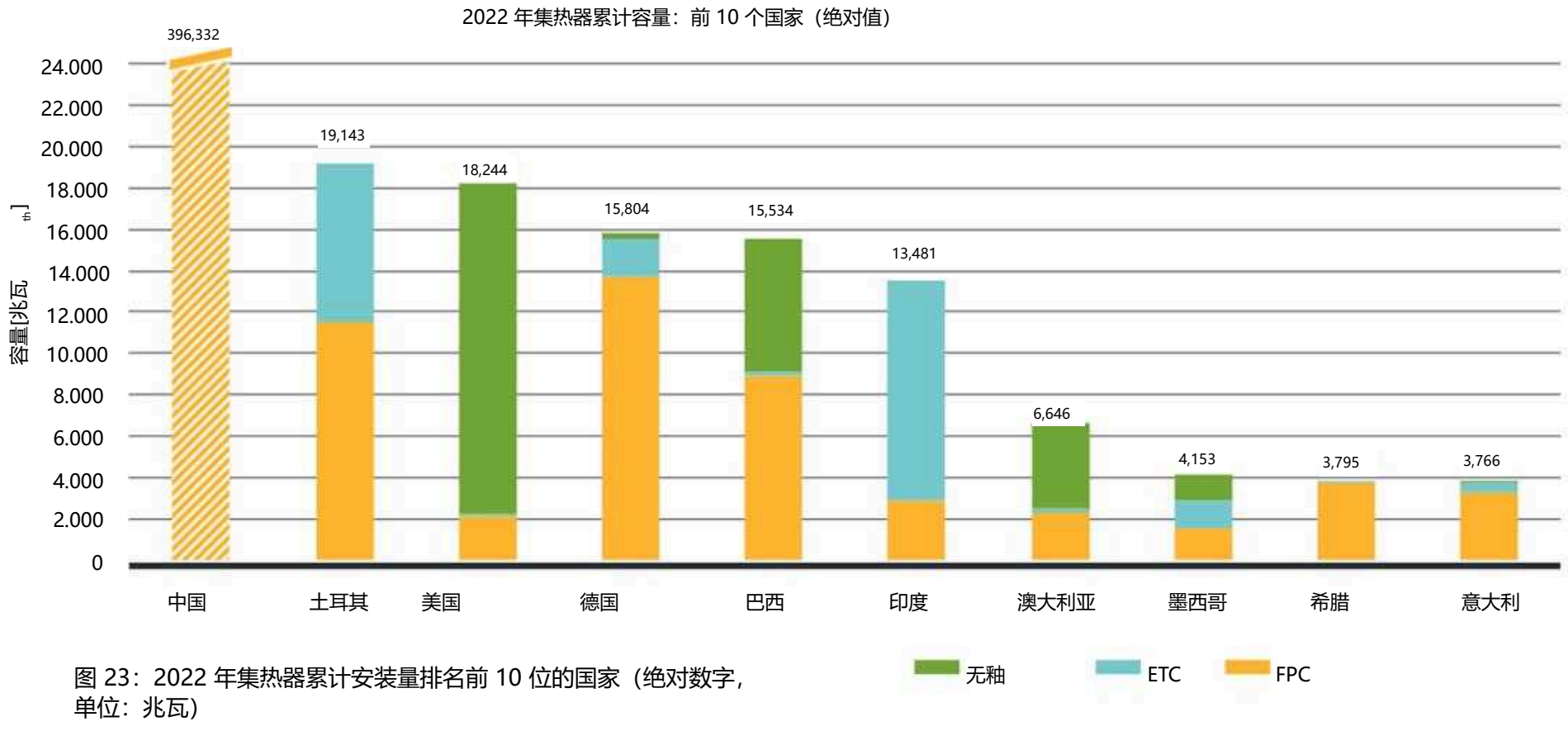

图 23：2022 年集热器累计安装量排名前 10 位的国家（绝对数字，单位：兆瓦）

与 2021 年相比，排名保持不变。中国的总装机容量仍居于世界首位，市场主要由真空管集热器占据。美国由于安装了大量无釉水集热器而稳居第三位。除美国外，只有澳大利亚和巴西在一定程度上安装了大量无釉集热器。在德国、奥地利和希腊等欧洲大市场，平板集热器是最主要的集热器技术。在土耳其，过去几年中，采用真空管集热器技术的趋势非常明显。

人均市场渗透率最高的前 10 个国家如图 24 所示。千居民）、希腊（360 千瓦/千居民）、中国（281 千瓦/千居民）、巴勒斯坦领土（268 千瓦/千居民）、法国（海外）（25 4 千瓦/千居民）、澳大利亚（254 千瓦/千居民）和土耳其（231 千瓦/千居民）。

图 24：2022 年按每千名居民累计安装集热器数量排序的前 10 个国家（相关数字单位：千瓦）

6.2
Total capacity of glazed water collectors in operation

In 2022, China maintained its dominant position as the leading country in total installed capacity of glazed water collectors, with 396.3 GW_{th}. Turkey, Germany, and India followed closely, with installed capacities ranging from 19 GW_{th} to 9 GW_{th}. (Figure 25).

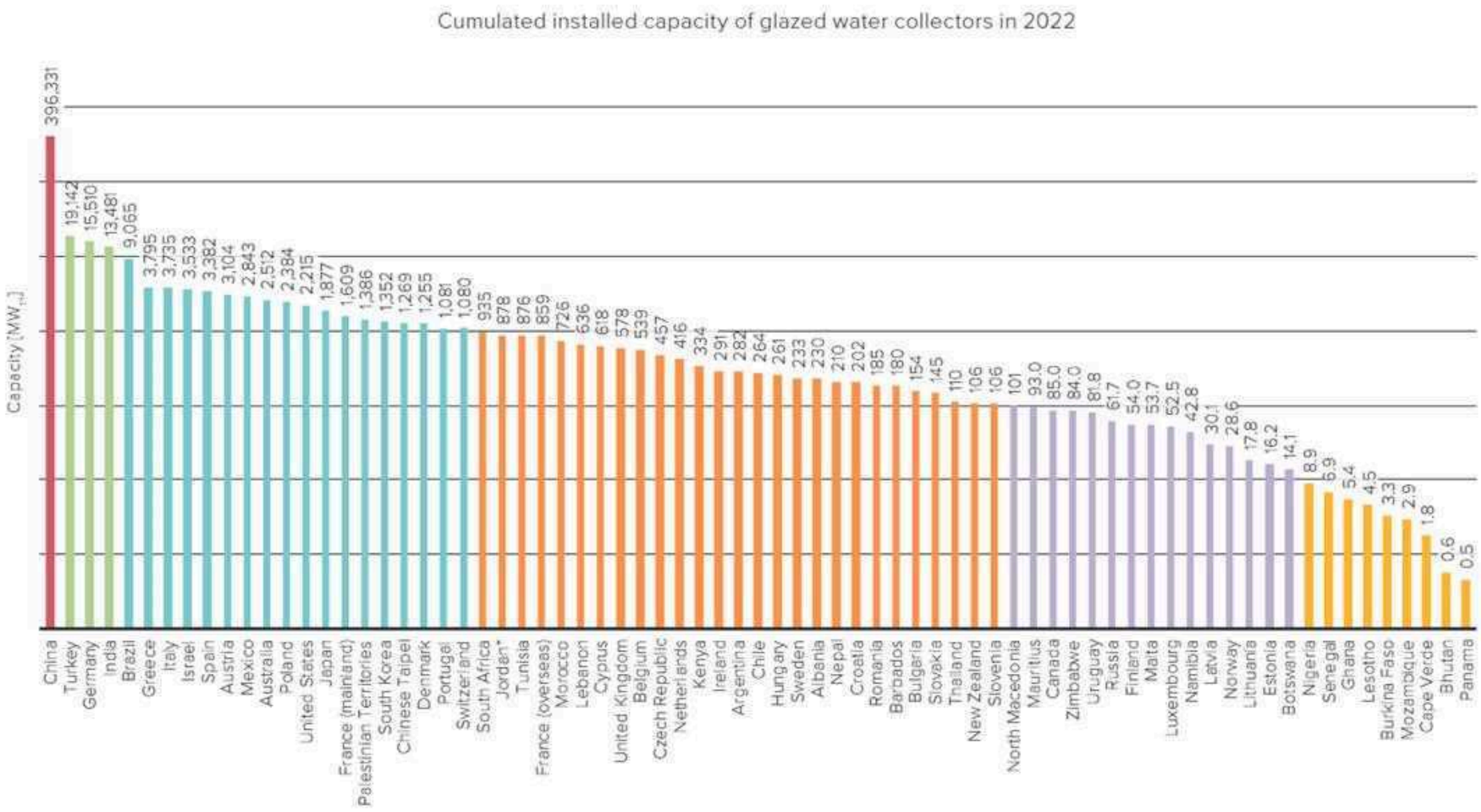

Figure 25: Total capacity of glazed water collectors in operation by the end of 2022

In terms of the total installed capacity of glazed water collectors in operation per 1,000 inhabitants, five countries continued their dominance: Barbados, Cyprus, Israel, Austria, and Greece. China ranks sixth in terms of market penetration. Nevertheless, it is remarkable that China, with its 1.41 billion inhabitants, exceeds the solar thermal per capita levels of the large European markets in Germany, Turkey, Denmark, and Spain (Figure 26)

Figure 26: Total Capacity of glazed water collectors in operation in kW_{th} per 1,000 inhabitants in 2022

6.2 运行中的釉面集热器总容量

2022 年，中国的琉璃集热器总装机容量达到 396.3 千兆瓦，继续保持其领先地位。土耳其、德国和印度紧随其后，装机容量从 19 千兆瓦到 9 千兆瓦不等（图 25）。

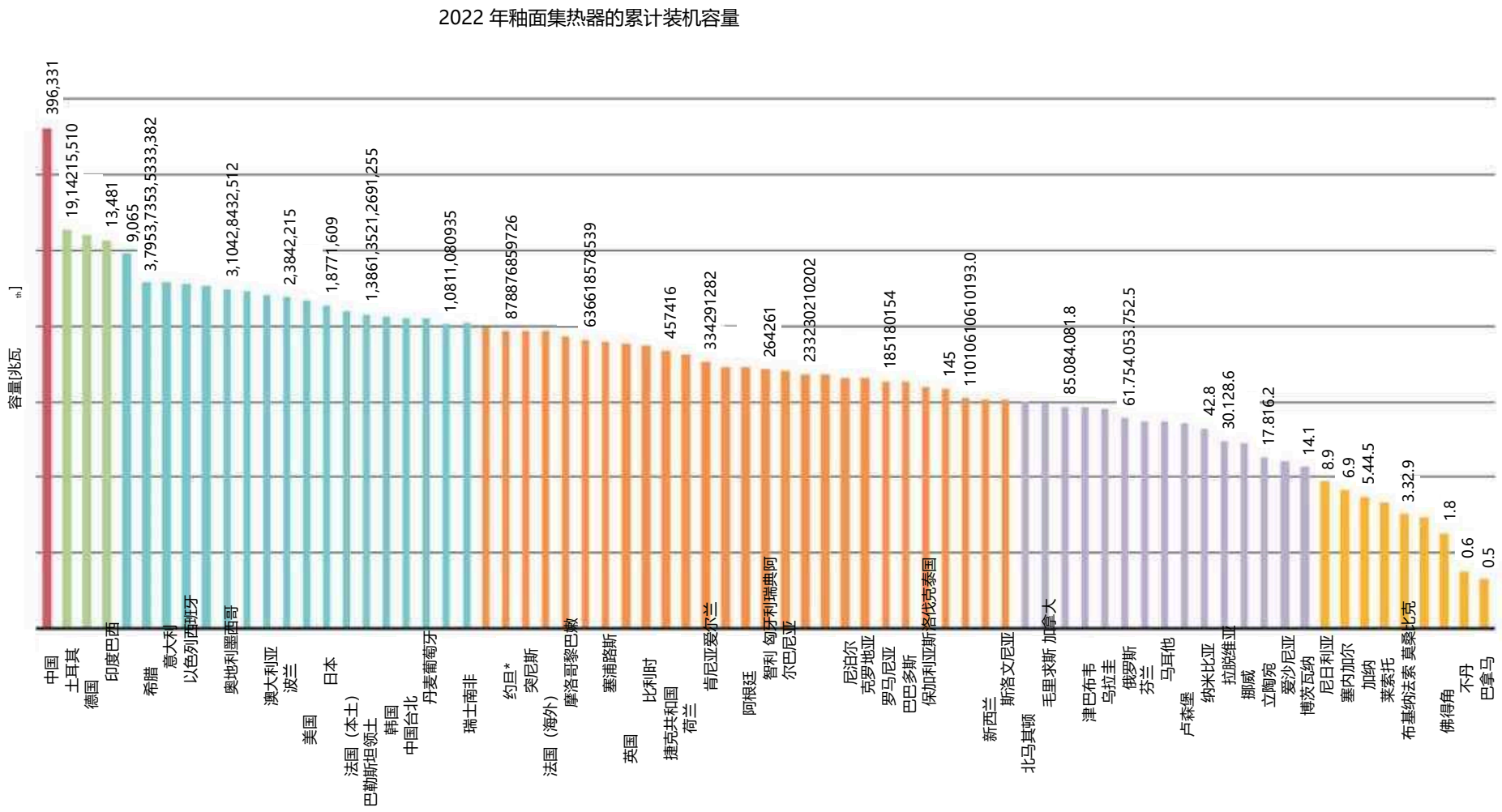

图 25：到 2022 年底投入使用的釉面集热器总容量

就每千名居民使用的釉面集热器的总装机容量而言，五个国家继续占据主导地位：巴巴多斯、塞浦路斯、以色列、奥地利和希腊。中国的市场渗透率排名第六。然而

值得注意的是，拥有 14.1 亿人口的中国的人均太阳能热利用水平超过了德国、土耳其、丹麦和西班牙等欧洲大型市场（图 26）。

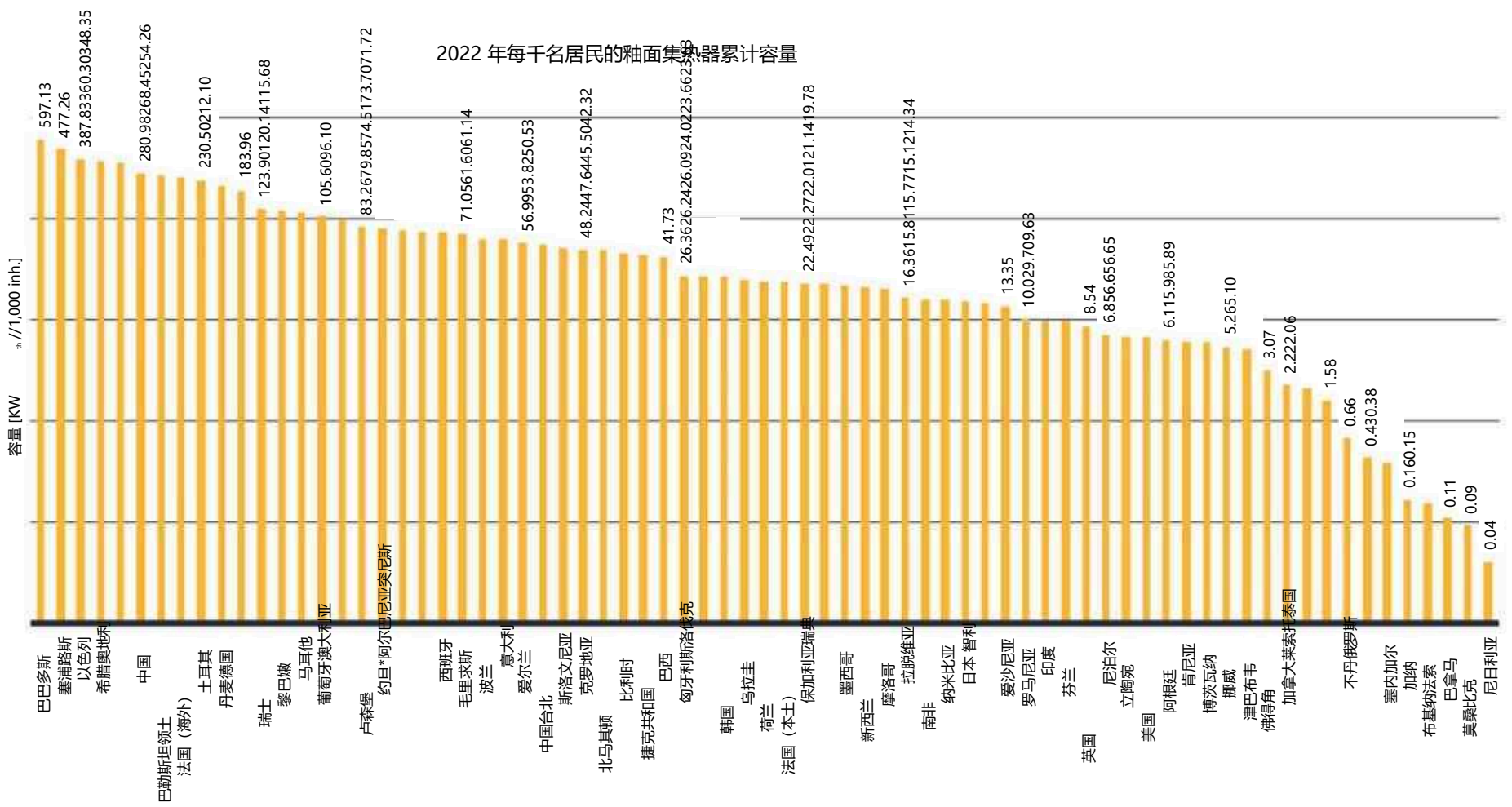

图 26：2022 年运行中的玻璃集热器总容量（千瓦/每千名居民

The following figures show the solar thermal market penetration per capita worldwide and in Europe.

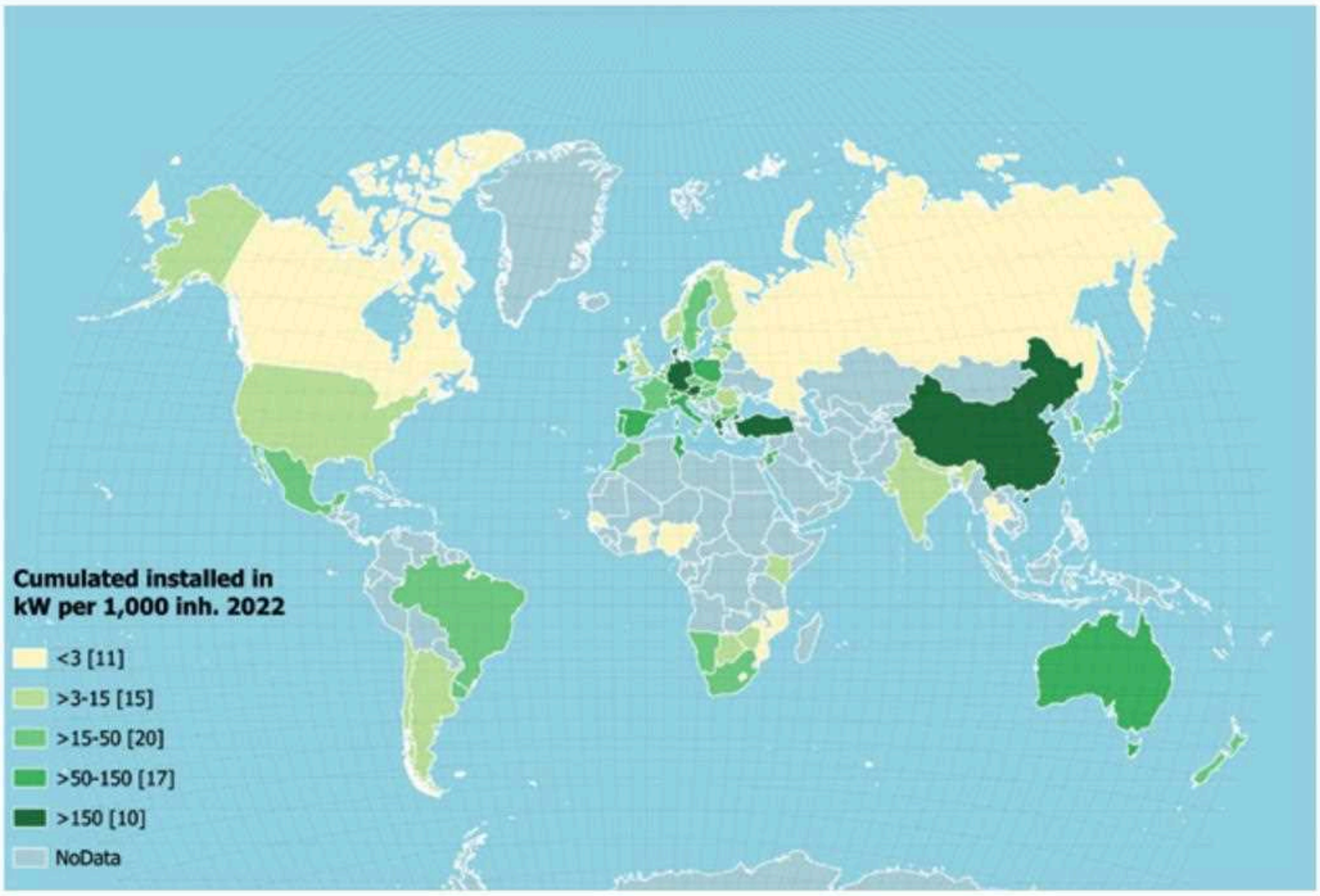

Figure 27: Solar thermal market penetration per capita in kW_{th} per 1,000 inhabitants – WORLD

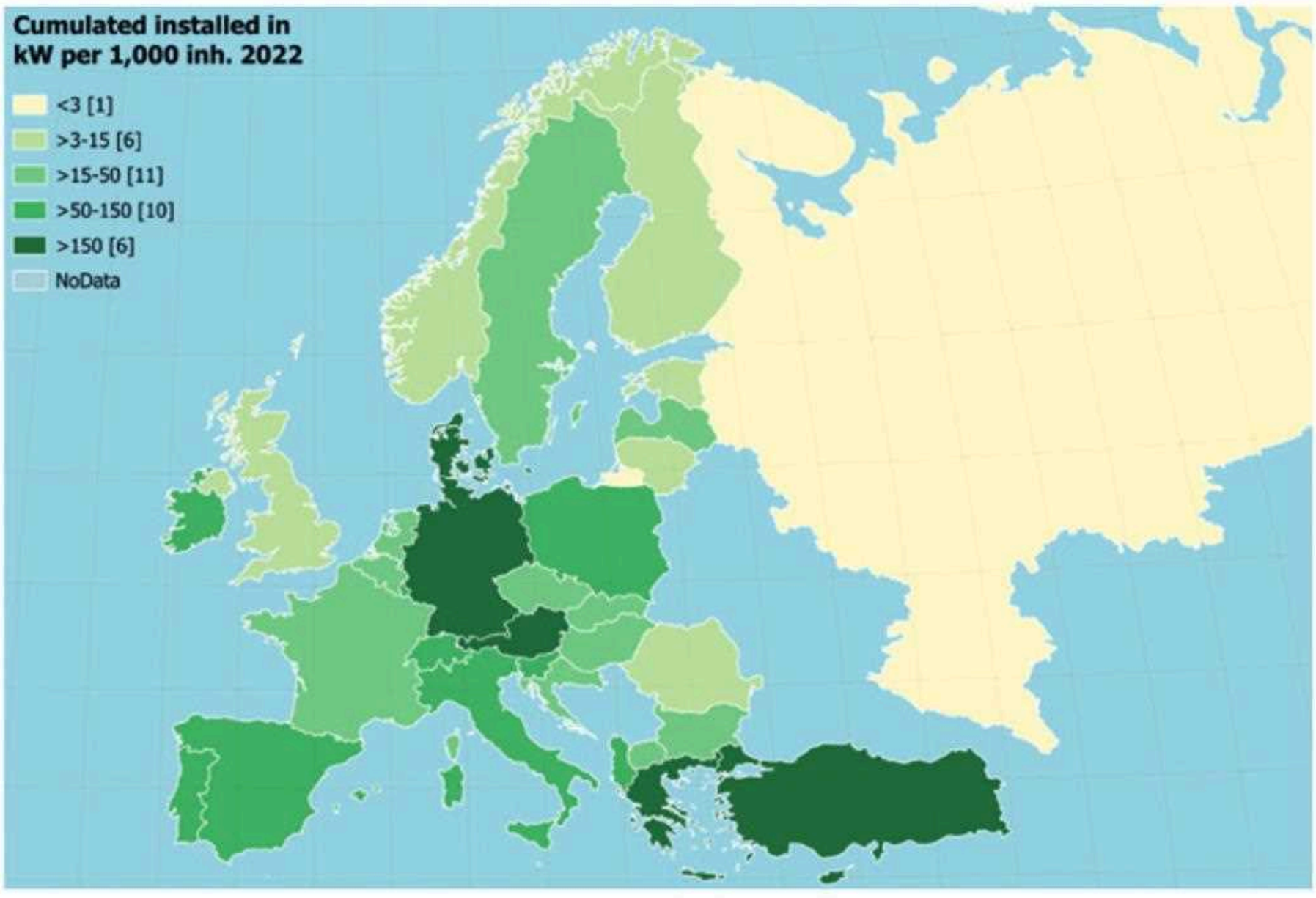

Figure 28: Solar thermal market penetration per capita in kW_{th} per 1,000 inhabitants – EUROPE

下图显示了全球和欧洲太阳能热利用的人均市场渗透率。

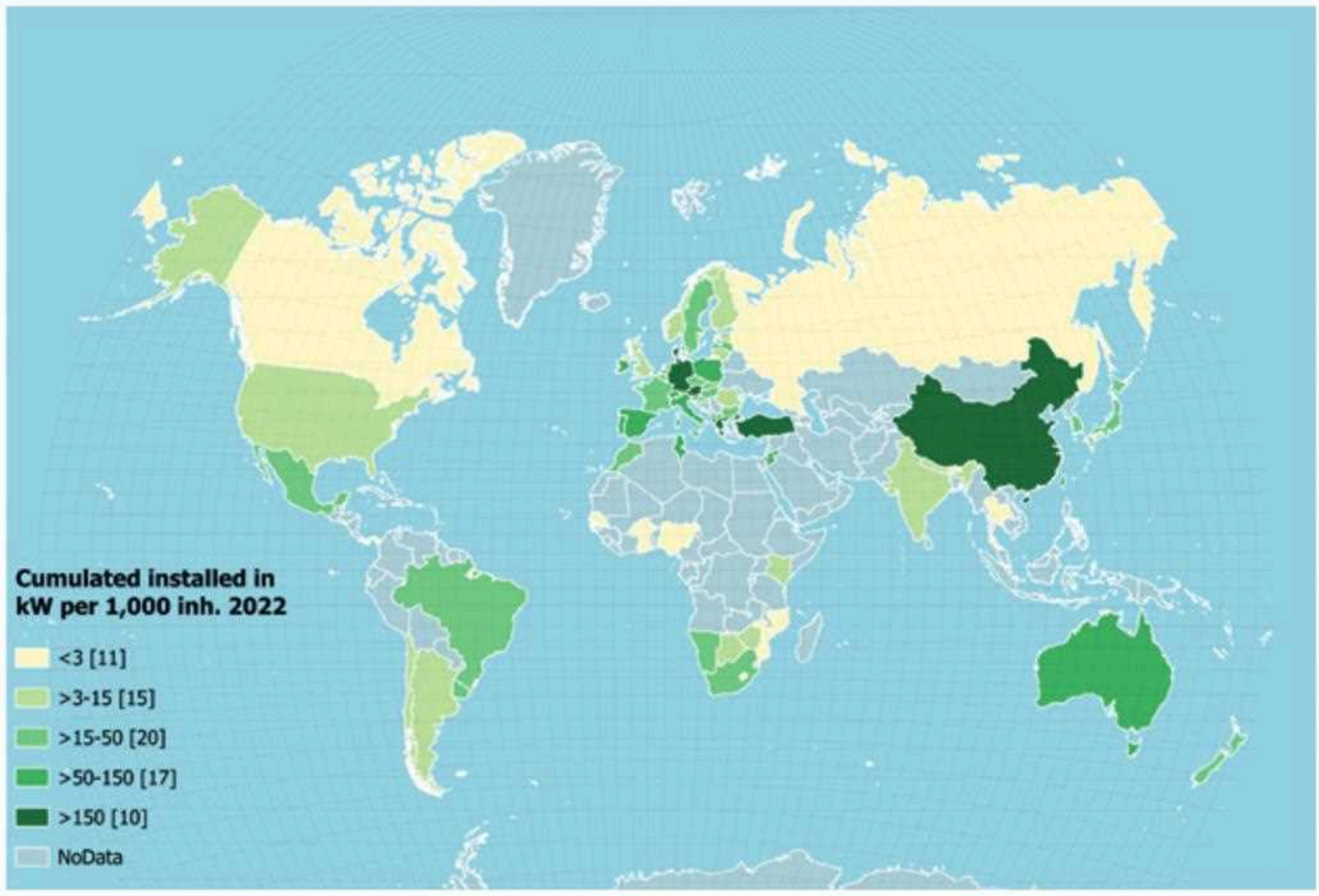

图 27：人均太阳能热利用市场渗透率（千瓦/千人）--世界

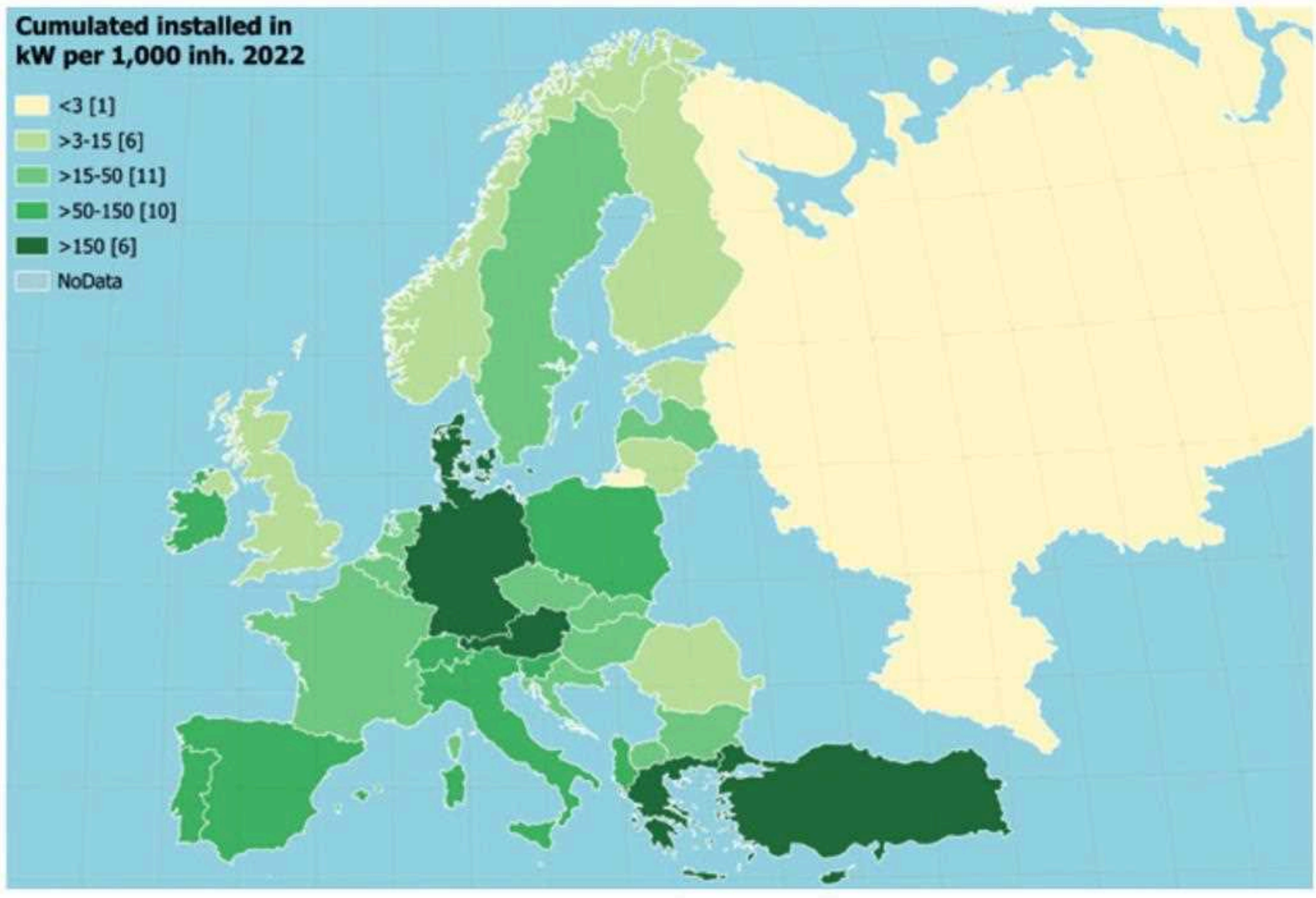

图 28：人均太阳能热利用市场渗透率（千瓦/千人）--欧洲

6.3
Total capacity of glazed water collectors in operation by economic region

When considering market penetration per capita by economic region, China remains at the forefront. Notably, the MENA countries and Australia surpass Europe in this regard, highlighting the significant imbalance in market distribution across Europe (Figure 29). Whereas some European countries like Cyprus, Austria and Greece belong to the world market leaders in terms of high market penetration, others like the Baltic countries have negligible solar thermal market penetration.

Heat storages for the Heineken brewery in Seville, Spain
Photo: Engie, Spain

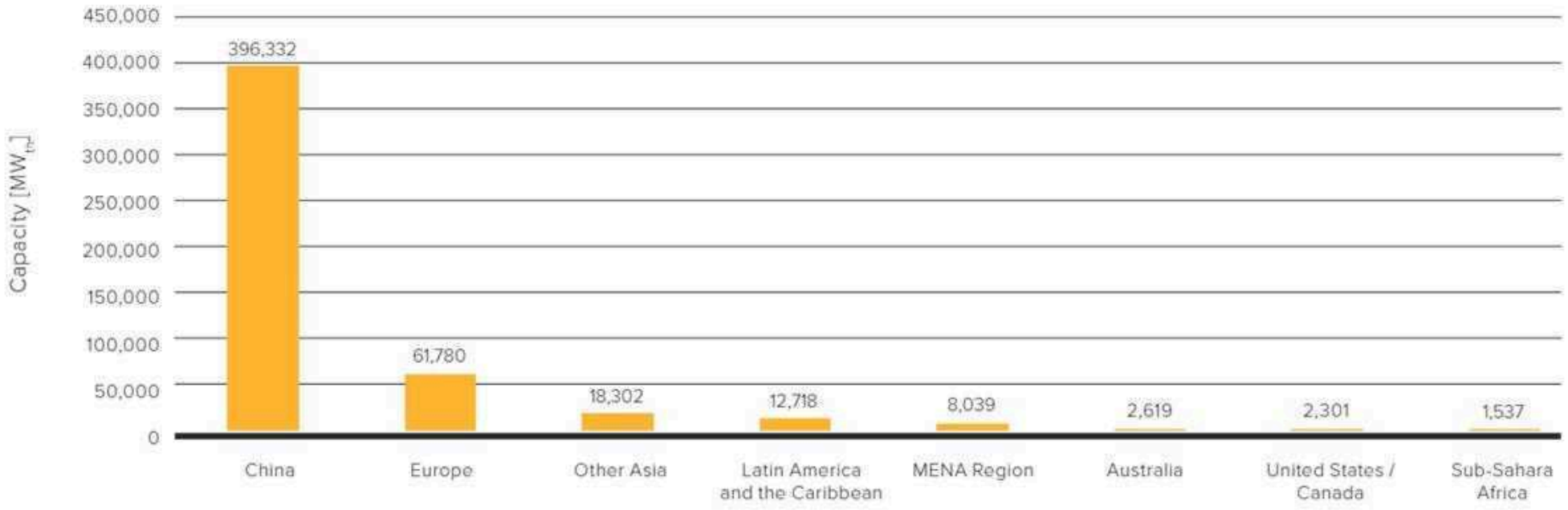

Figure 29: Total capacity of glazed flat plate and evacuated tube collectors in operation by economic region in 2022

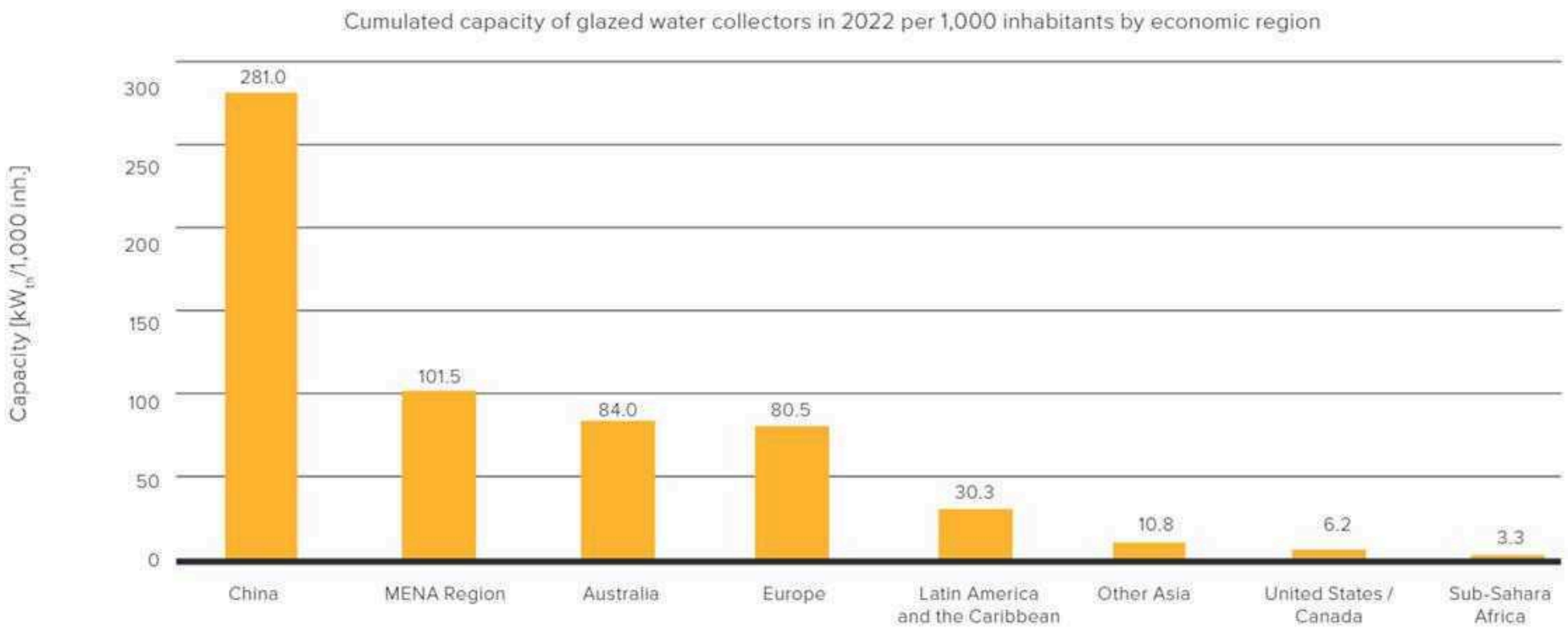

Figure 30: Total capacity of glazed flat plate and evacuated tube collectors in operation by economic region and in kW$_{th}$ per 1,000 inhabitants in 2022

Sub-Sahara Africa: Botswana, Burkina Faso, Cape Verde, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Other Asia: Bhutan, India, Japan, Nepal, South Korea, Chinese Taipei, Thailand
Latin America and the Caribbean: Argentina, Barbados, Brazil, Chile, Mexico, Panama, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

6.3 按经济区域划分的运行中的釉面集热器总容量

按经济区域划分的人均市场渗透率方面，中国仍处于领先地位。值得注意的是，中东和北非国家以及澳大利亚在这方面超过了欧洲，凸显了欧洲市场分布的严重失衡（图 29）。塞浦路斯、奥地利和希腊等一些欧洲国家的市场渗透率较高，属于世界市场领导者，而波罗的海国家等其他国家的太阳能热利用市场渗透率则微不足道。

西班牙塞维利亚喜力啤酒厂的蓄热器
照片西班牙 Engie 公司

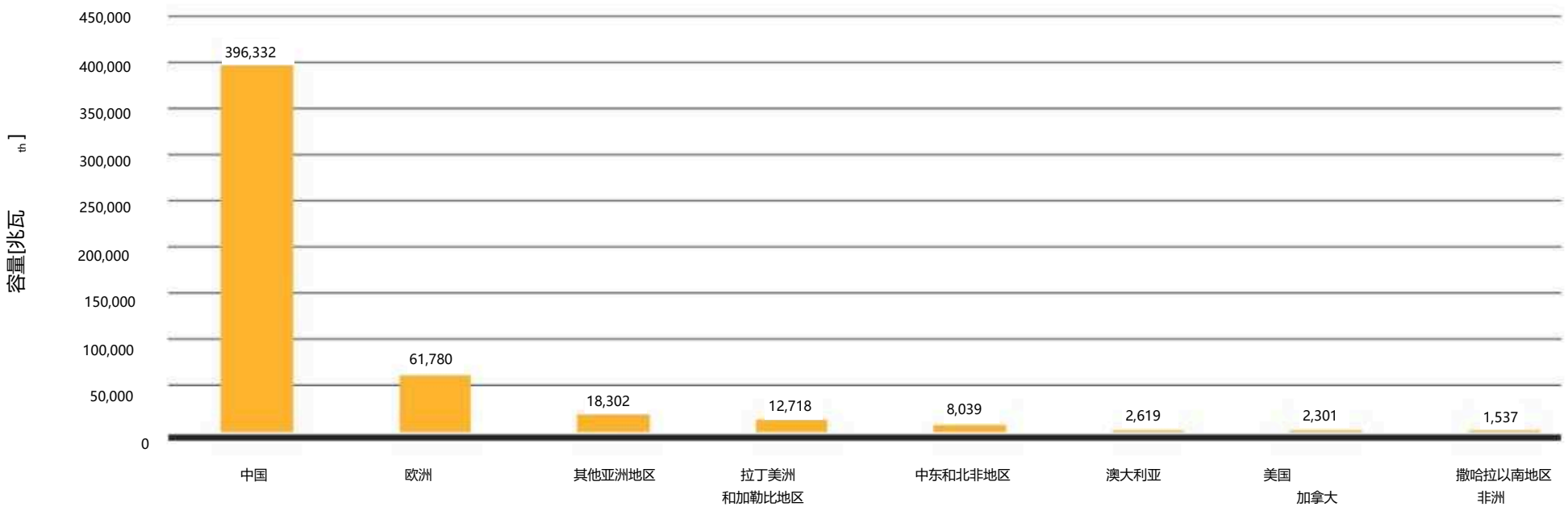

图 29：2022 年按经济区域分列的运行中的玻璃平板和真空管集热器总容量

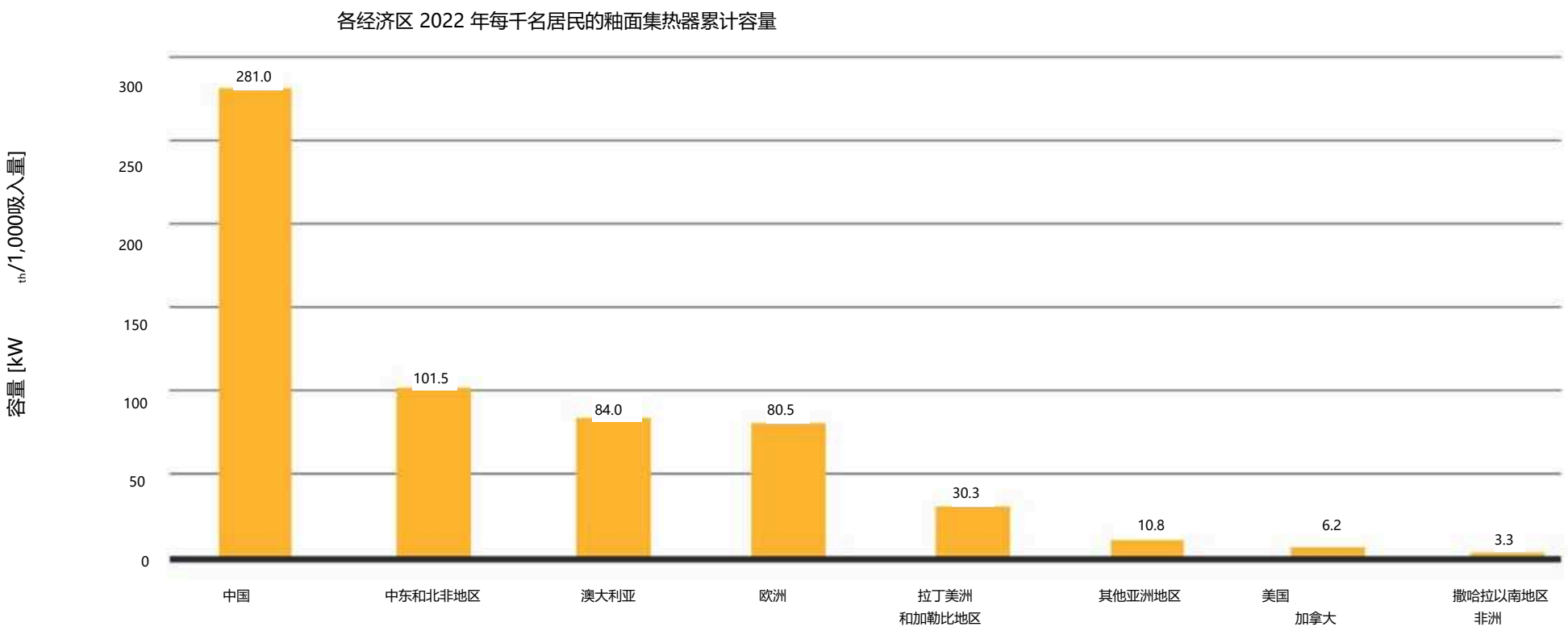

图 30：2022 年按经济区域和每千名居民千瓦计算的运行中的玻璃平板和真空管集热器总容量

撒哈拉以南非洲博茨瓦纳、布基纳法索、佛得角、加纳、肯尼亚、莱索托、毛里求斯、莫桑比 克、纳米比亚、尼日利亚、塞内加尔、南非、津巴布韦 其他亚洲国家：不丹、印度、日本、尼泊尔、韩国、中国台北、泰国 拉丁美洲及加勒比地区：阿根廷、巴巴多斯、巴西、智利、墨西哥、巴拿马、乌拉圭 欧洲：欧盟 27 国、阿尔巴尼亚、北马其顿、挪威、俄罗斯、瑞士、土耳其、英国

中东和北非国家：以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土、突尼斯

6.4
Total capacity of unglazed water collectors in operation

Unglazed water collectors are mainly used for swimming pool heating. This type of collector has lost a significant market share over the past decade. The percentage of unglazed water collectors in the total installed collector capacity was reduced from 21% in 2005[49] to just 6% in 2022. Figure 31 and Figure 32 show the total installed capacity of unglazed water collectors and the total installed capacity per 1,000 inhabitants at the end of 2022.

[49] Solar Heat Worldwide (Ed.2008), Figure 3

Flat plate collector system in Mexico
Photo: Mexichem / Solar Payback

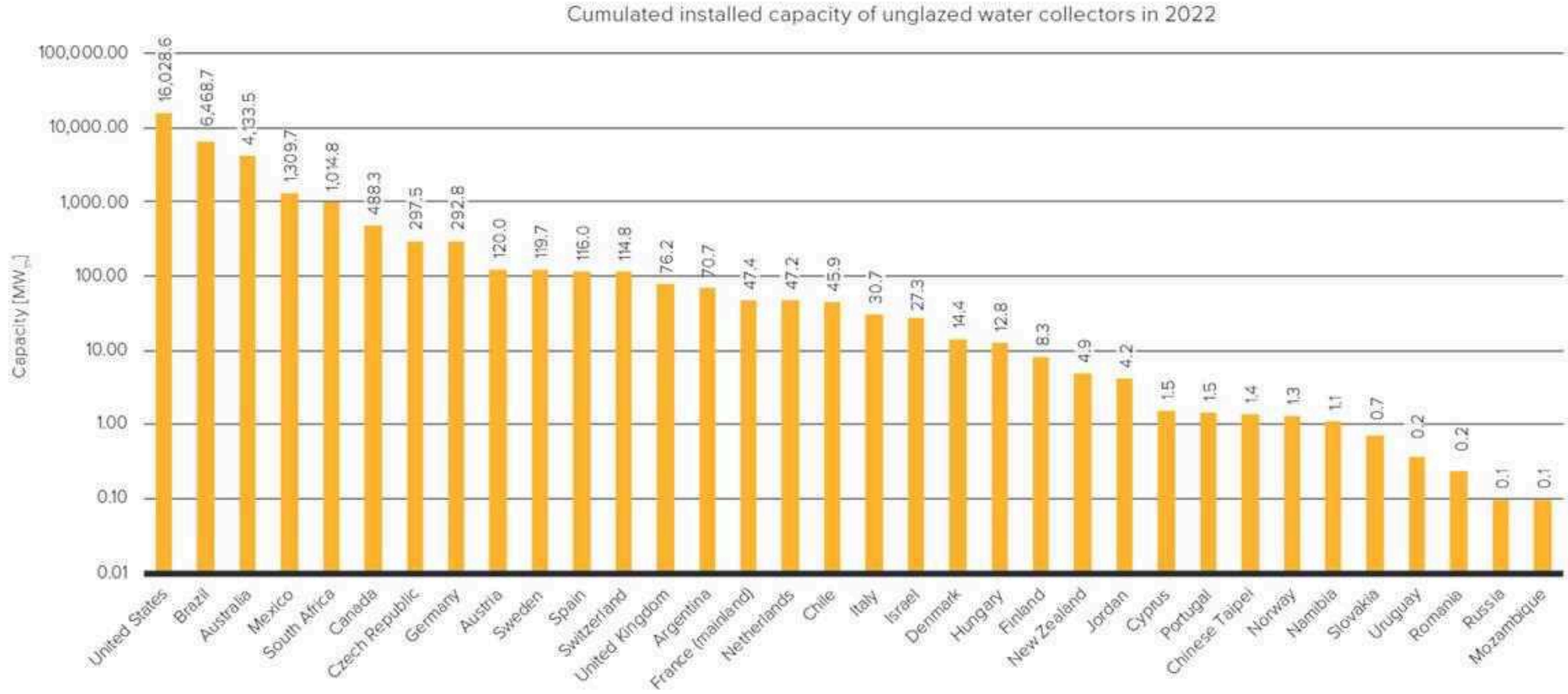

Figure 31: Total capacity of unglazed water collectors in operation in 2022

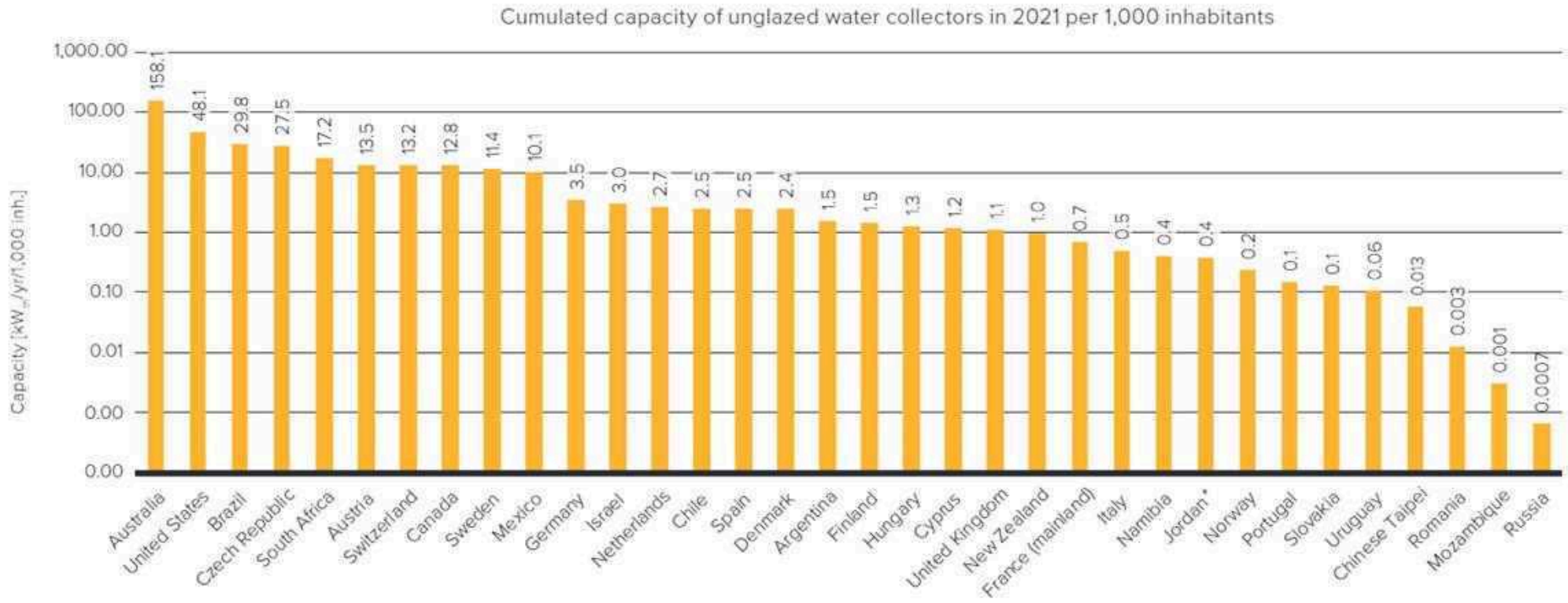

Figure 32: Total capacity of unglazed water collectors in operation in kW_{th} per 1,000 inhabitants in 2021

6.4 运行中的无釉集热器总容量

无釉集热器主要用于游泳池加热。在过去十年中，这种集热器的市场份额大幅下降。无釉水收集器在收集器总装机容量中所占比例从 2005 年的 21% 降至 2022 年的 6%。图 31 和图 32 显示了 2022 年底无釉水收集器的总装机容量和每千名居民的总装机容量。

墨西哥的平板集电系统
照片Mexichem / Solar Payback

[49] 《全球太阳能供热》（2008 年版），图 3

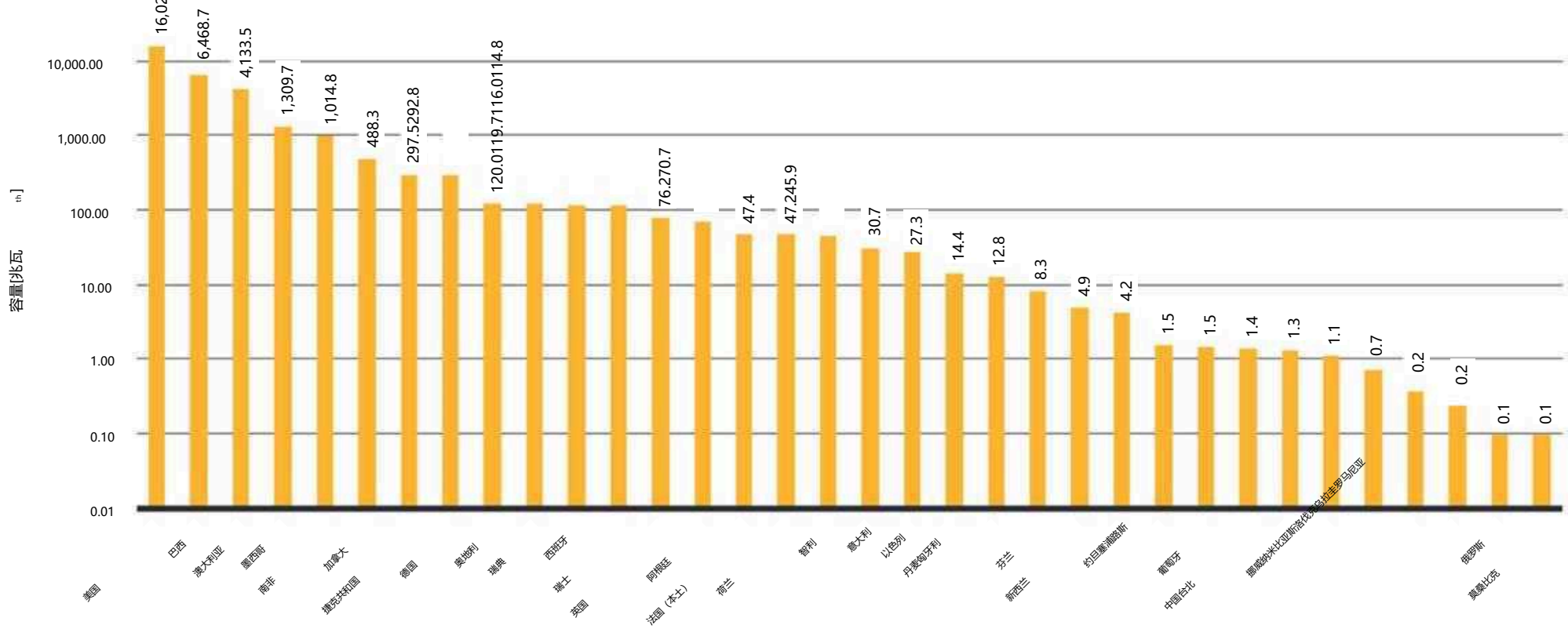

图 31：2022 年投入使用的无釉集热器总容量

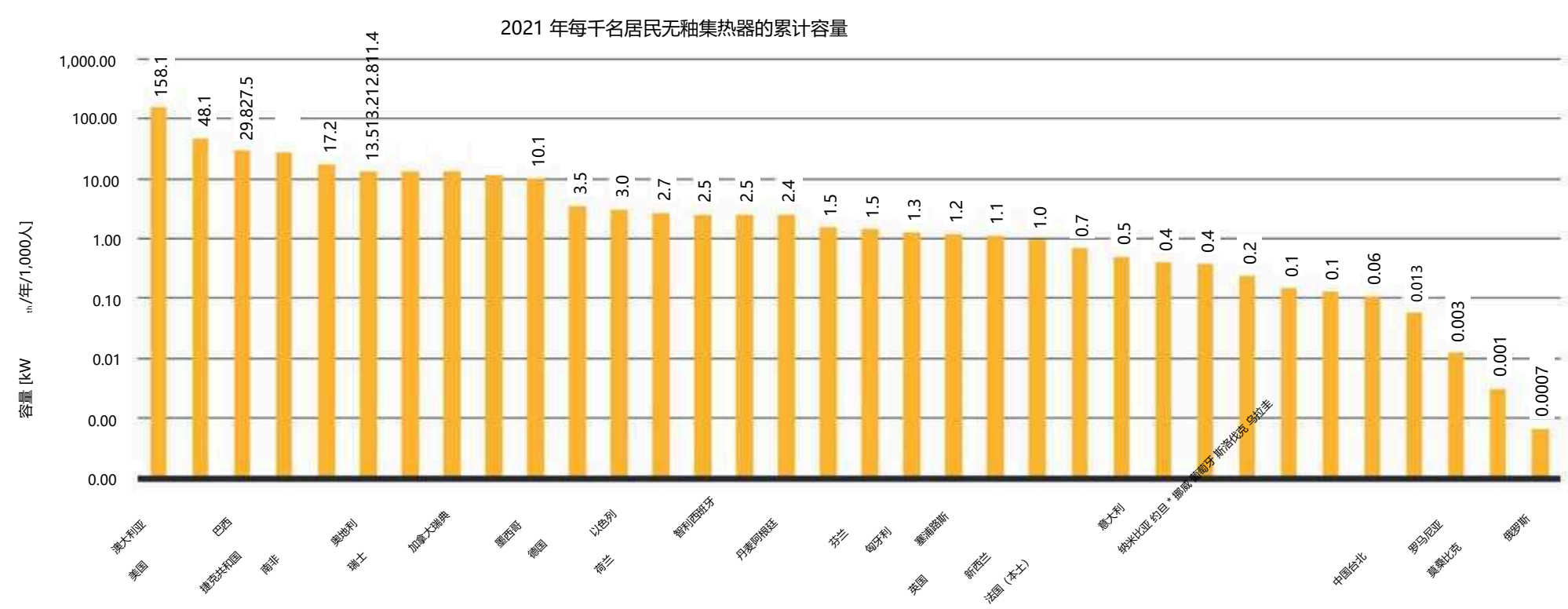

图 32：2021 年运行中的无釉集热器总容量（单位：千瓦/每千名居民

6.5
Newly installed capacity in 2022 and market development

In 2022, a total capacity of 22.7 GW_{th}, corresponding to 32.5 million m^2 of new solar collectors, was installed worldwide.

The main markets were China (15.0 GW_{th}) and Europe (3.0 GW_{th}), accounting for 79% of all 2022 collector installations. The rest of the market was shared between Latin America and the Caribbean (1.6 GW_{th}), Other Asia (1.2 GW_{th}), the United States and Canada (0.6 GW_{th}), MENA countries (0.5 GW_{th}), Australia (0.3 GW_{th}), and Sub-Sahara African countries (0.1 GW_{th}). The market volume of "all other countries" is estimated to be 0.4 GW_{th} (550,867 m^2).

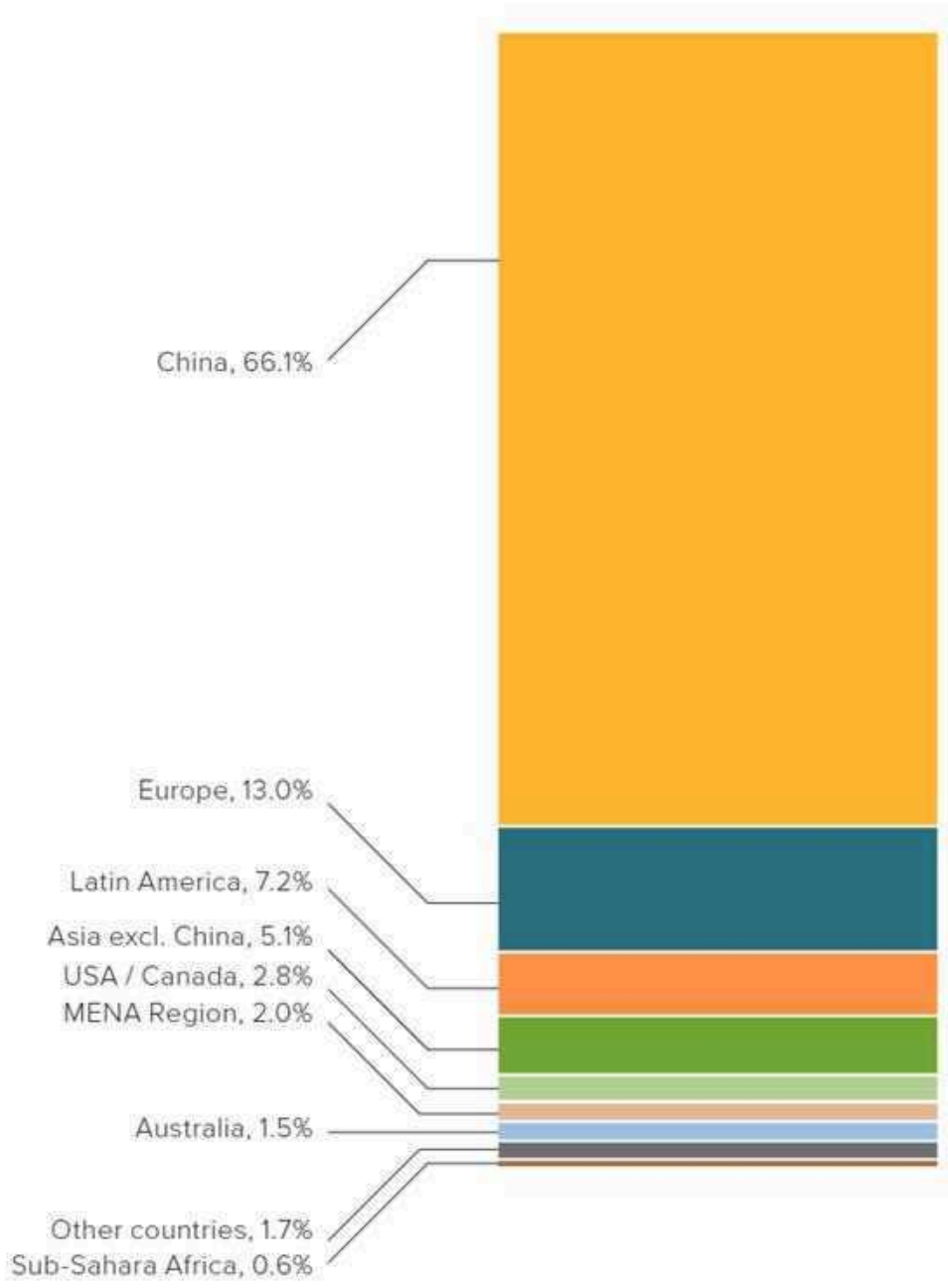

Figure 33: Share of newly installed capacity (glazed and unglazed water and air collectors) by economic regions in 2022

Sub-Sahara Africa: Botswana, Burkina Faso, Cape Verde, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Other Asia: Bhutan, India, Japan, South Korea, Chinese Taipei, Thailand
Latin America: Argentina, Barbados, Brazil, Chile, Mexico, Panama, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

Thermosiphon systems at the CPS Sisters youth hostel in Harare, Zimbabwe
Photo: Werner Weiss, AEE INTEC

6.5 2022 年新增装机容量与市场发展

2022 年，全球安装的太阳能集热器总容量为 22.7 千兆瓦，相当于 3250 万平方米。

主要市场是中国（15.0 千兆瓦）和欧洲（3.0 千兆瓦），占 2022 年集热器安装总量的 79%。其余市场由拉丁美洲和加勒比地区（1.6 千兆瓦）、其他亚洲国家（1.2 千兆瓦）、美国和加拿大（0.6 千兆瓦）、中东和北非国家（0.5 千兆瓦）、澳大利亚（0.3 千兆瓦）和撒哈拉以南非洲国家（0.1 千兆瓦）分享。所有其他国家 "的市场容量估计为 0.4 千兆瓦（550 867 平方米）。

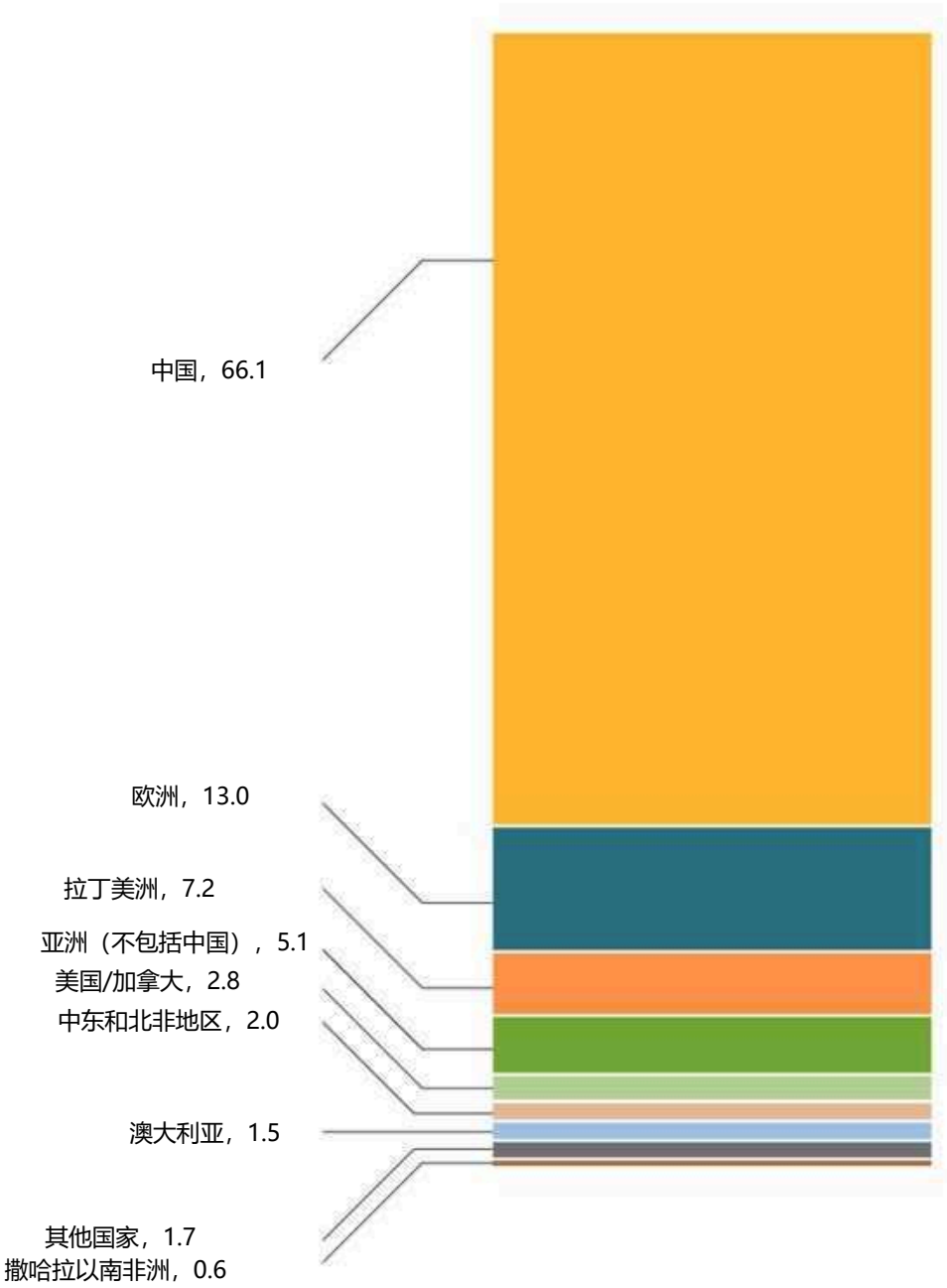

图 33：2022 年各经济区新增装机容量（有釉和无釉水和空气集热器）所占比例

撒哈拉以南非洲博茨瓦纳、布基纳法索、佛得角、加纳、肯尼亚、莱索托、毛里求斯、莫桑比克、纳米比亚、尼日利亚、塞内加尔、南非、津巴布韦

其他亚洲国家不丹、印度、日本、韩国、中国台北、泰国 拉丁美洲：阿根廷、巴巴多斯、巴西、智利、墨西哥、巴拿马、乌拉圭 欧洲：欧盟 27 国、阿尔巴尼亚、北马其顿、挪威、俄罗斯、瑞士、土耳其、英国 中东和北非国家：以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土、突尼斯

津巴布韦哈拉雷 CPS 姐妹青年旅舍的热虹吸系统
照片维尔纳-魏斯，AEE INTEC

Table 11: Newly installed capacity in 2022 [MW_{th}/a]

Country/Region/Economy	Water Collectors [m^2]			Air Collectors [m^2]		TOTAL [m^2]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		12.4	1			14
Argentina	4.7	24.5	49	0.01	0.1	78
Australia	245.0	86.5	10		1	342
Austria	1.0	39.8	0.5		0.1	41
Belgium		11.2	2			14
Bhutan		0.6				0.6
Botswana*		0.8	0.1			1
Brazil	644.3	574.9	27			1,246
Bulgaria		17.0				17
Canada	1.5	0.003	0.6	14	3	19
Chile		9.1				9
China		4,029.9	10,976	15	16	15,037
Croatia		8.4				8
Cyprus		51.7				52
Czech Republic		16.2	1.6			18
Denmark		1.9				2
Estonia		1.0				1
Finland		5.6				6
France (mainland)		45.0	2.0	0.1		47
France (overseas territories)		75.2				75
Germany		366.8	129.5			496
Ghana*		0.5	0.3			1
Greece		293.0	0.3			293
Hungary		9.8				10
India		52.9	1,009.0		0.01	1,062
Ireland		0.8				1
Israel*		245.0				245
Italy		157.3	13.9			171
Japan		41.9	0.2		1	43
Kenya*		5.9	2.9			9
Latvia		1.1				1
Lebanon		16.8	69.6			86
Lesotho			0.0			0
Lithuania		0.5	0.7			1
Luxembourg		2.5	0.0			3
Malta		1.2	0.0			1
Mexico	78.8	90.9	124.1		0.2	294
Morocco		50.2				50
Mozambique			0.8			1
Namibia		2.9	0.001			3
Nepal		4.9	43.7			49
Netherlands	1.8	18.2	9.4			29
North Macedonia		4.1	3.4		0.01	7
Norway		1.1	0.1			1
Palestinian Territories		36.0	0.0			36
Panama*		0.5				0
Poland		146.0	1.1			147
Portugal		44.9	1.4			46
Romania	0.0	11.2				11
Russia	0.0	0.5	0.2			1
Slovakia	0.0	11.9				12
Slovenia		0.6	0.05	0.004		1
South Africa	28.8	22.0	56.2			107
South Korea				0.5		0
Spain	1.4	95.6	4.9	3		105
Sweden		3.5				4
Switzerland	2.2	15.2	2.1			20
Tunisia		36.6	0.0			37
Turkey		653.8	638.4	2		1,294
United Kingdom	3.4	1.2	1.7	0.1		7
United States	587.4	29.3		3		619
Uruguay	0.4	2.1	4.6			7
Zimbabwe			23.0			23
Other (5% of the world market excluding China)	84.3	182.2	117.8	1.2	0.2	386
TOTAL	1,685.1	7,673	13,329	38	21	22,746

Note: If no data is given, no reliable database is available for this collector type.
* 0% growth assumed
+ only air collectors reported (provided by John Hollick)

表 11：2022 年新增装机容量 [兆瓦/a]

国家/地区/经济	集水池 [平方米]			空气收集器 [平方米]		总计 [m²]
	无釉	FPC	ETC	无釉	黄釉	
阿尔巴尼亚		12.4	1			14
阿根廷	4.7	24.5	49	0.01	0.1	78
澳大利亚	245.0	86.5	10		1	342
奥地利	1.0	39.8	0.5		0.1	41
比利时		11.2	2			14
不丹		0.6				0.6
博茨瓦纳*		0.8	0.1			1
巴西	644.3	574.9	27			1,246
保加利亚		17.0				17
加拿大	1.5	0.003	0.6	14	3	19
智利		9.1				9
中国		4,029.9	10,976	15	16	15,037
克罗地亚		8.4				8
塞浦路斯		51.7				52
捷克共和国		16.2	1.6			18
丹麦		1.9				2
爱沙尼亚		1.0				1
芬兰		5.6				6
法国（本土）		45.0	2.0	0.1		47
法国（海外领地）		75.2				75
德国		366.8	129.5			496
加纳*		0.5	0.3			1
希腊		293.0	0.3			293
匈牙利		9.8				10
印度		52.9	1,009.0		0.01	1,062
爱尔兰		0.8				1
以色列*		245.0				245
意大利		157.3	13.9			171
日本		41.9	0.2		1	43
肯尼亚		5.9	2.9			9
拉脱维亚		1.1				1
黎巴嫩		16.8	69.6			86
莱索托			0.0			0
立陶宛		0.5	0.7			1
卢森堡		2.5	0.0			3
马耳他		1.2	0.0			1
墨西哥	78.8	90.9	124.1		0.2	294
摩洛哥		50.2				50
莫桑比克			0.8			1
纳米比亚		2.9	0.001			3
尼泊尔		4.9	43.7			49
荷兰	1.8	18.2	9.4			29
北马其顿		4.1	3.4		0.01	7
挪威		1.1	0.1			1
巴勒斯坦领土		36.0	0.0			36
巴拿马*		0.5				0
波兰		146.0	1.1			147
葡萄牙		44.9	1.4			46
罗马尼亚	0.0	11.2				11
俄罗斯	0.0	0.5	0.2			1
斯洛伐克	0.0	11.9				12
斯洛文尼亚		0.6	0.05	0.004		1
南非	28.8	22.0	56.2			107
韩国				0.5		0
西班牙	1.4	95.6	4.9	3		105
瑞典		3.5				4
瑞士	2.2	15.2	2.1			20
突尼斯		36.6	0.0			37
土耳其		653.8	638.4	2		1,294
英国	3.4	1.2	1.7	0.1		7
美国	587.4	29.3		3		619
乌拉圭	0.4	2.1	4.6			7
津巴布韦			23.0			23
其他（占世界市场的 5%，不包括中国）	84.3	182.2	117.8	1.2	0.2	386
总计	1,685.1	7,673	13,329	38	21	22,746

注：如果没有提供数据，则表示没有关于该类型集热器的可靠数据库。* 假设增长率为 0% +
仅报告了空气集热器（由 John Hollick 提供）

Table 12: Newly installed collector area in 2022 [m²/a]

Country/Region/Economy	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		17,680	1,640			19,320
Argentina	6,769	35,000	69,373	20	158	111,320
Australia	350,000	123,533	13,728		1,000	488,261
Austria	1,480	56,830	660		190	59,160
Belgium		16,000	3,500			19,500
Bhutan		824				824
Botswana*		1,190	210			1,400
Brazil	920,463	821,248	38,124			1,779,835
Bulgaria		24,296				24,296
Canada	2,100	4	902	19,991	4,325	27,322
Chile		13,071				13,071
China		5,757,000	15,680,491	20,819	23,000	21,481,310
Croatia		12,000				12,000
Cyprus		73,924				73,924
Czech Republic		23,167	2,336			25,503
Denmark		2,664				2,664
Estonia		1,425				1,425
Finland		8,000				8,000
France (mainland)		64,355	2,795	200		67,350
France (overseas territories)		107,410				107,410
Germany		524,000	185,000			709,000
Ghana*		700	450			1,150
Greece		418,600	400			419,000
Hungary		14,000				14,000
India		75,572	1,441,467		15	1,517,054
Ireland		1,116				1,116
Israel*		350,000				350,000
Italy		224,695	19,923			244,618
Japan		59,898	354		753	61,005
Kenya*		8,364	4,182			12,546
Latvia		1,600				1,600
Lebanon		23,952	99,378			123,330
Lesotho			55			55
Lithuania		700	1,000			1,700
Luxembourg		3,574	0			3,574
Malta		1,772	8			1,780
Mexico	112,640	129,905	177,265		288	420,098
Morocco		71,700				71,700
Mozambique			1,180			1,180
Namibia		4,094	2			4,096
Nepal		6,940	62,462			69,402
Netherlands	2,620	26,050	13,420			
North Macedonia		5,868	4,800		20	10,688
Norway		1,512	82			1,594
Palestinian Territories		51,378	0			51,378
Panama*		665				665
Poland		208,500	1,500			210,000
Portugal		64,117	1,983			66,100
Romania	0	15,960				15,960
Russia	0	682	239			921
Slovakia	0	17,000				17,000
Slovenia		800	70	5		875
South Africa	41,168	31,415	80,269			152,852
South Korea				700		700
Spain	2,000	136,500	7,000	4,800		150,300
Sweden		5,000				5,000
Switzerland	3,210	21,770	2,970			27,950
Tunisia		52,340	0			52,340
Turkey		934,000	912,000	2,245		1,848,245
United Kingdom	4,891	1,773	2,432	200		9,295
United States	839,122	41,834		4,000		884,956
Uruguay	509	3,053	6,614			10,176
Zimbabwe			32,898			32,898
Other (5% of the world market excluding China)	120,367	260,232	168,220	1,693	355	550,867
TOTAL	2,407,339	10,961,252	19,041,382	54,673	30,104	32,494,750

Note: If no data is given, no reliable database is available for this collector type.
* 0% growth assumed
\+ only air collectors reported (provided by John Hollick)

表 12：2022 年新安装的集热器面积[平方米/平方米]

国家/地区/经济	集水池 [平方米]			空气收集器 [平方米]		总计 [m²]
	无釉	FPC	ETC	无釉	黄釉	
阿尔巴尼亚		17,680	1,640			19,320
阿根廷	6,769	35,000	69,373	20	158	111,320
澳大利亚	350,000	123,533	13,728		1,000	488,261
奥地利	1,480	56,830	660		190	59,160
比利时		16,000	3,500			19,500
不丹		824				824
博茨瓦纳*		1,190	210			1,400
巴西	920,463	821,248	38,124			1,779,835
保加利亚		24,296				24,296
加拿大	2,100	4	902	19,991	4,325	27,322
智利		13,071				13,071
中国		5,757,000	15,680,491	20,819	23,000	21,481,310
克罗地亚		12,000				12,000
塞浦路斯		73,924				73,924
捷克共和国		23,167	2,336			25,503
丹麦		2,664				2,664
爱沙尼亚		1,425				1,425
芬兰		8,000				8,000
法国（本土）		64,355	2,795	200		67,350
法国（海外领地）		107,410				107,410
德国		524,000	185,000			709,000
加纳*		700	450			1,150
希腊		418,600	400			419,000
匈牙利		14,000				14,000
印度		75,572	1,441,467		15	1,517,054
爱尔兰		1,116				1,116
以色列*		350,000				350,000
意大利		224,695	19,923			244,618
日本		59,898	354		753	61,005
肯尼亚		8,364	4,182			12,546
拉脱维亚		1,600				1,600
黎巴嫩		23,952	99,378			123,330
莱索托			55			55
立陶宛		700	1,000			1,700
卢森堡		3,574	0			3,574
马耳他		1,772	8			1,780
墨西哥	112,640	129,905	177,265		288	420,098
摩洛哥		71,700				71,700
莫桑比克			1,180			1,180
纳米比亚		4,094	2			4,096
尼泊尔		6,940	62,462			69,402
荷兰	2,620	26,050	13,420			
北马其顿		5,868	4,800		20	10,688
挪威		1,512	82			1,594
巴勒斯坦领土		51,378	0			51,378
巴拿马*		665				665
波兰		208,500	1,500			210,000
葡萄牙		64,117	1,983			66,100
罗马尼亚	0	15,960				15,960
俄罗斯	0	682	239			921
斯洛伐克	0	17,000				17,000
斯洛文尼亚		800	70	5		875
南非	41,168	31,415	80,269			152,852
韩国				700		700
西班牙	2,000	136,500	7,000	4,800		150,300
瑞典		5,000				5,000
瑞士	3,210	21,770	2,970			27,950
突尼斯		52,340	0			52,340
土耳其		934,000	912,000	2,245		1,848,245
英国	4,891	1,773	2,432	200		9,295
美国	839,122	41,834		4,000		884,956
乌拉圭	509	3,053	6,614			10,176
津巴布韦			32,898			32,898
其他（占世界市场的 5%，不包括中国）	120,367	260,232	168,220	1,693	355	550,867
总计	2,407,339	10,961,252	19,041,382	54,673	30,104	32,494,750

注：如果没有提供数据，则表示没有关于该类型集热器的可靠数据库。* 假设增长率为 0% +
仅报告了空气集热器（由 John Hollick 提供）

New installations in 2022 by collector type: flat plate collectors: 7.7 GW_{th} (11 million m^2), evacuated tube collectors: 13.3 GW_{th} (19.1 m^2), unglazed water collectors: 1.7 GW_{th} (2.4 million m^2), and glazed and unglazed air collectors: 0.06 GW_{th} (0.085 million m^2).

Evacuated tube collectors, with a 59% share, remain the most important solar thermal collector technology worldwide (Figure 34).

In a global context, this breakdown is mainly driven by the dominance of the Chinese market, where around 73% of all newly installed collectors in 2022 were evacuated tube collectors. Nevertheless, it is notable that the share of evacuated tube collectors decreased from about 82% in 2011 to 59% in 2022, while flat plate collectors increased their share from 14.7% to 34% in the same time frame.

In Europe, the situation is almost the opposite of China, with 71.9% of all solar thermal collectors installed in 2022 being flat plate collectors (Figure 35). In the medium term, the share of flat plate collectors decreased in Europe from 81.5% in 2011 to 71.9% in 2022. Driven mainly by the markets in Turkey, Poland, Switzerland, and Germany, evacuated tube collectors increased their share in Europe between 2011 and 2020 from 15.6% to 27.6%.

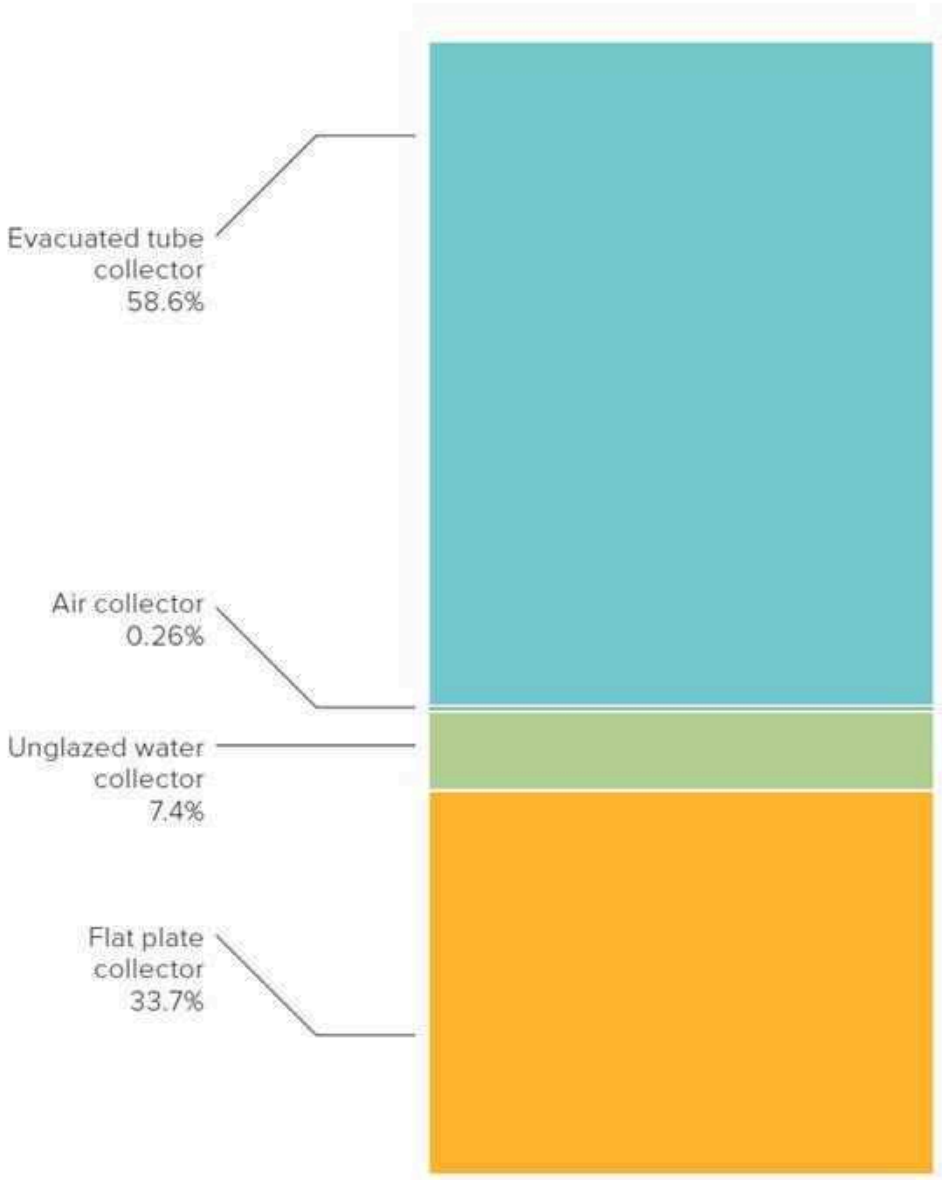

Figure 34: Distribution of the newly installed capacity by collector type in 2022 – WORLD

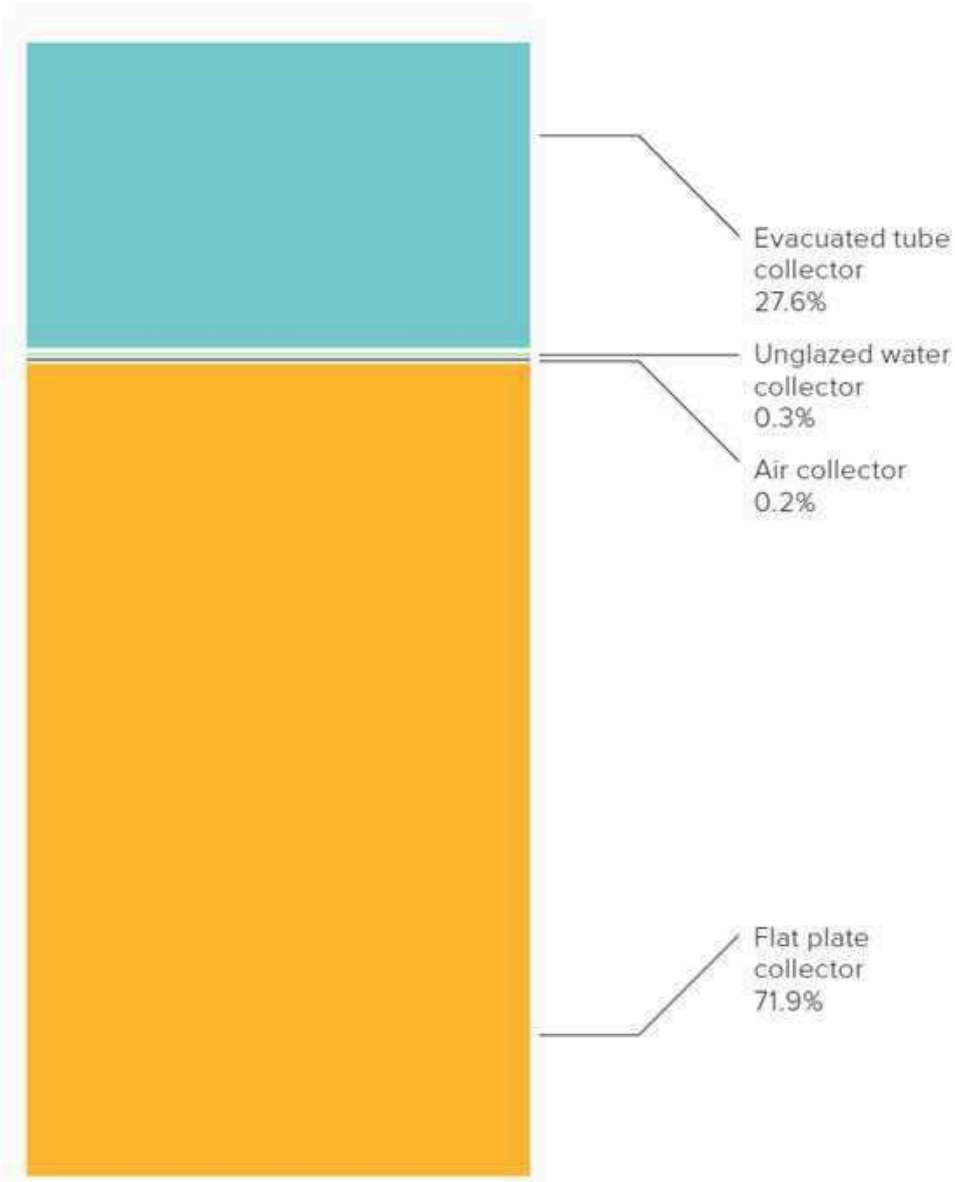

Figure 35: Distribution of the newly installed capacity by collector type in 2022 – EUROPE

Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom

Pumped 210 m^2 flat-plate collector system at the Lady Pohamba hospital in Windhoek, Namibia
Photo: Werner Weiss, AEE INTEC

按集热器类型分列的 2022 年新增安装量：平板集热器：7.7 吉瓦（1100万米），真空管集热器13.3吉瓦（19.1万米），无釉水收集器1.7吉瓦（240万平方米），有釉和无釉空气集热器：0.06 GW（0.085 亿平方米）。

蒸发管集热器占 59%，仍然是全球最重要的太阳能集热技术（图 34）。

在全球范围内，这种细分主要是由于中国市场的主导地位，2022 年中国新安装的集热器中约有 73% 是抽真空管集热器。然而

值得注意的是，真空管集热器的份额从 2011 年的约 82% 下降到 2022 年的 59%，而平板集热器的份额在同一时期从 14.7% 增加到 34%。

欧洲的情况几乎与中国相反，2022 年安装的所有太阳能集热器中有 71.9% 是平板集热器（图 35）。从中期来看，平板集热器在欧洲所占的比例从 2011 年的 81.5%下降到 2022 年的 71.9%。主要受土耳其、波兰、瑞士和德国市场的推动，2011 年至 2020 年，真空管集热器在欧洲的份额从 15.6% 增加到 27.6%。

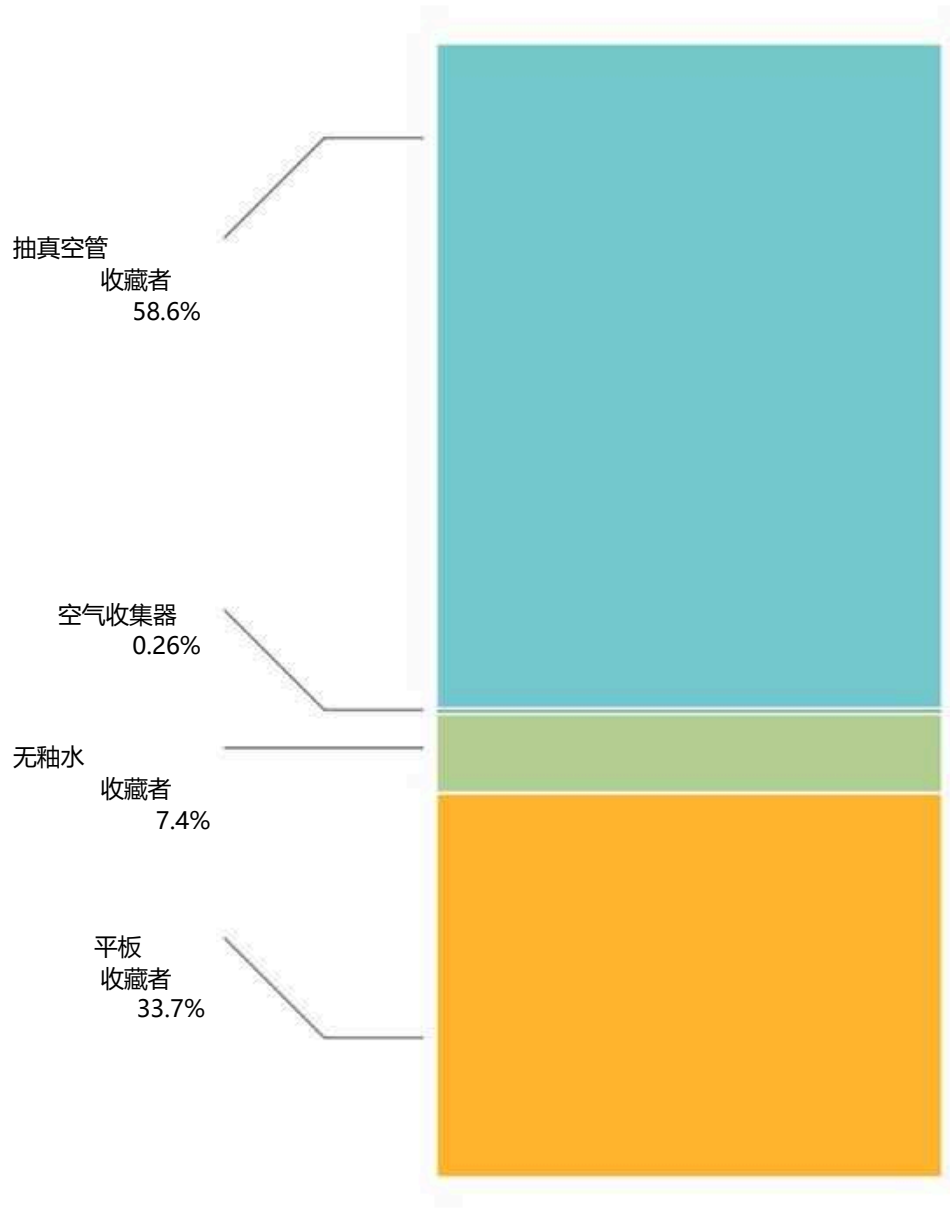

图 34：2022 年按集热器类型分列的新增装机容量分布 - 世界

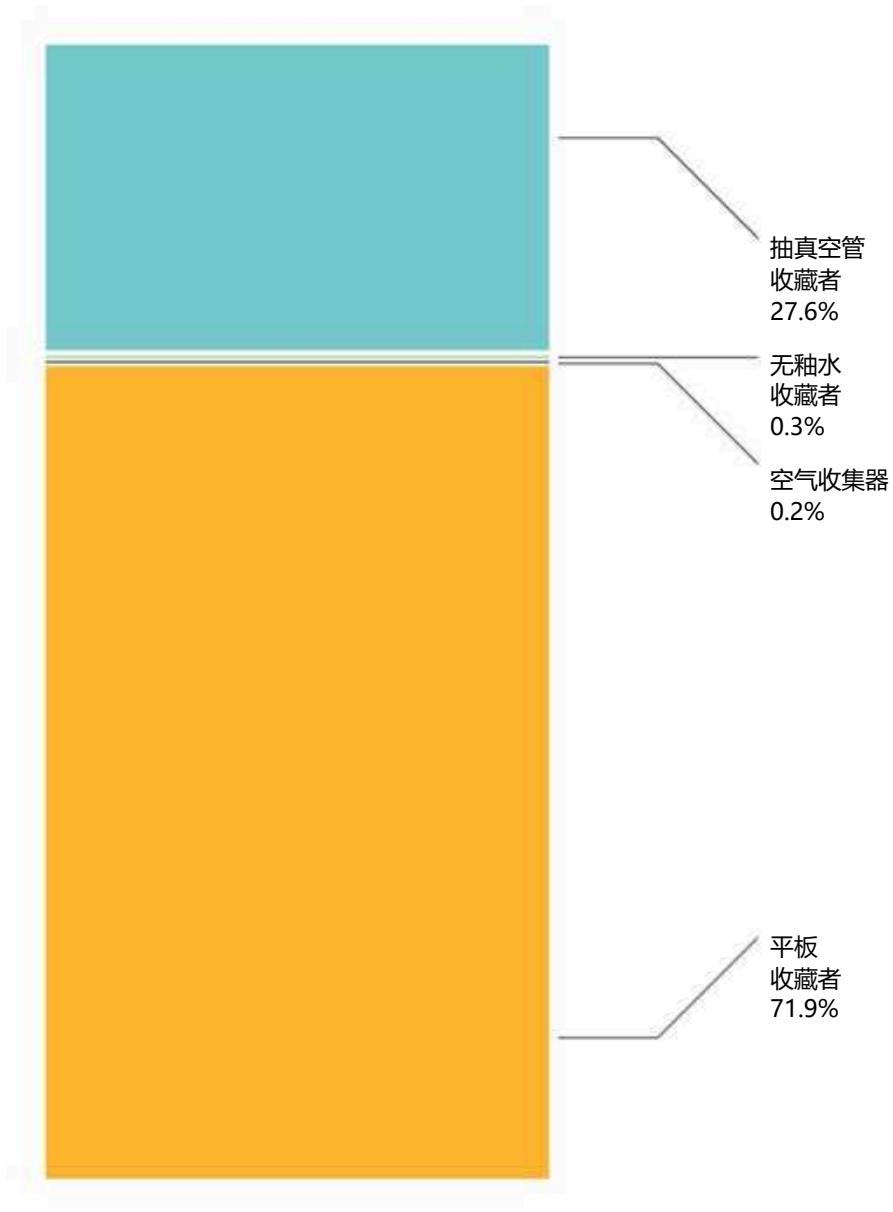

图 35：2022 年按集热器类型分列的新增装机容量分布 - 欧洲

欧洲：欧盟 27 国、阿尔巴尼亚、北马其顿、挪威、俄罗斯、瑞士、土耳其、英国

纳米比亚温得和克波汉巴夫人医院的 210 平方米抽水平板集热系统
照片维尔纳-魏斯，AEE INTEC

Figure 36 shows the total capacity of newly installed glazed and unglazed water collectors for the 10 leading markets in 2022. China remained the market leader in absolute terms, followed by Turkey and Brazil. India and the United States rank fourth and fifth, ahead of Germany and Australia. Mexico, Greece, and Israel are among the top 10 countries, ranking ninth and tenth.

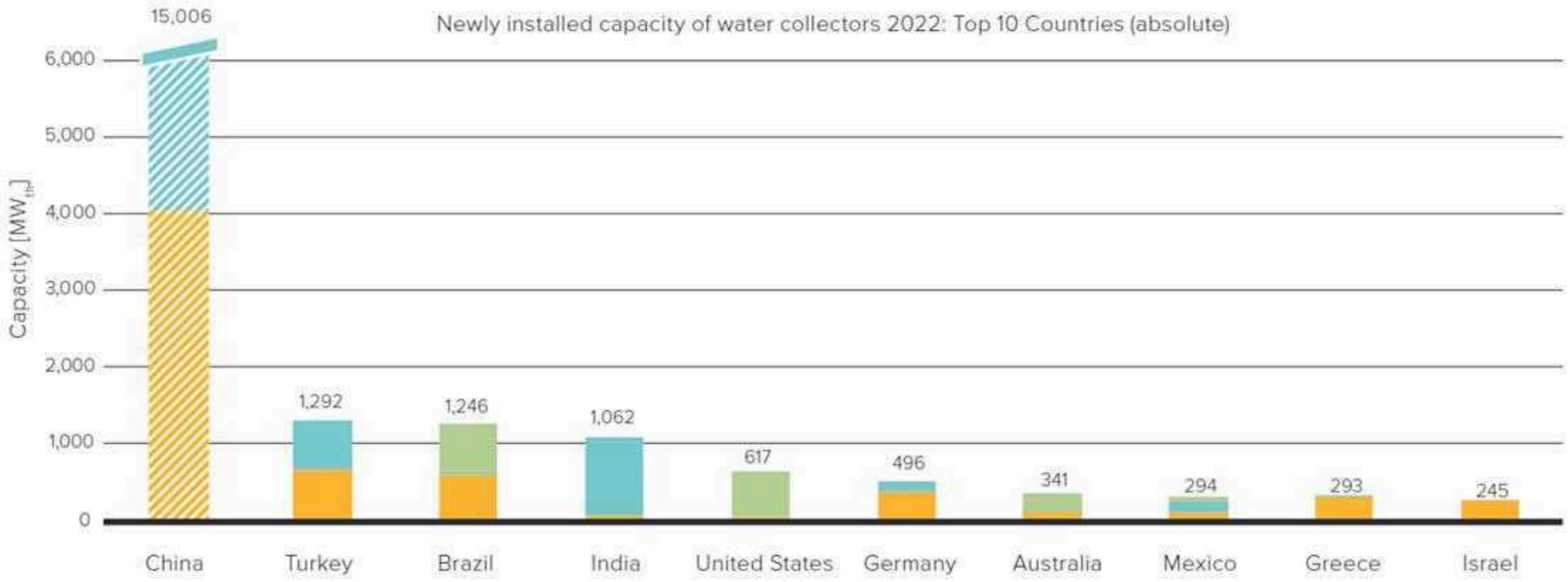

Figure 36: Top 10 markets for glazed and unglazed water collectors in 2022 (absolute figures in MW_{th})

In terms of newly installed solar thermal capacity per 1,000 inhabitants in 2022, the top 10 countries are shown in Figure 37.

Cyprus, Greece, Israel, and France (overseas) rank first to fourth, followed by Lebanon, Turkey, Australia, and China, ranking fifth to eighth, the Palestinian Territories ninth place, and Germany tenth.

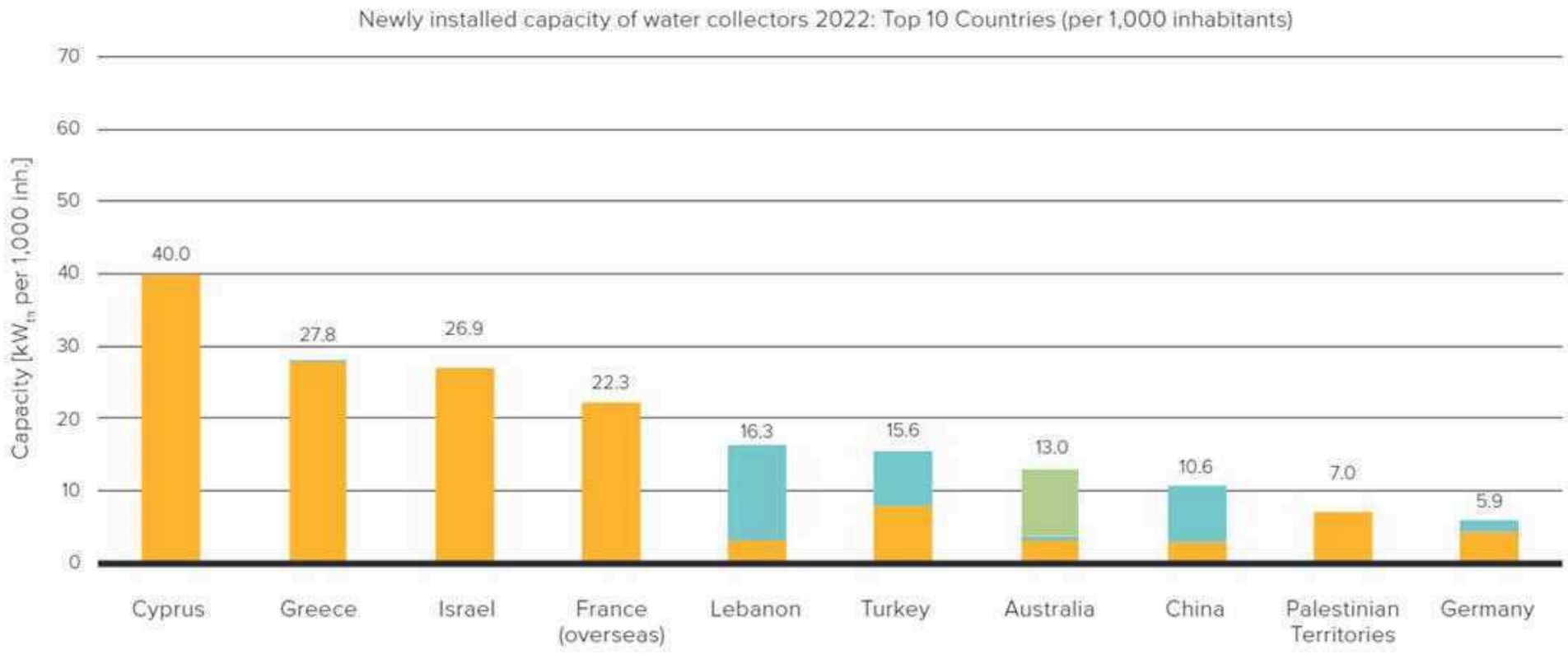

Figure 37: Top 10 markets for glazed and unglazed water collectors in 2022 (in kW_{th} per 1,000 inhabitants)

图 36 显示了 10 个主要市场在 2022 年新安装的有釉和无釉集热器的总容量。就绝对值而言，中国仍然是市场领导者其次是土耳其和巴西。印度和美国分列第四和第五位，排在德国和澳大利亚之前。墨西哥、希腊和以色列跻身前十名，分列第九和第十位。

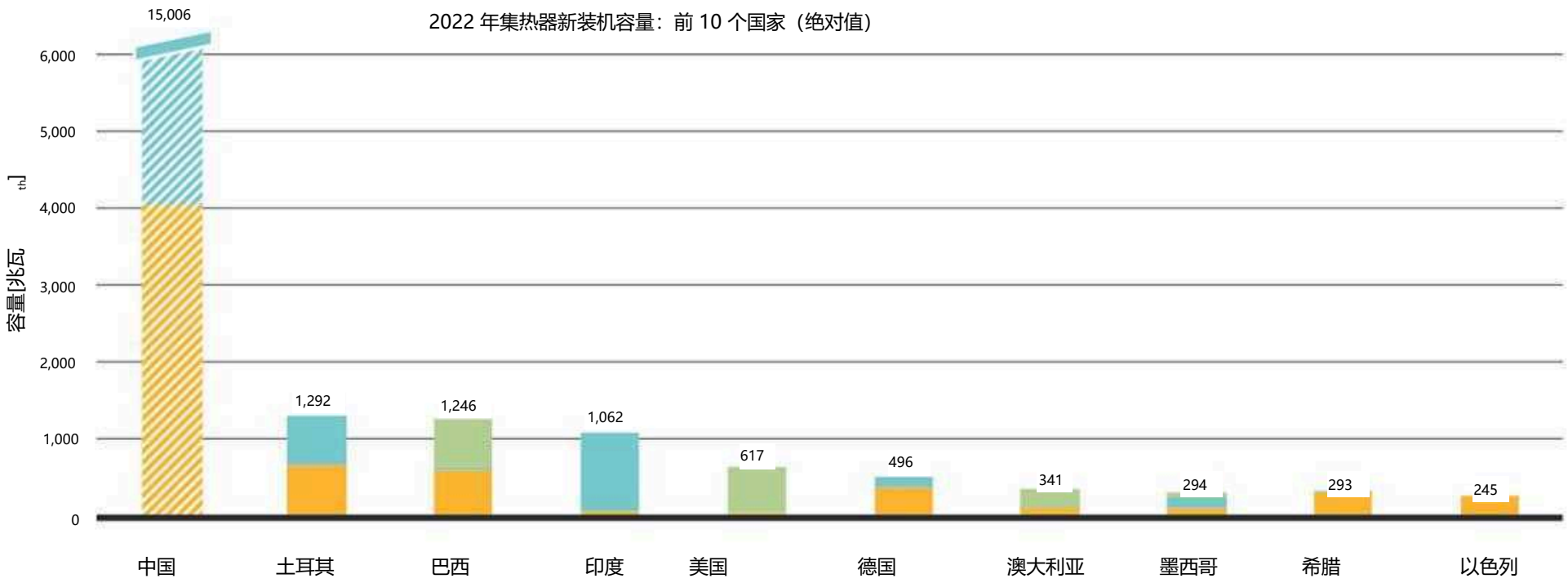

图 36：2022 年有釉和无釉集热器的 10 大市场（绝对数字，单位：兆瓦）

就 2022 年每千名居民新增太阳能热发电装机容量而言，排名前 10 位的国家如图 37 所示。塞浦路斯、希腊、以色列和法国（海外）分列第一至第四位，黎巴嫩、土耳其、澳大利亚和中国分列第五至第八位，巴勒斯坦领土第九位，德国第十位。

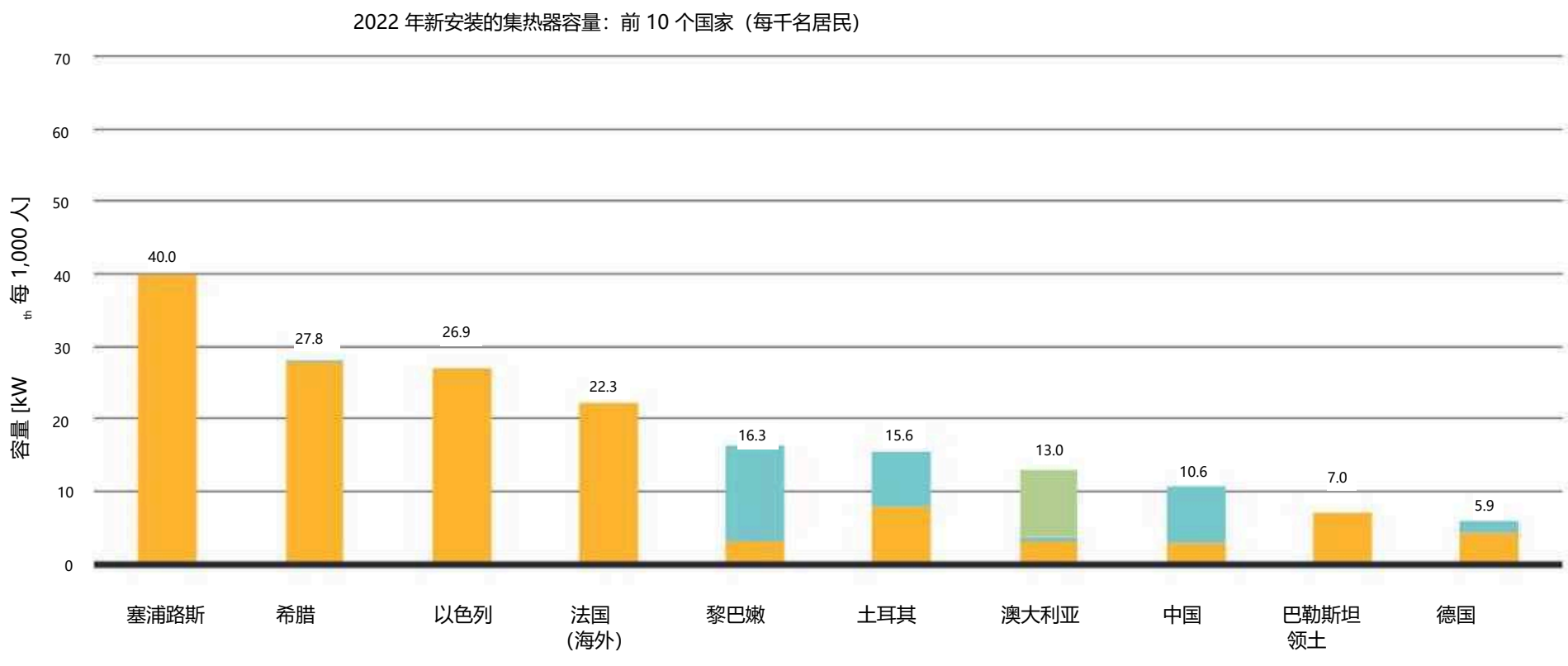

图 37：2022 年有釉和无釉集热器的 10 大市场（单位：千瓦/千人）

6.6 Newly installed capacity of glazed water collectors

In 2022, glazed water collectors accounted for 92% of the total newly installed capacity. China was the most influential market in the global context (Figure 38).

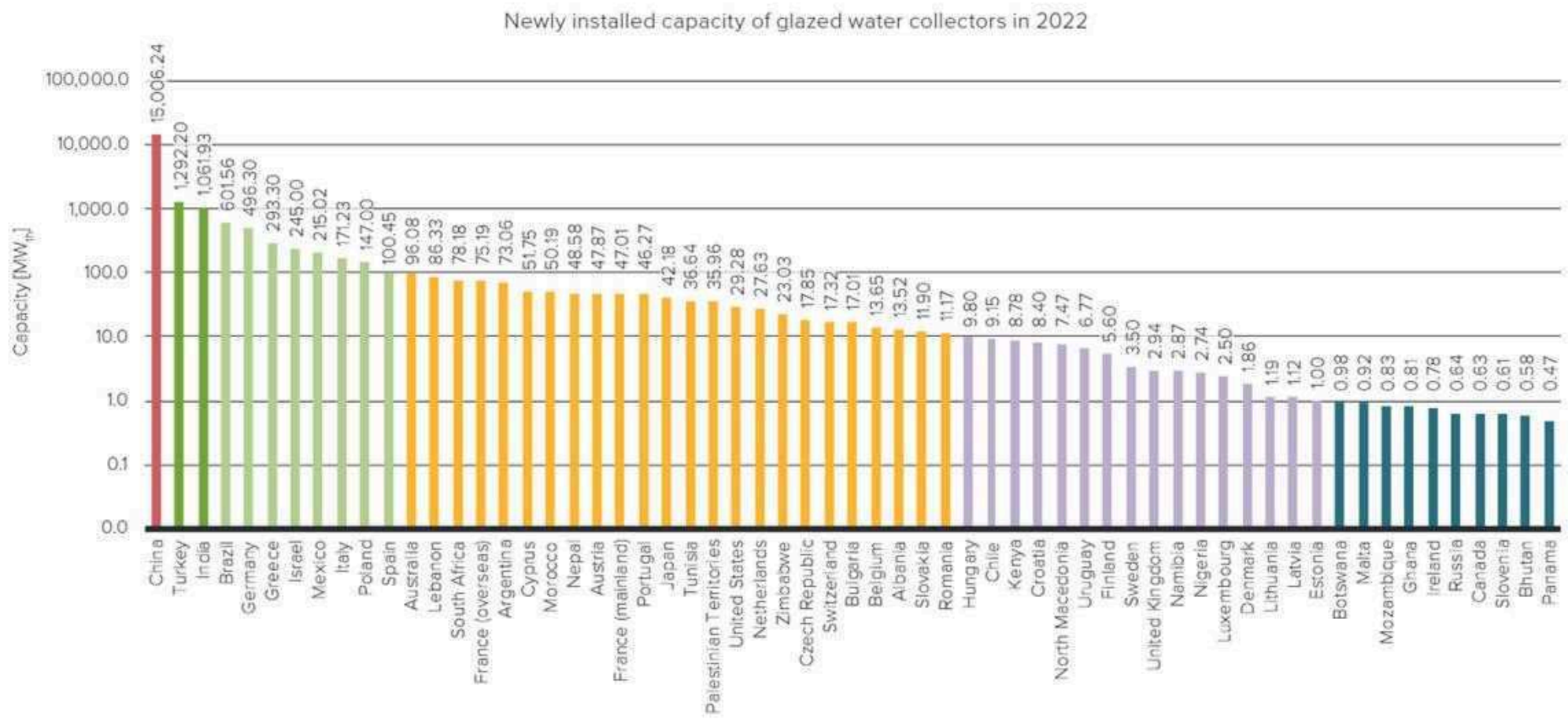

Figure 38: Newly installed capacity of glazed water collectors in 2022

In terms of newly installed glazed water collector capacity per 1,000 inhabitants, Cyprus is again the leader ahead of Israel, Greece, and France (overseas). In this respect, China ranks in 7th place (Figure 39).

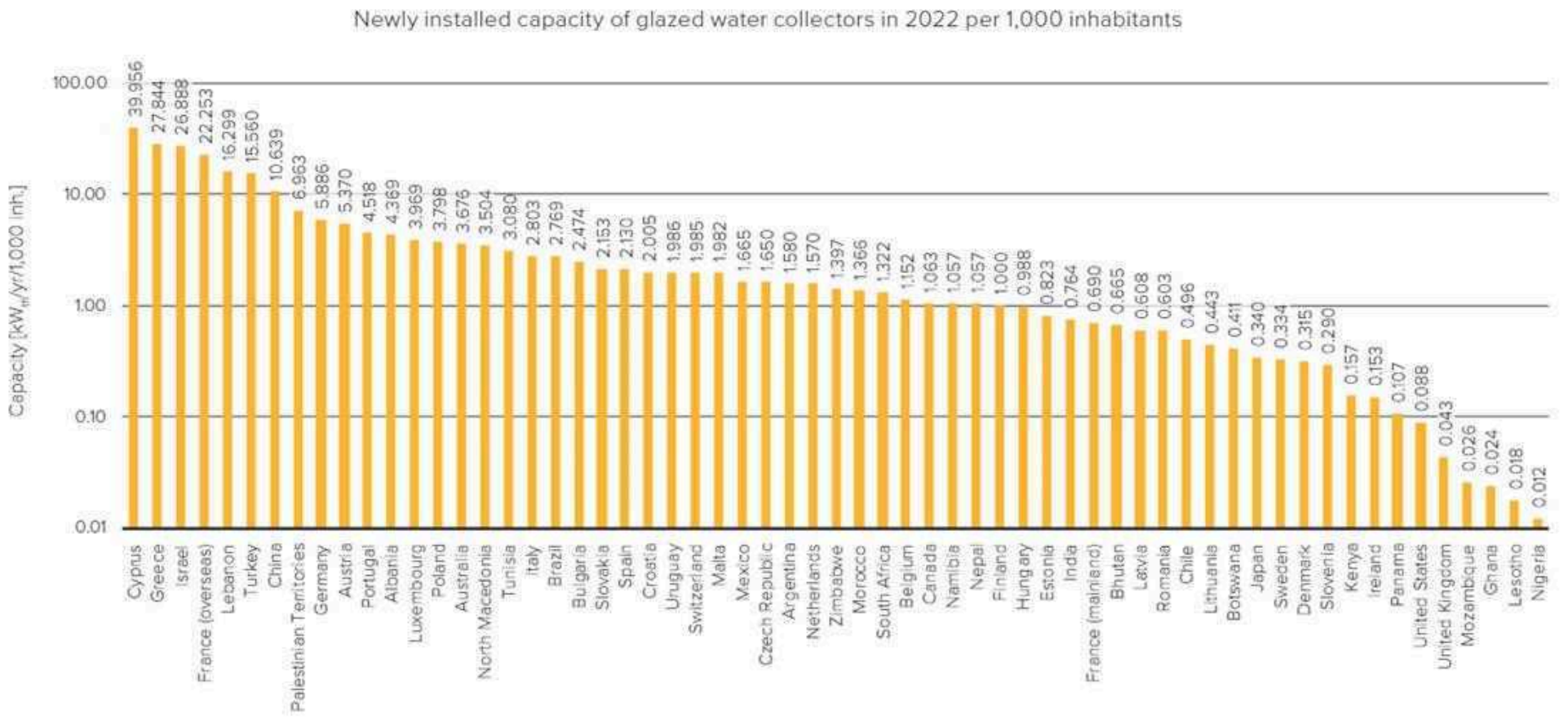

Figure 39: Newly installed capacity of glazed water collectors in 2022 in kW$_{th}$ per 1,000 inhabitants

6.6 新安装的釉面集热器容量

2022 年，釉面集热器占新安装总容量的 92%。中国是全球最具影响力的市场（图 38）。

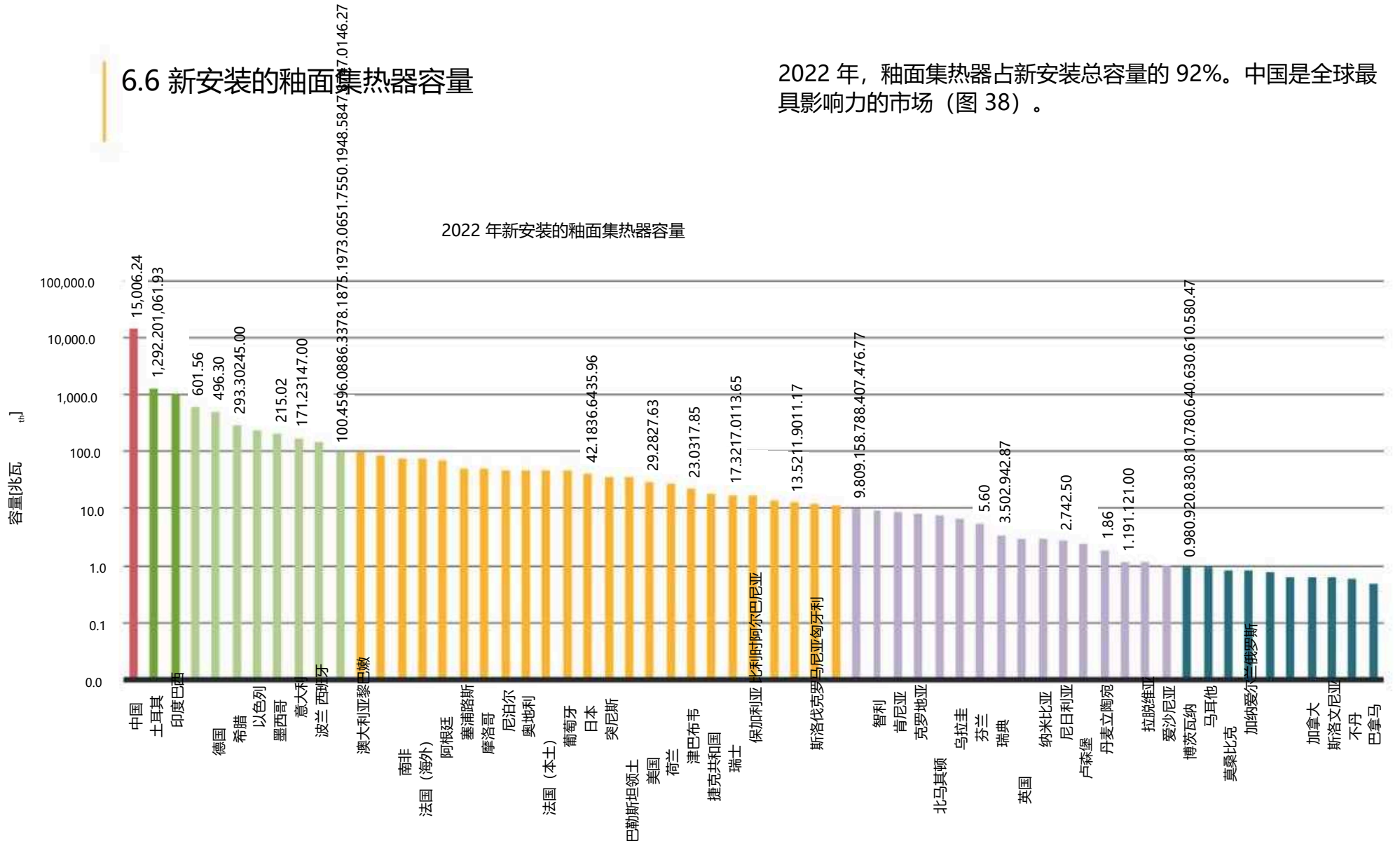

图 38：2022 年釉面集热器的新装机容量

就每千名居民新安装的玻璃集热器容量而言，塞浦路斯再次领先于以色列、希腊和法国（海外）。

在这方面，中国排名第 7 位（图 39）。

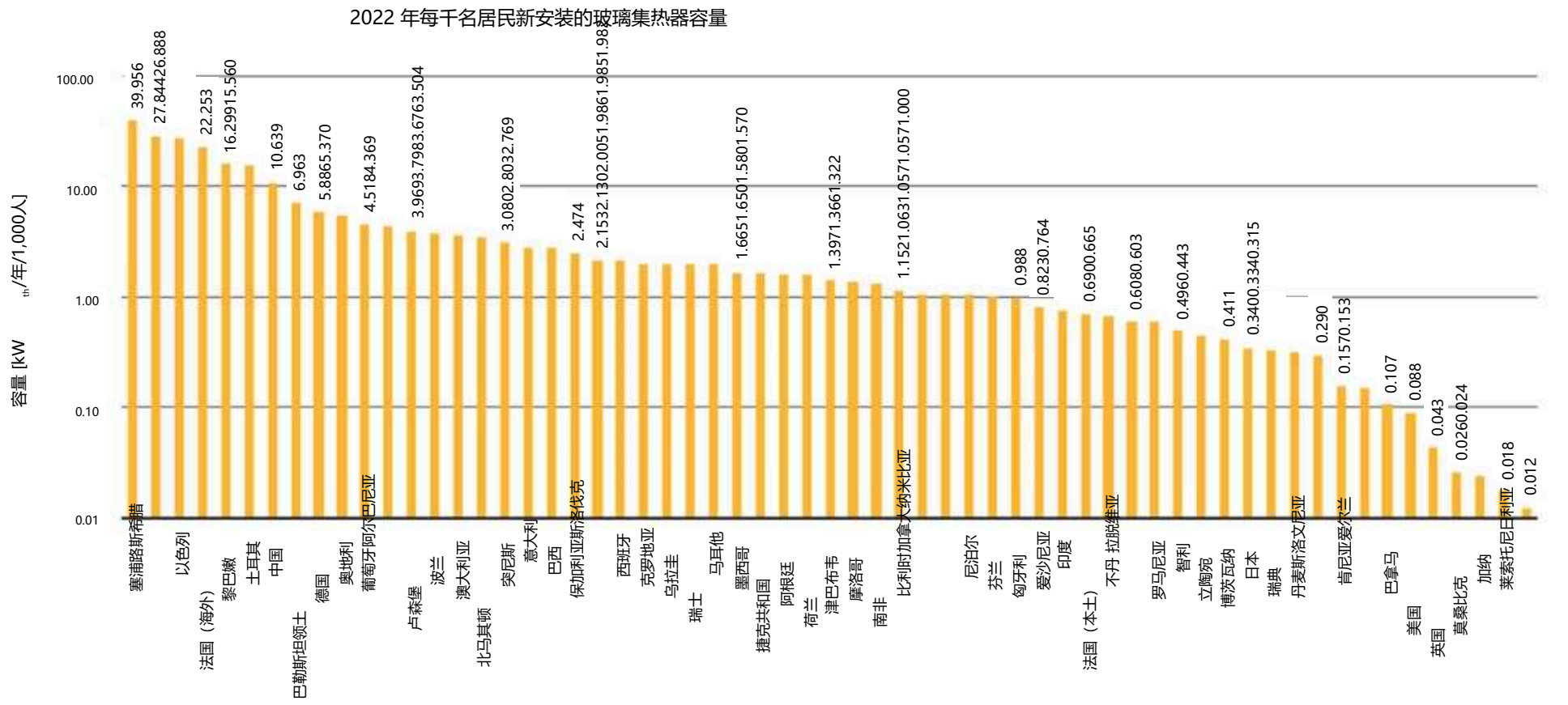

图 39：2022 年玻璃集热器的新装机容量（千瓦/每千名居民

The following figures show the solar thermal market penetration per capita of the newly installed capacity in 2022 worldwide and in Europe.

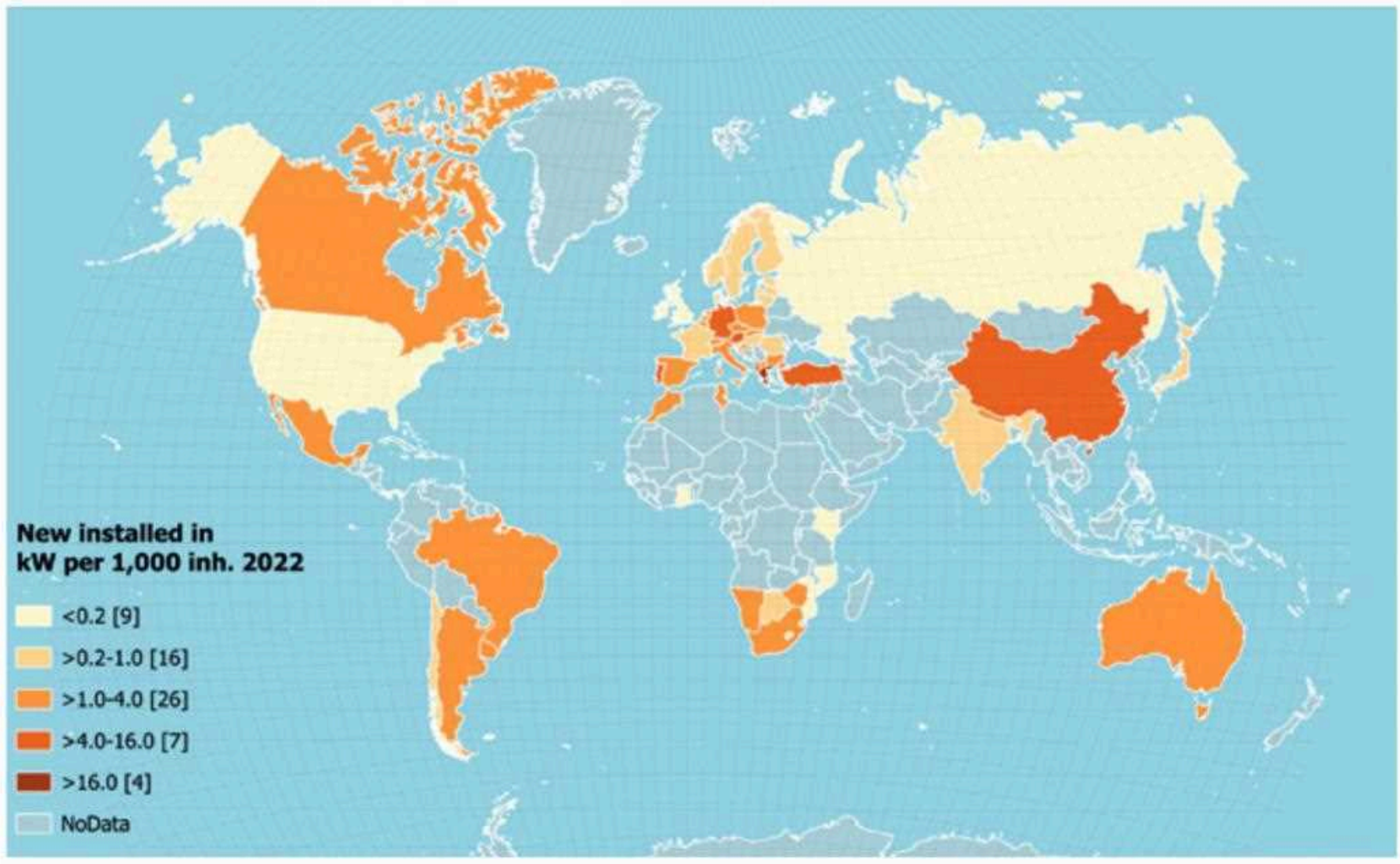

Figure 40: Newly installed capacity in 2022 in kW_{th} per 1,000 inhabitants – WORLD
Source: Natural Earth v.4.1.0, 2020/ AEE INTEC)

Figure 41: New Installed capacity in 2022 in kW_{th} per 1,000 inhabitants – EUROPE
Source: Natural Earth v.4.1.0, 2020/ AEE INTEC

下图显示了 2022 年全球和欧洲新增装机容量中人均光热市场渗透率。

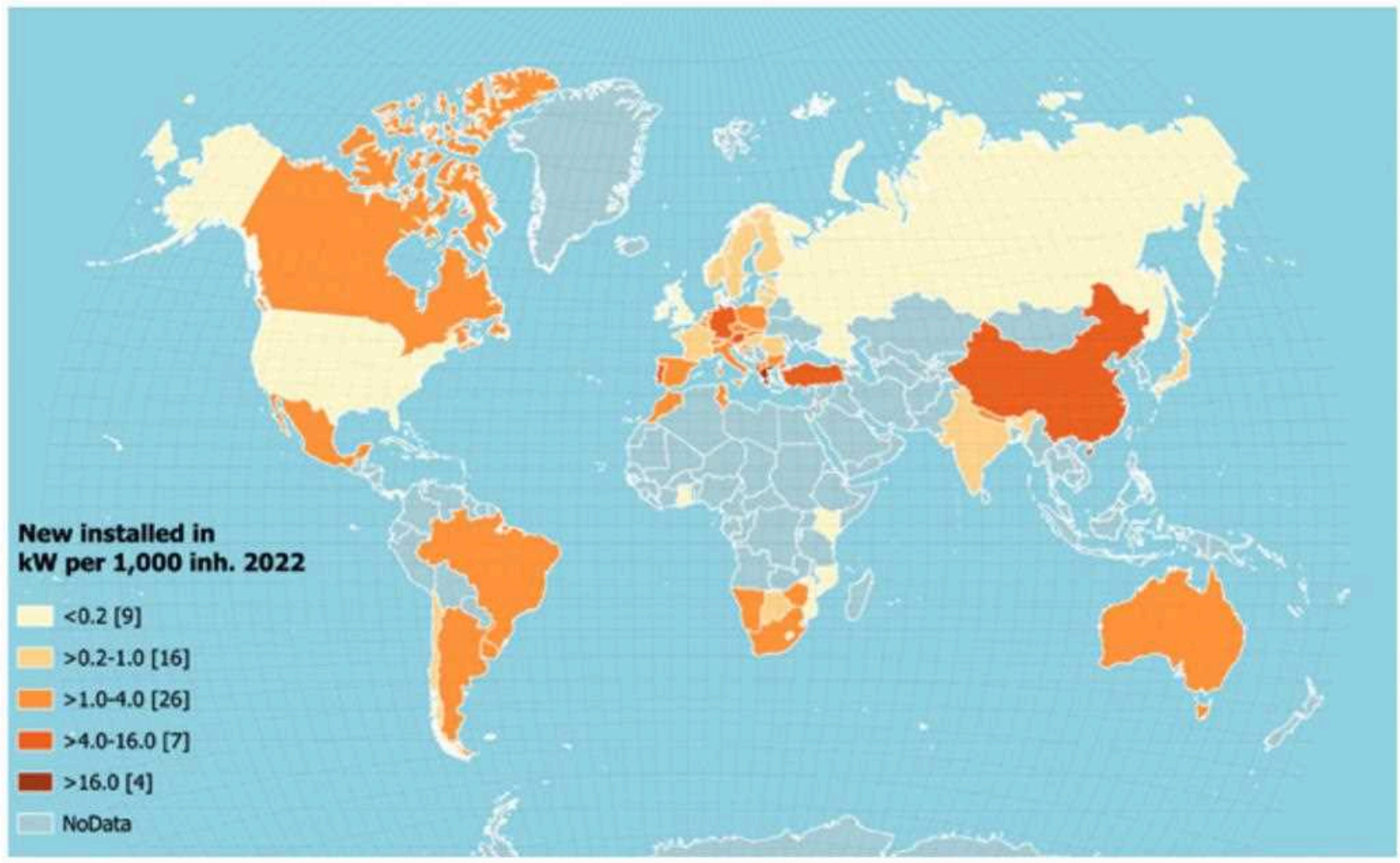

图 40：2022 年每千名居民新增装机容量（千瓦）--世界
来源：Natural Earth v.4.1.0, 2020/ AEE INTEC资料来源：Natural Earth v.4.1.0, 2020/ AEE INTEC)

图 41：2022 年新增装机容量（千瓦/千人）--欧洲
资料来源资料来源：Natural Earth v.4.1.0，2020/ AEE INTEC

6.7
Market development of glazed water collectors between 2000 and 2022

The worldwide market of glazed water collectors saw a steady upward trend between 2000 and 2013, with a high of around 50 GW_{th} in 2013. However, from 2014 onwards, the market for glazed collectors experienced a continuous decline, reaching a low of 21 GW_{th} in 2022. (Figure 42).

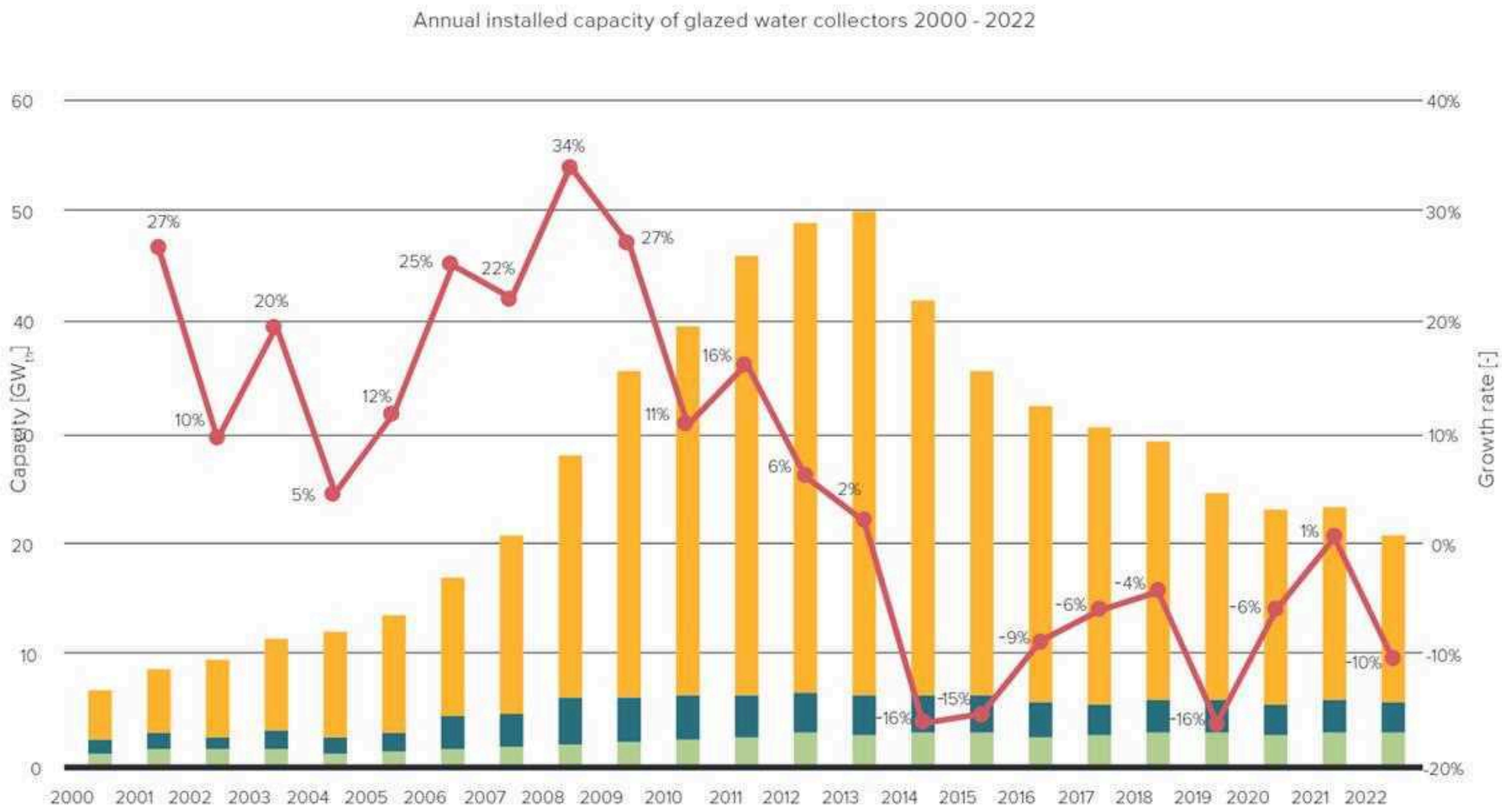

Figure 42: Global market development of glazed water collectors from 2000-2022

Figure 43 illustrates the market development in two key regions, Europe and China, from 2000 to 2022. In Europe, the installed capacity tripled from 2000 to 2008, followed by a continuous decline from 2009 onwards. China experienced rapid annual growth in installed capacity since the early 2000s, with a tenfold increase in annual installed capacity by 2013 compared to the year 2000. However, from 2014 onwards, China has seen a continuous decline.

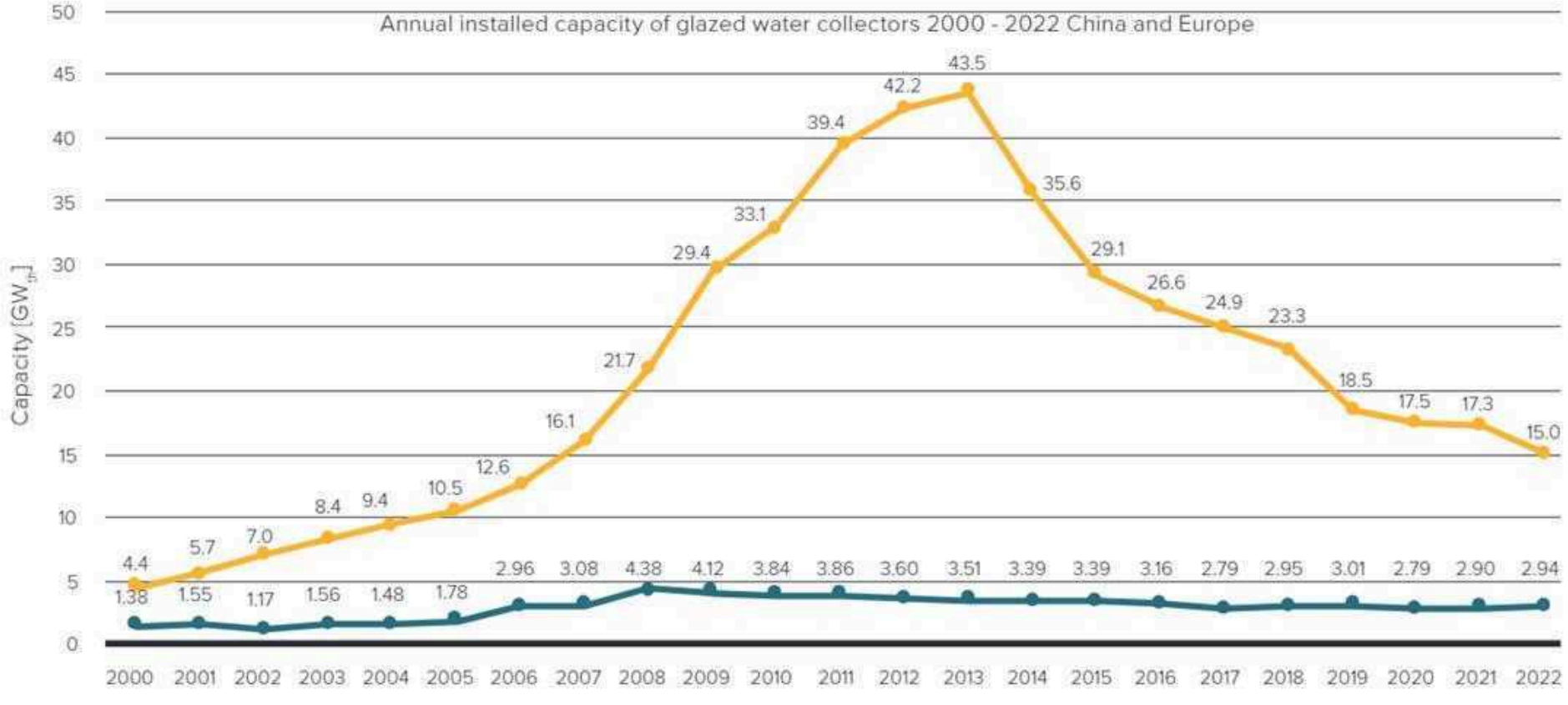

Figure 43: Market development of glazed water collectors in China and Europe 2000-2022

6.7 2000 年至 2022 年釉面集热器的市场发展情况

2000 年至 2013 年期间，全球釉面集热器市场呈稳步上升趋势，2013 年达到约 50 千兆瓦的高点。然而，从 2014 年开始，琉璃集热器市场经历了持续下滑，到 2022 年达到 21 千兆瓦的最低点（图 42）。(图 42）。中国

图 42：2000-2022 年全球釉面集热器市场发展情况

图 43 展示了 2000 年至 2022 年欧洲和中国这两个主要地区的市场发展情况。在欧洲，装机容量从 2000 年到 2008 年增加了两倍，从 2009 年开始持续下降

自 2000 年代初以来，中国的装机容量每年都在快速增长，与 2000 年相比，2013 年的年装机容量增长了 10 倍。然而，从 2014 年开始，中国的装机容量持续下降。

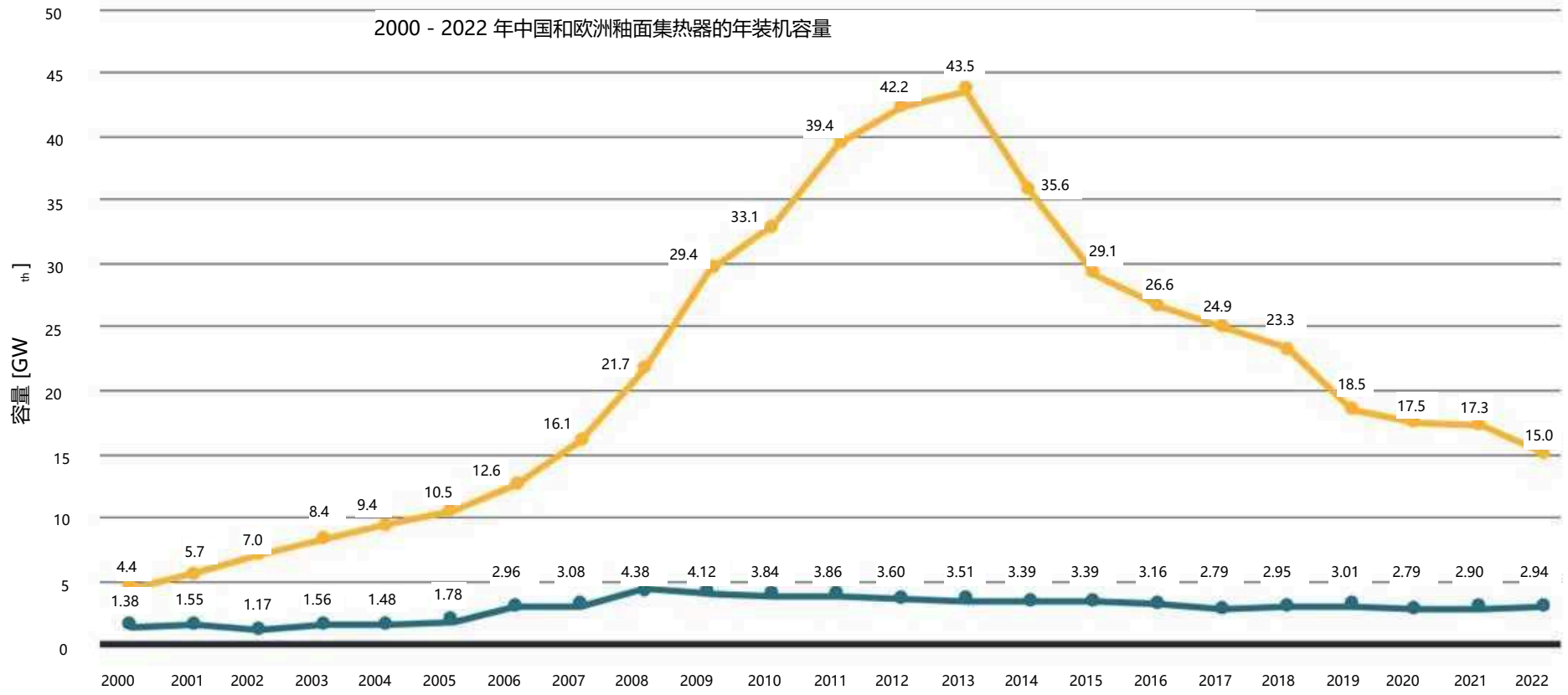

图 43：2000-2022 年中国和欧洲釉面集热器市场发展情况

The European market peaked at 4.4 GW_{th} installed capacity in 2008 and has decreased steadily to 2.8 GW_{th} in 2017, with a slight recovery in 2019 and then down to 2.8 GW_{th} in 2020. In Europe, a slight increase can also be seen again in 2021. In the "remaining markets worldwide" (RoW), an upward trend is observed between 2002 and 2012. With the exception of 2016 and 2020, there has been continuous market growth in these countries since 2013 (Figure 44).

Annual installed capacity of glazed water collectors 2000 - 2022 Europe and RoW

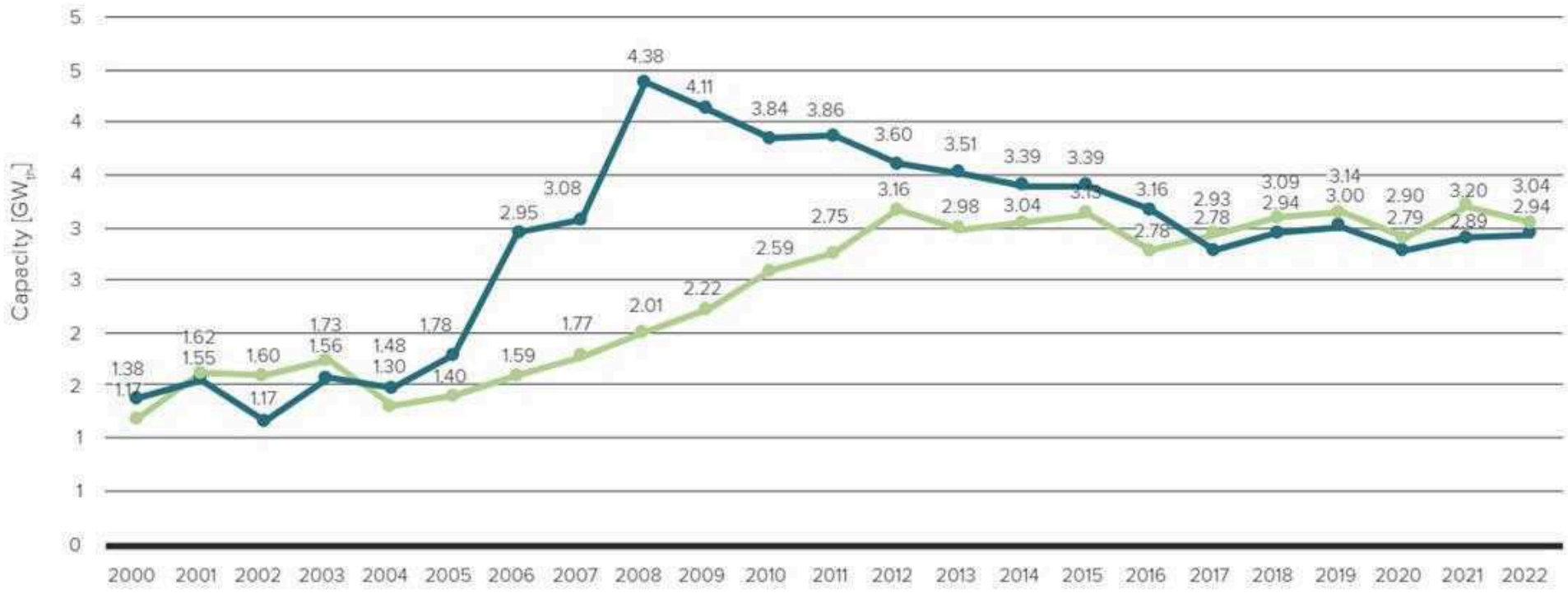

Figure 44: Market development of glazed water collectors in Europe and the rest of the world (RoW, excluding China) from 2000 to 2022

Rest of World (RoW, excluding China): Asia (Bhutan, India, Japan, Nepal, South Korea, Chinese Taipei, Thailand), Australia, Canada, United States
Latin America (Argentina, Brazil, Chile, Mexico, Panama, Uruguay)
MENA countries (Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia)
Sub-Sahara Africa (Botswana, Burkina Faso, Cape Verde, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe),
"All other countries" see figures for 2022 in Tables 4 and 5

The Rest of the World (RoW) includes all economic regions other than China and Europe. Of these regions, Other Asia, Latin America, and the MENA countries hold the largest market shares (see Figure 45).

"Other Asia" is mainly influenced by the large Indian market. Other countries in this economic region with a significant solar thermal market are Japan and South Korea. The growth phase in this region reached its first peak in 2012. In the following decade, up to 2022, the market stabilized with some ups and downs at an annual installed capacity of around 1.2 GW_{th}.

Latin America demonstrated the most consistent and dynamic upward trend among all economic regions. The annual installed capacity surged ninefold between 2000 and 2022. This growth can be attributed to the dominant Brazilian market, the substantial Mexican market, and the emerging markets in countries like Chile and Argentina.

The glazed water collector markets in the MENA countries experienced steady growth from 2000 to 2013. However, the decline in the market starting in 2014, as depicted in Figure 45, can be attributed to the absence of data for the two major markets – Morocco and Jordan – from 2015 onwards. Additionally, sales in the key market, Israel, saw a slight decrease in 2020. Since 2021, the MENA region has witnessed a slight upward trend again, primarily driven by the solar thermal markets in Lebanon and the Palestinian Territories.

The Australian market saw continuous growth from 2000 to 2009. However, from 2010 to 2022, a clear and sustained decline in annual sales is evident.

Sub-Saharan African markets have grown continuously since 2000, overtaking previously strong players like Australia, the USA, and Canada.

After a period of growth in the United States and Canada until 2013, there were severe slumps, and in 2020, the installed capacity fell well below the level of the sub-Saharan countries.

欧洲市场的装机容量在 2008 年达到峰值 4.4 千兆瓦，2017 年稳步下降至 2.8 千兆瓦，2019 年略有回升，2020 年又降至 2.8 千兆瓦。2021 年，欧洲市场还将再次出现小幅增长。欧洲

在 "全球其他市场"（RoW）方面，2002 年至 2012 年间呈现上升趋势。除 2016 年和 2020 年外，这些国家的市场自 2013 年以来持续增长（图 44）。

图 44：2000 至 2022 年欧洲和世界其他地区（RoW，不包括中国）釉面水收集器的市场发展情况

世界其他地区（RoW，不包括中国）：亚洲（不丹、印度、日本、尼泊尔、韩国、中国台北、泰国）、澳大利亚、加拿大、美国 拉丁美洲（阿根廷、巴西、智利、墨西哥、巴拿马、乌拉圭） 中东和北非国家（以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土、突尼斯） 撒哈拉以南非洲（博茨瓦纳、布基纳法索、佛得角、加纳、肯尼亚、莱索托、毛里求 斯、莫桑比克撒哈拉以南非洲（博茨瓦纳、布基纳法索、佛得角、加纳、肯尼亚、莱索托、毛里求斯、莫桑比 克、纳米比亚、尼日利亚、塞内加尔、南非、津巴布韦），"所有其他国家 "见表 4 和表 5 中 2022 年的数字。

世界其他地区（RoW）包括除中国和欧洲以外的所有经济区域。在这些地区中，其他亚洲、拉丁美洲和中东及北非国家占有最大的市场份额（见图 45）。

"其他亚洲 "主要受印度庞大市场的影响。日本和韩国也是该经济区中光热市场较大的国家。该地区的增长阶段在 2012 年达到第一个高峰。在接下来的十年中，直至 2022 年，市场在一些起伏中趋于稳定，年装机容量约为 1.2 千兆瓦。

在所有经济区域中，拉丁美洲的增长趋势最为持续和活跃。从 2000 年到 2022 年，年投放量激增了九倍。这一增长得益于占主导地位的巴西市场、巨大的墨西哥市场以及智利和阿根廷等国的新兴市场。

2000 年至 2013 年，中东和北非国家的釉面集热器市场经历了稳定增长。然而，如图 45 所示，市场从 2014 年开始出现下滑，这可能是由于从 20 15 年起缺少了两个主要市场--摩洛哥和约旦的数据。此外，主要市场以色列的销售额在 2020 年略有下降。自 2021 年以来，中东和北非地区再次出现小幅上升趋势，主要是受黎巴嫩和巴勒斯坦领土光热市场的推动。

2000 年至 2009 年，澳大利亚市场持续增长。然而，从 2010 年到 2022 年，年销售额明显持续下降。

自 2000 年以来，撒哈拉以南非洲市场持续增长，超过了澳大利亚、美国和加拿大等以往的强势市场。

美国和加拿大在经历了 2013 年之前的增长期之后，出现了严重的下滑，2020 年的装机容量远远低于撒哈拉以南国家的水平。

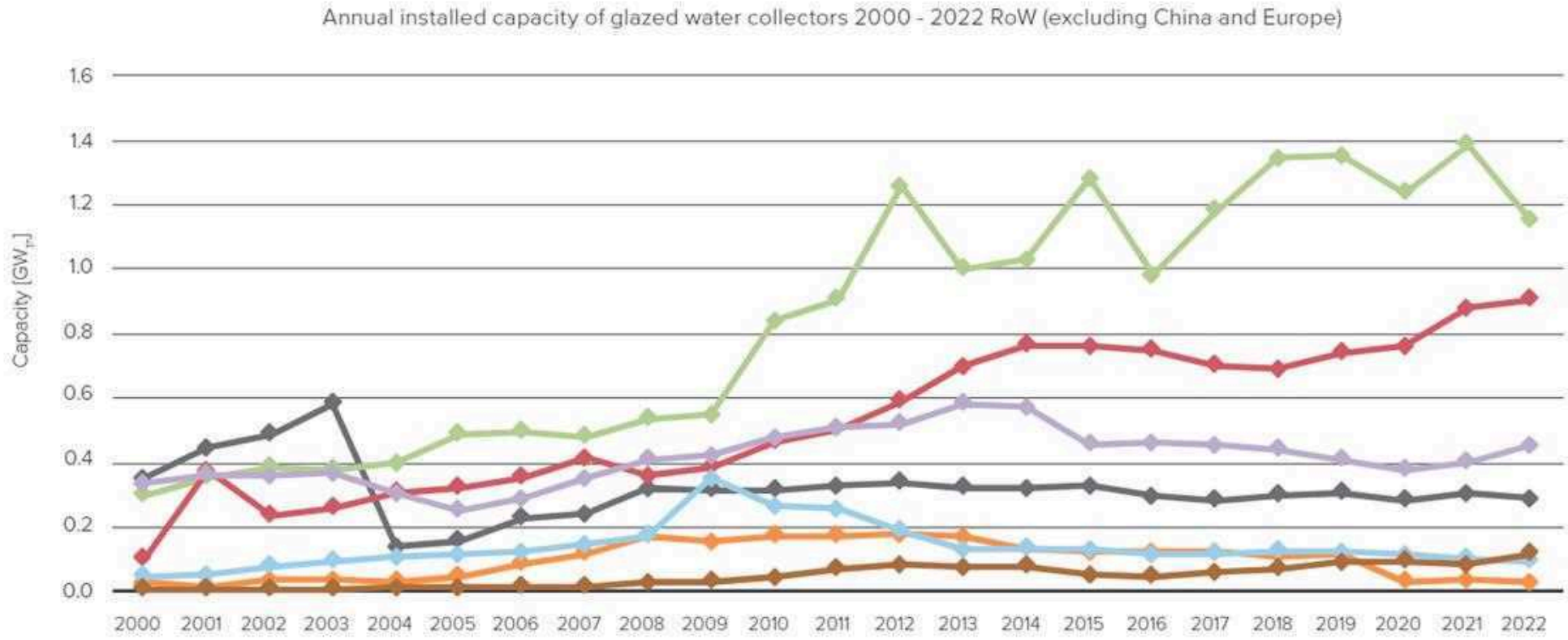

Figure 45: Market development of glazed water collectors in Latin America, United States / Canada, Sub-Sahara Africa, Other Asia, the MENA region, and Australia (excluding China and Europe) from 2000 to 2022

Other Asia: Bhutan, India, Japan, Nepal, South Korea, Chinese Taipei, Thailand
Latin America: Argentina, Brazil, Chile, Mexico, Panama, Uruguay
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia
Sub-Sahara Africa: Botswana, Burkina Faso, Cape Verde, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe

In relative figures, the annual global market volume for glazed water collectors grew from 1.2 kW$_{th}$ per 1,000 inhabitants in 2000 to 7.1 kW$_{th}$ per 1,000 inhabitants in 2013 and dropped to 2.7 kW$_{th}$ per 1,000 inhabitants in 2022 (Figure 46).

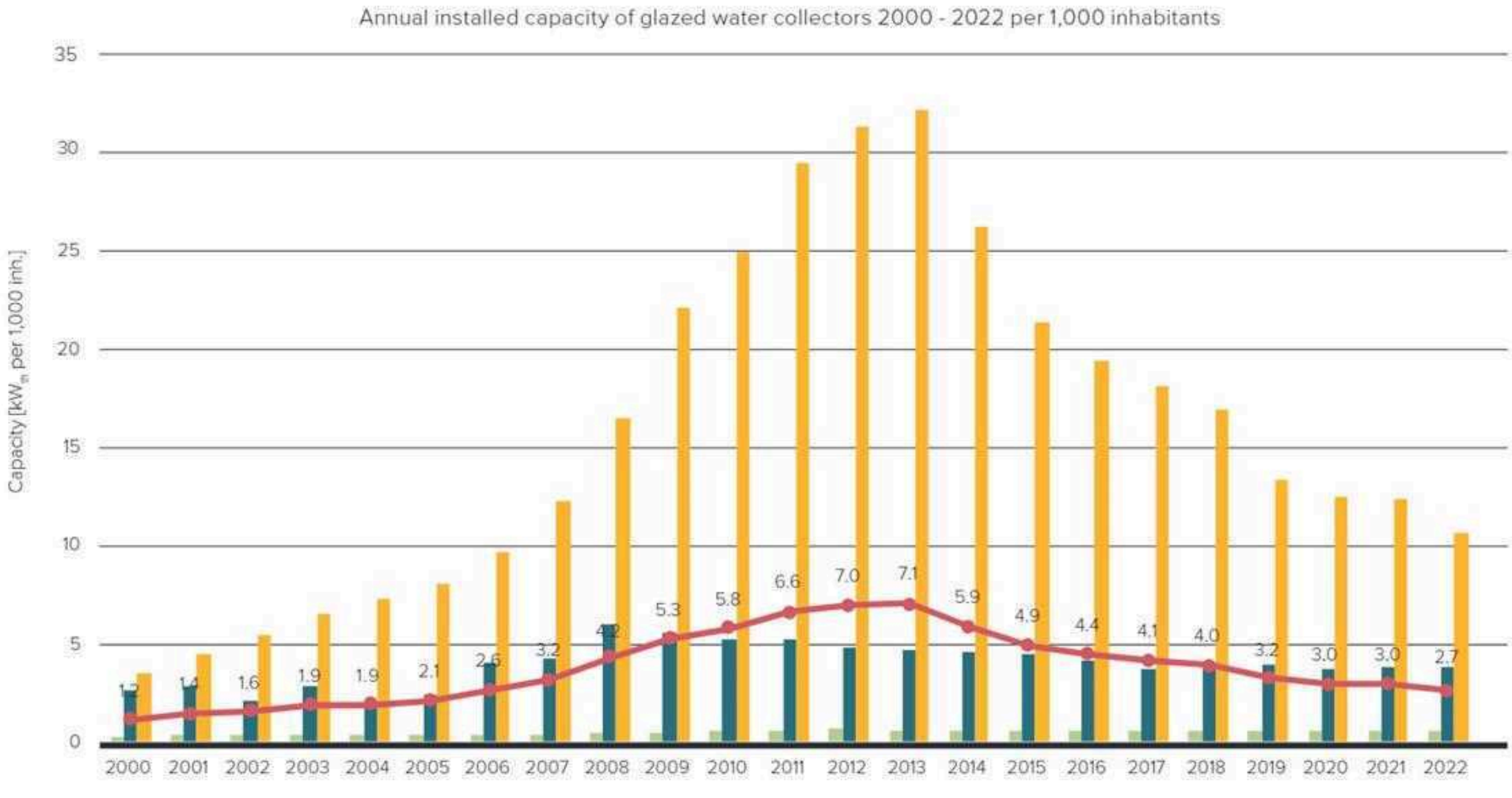

Figure 46: Annually installed capacity of glazed water collectors in kW$_{th}$ per 1,000 inhabitants from 2000 to 2022

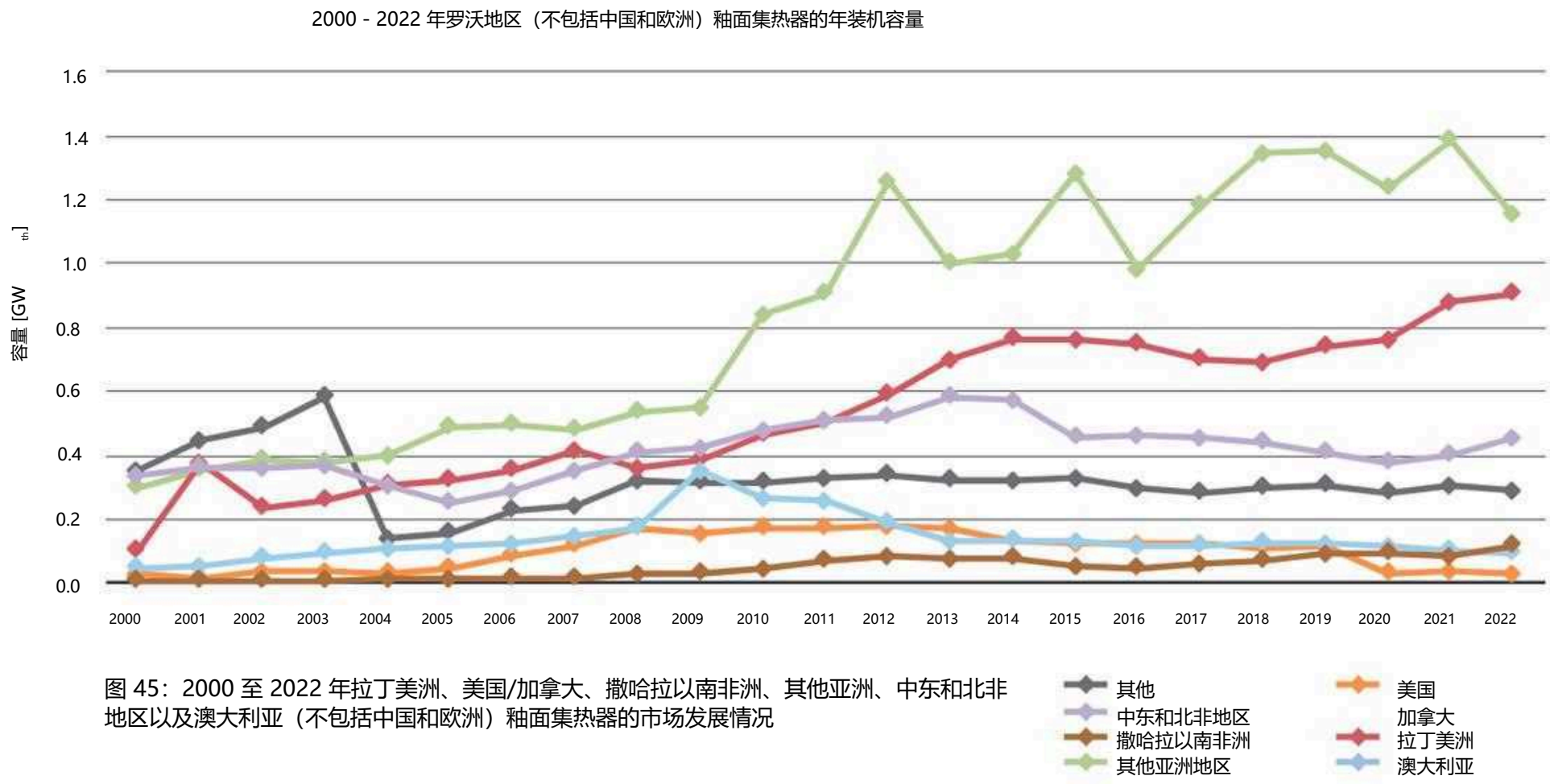

图 45：2000 至 2022 年拉丁美洲、美国/加拿大、撒哈拉以南非洲、其他亚洲、中东和北非地区以及澳大利亚（不包括中国和欧洲）釉面集热器的市场发展情况

其他亚洲国家不丹、印度、日本、尼泊尔、韩国、中国台北、泰国 拉丁美洲：阿根廷、巴西、智利、墨西哥、巴拿马、乌拉圭 MENA 国家：以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土、突尼斯 撒哈拉以南非洲地区博茨瓦纳、布基纳法索、佛得角、加纳、肯尼亚、莱索托、毛里求斯、莫桑比克、纳米比亚、尼日利亚、塞内加尔、南非、津巴布韦

相对而言，全球玻璃集热器的年市场容量从 2000 年的每千名居民 1.2 千瓦增长到 2013 年的每千名居民 7.1 千瓦，到 2022 年降至每千名居民 2.7 千瓦（图 46）。

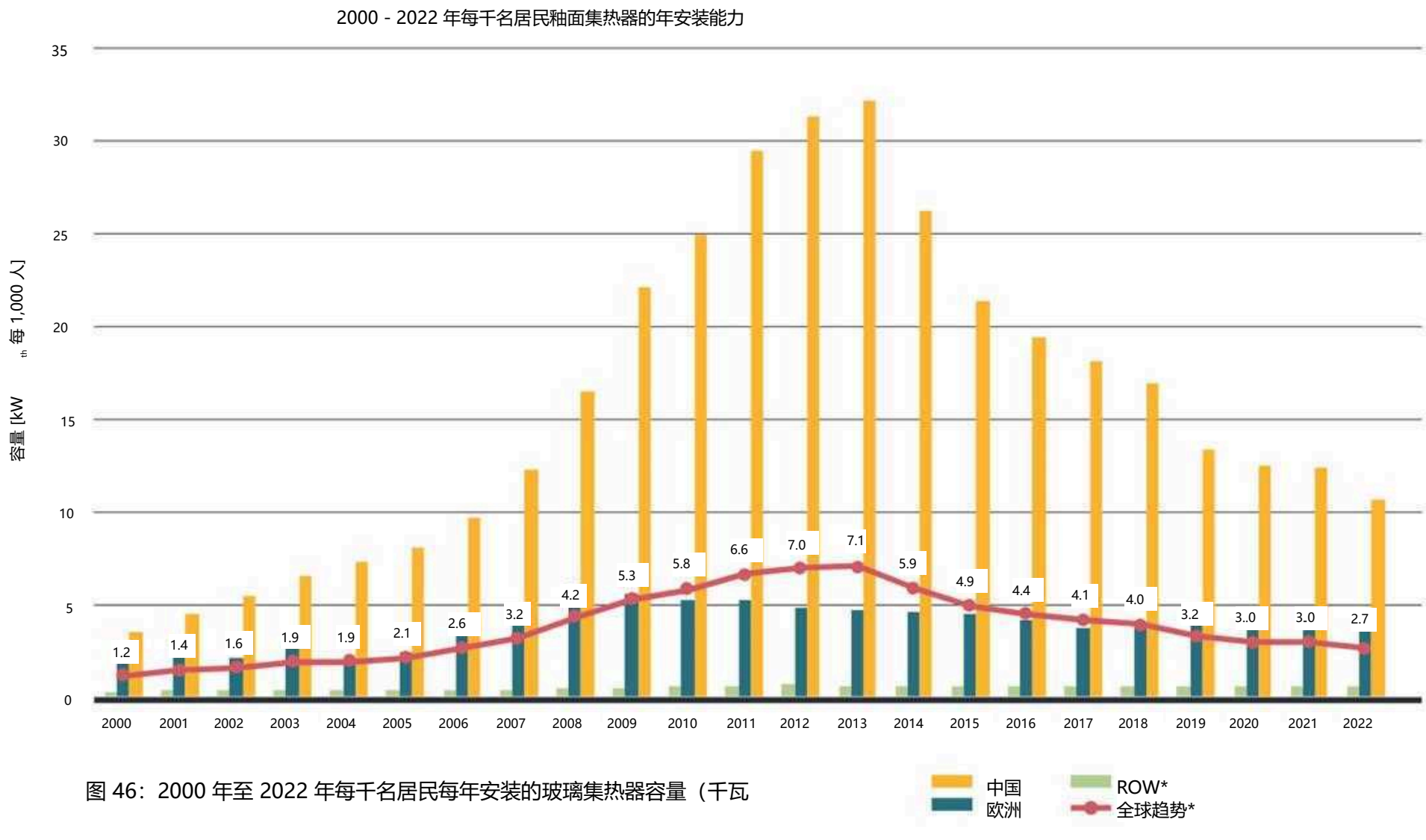

图 46：2000 年至 2022 年每千名居民每年安装的玻璃集热器容量（千瓦

The fact that China suffered major market declines from 2014 to 2016 is reflected in the market penetration of glazed water collector installations per capita. The annual installed capacity rose from 3.5 kW_{th} per 1,000 inhabitants in 2000, peaked at 32.2 kW_{th} per 1,000 inhabitants in 2013, and then fell to 10.6 kW_{th} per 1,000 inhabitants in 2022.

In Europe, market penetration peaked in 2008 at 5.9 kW_{th} per 1,000 inhabitants. The downward trend between 2009 and 2013 seems to have stabilized from 2014 onwards and was 2.7 kW_{th} per 1,000 inhabitants in 2022.

Solar district heating Jelling, Denmark
Photo: SavoSolar / Solar Heat Europe

6.8 Market development of unglazed water collectors between 2000 and 2022

With a newly installed capacity of 1.7 GW_{th} in 2022, unglazed water collectors accounted for 7.4% of the total installed solar thermal capacity (Figure 34). Compared to 2021, the market slightly decreased by -3.0% because of decreases in Brazil (-3%) and Australia (-7.9%). The second largest market, the United States, saw a market increase (+3.8%).

The most important markets for unglazed water collectors in 2022 were the United States (587 MW_{th}), Brazil (644 MW_{th}), and Australia (245 MWth). Mexico reported 79 MW_{th} installed unglazed water collector area and South Africa 29 MWt_{th}. The capacity in these countries accounted for 94% of the recorded unglazed water collector installations worldwide. Switzerland (2.2 MW_{th}), Spain (1.4 MW_{th}), and the Netherlands (1.8 MW_{th}) also reported unglazed water collector installations in 2022.

The unglazed water collector market in the United States peaked in 2006 (1.01 GW_{th}) and has about halved since then (0.47 GW_{th} in 2019). Nevertheless, the annual global market volume for unglazed water collectors has remained nearly constant because of the Brazilian market, which entered in 2007 and peaked in 2021 at 0.66 GW_{th}. Australia has faced a market decline since 2010 and is now the third largest market for unglazed water collectors, behind the United States and Brazil.

Annual installed capacity of unglazed water collectors 2000 - 2022

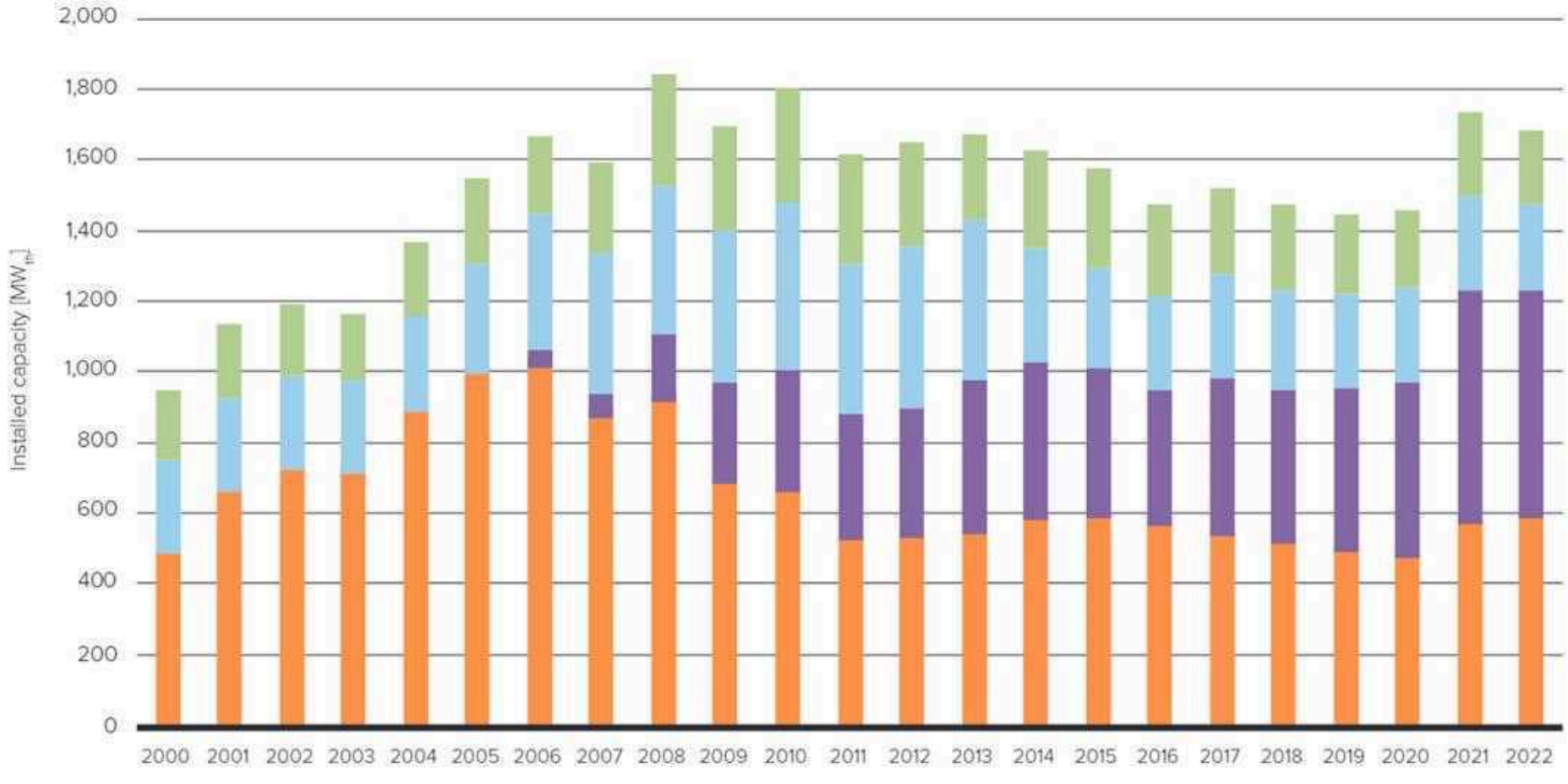

Figure 47: Global market development of unglazed water collectors from 2000 to 2022

从人均琉璃集热器安装量的市场渗透率可以看出，2014 年至 2016 年，中国市场出现了大幅下滑。年装机容量从 2000 年的每千人 3.5 千瓦上升到 2013 年的每千人 32.2 千瓦，然后下降到 2022 年的每千人 10.6 千瓦。

在欧洲，市场渗透率在 2008 年达到顶峰，为每千名居民 5.9 千瓦。2009 年至 2013 年间的下降趋势似乎从 2014 年起趋于稳定，到 2022 年达到每千名居民 2.7 千瓦。

丹麦耶灵太阳能区域供热
照片SavoSolar / 欧洲太阳能供热公司

6.8 2000 年至 2022 年无釉集热器的市场发展情况

2022 年，无釉水集热器的新增装机容量为 1.7 千兆瓦，占太阳能光热总装机容量的 7.4%（图 34）。与2021年相比，由于巴西（-3%）和澳大利亚（-7.9%）的减少，市场略微下降了-3.0%。第二大市场美国的市场则有所增长（+3.8%）。

2022 年无釉集热器最重要的市场是美国（587 兆瓦）、巴西（644 兆瓦）和澳大利亚（245 兆瓦）。墨西哥的无釉集热器安装量为 79 兆瓦，南非为 29 兆瓦。这些国家的无釉集热器安装量占全球无釉集热器安装量的 94%。瑞士（2.2 兆瓦）、西班牙（1.4 兆瓦）和荷兰（1.8 兆瓦）也报告了 2022 年的无釉集热器安装情况。

美国的无釉集热器市场在 2006 年达到顶峰（1.01 千兆瓦），此后减少了约一半（2019 年为 0.47 千兆瓦）。不过，由于巴西市场于 2007 年进入，全球无釉水收集器的年市场容量几乎保持不变，并于 2021 年达到 0.66 千兆瓦的峰值。澳大利亚自 2010 年以来一直面临市场下滑，目前是无釉集热器的第三大市场，仅次于美国和巴西。

2000 - 2022 年无釉集热器的年装机容量

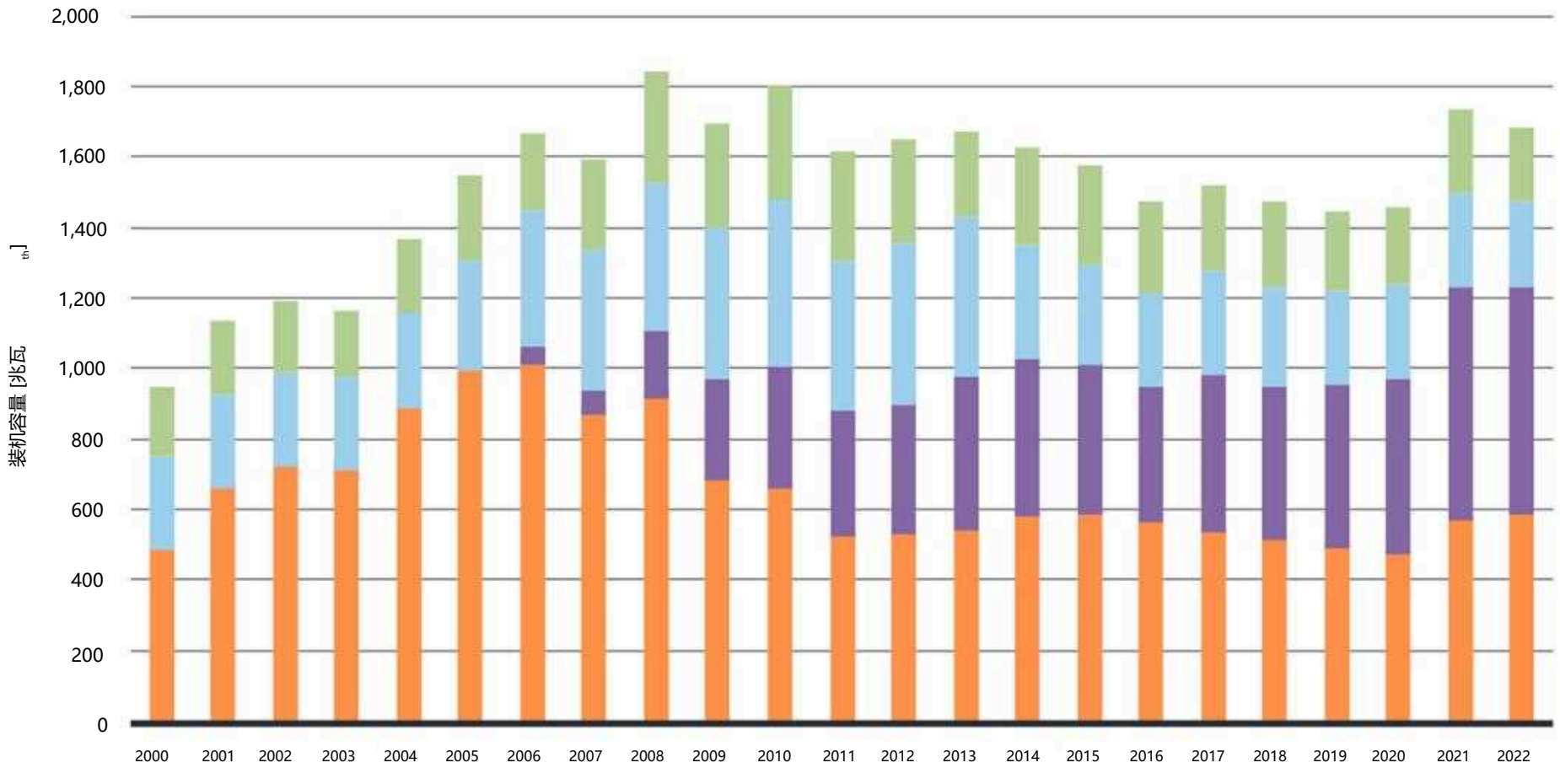

图 47：2000 年至 2022 年无釉集热器的全球市场发展情况

7 Contribution to the energy supply and CO_2 reduction in 2022

This section reports on the total installed glazed and unglazed water collectors' contribution to the thermal energy supply and CO_2 reduction.

At the end of 2022 in the 72 recorded countries, the annual collector yield of all water-based solar thermal systems for the simulated applications (swimming pool, DHW for single-family houses, DHW for multi-family houses, and solar combi-systems) is 443 TWh (= 1,594 PJ). This corresponds to a final energy savings equivalent to 47.6 million tons of oil and 150.7 million tons of CO_2. The calculated number of solar thermal systems in operation is around 122 million (Table 13). Therefore, the CO_2 emissions saved by the thermal solar systems in operation is about 150.7 million t/a or 3.6 times the CO_2 emissions of Switzerland (2022).[50]

The basis for these calculations is the total glazed and unglazed water collector area in operation in each country, as shown in Table 10. The 0.9 GW_{th} contribution of the total installed air collector capacity in operation in 2022 is omitted from the calculation due to its small 0.2% share of the total installed collector capacity.

The results are based on calculations using the simulation tool, T-SOL expert 4.5, www.valentin-software.comfor each country. For the simulations, different types of collectors and applications and characteristic climatic conditions are considered for each country. A more detailed description of the methodology can be found in the appendix (see Chapter 9).

Table 13 summarizes the calculated annual collector yields and the corresponding oil equivalents and CO_2 reductions of all water-based solar thermal systems in 2022.

[50] https://www.bafu.admin.ch/bafu/de/home/themen/klima/inkuerze.html

* Total capacity in operation refers to the year 2014
** Total capacity in operation refers to the year 2015
*** Total capacity in operation refers to the year 2009
**** Total capacity in operation refers to the year 2016
\+ Total capacity in operation refers to the year 2020
++ Calculated based on 0% growth 2022
+++ New in ed. 2024

7 本节介绍了已安装的有玻璃和无玻璃集热器对热能供应和二氧化碳减排的贡献。

对
能源供应
和二氧化碳减排
2022年

到 2022 年底，在 72 个记录在案的国家中，所有水基太阳能热系统的模拟应用（游泳池、单户住宅的热水、多户住宅的热水和太阳能组合系统）的年集热器产量为 443 太瓦时（= 1594 PJ）。这相当于最终节约了 4760 万吨石油和 1.507 亿吨二氧化碳。经计算，运行中的太阳能热系统数量约为 1.22 亿个（表 13）。因此，运行中的太阳能热系统节省的二氧化碳排放量约为 1.507 亿吨/年，是瑞士（2022 年）二氧化碳排放量的 3.6 倍。

如表 10 所示，这些计算的基础是各国运行中的有玻璃和无玻璃集热器总面积。0

由于 2022 年运行的空气集热器总装机容量仅占总装机容量的 0.2%，因此计算中省略了 9 千兆瓦。

结果基于使用模拟工具 T-SOL expert 4.5 进行的计算，www.valentinsoftware.comfor。在模拟过程中，考虑了每个国家不同类型的集热器和应用以及不同的气候条件。更详细的方法说明见附录（见第 9 章）。

表 13 总结了计算得出的 2022 年所有水基太阳能热系统的年集热器产量以及相应的油当量和二氧化碳减排量。

[50] https://www.bafu.admin.ch/bafu/de/home/themen/klima/inkuerze.html

* 运行中的总容量
指 2014 年
** 运行中的总容量指 2015 年
*** 运行总容量指 2009 年
**** 运行中的总容量指 2016 年
+ 运行中的总容量指 2020 年
++ 按 0% 增长率计算 2022 年
+++ 2024 年版新内容

Table 13: Calculated annual collector yield and corresponding oil equivalent and CO_2 reduction of glazed and unglazed water collectors in operation by the end of 2022

Country/Region/ Economy	Energy calculation ALL Water based systems						
	YIELD - Total						
	Total collector area [m^2]	Total capacity [MW_{th}]	Calculated number of systems	Collector yield [GWh/a]	Collector yield [TJ/a]	Energy savings [t_{oe}/a]	CO_2 reduction [t_{CO2e}/a]
Albania	329,485	231	30,702	230	828	24,728	78,265
Argentina	504,445	353	72,214	335	1,207	36,037	114,057
Australia	9,494,000	6,646	1,188,757	5,775	20,791	620,734	1,964,624
Austria	4,607,016	3,225	495,850	1,910	6,875	205,259	649,644
Barbados+	258,192	181	59,797	227	817	24,400	77,226
Belgium	770,000	539	132,090	305	1,097	32,742	103,629
Bhutan	824	0.6	138	0.6	2	62	195
Botswana++	20,075	14	3,279	19	68	2,023	6,402
Brazil	22,191,721	15,534	6,036,473	13,850	49,860	1,488,596	4,711,405
Bulgaria	220,788	155	40,264	111	398	11,897	37,653
Burkina Faso+	4,681	3	296	4	16	469	1,484
Canada	819,000	573	32,252	343	1,233	36,821	116,540
Chile	443,003	310	141,910	311	1,121	33,467	105,923
China	566,187,921	396,332	81,059,237	309,937	1,115,774	33,312,259	105,433,299
Croatia	288,701	202	52,649	148	532	15,871	50,231
Cyprus	885,210	620	386,801	787	2,832	84,556	267,619
Czech Republic	1,079,006	755	98,260	370	1,333	39,793	125,946
Denmark	1,814,453	1,270	108,477	757	2,726	81,385	257,584
Estonia	23,103	16	4,213	9	34	1,014	3,210
Finland	88,886	62	13,908	35	125	3,721	11,778
France (mainland)	2,366,856	1,657	494,232	1,156	4,160	124,208	393,120
France (overseas)	1,227,217	859	287,611	996	3,587	107,101	338,976
Germany	22,576,697	15,804	2,666,131	9,211	33,161	990,035	3,133,460
Ghana++	7,678	5	402	7	25	744	2,354
Greece	5,422,000	3,795	1,517,572	3,850	13,859	413,761	1,309,554
Hungary	391,899	274	54,413	183	658	19,632	62,136
India	19,259,079	13,481	8,717,275	16,746	60,286	1,799,876	5,696,607
Ireland	416,875	292	96,479	175	628	18,760	59,374
Israel++	5,087,434	3,561	1,682,448	4,756	17,123	511,220	1,618,012
Italy	5,380,166	3,766	972,566	3,319	11,950	356,765	1,129,162
Japan	2,682,758	1,878	645,916	1,549	5,575	166,458	526,839
Jordan*	1,260,506	882	223,109	1,194	4,297	128,286	406,026
Kenya++	477,521	334	108,278	406	1,462	43,653	138,162
Latvia	43,062	30	7,853	19	67	1,999	6,327
Lebanon	909,071	636	151,914	764	2,750	82,103	259,856
Lesotho	6,472	5	1,848	6	21	613	1,940
Lithuania	25,491	18	4,649	11	39	1,167	3,693
Luxembourg	74,980	52	13,674	32	116	3,467	10,974
Malta	76,711	54	30,684	67	240	7,156	22,648
Mauritius**	132,793	93	88,529	113	408	12,183	38,558
Mexico	5,932,707	4,153	740,135	3,495	12,583	375,666	1,188,982
Morocco++	1,038,000	727	145,789	895	3,221	96,168	304,370
Mozambique	4,313	3	628	3	13	376	1,189
Namibia	62,669	44	7,561	57	204	6,090	19,276
Nepal+++	300,000	210	144,095	243	873	26,065	82,495
Netherlands	662,360	464	146,308	267	960	28,654	90,690
New Zealand***	159,645	112	33,595	100	359	10,708	33,889
Nigeria+	12,648	9	4,836	11	40	1,192	3,773
North Macedonia	145,036	102	33,314	90	324	9,681	30,641
Norway	42,775	30	2,132	16	57	1,692	5,356
Palestinian Territories	1,980,900	1,387	708,103	1,877	6,756	201,693	638,359
Poland	3,405,690	2,384	440,810	1,364	4,911	146,616	464,038
Portugal	1,547,185	1,083	281,288	1,196	4,306	128,562	406,899
Romania	265,409	186	48,354	149	537	16,027	50,727
Russia	88,271	62	16,407	38	138	4,107	13,000
Senegal+	9,824	7	2,448	10	34	1,029	3,258
Slovakia	208,210	146	26,561	99	355	10,589	33,514
Slovenia	151,670	106	23,703	64	229	6,844	21,661
South Africa	2,785,885	1,950	722,797	2,076	7,472	223,084	706,060
South Korea	1,932,096	1,352	446,134	1,006	3,621	108,104	342,151
Spain	4,998,250	3,499	597,527	3,505	12,616	376,671	1,192,164
Sweden	504,515	353	36,201	182	656	19,591	62,005
Switzerland	1,708,200	1,196	222,135	690	2,485	74,190	234,811
Chinese Taipei+	1,815,055	1,271	360,690	1,108	3,988	119,050	376,793
Thailand****	157,536	110	36,288	133	478	14,262	45,138
Tunisia	1,252,601	877	368,117	1,124	4,045	120,770	382,238
Turkey	27,346,597	19,143	6,317,064	24,533	88,320	2,636,870	8,345,694
United Kingdom	935,627	655	146,800	331	1,192	35,579	112,608
United States	26,063,441	18,244	403,637	10,978	39,520	1,179,903	3,734,393
Uruguay	117,431	82	24,489	79	285	8,498	26,898
Zimbabwe	120,036	84	48,765	102	368	10,990	34,784
Other (5% of world market excluding China)	10,390,827	7,274	1,544,680	5,650	20,339	607,234	1,921,897
TOTAL	**774,004,464**	**541,803**	**122,245,349**	**442,854**	**1,594,273**	**47,598,193**	**150,648,281**

表 13：到 2022 年底运行的有釉和无釉集热器的计算年集热器产量及相应的油当量和二氧化碳减排量

国家/地区/经济	能源计算 ALL 水基系统						
	产量 - 总计						
	总计集水区 [m²]	总容量 [MW][I]	计算数量系统	收藏家产量 [GWh/a]	收藏家产量 [TJ/a]	能源储蓄 [t /a]	CO 减少 [t /a]
阿尔巴尼亚	329,485	231	30,702	230	828	24,728	78,265
阿根廷	504,445	353	72,214	335	1,207	36,037	114,057
澳大利亚	9,494,000	6,646	1,188,757	5,775	20,791	620,734	1,964,624
奥地利	4,607,016	3,225	495,850	1,910	6,875	205,259	649,644
巴巴多斯+	258,192	181	59,797	227	817	24,400	77,226
比利时	770,000	539	132,090	305	1,097	32,742	103,629
不丹	824	0.6	138	0.6	2	62	195
博茨瓦纳++	20,075	14	3,279	19	68	2,023	6,402
巴西	22,191,721	15,534	6,036,473	13,850	49,860	1,488,596	4,711,405
保加利亚	220,788	155	40,264	111	398	11,897	37,653
布基纳法索+	4,681	3	296	4	16	469	1,484
加拿大	819,000	573	32,252	343	1,233	36,821	116,540
智利	443,003	310	141,910	311	1,121	33,467	105,923
中国	566,187,921	396,332	81,059,237	309,937	1,115,774	33,312,259	105,433,299
克罗地亚	288,701	202	52,649	148	532	15,871	50,231
塞浦路斯	885,210	620	386,801	787	2,832	84,556	267,619
捷克共和国	1,079,006	755	98,260	370	1,333	39,793	125,946
丹麦	1,814,453	1,270	108,477	757	2,726	81,385	257,584
爱沙尼亚	23,103	16	4,213	9	34	1,014	3,210
芬兰	88,886	62	13,908	35	125	3,721	11,778
法国（本土）	2,366,856	1,657	494,232	1,156	4,160	124,208	393,120
法国（海外）	1,227,217	859	287,611	996	3,587	107,101	338,976
德国	22,576,697	15,804	2,666,131	9,211	33,161	990,035	3,133,460
加纳++	7,678	5	402	7	25	744	2,354
希腊	5,422,000	3,795	1,517,572	3,850	13,859	413,761	1,309,554
匈牙利	391,899	274	54,413	183	658	19,632	62,136
印度	19,259,079	13,481	8,717,275	16,746	60,286	1,799,876	5,696,607
爱尔兰	416,875	292	96,479	175	628	18,760	59,374
以色列++	5,087,434	3,561	1,682,448	4,756	17,123	511,220	1,618,012
意大利	5,380,166	3,766	972,566	3,319	11,950	356,765	1,129,162
日本	2,682,758	1,878	645,916	1,549	5,575	166,458	526,839
约旦*	1,260,506	882	223,109	1,194	4,297	128,286	406,026
肯尼亚++++。	477,521	334	108,278	406	1,462	43,653	138,162
拉脱维亚	43,062	30	7,853	19	67	1,999	6,327
黎巴嫩	909,071	636	151,914	764	2,750	82,103	259,856
莱索托	6,472	5	1,848	6	21	613	1,940
立陶宛	25,491	18	4,649	11	39	1,167	3,693
卢森堡	74,980	52	13,674	32	116	3,467	10,974
马耳他	76,711	54	30,684	67	240	7,156	22,648
毛里求斯**	132,793	93	88,529	113	408	12,183	38,558
墨西哥	5,932,707	4,153	740,135	3,495	12,583	375,666	1,188,982
摩洛哥++	1,038,000	727	145,789	895	3,221	96,168	304,370
莫桑比克	4,313	3	628	3	13	376	1,189
纳米比亚	62,669	44	7,561	57	204	6,090	19,276
尼泊尔+++	300,000	210	144,095	243	873	26,065	82,495
荷兰	662,360	464	146,308	267	960	28,654	90,690
新西兰***	159,645	112	33,595	100	359	10,708	33,889
尼日利亚+	12,648	9	4,836	11	40	1,192	3,773
北马其顿	145,036	102	33,314	90	324	9,681	30,641
挪威	42,775	30	2,132	16	57	1,692	5,356
巴勒斯坦领土	1,980,900	1,387	708,103	1,877	6,756	201,693	638,359
波兰	3,405,690	2,384	440,810	1,364	4,911	146,616	464,038
葡萄牙	1,547,185	1,083	281,288	1,196	4,306	128,562	406,899
罗马尼亚	265,409	186	48,354	149	537	16,027	50,727
俄罗斯	88,271	62	16,407	38	138	4,107	13,000
塞内加尔+	9,824	7	2,448	10	34	1,029	3,258
斯洛伐克	208,210	146	26,561	99	355	10,589	33,514
斯洛文尼亚	151,670	106	23,703	64	229	6,844	21,661
南非	2,785,885	1,950	722,797	2,076	7,472	223,084	706,060
韩国	1,932,096	1,352	446,134	1,006	3,621	108,104	342,151
西班牙	4,998,250	3,499	597,527	3,505	12,616	376,671	1,192,164
瑞典	504,515	353	36,201	182	656	19,591	62,005
瑞士	1,708,200	1,196	222,135	690	2,485	74,190	234,811
中国台北+	1,815,055	1,271	360,690	1,108	3,988	119,050	376,793
泰国****	157,536	110	36,288	133	478	14,262	45,138
突尼斯	1,252,601	877	368,117	1,124	4,045	120,770	382,238
土耳其	27,346,597	19,143	6,317,064	24,533	88,320	2,636,870	8,345,694
英国	935,627	655	146,800	331	1,192	35,579	112,608
美国	26,063,441	18,244	403,637	10,978	39,520	1,179,903	3,734,393
乌拉圭	117,431	82	24,489	79	285	8,498	26,898
津巴布韦	120,036	84	48,765	102	368	10,990	34,784
其他（占世界的 5 市场不包括中国）	10,390,827	7,274	1,544,680	5,650	20,339	607,234	1,921,897
总计	774,004,464	541,803	122,245,349	442,854	1,594,273	47,598,193	150,648,281

8 Distribution of systems by type and application in 2022

The use of solar thermal energy varies significantly from region to region. It can be roughly distinguished by the type of solar thermal collector used (unglazed water collectors, evacuated tube collectors, flat plate collectors, glazed and unglazed air collectors, concentrating collectors), the type of system operation (pumped solar thermal systems, thermosiphon systems), and the main type of application (swimming pool heating, domestic hot water preparation, space heating, others such as heating of industrial processes, solar district heating or solar thermal cooling).

8.1 Distribution by type of solar thermal collector

In terms of the total water collector capacity worldwide in 2022, evacuated tube collectors dominated with 68.7% of the cumulated capacity in operation (Figure 48) and a share of 58.7% of the newly installed capacity (Figure 49). Worldwide, flat plate collectors accounted for about 25.3% of the cumulated capacity in operation (Figure 48) and a 33.8% share of the newly installed capacity (Figure 49). Unglazed water collectors accounted for 6% of the cumulated water collectors installed worldwide and 7.4% of the newly installed capacity.

In China, evacuated tube collectors are dominant. In North America, Australia, and Sub- Sahara Africa (mainly driven by South Africa), unglazed water collectors are the collector type with the largest share. In the other regions, flat plate collectors are dominant.

8 分布情况按类型划分的系统和应用2022年

不同地区对太阳能热能的利用差别很大。大致可根据所使用的太阳能集热器类型（无釉水集热器、抽真空管集热器、平板集热器、有釉和无釉空气集热器、聚光集热器）、系统运行类型（抽水式太阳能热系统、热虹吸系统）和主要应用类型（游泳池加热、穹顶热水制备、空间加热，其他如工业过程加热、太阳能区域加热或太阳能热制冷）来区分。

8.1 按太阳能集热器类型分列的分布情况

就 2022 年全球集热器总容量而言，排空管集热器占主导地位，占累计运行容量的 68.7%（图 48），占新安装容量的 58.7%（图 49）。在全球范围内，平板集热器约占 25 .3%（图 48），占新安装容量的 33.8%（图 49）。无釉面集热器占全球累计安装集热器的 6%，占新安装容量的 7.4%。

在中国，真空管集热器占主导地位。在北美、澳大利亚和撒哈拉以南非洲地区（主要是南非），无釉水集热器是份额最大的集热器类型。在其他地区，平板集热器占主导地位。

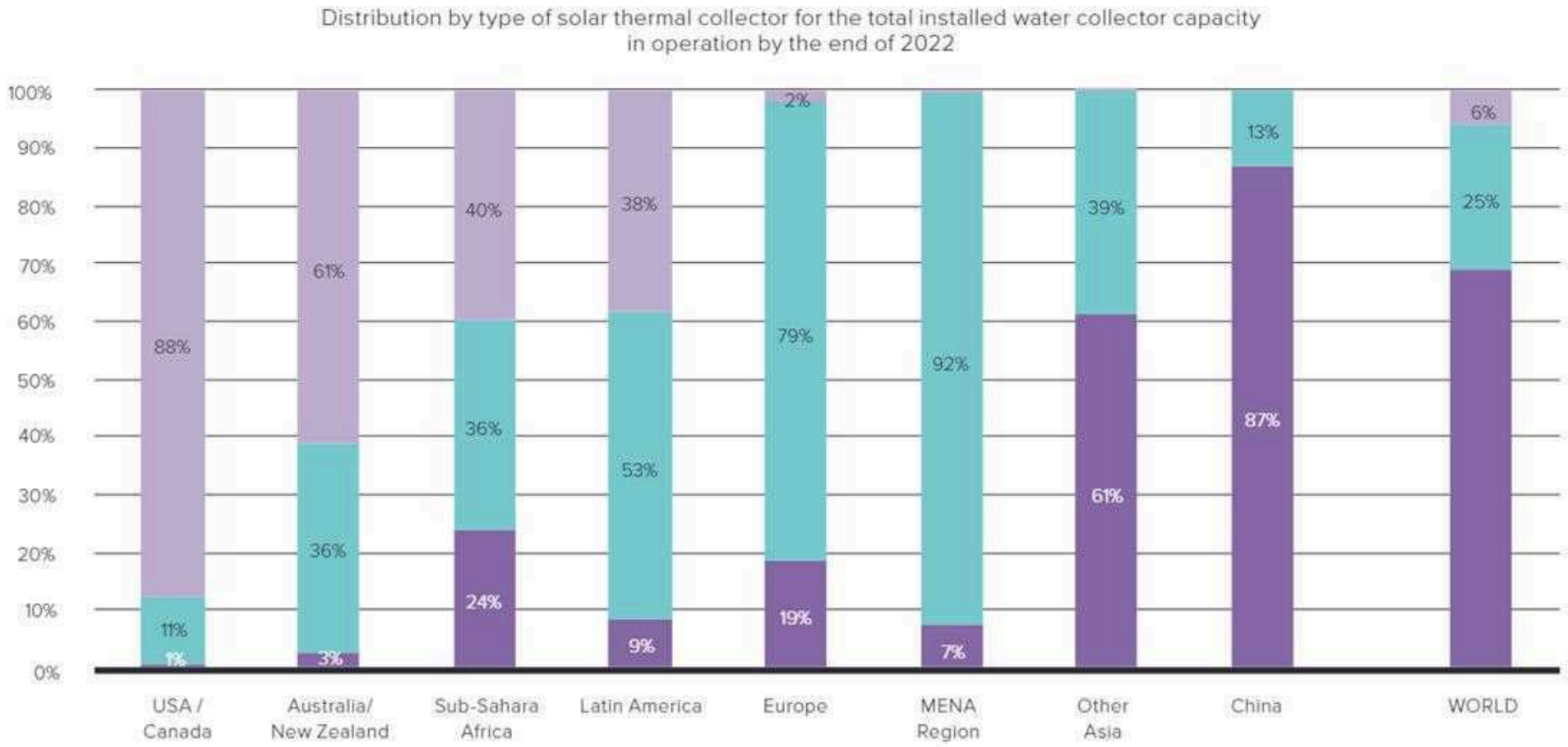

Figure 48: Distribution by type of solar thermal collector for the total installed water collector capacity in operation by the end of 2022

Sub-Sahara Africa: Botswana, Burkina Faso, Cape Verde, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Other Asia: Bhutan, India, Japan, South Korea, Chinese Taipei, Thailand
Latin America and the Caribbean: Argentina, Barbados, Brazil, Chile, Mexico, Panama, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

The distribution of the newly installed collector area is shown below. Evacuated tube collectors are dominant in China, Other Asia, driven by development in India, and with an increasing share in Sub-Sahara Africa.

Unglazed collectors are dominant in North America and Australia. Flat plate collectors are dominant in Latin America, Europe, and the MENA region.

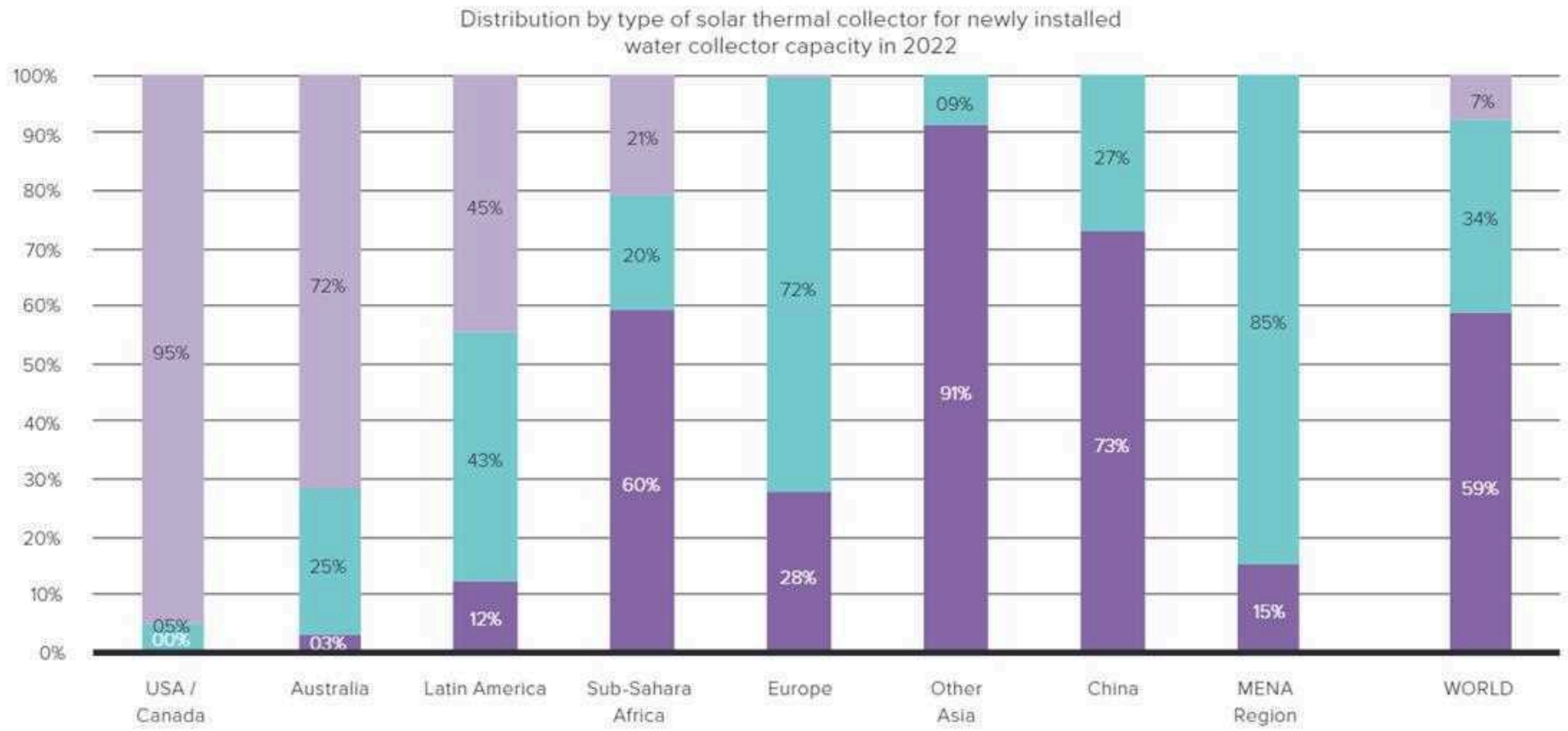

Figure 49: Distribution by type of solar thermal collector for newly installed water collector capacity in 2022

Sub-Sahara Africa: Botswana, Burkina Faso, Cape Verde, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Other Asia: Bhutan, India, Japan, South Korea, Chinese Taipei, Thailand
Latin America: Argentina, Brazil, Chile, Mexico, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

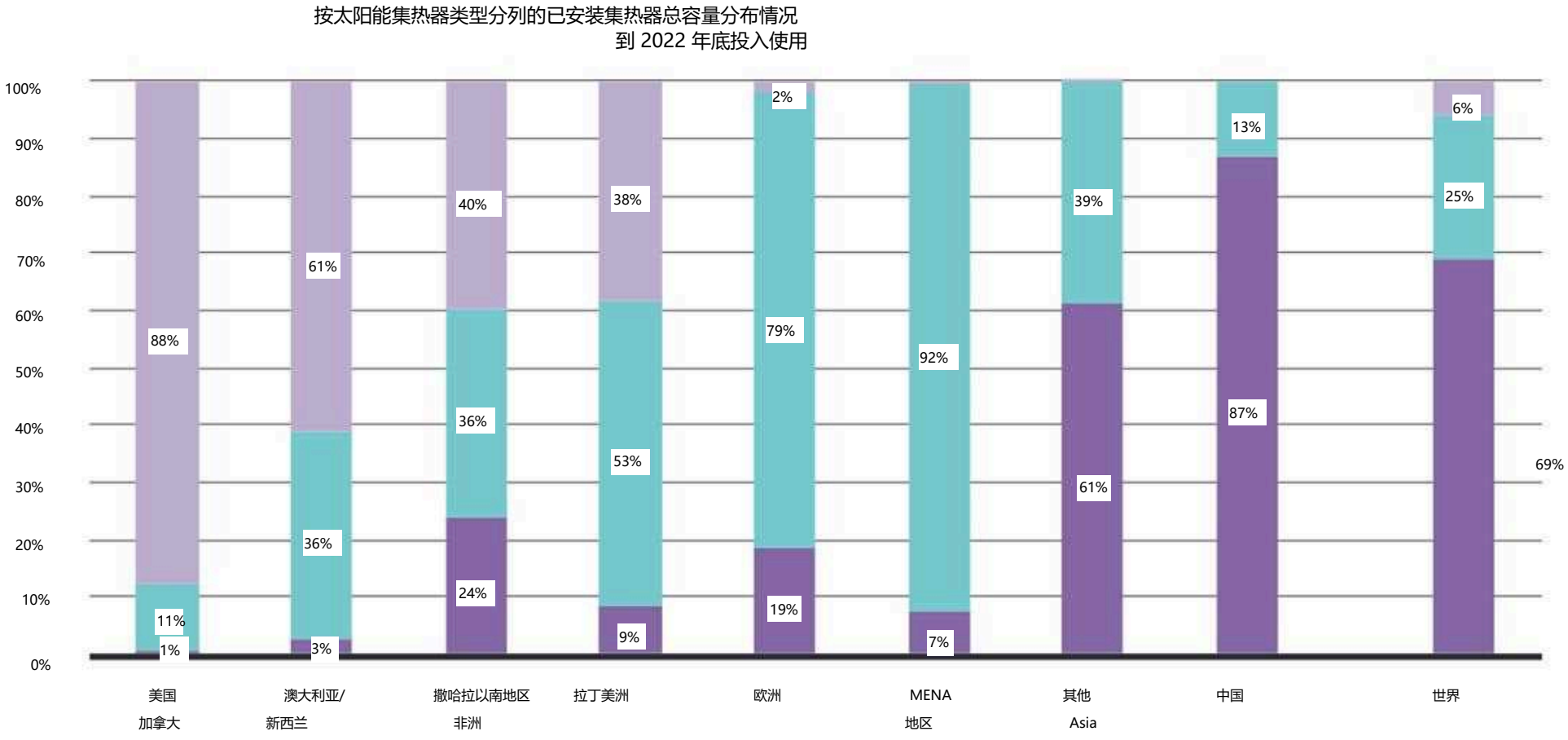

图 48：按太阳能集热器类型分列的到 2022 年底投入使用的集热器总装机容量分布图

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中东和北非国家：以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土、突尼斯

新安装的集热器面积分布如下。蒸发管式集热器在中国和其他亚洲地区占主导地位，印度的发展带动了这一趋势，撒哈拉以南非洲地区的份额也在不断增加。

无釉集热器在北美和澳大利亚占主导地位。平板集热器在拉丁美洲、欧洲和中东及北非地区占主导地位。

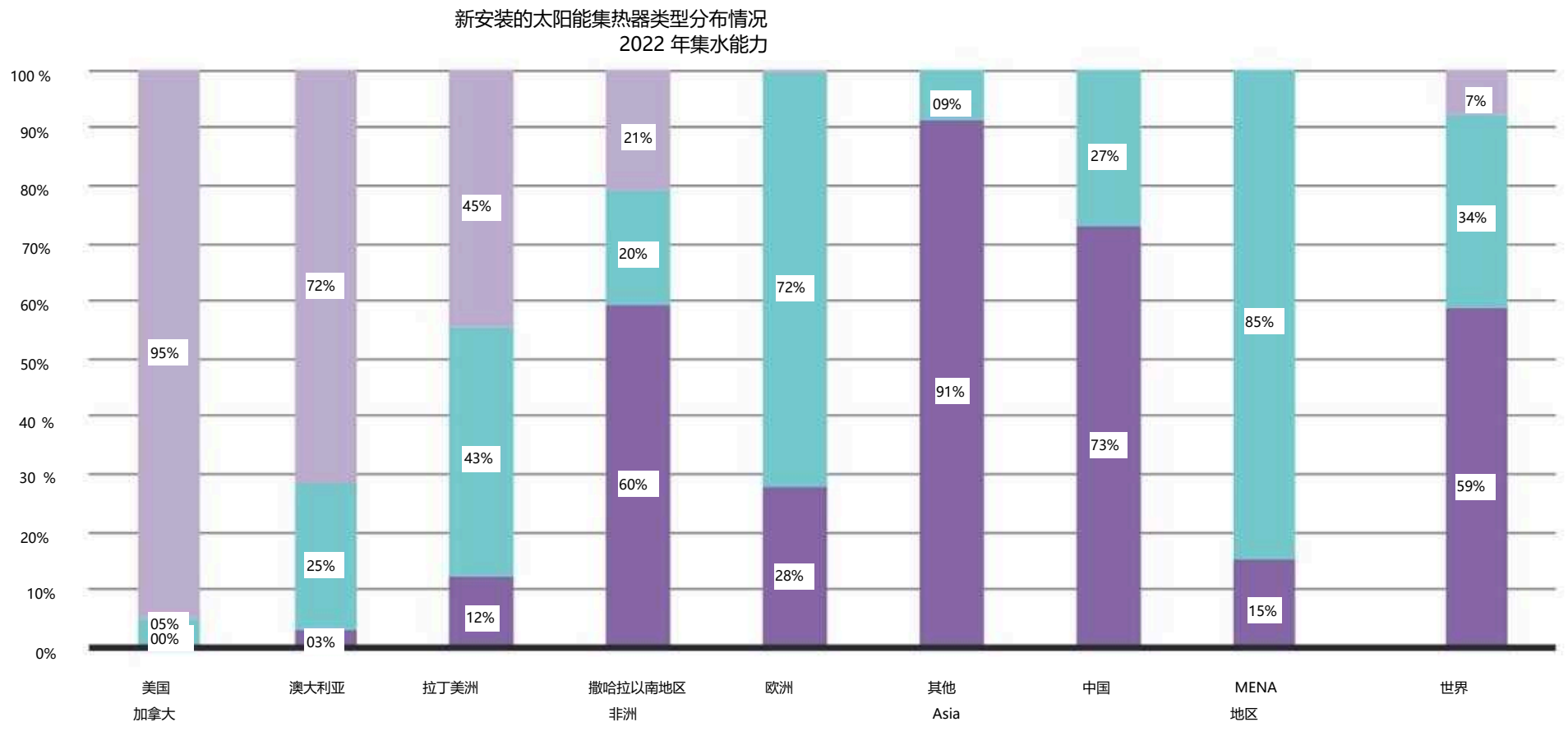

图 49：2022 年按太阳能集热器类型划分的新安装集热器容量分布图

撒哈拉以南非洲博茨瓦纳、布基纳法索、佛得角、肯尼亚、莱索托、毛里求斯、莫桑比克、纳米比亚、尼日利 亚、塞内加尔、南非、津巴布韦 其他亚洲：不丹、印度、日本、韩国、中国台北、泰国 拉丁美洲：阿根廷、巴西、智利、墨西哥、乌拉圭 欧洲：欧盟 27 国、阿尔巴尼亚、北马其顿、挪威、俄罗斯、瑞士、土耳其、英国 中东和北非国家：以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土、突尼斯

Photo: Werner Weiss, AEE INTEC

8.2 Distribution by type of system

Worldwide, about 55% of all solar thermal systems installed are thermosiphon systems; the rest are pumped solar heating systems (Figure 50).

Similar to the distribution by type of solar thermal collector in total numbers, the Chinese market influenced the overall figures the most. 28% of all newly installed systems in China were thermosiphon systems, while pumped systems accounted for 72%. The share of thermosiphon systems has decreased in China for several years (Figure 51).

In general, thermosiphon systems are more common in warm climates, such as in Africa, South America, southern Europe, and the MENA countries. In these regions, thermosiphon systems are more often equipped with flat plate collectors, while in China, the typical thermosiphon system for domestic hot water preparation is equipped with evacuated tubes.

照片维尔纳-魏斯，AEE INTEC

8.2 系统类型分布

在全世界安装的所有太阳能热系统中，约 55% 是热虹吸系统，其余的是抽水太阳能供热系统（图 50）。

与太阳能热利用系统类型在总量上的分布相似，中国市场对总体数据的影响最大。在中国新安装的所有系统中，28%是热虹吸系统，而泵送系统占 72%。几年来，热虹吸系统在中国所占的比例有所下降（图 51）。

一般来说，热虹吸系统在气候温暖的地区更为常见，如非洲、南美洲、南欧和中东及北非国家。在这些地区，热虹吸系统多采用平板集热器，而在中国，用于制备生活热水的典型热虹吸系统则采用真空管。

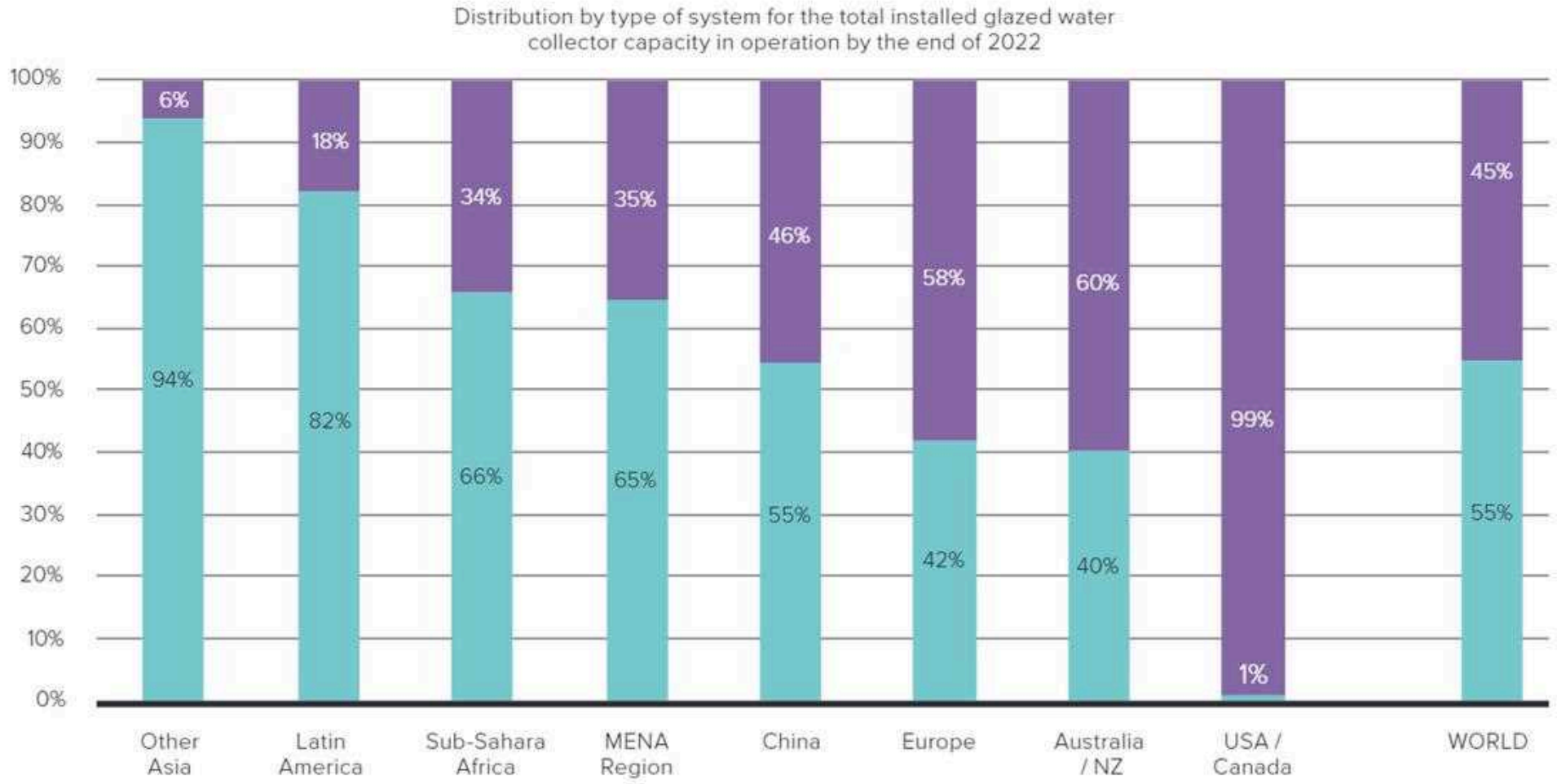

Figure 50: Distribution by type of system for the total installed glazed water collector capacity in operation by the end of 2022

Sub-Sahara Africa: Botswana, Burkina Faso, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Other Asia: Bhutan, India, Japan, South Korea, Chinese Taipei Thailand
Latin America and the Caribbean: Argentina, Barbados, Brazil, Chile, Mexico, Panama, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

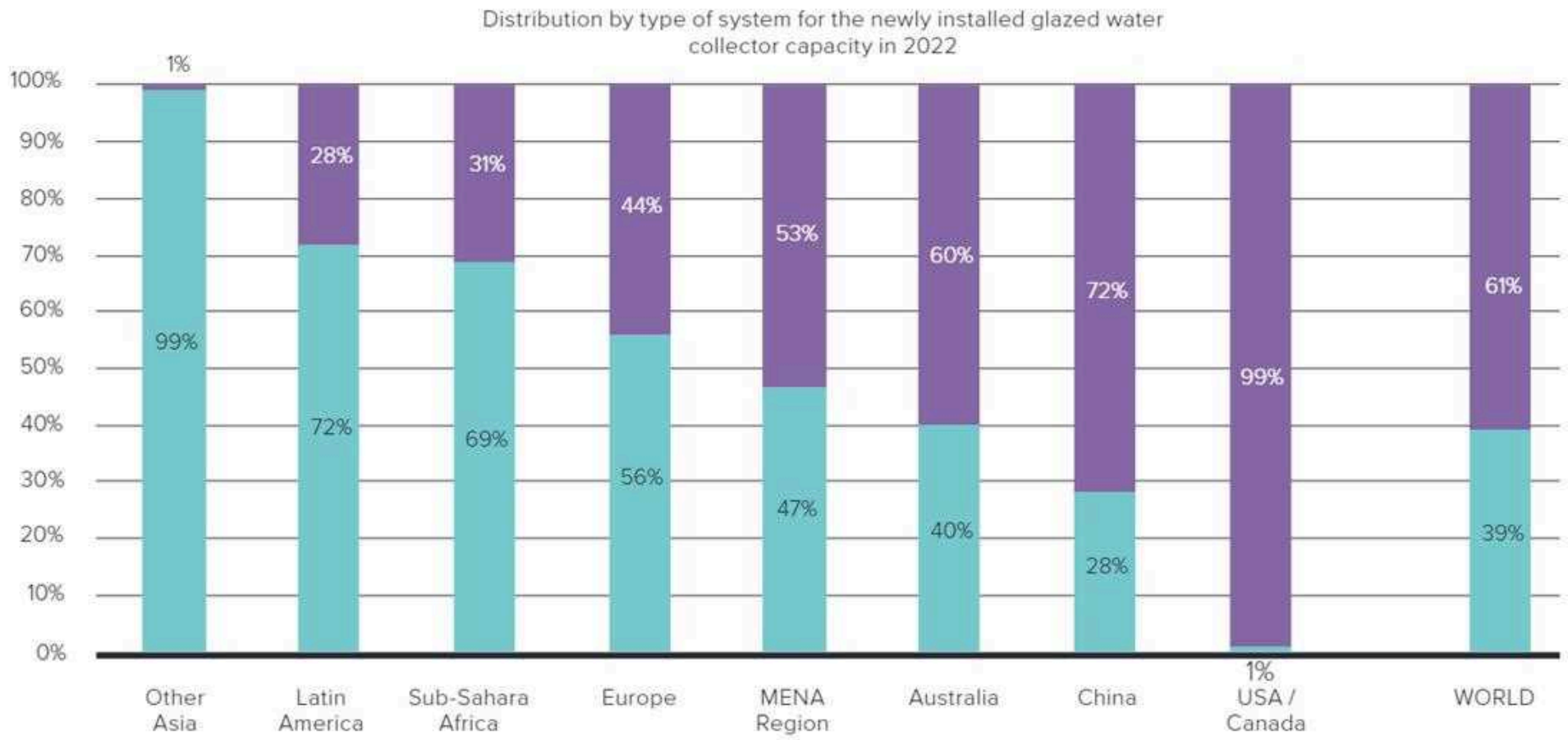

Figure 51: Distribution by type of system for the newly installed glazed water collector capacity in 2022

Sub-Sahara Africa: Botswana, Burkina Faso, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Senegal, South Africa, Zimbabwe
Other Asia: Bhutan, India, Japan, South Korea, Chinese Taipei, Thailand
Latin America and the Caribbean: Argentina, Barbados, Brazil, Chile, Mexico, Panama, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

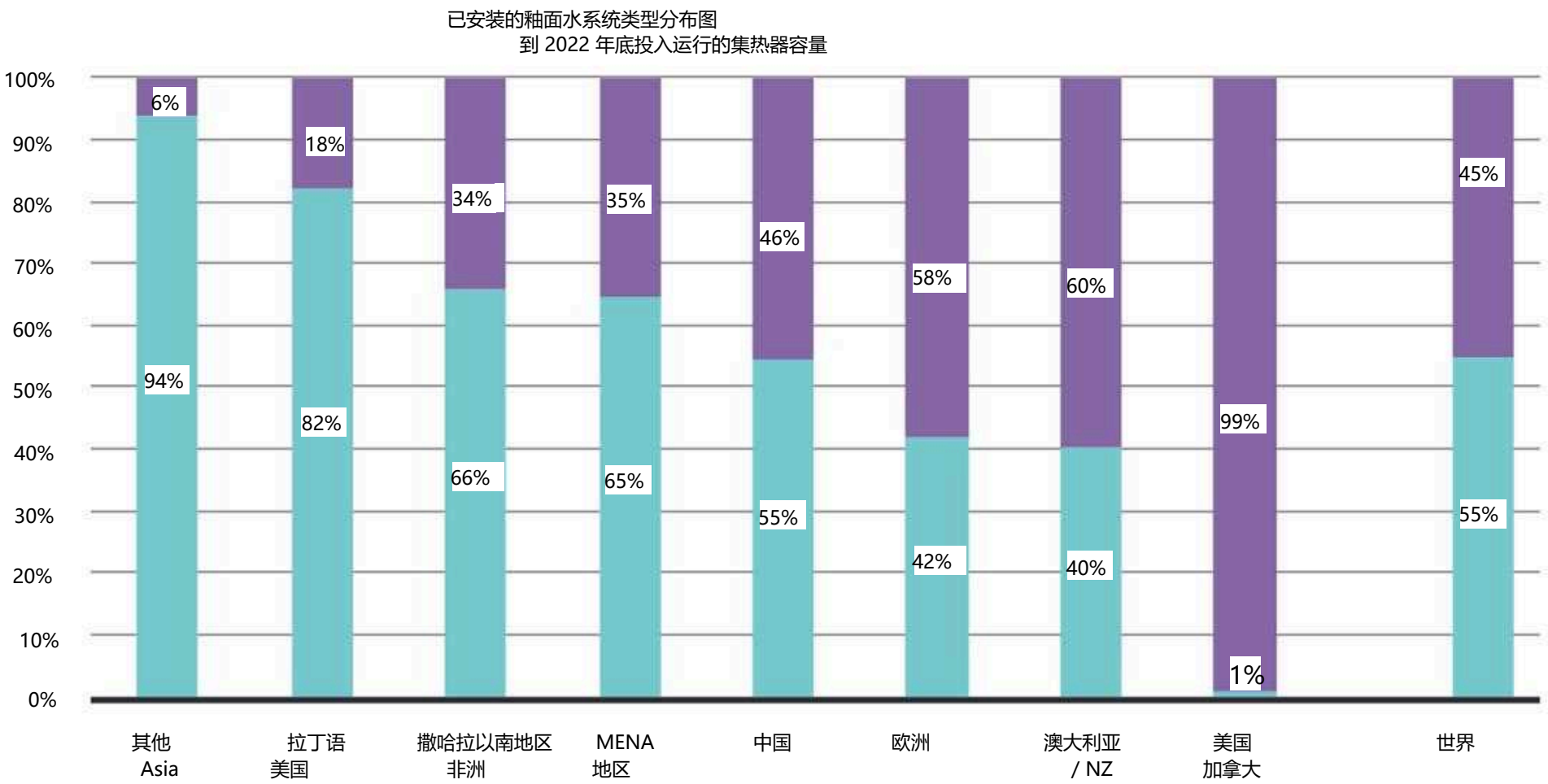

图 50：到 2022 年底，按系统类型划分的已安装运行的玻璃水收集器总容量分布情况

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中东和北非国家：以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土、突尼斯

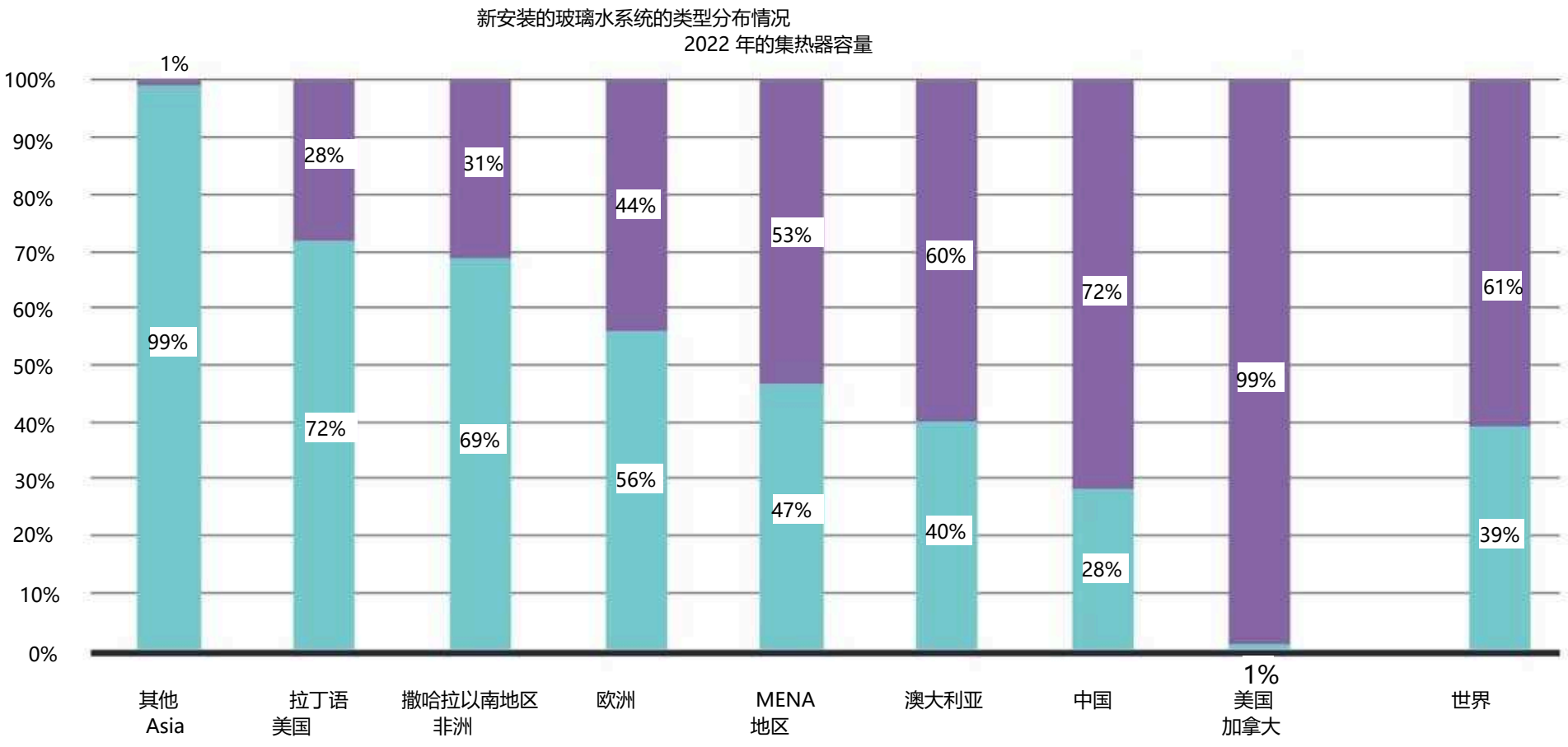

图 51：2022 年新安装的玻璃水收集器的系统类型分布图

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中东和北非国家：以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土、突尼斯

8.3 Distribution by type of application

The newly installed water-based solar thermal collector area in 2022 is 32.4 million, corresponding to 22.7 GW_{th} of thermal peak capacity (Table 11).

The largest share of the collector area installed in 2022 was for large domestic hot water systems for multi-family houses, tourism, and the public sector. Domestic hot water systems in single-family homes accounted for about 36% of installations in 2022. The share of swimming pool heating was 7.5%. The share for other applications, such as solar district heating and solar process heat, is about 2% globally (Figure 52).

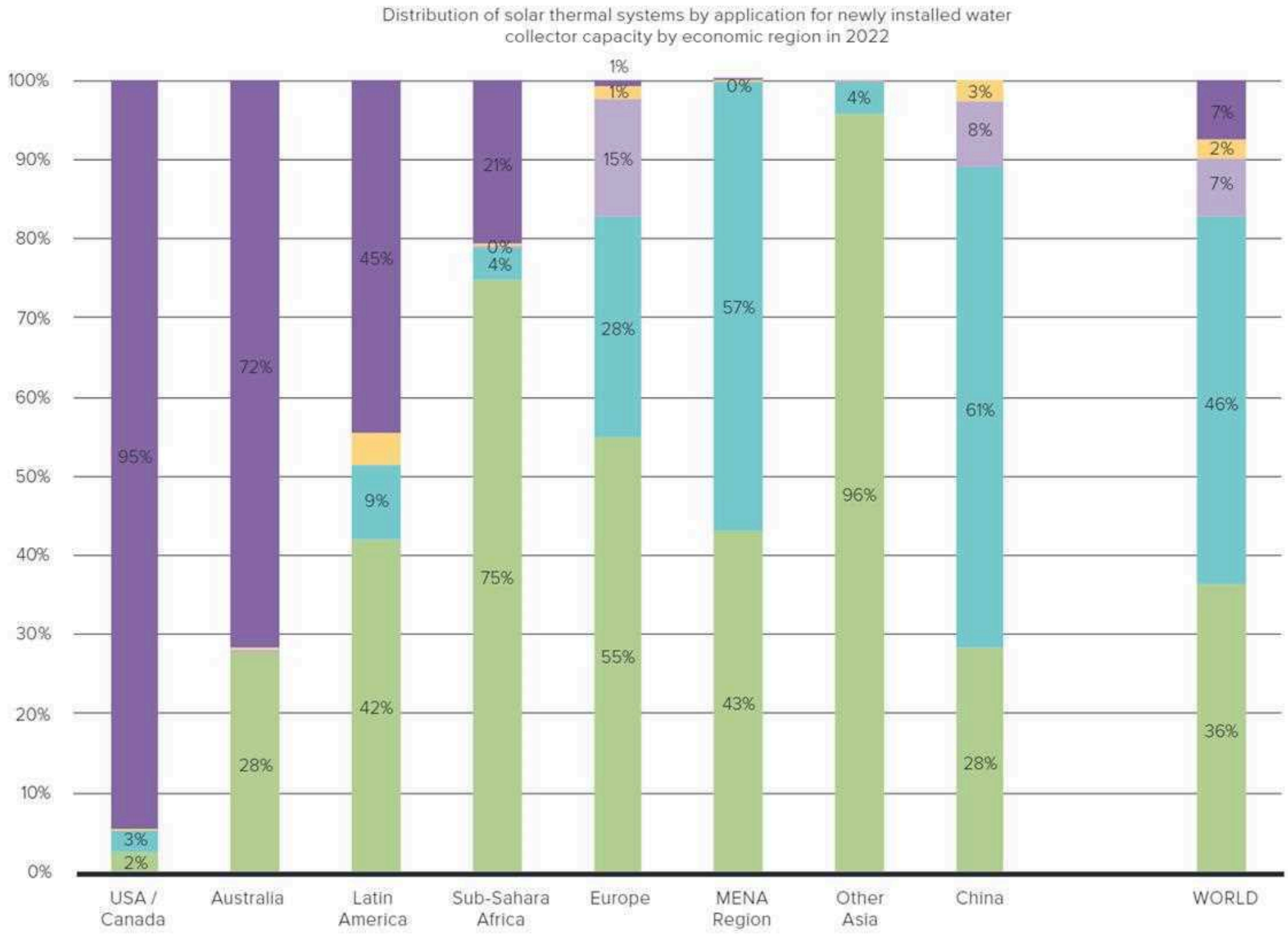

Figure 52: Distribution of solar thermal systems by application for newly installed water collector capacity by economic region in 2022

Sub-Sahara Africa: Botswana, Burkina Faso, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zimbabwe
Other Asia: Bhutan, India, Japan, South Korea, Chinese Taipei, Thailand
Latin America and the Caribbean: Barbados, Brazil, Chile, Mexico, Panama, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

8.3 按应用类型分布

2022 年新安装的水基太阳能集热器面积为 3240 万平方米，相当于 22.7 千兆瓦的热峰值容量（表 11）。

在 2022 年安装的集热器面积中，用于多户住宅、旅游业和公共部门的大型生活热水系统所占比例最大。2022 年，单户住宅的生活热水系统约占安装量的 36%。游泳池供暖占 7.5%。其他应用，如太阳能区域供热和太阳能工艺加热，在全球所占份额约为 2%（图 52）。

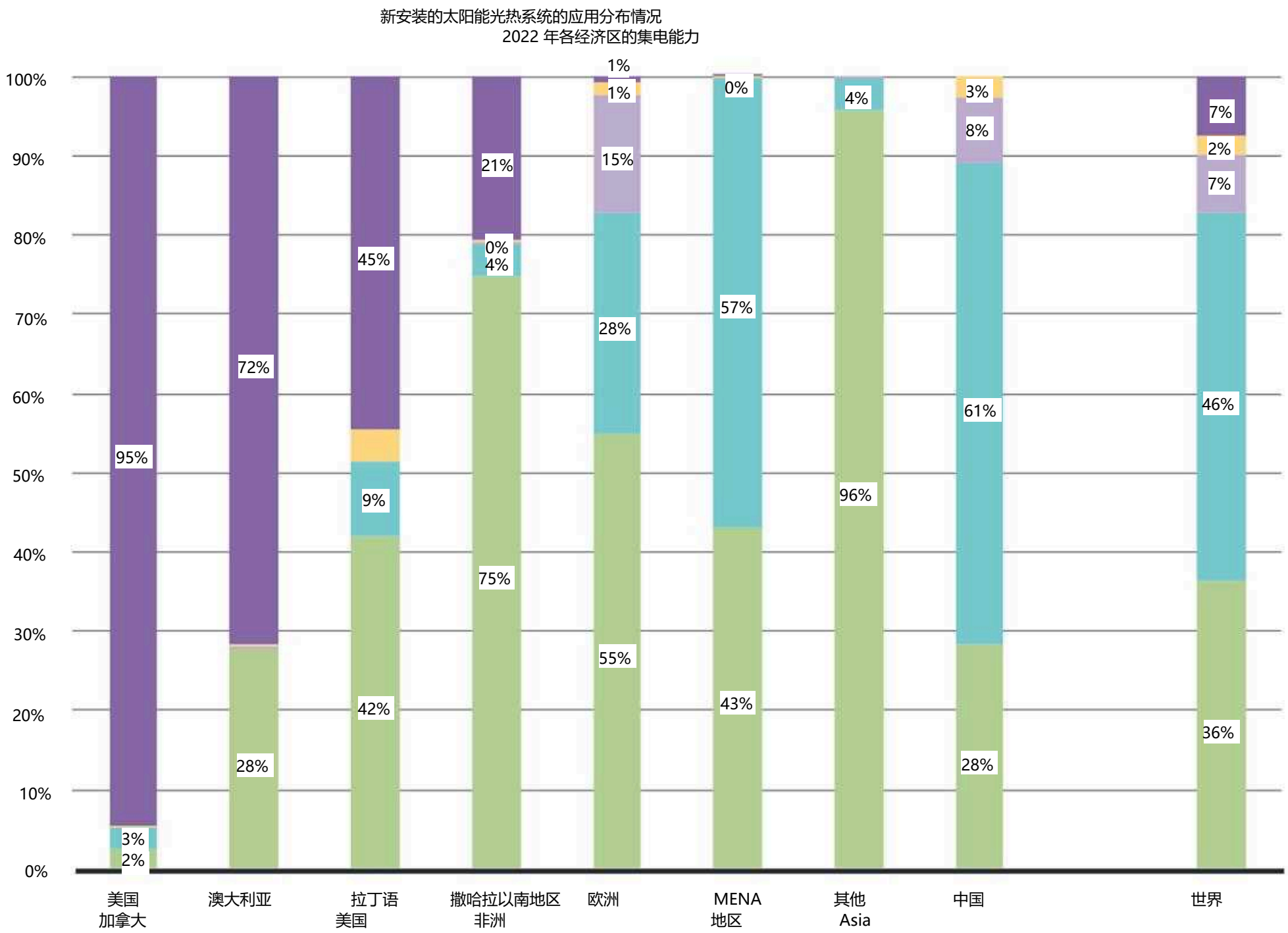

图 52：2022 年各经济区新安装集热器容量的太阳能热系统应用分布图

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9 Appendix

9.1 Methodological approach for the energy calculation

To obtain the energy yield of solar thermal systems, the oil equivalent saved, and the CO_2 emissions avoided, the following procedure was used:

- Only water collectors were used in the calculations (unglazed water collectors, flat plate collectors, and evacuated tube collectors). Air collectors were not included.
- For each country, the cumulated water collector area was allocated to the following applications (based on available country market data):
  - » Solar thermal systems for swimming pool heating
  - » Solar domestic hot water systems for single-family houses,
  - » Solar domestic hot water systems for multi-family houses, tourism sector, and public sector (to simplify the analysis, solar district heating systems, solar process heat, and solar cooling applications were included), and
  - » Solar combisystems for domestic hot water and space heating for single- and multi-family houses.
- Reference systems were defined for each country and each type of application (pumped or thermosiphon solar thermal system).
- The number of systems per country was determined from the share of collector area for each application and the collector area defined for the reference system.

Apart from the reference applications and systems mentioned above, reference collectors and reference climates were determined. Based on these boundary conditions, simulations were performed using T-Sol [T-Sol, Version 4.5 Expert, Valentin Energiesoftware, www.valentin-software.com], and gross solar yields for each country and each system were obtained. The gross solar yields refer to the solar collector heat output and do not include heat losses through transmission piping or storage heat losses.[51]

The amount of final energy saved is calculated from the gross solar yields considering a utilization rate of the auxiliary heating system of 0.8. Final energy savings are expressed in tons of oil equivalent (toe): 1 toe = 11,630 kWh.

Finally, the CO_2 emissions avoided by the different solar thermal applications are quoted as kilograms of carbon dioxide equivalent ($kgCO_2e$) per ton of oil equivalent: 1 toe = 3.165 t CO_2e[52]. The emission factor only accounts for direct emissions.

To obtain an exact statement about the CO_2emissions avoided, the substituted energy medium would have to be ascertained for each country. Since this could only be done in a very detailed survey, which goes beyond the scope of this report, the energy savings and the CO_2 emissions avoided relate to fuel oil. It is obvious that not all solar thermal systems just replace systems running on oil. This represents a simplification since gas, coal, biomass, or electricity can be used as an energy source for the auxiliary heating system instead of oil.

The following tables describe the key data of the reference systems in the different countries, the location of the reference climate used, and the share of the total collector area in use for the respective application.[53] Furthermore, a hydraulic scheme is shown for each reference system.

[51] Using gross solar yields for the energy calculations is based on a definition for Renewable Heat by EUROSTAT and IEA SHC. In editions of this report prior to 2011 solar yields calculated included heat losses through transmission piping and hence energy savings considered were about 5 to 15 % less depending on the system, the application and the climate.
[52] Source: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020 (07/05/2024)
[53] For some countries no specific estimations are available concerning shares by type of application. In these cases shares given in previous reports were used for the calculation.

9 附录

9.1 能源计算方法

为了获得太阳能热系统的能量产出、节省的石油当量和避免的二氧化碳排放量，我们采用了以下程序：

- 计算中只使用了水收集器（无釉水收集器、平板收集器和真空管收集器）。空气集热器不包括在内。

- 对于每个国家，累计集水池面积被分配给以下用途（基于现有的国家市场数据）：
  "用于游泳池加热的太阳能热系统"，"用于单户住宅的太阳能生活热水系统"，"用于多户住宅、旅游部门和公共部门的太阳能生活热水系统（为简化分析，还包括太阳能区域供热系统、太阳能工艺热和太阳能制冷应用）"，以及 "用于单户和多户住宅的生活热水和空间供热的太阳能组合系统"。

对每个国家和每种应用类型（泵式或热虹吸式太阳能热系统）进行了分析。

确定了每个国家的系统数量

根据每个应用的集热器面积份额和参考系统定义的集热器面积得出。

除上述参考应用和系统外，还确定了参考集热器和参考气候。根据这些边界条件，使用 T-Sol [T-Sol, Version 4.5 Expert, Valentin Energiesoftware, www.valentin-software.com]进行了模拟，得出了每个国家和每个系统的总太阳能产量。总太阳能产量指的是太阳能集热器的热输出，不包括通过传输管道的热损失或储存热损失。

最终节约的能源量是根据总太阳能产量计算得出的，考虑到辅助加热系统的利用率为 0.8。最终节约的能源以吨油当量 (toe) 表示：1 油当量 = 11,630 千瓦时。

最后，不同光热应用所避免的二氧化碳排放量以每吨油当量的二氧化碳千克当量（kgCOe）表示：1 toe = 3.165 t COe。排放系数只考虑直接排放。

为了准确说明所避免的二氧化碳排放量，必须确定每个国家的替代能源介质。由于这只能通过非常详细的调查来完成，超出了本报告的范围，因此节省的能源和避免的二氧化碳排放量与燃油有关。显然，并非所有太阳能热利用系统都能取代燃油系统。这只是一种简化，因为燃气、煤炭、生物质或电力都可以代替燃油作为辅助加热系统的能源。

下表介绍了不同国家参考系统的主要数据、所用参考气候的位置以及在各自应用中使用的集热器总面积所占的比例。此外，还列出了每个参考系统的水力方案。

[51] 使用总太阳能产量进行能源计算是基于欧洲统计局（EUROSTAT）和国际能源机构（IEA SHC）对可再生能源供热的定义。在本报告 2011 年之前的版本中，计算的太阳能发电量包括通过传输管道的热损失，因此根据系统、应用和气候的不同，考虑的节能效果要低 5% 至 15%。

[52] 来源：https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020 (07/05/2024)

[53] 有些国家没有按应用类型对份额进行具体估算。在这些情况下，计算时使用了以前报告中提供的份额。

9.1.1
Reference systems for swimming pool heating

Table 14 refers to the total capacity of water collectors in operation used for swimming pool heating as reported from each country by the end of 2022.

Table 14: Solar thermal systems for swimming pool heating in 2022

Energy calculation Swimming Pool						
Swimming Pool - Total						
Country/Region/ Economy	Reference climate	Horizontal irradiation [kWh/m²*a]	Total collector area (swimming pool) [m²]	Collector area per system [m²]	Total number of systems [-]	Specific solar yield (swimming pool) [kWh/m²*a]
Argentina	Buenos Aires	1,748	156,378	200	782	470
Australia	Sydney	1,674	5,895,774	35	168,451	466
Austria	Graz	1,126	171,445	200	857	283
Belgium	Brussels	971	46,970	200	235	261
Brazil	Brasília	1,793	8,743,538	32	273,236	375
Canada	Montreal	1,351	704,340	25	28,174	386
Chile	Santiago de Chile	1,753	89,496	15	5,966	471
Cyprus	Nicosia	1,886	2,390	200	12	507
Czech Republic	Praha	998	476,921	200	2,385	303
Finland	Helsinki	948	12,800	200	64	256
France (mainland)	Paris	1,112	71,006	200	355	328
Germany	Würzburg	1,091	532,810	30	17,760	314
Hungary	Budapest	1,199	19,203	10	1,920	344
Israel	Jerusalem	2,198	40,699	200	203	568
Italy	Bologna	1,419	48,421	200	242	442
Jordan	Amman	2,145	6,661	200	33	578
Mexico	Mexico City	1,706	1,868,803	200	9,344	311
Mozambique	Maputo	1,910	233	40	6	514
Namibia	Windhoek	2,363	1,817	40	45	636
Netherlands	Amsterdam	999	88,520	40	2,213	272
New Zealand	Wellington	1,401	7,024	200	35	378
Norway	Oslo	971	1,788	200	9	316
Poland	Warsaw	1,024	68,114	200	341	276
Portugal	Lisbon	1,686	3,094	200	15	421
Romania	Bucharest	1,324	265	200	1	356
Russia	Moscow	996	335	200	2	268
Slovakia	Bratislava	1,214	1,041	200	5	327
Slovenia	Ljubjana	1,115	1,517	200	8	
South Africa	Johannesburg	2,075	1,448,660	40	36,217	505
Spain	Madrid	1,644	169,941	200	850	472
Sweden	Gothenburg	934	165,481	200	827	295
Switzerland	Zürich	1,094	174,236	200	871	277
Chinese Taipei	Taipei	1,372	1,997	175	11	319
United Kingdom	London	943	355,538	200	1,778	254
United States	LA, Indianapolis	1,646	22,883,701	200	114,419	387
Uruguay	Montevideo	1,534	470		2	413
Other (5%)		1,449	2,329,616	200	11,648	392
TOTAL			46,591,044		679,322	
AVG		1,427		152		382

Figure 53 shows the hydraulic scheme of the swimming pool reference system used for the simulations of the solar energy yields.

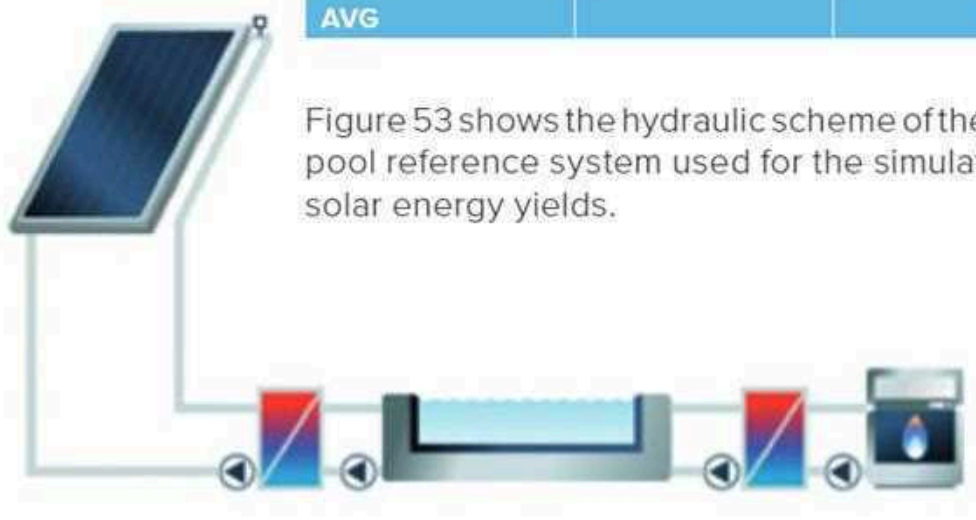

Figure 53: Hydraulic scheme of the swimming pool reference system

9.1.2
Reference systems for domestic hot water preparation in single-family houses

The information in Table 15 refers to the total capacity of water collectors used for domestic hot water heating in single-family houses at the end of 2022, as reported by each country.

9.1.1 游泳池加热参考系统

表 14 列出了各国报告的截至 2022 年底用于泳池加热的水收集器总容量。

表 14：2022 年用于游泳池加热的太阳能热系统

能源计算 游泳池						
游泳池 - 总计						
国家/地区/经济	参考资料气候	横向照射 [千瓦时/平方米*a]	收集器总数 area (游泳池) [m²]	集电区 每个系统 [m²]	总数 系统 [-]	特定太阳能屈服 (游泳池) [千瓦时/平方米*a]
阿根廷	布宜诺斯艾利斯	1,748	156,378	200	782	470
澳大利亚 悉尼		1,674	5,895,774	35	168,451	466
奥地利	Graz	1,126	171,445	200	857	283
比利时	布鲁塞尔	971	46,970	200	235	261
巴西	巴西利亚	1,793	8,743,538	32	273,236	375
加拿大	蒙特利尔	1,351	704,340	25	28,174	386
智利	智利圣地亚哥	1,753	89,496	15	5,966	471
塞浦路斯	尼科西亚	1,886	2,390	200	12	507
捷克共和国	普拉亚	998	476,921	200	2,385	303
芬兰	赫尔辛基	948	12,800	200	64	256
法国（本土）	巴黎	1,112	71,006	200	355	328
德国	维尔茨堡	1,091	532,810	30	17,760	314
匈牙利	布达佩斯	1,199	19,203	10	1,920	344
以色列	耶路撒冷	2,198	40,699	200	203	568
意大利	博洛尼亚	1,419	48,421	200	242	442
约旦	安曼	2,145	6,661	200	33	578
墨西哥	墨西哥城	1,706	1,868,803	200	9,344	311
莫桑比克	马普托	1,910	233	40	6	514
纳米比亚	温得和克	2,363	1,817	40	45	636
荷兰	阿姆斯特丹	999	88,520	40	2,213	272
新西兰	惠灵顿	1,401	7,024	200	35	378
挪威	Oslo	971	1,788	200	9	316
波兰	华沙	1,024	68,114	200	341	276
葡萄牙	里斯本	1,686	3,094	200	15	421
罗马尼亚	布加勒斯特	1,324	265	200	1	356
俄罗斯	莫斯科	996	335	200	2	268
斯洛伐克	布拉迪斯拉发	1,214	1,041	200	5	327
斯洛文尼亚	卢布尔雅那	1,115	1,517	200	8	
南非 约翰内斯堡		2,075	1,448,660	40	36,217	505
西班牙	马德里	1,644	169,941	200	850	472
瑞典	哥德堡	934	165,481	200	827	295
瑞士	苏黎世	1,094	174,236	200	871	277
中国台北	台北	1,372	1,997	175	11	319
英国	伦敦	943	355,538	200	1,778	254
美国洛杉矶，印第安纳波利斯		1,646	22,883,701	200	114,419	387
乌拉圭	蒙得维的亚	1,534	470		2	413
其他 (5%)		1,449	2,329,616	200	11,648	392
总计			46,591,044		679,322	
AVG		1,427		152		382

*表中未列出的国家未报告任何用于游泳池加热的集热器份额。

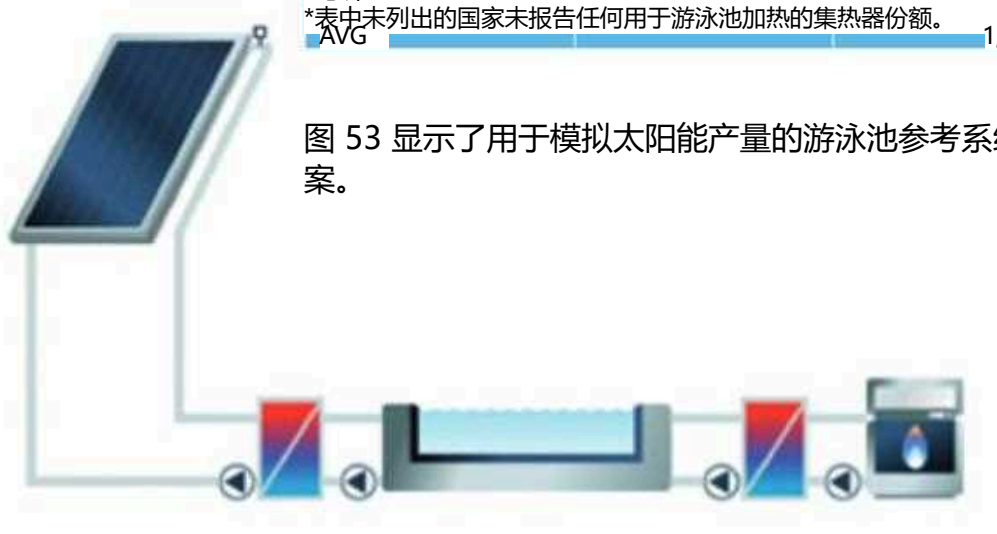

图 53：游泳池参照系统的水力方案

图 53 显示了用于模拟太阳能产量的游泳池参考系统的水力方案。

9.1.2 独户住宅生活热水制备参考系统

表 15 中的信息指的是各国报告的 2022 年底独户住宅用于家庭热水加热的集热器总容量。

Table 15: Solar thermal systems for domestic hot water heating in single-family houses by the end of 2022

Energy calculation DHW-SFH							
DHW-MFH - Total							
Country/Region/ Economy	Reference climate	Horizontal irradiation [kWh/m²*a]	Total collector area (DHW-SFH) [m²]	Collector area per system [m²]	Total number of systems [-]	SSpecific solar yield (DHW-SFH) [kWh/m²*a]	Type of system
Albania	Tirana	1,604	76,955	3	25,652	713	TS
Argentina	Buenos Aires	1,748	268,393	4	67,098	777	PS
Australia	Sydney	1,674	3,569,744	3.5	1,019,927	844	PS
Austria	Graz	1,126	2,081,759	6	346,960	451	PS
Barbados	Grantley Adams	2,016	237,537	4	59,384	882	TS
Belgium	Brussels	971	470,098	4	117,524	423	PDS / PS
Bhuthan	Thimphu	1,623	371	4	93	721	TS
Botswana	Gaborone	2,161	12,045	4	3,011	961	TS
Brazil	Brasília	1,793	11,460,184	2	5,730,092	809	TS
Bulgaria	Sofia	1,188	143,551	4	35,888	524	PS
Burkina Faso	Ouagadougou	2,212	647	4	162	983	TS
Canada	Montreal	1,351	12,128	6	2,021	556	PS
Chile	Santiago de Chile	1,753	268,487	2	134,243	771	PS
China	Shanghai	1,282	300,079,598	4	75,019,900	592	TS
Croatia	Zagreb	1,212	187,707	4	46,927	539	PS
Cyprus	Nicosia	1,886	767,162	2	383,581	912	TS
Czech Republic	Praha	998	309,037	4.7	65,753	385	PS
Denmark	Copenhagen	989	284,869	4	71,217	454	PS
Estonia	Tallin	960	15,021	4	3,755	432	PS
Finland	Helsinki	948	49,277	4	12,319	441	PS
France (mainland)	Paris	1,112	1,443,782	3.2	451,182	496	PS
France (overseas departments)	"Basse-Terre, Papeete, Saint Pierre (Miquelon), Cayenne, Noumea"	1,834	1,143,766	4	285,942	815	TS
Germany	Würzburg	1,091	9,940,614	5.6	1,775,110	424	PS
Ghana	Accra	2,146	676	4	169	954	TS
Greece	Athens	1,585	3,525,262	2.5	1,410,105	772	TS
Hungary	Budapest	1,199	215,119	5	43,024	473	PS
India	Neu-Delhi	1,961	17,358,208	2	8,679,104	882	TS
Ireland	Dublin	949	375,188	4	93,797	423	PS
Israel	Jerusalem	2,198	946,263	3	315,421	1,024	TS
Italy	Bologna	1,419	3,466,580	4	866,645	661	PS
Japan	Tokyo	1,175	2,538,187	4	634,547	586	TS
Jordan	Amman	2,145	1,003,076	4.6	218,060	986	TS
Kenya	Nairobi	1,931	403,506	4	100,876	859	TS
Latvia	Riga	991	27,998	4	6,999	462	PS
Lebanon	Beirut	1,935	572,715	4	143,179	860	TS
Lesotho	Maseru	2,050	3,002	2	1,501	911	TS
Lithuania	Vilnius	1,001	16,574	4	4,143	450	PS
Luxembourg	Luxembourg	1,037	48,750	4	12,188	450	PS
Malta	Luqa	1,902	76,711	2.5	30,684	868	PS
Mauritius	Port Louis	1,920	132,793	1.5	88,529	854	TS
Mexico	Mexico City	1,706	2,823,969	4	705,992	718	PS
Morocco	Rabat	2,000	540,625	4	135,156	889	TS
Mozambique	Maputo	1,910	2,350	4	588	849	TS
Namibia	Windhoek	2,363	27,383	4	6,846	1,032	TS
Nepal	Kathmandu	1,771	135,000	4	33,750	787	TS
Netherlands	Amsterdam	999	372,370	2.8	132,989	433	PDS / PS
New Zealand	Wellington	1,401	131,287	4	32,822	647	PS
Nigeria	Abuja	2,007	9,043	4	2,261	892	TS
North Macedonia	Skopje	1,381	131,716	4	32,929	627	PS
Norway	Oslo	971	1,486	6	248	430	PS
Palestinian Territories	Jerusalem	2,198	1,031,719	1.5	687,813	977	TS
Poland	Warsaw	1,024	2,401,011	6	400,169	397	PS
Portugal	Lisbon	1,686	1,078,536	4	269,634	804	PS
Romania	Bucharest	1,324	172,390	4	43,098	594	PS
Russia	Moscow	996	63,220	4	15,805	443	PS
Senegal	Dakar	2,197	9,529	4	2,382	977	TS
Slovakia	Bratislava	1,214	134,697	6	22,449	481	PS
Slovenia	Ljubjana	1,115	136,503	6	22,751	424	PS
South Africa	Johannesburg	2,075	1,303,794	1.9	686,207	1,009	TS
South Korea	Seoul	1,161	1,765,900	4	441,475	525	PS
Spain	Madrid	1,644	2,032,972	4	508,243	766	PS
Sweden	Gothenburg	934	35,561	4	8,890	383	PS
Switzerland	Zürich	1,094	1,027,558	5.7	180,273	426	PS
Chinese Teipei	Taipei	1,372	1,715,815	4.8	357,461	616	TS
Thailand	Bangkok	1,765	143,985	4	35,996	854	TS
Tunisia	Tunis	1,808	1,212,142	3.3	367,316	902	TS
Turkey	Antalya	1,795	25,158,869	4	6,289,717	910	TS
United Kingdom	London	943	580,089	4	145,022	415	PS
United States	LA, Indianapolis	1,646	1,539,249	6	256,542	646	PS
Uruguay	Montevideo	1,534	96,293	4	24,073	682	TS
Zimbabwe	Harare	2,017	96,029	2	48,014	854	TS
Other (5% of world market excluding China)		1,433	5,734,217	4	1,433,554	637	
TOTAL			**415,178,645**		**111,637,176**		
AVG		**1,537**		**4**		**686**	

PS: pumped system TS: thermosiphon system PDS: pumped drain back system

表 15：到 2022 年底用于独户住宅生活热水加热的太阳能热系统

DHW-SFH 能源计算							
DHW-MFH - 总计							
国家/地区/经济	参考气候	横向照射 [千瓦时/平方米*a]	收集器总数面积（DHW-SFH） [m²]	集电区每个系统 [m²]	总数系统 [-]	具体太阳能产量 (DHW-SFH) [千瓦时/平方米*a]	Type系统的
阿尔巴尼亚	地拉那	1,604	76,955	3	25,652	713	TS
阿根廷	布宜诺斯艾利斯	1,748	268,393	4	67,098	777	PS
澳大利亚	悉尼	1,674	3,569,744	3.5	1,019,927	844	PS
奥地利	Graz	1,126	2,081,759	6	346,960	451	PS
巴巴多斯	格兰特利-亚当斯	2,016	237,537	4	59,384	882	TS
比利时	布鲁塞尔	971	470,098	4	117,524	423	PDS / PS
布坦	廷布	1,623	371	4	93	721	TS
博茨瓦纳	哈博罗内	2,161	12,045	4	3,011	961	TS
巴西	巴西利亚	1,793	11,460,184	2	5,730,092	809	TS
保加利亚	索菲亚	1,188	143,551	4	35,888	524	PS
布基纳法索 瓦加杜古		2,212	647	4	162	983	TS
加拿大	蒙特利尔	1,351	12,128	6	2,021	556	PS
智利	智利圣地亚哥	1,753	268,487	2	134,243	771	PS
中国	上海	1,282	300,079,598	4	75,019,900	592	TS
克罗地亚	萨格勒布	1,212	187,707	4	46,927	539	PS
塞浦路斯	尼科西亚	1,886	767,162	2	383,581	912	TS
捷克共和国		998	309,037	4.7	65,753	385	PS
丹麦	哥本哈根	989	284,869	4	71,217	454	PS
爱沙尼亚	塔林	960	15,021	4	3,755	432	PS
芬兰	赫尔辛基	948	49,277	4	12,319	441	PS
法国（本土）	巴黎	1,112	1,443,782	3.2	451,182	496	PS
法国（海外部门）	"下特雷岛、帕皮提、圣皮埃尔（密克隆）、卡宴、努美阿"。	1,834	1,143,766	4	285,942	815	TS
德国	维尔茨堡	1,091	9,940,614	5.6	1,775,110	424	PS
加纳	阿克拉	2,146	676	4	169	954	TS
希腊	雅典	1,585	3,525,262	2.5	1,410,105	772	TS
匈牙利	布达佩斯	1,199	215,119	5	43,024	473	PS
印度	新德里	1,961	17,358,208	2	8,679,104	882	TS
爱尔兰	都柏林	949	375,188	4	93,797	423	PS
以色列	耶路撒冷	2,198	946,263	3	315,421	1,024	TS
意大利	博洛尼亚	1,419	3,466,580	4	866,645	661	PS
日本	东京	1,175	2,538,187	4	634,547	586	TS
约旦	安曼	2,145	1,003,076	4.6	218,060	986	TS
肯尼亚	内罗毕	1,931	403,506	4	100,876	859	TS
拉脱维亚	Riga	991	27,998	4	6,999	462	PS
黎巴嫩	贝鲁特	1,935	572,715	4	143,179	860	TS
莱索托	马塞卢	2,050	3,002	2	1,501	911	TS
立陶宛	维尔纽斯	1,001	16,574	4	4,143	450	PS
卢森堡 卢森堡		1,037	48,750	4	12,188	450	PS
马耳他	Luqa	1,902	76,711	2.5	30,684	868	PS
毛里求斯	路易港	1,920	132,793	1.5	88,529	854	TS
墨西哥	墨西哥城	1,706	2,823,969	4	705,992	718	PS
摩洛哥	拉巴特	2,000	540,625	4	135,156	889	TS
莫桑比克 马普托		1,910	2,350	4	588	849	TS
纳米比亚	温得和克	2,363	27,383	4	6,846	1,032	TS
尼泊尔	加德满都	1,771	135,000	4	33,750	787	TS
荷兰 阿姆斯特丹		999	372,370	2.8	132,989	433	PDS / PS
新西兰惠灵顿		1,401	131,287	4	32,822	647	PS
尼日利亚	阿布贾	2,007	9,043	4	2,261	892	TS
北马其顿 斯科普里		1,381	131,716	4	32,929	627	PS
挪威	Oslo	971	1,486	6	248	430	PS
巴勒斯坦领土	耶路撒冷	2,198	1,031,719	1.5	687,813	977	TS
波兰	华沙	1,024	2,401,011	6	400,169	397	PS
葡萄牙	里斯本	1,686	1,078,536	4	269,634	804	PS
罗马尼亚	布加勒斯特	1,324	172,390	4	43,098	594	PS
俄罗斯	莫斯科	996	63,220	4	15,805	443	PS
塞内加尔	达喀尔	2,197	9,529	4	2,382	977	TS
斯洛伐克	布拉迪斯拉发	1,214	134,697	6	22,449	481	PS
斯洛文尼亚	卢布尔雅那	1,115	136,503	6	22,751	424	PS
南非 约翰内斯堡		2,075	1,303,794	1.9	686,207	1,009	TS
韩国首尔		1,161	1,765,900	4	441,475	525	PS
西班牙	马德里	1,644	2,032,972	4	508,243	766	PS
瑞典	哥德堡	934	35,561	4	8,890	383	PS
瑞士 苏黎世		1,094	1,027,558	5.7	180,273	426	PS
中国 台北		1,372	1,715,815	4.8	357,461	616	TS
泰国	曼谷	1,765	143,985	4	35,996	854	TS
突尼斯	突尼斯	1,808	1,212,142	3.3	367,316	902	TS
土耳其	安塔利亚	1,795	25,158,869	4	6,289,717	910	TS
英国伦敦		943	580,089	4	145,022	415	PS
美国洛杉矶，印第安纳波利斯		1,646	1,539,249	6	256,542	646	PS
乌拉圭	蒙得维的亚	1,534	96,293	4	24,073	682	TS
津巴布韦 哈拉雷		2,017	96,029	2	48,014	854	TS
其他（占世界的 5 市场不包括中国）		1,433	5,734,217	4	1,433,554	637	
总计			415,178,645		111,637,176		
AVG		1,537		4		686	

PS：泵送系统　　TS：热虹吸系统　　PDS：抽水回流系统

Figure 54 shows the hydraulic scheme used for the energy calculation for all pumped solar thermal systems and Figure 56 refers to the thermosiphon systems.

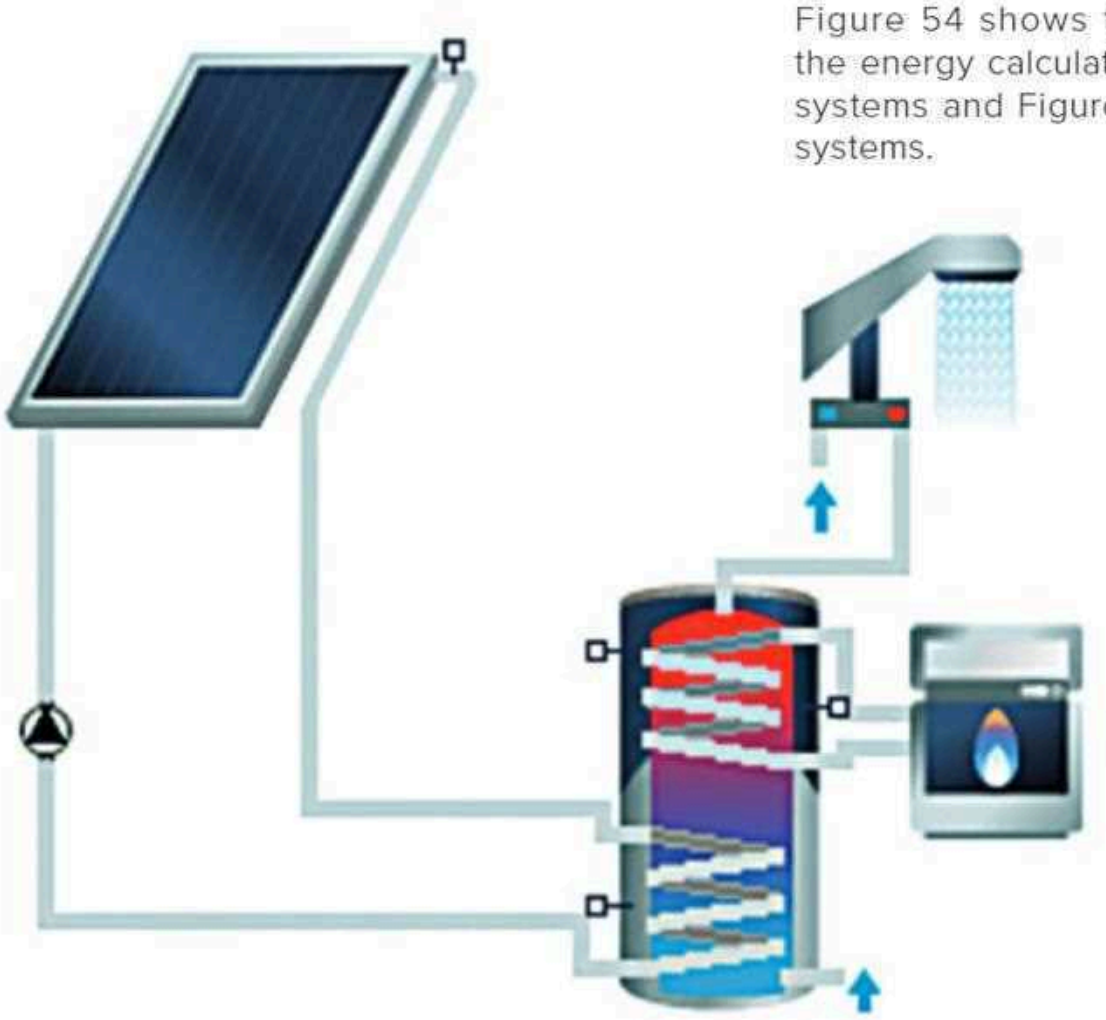

Figure 54: Hydraulic scheme of the domestic hot water pumped reference system for single-family houses

Figure 55: Hydraulic scheme of the domestic hot water thermosiphon reference system for single-family houses

For the Chinese thermosiphon systems, the reference system above was used, but instead of a flat plate collector, as shown in Figure 55, a representative Chinese vacuum tube collector was used for the simulation.

9.1.3
Reference systems for domestic hot water preparation in multi-family houses

The information in Table 16 refers to the total capacity of water collectors used for domestic hot water heating in multi-family houses at the end of 2022, as reported by each country.

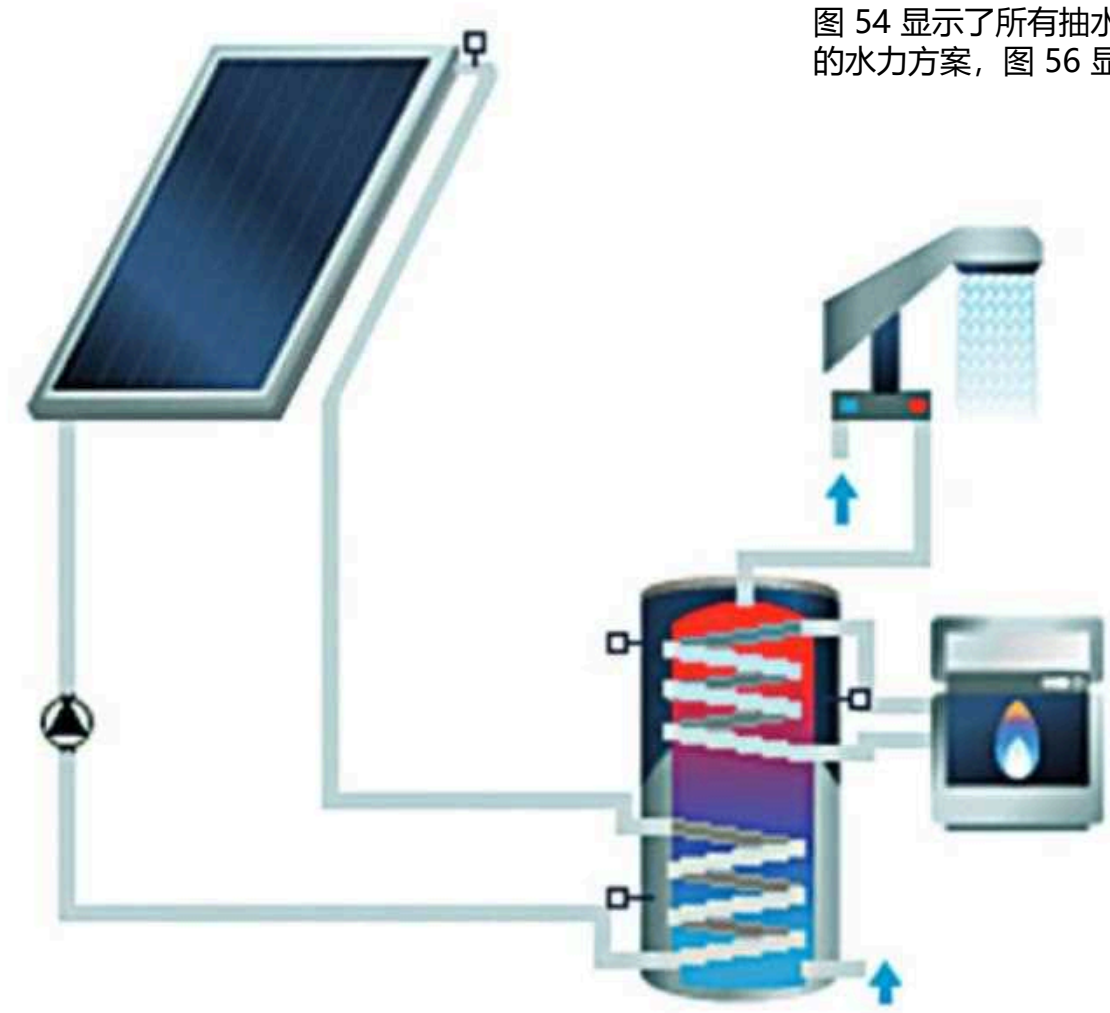

图 54：独户住宅用抽水式家用热水参考系统的水力方案

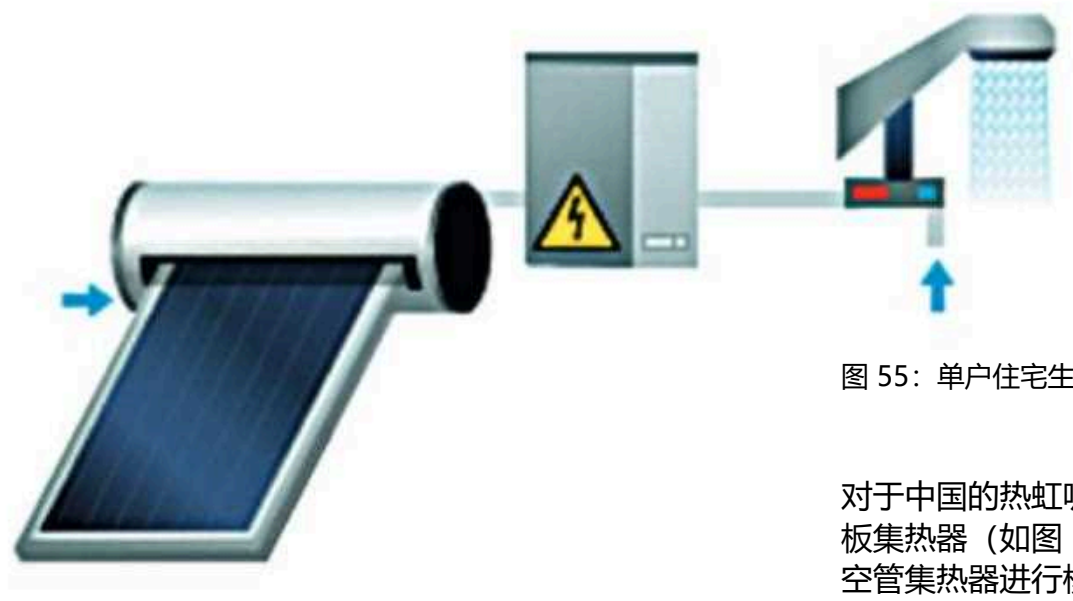

图 55：单户住宅生活热水热虹吸参考系统的水力方案

图 54 显示了所有抽水式太阳能热利用系统的能量计算所采用的水力方案，图 56 显示了热虹吸系统。

对于中国的热虹吸系统，使用了上述参考系统，但没有使用平板集热器（如图 55 所示），而是使用了具有代表性的中国真空管集热器进行模拟。

9.1.3 多户住宅生活热水制备参考系统

表 16 中的信息指的是各国报告的 2022 年底多户住宅用于家庭热水加热的集热器总容量。

Table 16: Solar thermal systems for domestic hot water heating in multi-family houses by the end of 2022

Energy calculation DHW-MFH						
DHW-MFH - Total						
Country/Region/ Economy	Reference climate	Horizontal irradiation [kWh/m²*a]	Total collector area (DHW-MFH) [m²]	Collector area per system [m²]	Total number of systems [-]	Specific solar yield (DHW-MFH) [kWh/m²*a]
Albania	Tirana	1,604	252,530	50	5,051	694
Argentina	Buenos Aires	1,748	36,404	50	728	730
Australia	Sydney	1,674	18,988	50	380	725
Austria	Graz	1,126	388,274	50	7,765	505
Barbados	Grantley Adams	2,016	20,655	50	413	842
Belgium	Brussels	971	106,892	50	2,138	406
Bhutan	Thimphu	1,623	453	10	45	678
Botswana	Gaborone	2,161	8,030	30	268	903
Brazil	Brasília	1,793	1,988,712	60	33,145	658
Bulgaria	Sofia	1,188	32,641	50	653	515
Burkina Faso	Ouagadougou	2,212	4,033	30	134	924
Canada	Montreal	1,351	102,533	50	2,051	621
Chile	Santiago de Chile	1,753	85,021	50	1,700	732
China	Shanghai	1,282	254,784,564	50	5,095,691	502
Croatia	Zagreb	1,212	42,681	50	854	506
Cyprus	Nicosia	1,886	101,523	50	2,030	750
Czech Republic	Praha	998	46,718	42.4	1,102	436
Denmark	Copenhagen	989	1,466,078	50	29,322	413
Estonia	Tallin	960	3,416	50	68	401
Finland	Helsinki	948	11,154	50	223	396
France (mainland)	Paris	1,112	852,068	20	42,603	489
France (overseas departments)	Basse-Terre, Papeete, Saint Pierre (Miquelon), Cayenne, Noumea	1,834	83,451	50	1,669	766
Germany	Würzburg	1,091	2,686,456	50	53,729	472
Ghana	Accra	2,146	7,002	30	233	896
Greece	Athens	1,585	801,580	50	16,032	642
Hungary	Budapest	1,199	78,394	50	1,568	522
India	Neu-Delhi	1,961	1,908,575	50	38,171	749
Ireland	Dublin	949	12,506	50	250	425
Israel	Jerusalem	2,198	4,100,472	3	1,366,824	918
Italy	Bologna	1,419	788,237	50	15,765	593
Japan	Tokyo	1,175	9,569	50	191	516
Jordan	Amman	2,145	250,769	50	5,015	801
Kenya	Nairobi	1,931	74,016	10	7,402	807
Latvia	Riga	991	6,366	50	127	414
Lebanon	Beirut	1,935	331,233	40	8,281	808
Lesotho	Maseru	2,050	3,449	10	345	856
Lithuania	Vilnius	1,001	3,769	50	75	418
Luxembourg	Luxembourg	1,037	11,085	50	222	433
Mexico	Mexico City	1,706	1,239,936	50	24,799	713
Morocco	Rabat	2,000	486,563	50	9,731	835
Mozambique	Maputo	1,910	1,730	50	35	798
Namibia	Windhoek	2,363	33,468	50	669	814
Nepal	Kathmandu	1,771	165,000	50	3,300	740
Netherlands	Amsterdam	999	158,550	40	3,964	418
New Zealand	Wellington	1,401	16,411	50	328	585
Nigeria	Abuja	2,007	3,605	1.4	2,575	838
North Macedonia	Skopje	1,381	11,840	50	237	577
Norway	Oslo	971	16,250	50	325	406
Palestinian Territories	Jerusalem	2,198	928,547	50	18,571	918
Poland	Warsaw	1,024	595,996	50	11,920	447
Portugal	Lisbon	1,686	465,555	40	11,639	705
Romania	Bucharest	1,324	39,198	50	784	553
Russia	Moscow	996	22,438	50	449	416
Senegal	Dakar	2,197	295	4.5	65	918
Slovakia	Bratislava	1,214	30,628	50	613	507
Slovenia	Ljubjana	1,115	3,033	50	61	477
South Africa	Johannesburg	2,075	32,414	87	373	867
South Korea	Seoul	1,161	144,967	50	2,899	485
Spain	Madrid	1,644	2,388,743	50	47,775	676
Sweden	Gothenburg	934	48,177	50	964	430
Switzerland	Zürich	1,094	122,693	20	6,135	457
Chinese Teipei	Taipei	1,372	96,511	30	3,217	518
Thailand	Bangkok	1,765	11,820	80	148	737
Tunisia	Tunis	1,808	40,083	50	802	755
Turkey	Antalya	1,795	2,187,728	80	27,347	750
United States	LA, Indianapolis	1,646	1,633,846	50	32,677	688
Uruguay	Montevideo	1,534	20,668	50	413	641
Zimbabwe	Harare	2,017	24,007	32	750	842
Other (5% of world market excluding China)		1,244	1,449,131	50	28,983	519
TOTAL			283,930,124		6,984,809	
AVG		1,535		45		638

表 16：到 2022 年底用于多户住宅生活热水加热的太阳能热系统

表 18：到 2021 年底用于多户住宅生活热水加热的太阳能热系统

DHW-MFH 能源计算						
DHW-MFH - 总计						
国家/地区/经济	参考气候	横向照射 [千瓦时/平方米*a]	收集器总数面积（DHW-MFH） [m²]	集电区每个系统 [m²]	总数系统 [-]	特定太阳能产量（DHW-MFH） [千瓦时/平方米*a]
阿尔巴尼亚	地拉那	1,604	252,530	50	5,051	694
阿根廷	布宜诺斯艾利斯	1,748	36,404	50	728	730
澳大利亚	悉尼	1,674	18,988	50	380	725
奥地利	Graz	1,126	388,274	50	7,765	505
巴巴多斯	格兰特利-亚当斯	2,016	20,655	50	413	842
比利时	布鲁塞尔	971	106,892	50	2,138	406
不丹	廷布	1,623	453	10	45	678
博茨瓦纳	哈博罗内	2,161	8,030	30	268	903
巴西	巴西利亚	1,793	1,988,712	60	33,145	658
保加利亚	索菲亚	1,188	32,641	50	653	515
布基纳法索	瓦加杜古	2,212	4,033	30	134	924
加拿大	蒙特利尔	1,351	102,533	50	2,051	621
智利	智利圣地亚哥	1,753	85,021	50	1,700	732
中国	上海	1,282	254,784,564	50	5,095,691	502
克罗地亚	萨格勒布	1,212	42,681	50	854	506
塞浦路斯	尼科西亚	1,886	101,523	50	2,030	750
捷克共和国	普拉亚	998	46,718	42.4	1,102	436
丹麦	哥本哈根	989	1,466,078	50	29,322	413
爱沙尼亚	塔林	960	3,416	50	68	401
芬兰	赫尔辛基	948	11,154	50	223	396
法国（本土）	巴黎	1,112	852,068	20	42,603	489
法国（海外部门）	下特雷岛、帕皮提、圣皮埃尔（密克隆）、卡宴、努美阿	1,834	83,451	50	1,669	766
德国	维尔茨堡	1,091	2,686,456	50	53,729	472
加纳	阿克拉	2,146	7,002	30	233	896
希腊	雅典	1,585	801,580	50	16,032	642
匈牙利	布达佩斯	1,199	78,394	50	1,568	522
印度	新德里	1,961	1,908,575	50	38,171	749
爱尔兰	都柏林	949	12,506	50	250	425
以色列	耶路撒冷	2,198	4,100,472	3	1,366,824	918
意大利	博洛尼亚	1,419	788,237	50	15,765	593
日本	东京	1,175	9,569	50	191	516
约旦	安曼	2,145	250,769	50	5,015	801
肯尼亚	内罗毕	1,931	74,016	10	7,402	807
拉脱维亚	Riga	991	6,366	50	127	414
黎巴嫩	贝鲁特	1,935	331,233	40	8,281	808
莱索托	马塞卢	2,050	3,449	10	345	856
立陶宛	维尔纽斯	1,001	3,769	50	75	418
卢森堡	卢森堡	1,037	11,085	50	222	433
墨西哥	墨西哥城	1,706	1,239,936	50	24,799	713
摩洛哥	拉巴特	2,000	486,563	50	9,731	835
莫桑比克	马普托	1,910	1,730	50	35	798
纳米比亚	温得和克	2,363	33,468	50	669	814
尼泊尔	加德满都	1,771	165,000	50	3,300	740
荷兰	阿姆斯特丹	999	158,550	40	3,964	418
新西兰	惠灵顿	1,401	16,411	50	328	585
尼日利亚	阿布贾	2,007	3,605	1.4	2,575	838
北马其顿	斯科普里	1,381	11,840	50	237	577
挪威	Oslo	971	16,250	50	325	406
巴勒斯坦领土	耶路撒冷	2,198	928,547	50	18,571	918
波兰	华沙	1,024	595,996	50	11,920	447
葡萄牙	里斯本	1,686	465,555	40	11,639	705
罗马尼亚	布加勒斯特	1,324	39,198	50	784	553
俄罗斯	莫斯科	996	22,438	50	449	416
塞内加尔	达喀尔	2,197	295	4.5	65	918
斯洛伐克	布拉迪斯拉发	1,214	30,628	50	613	507
斯洛文尼亚	卢布尔雅那	1,115	3,033	50	61	477
南非	约翰内斯堡	2,075	32,414	87	373	867
韩国	首尔	1,161	144,967	50	2,899	485
西班牙	马德里	1,644	2,388,743	50	47,775	676
瑞典	哥德堡	934	48,177	50	964	430
瑞士	苏黎世	1,094	122,693	20	6,135	457
中国帝培	台北	1,372	96,511	30	3,217	518
泰国	曼谷	1,765	11,820	80	148	737
突尼斯	突尼斯	1,808	40,083	50	802	755
土耳其	安塔利亚	1,795	2,187,728	80	27,347	750
美国	洛杉矶、印第安纳波利斯	1,646	1,633,846	50	32,677	688
乌拉圭	蒙得维的亚	1,534	20,668	50	413	641
津巴布韦	哈拉雷	2,017	24,007	32	750	842
其他（占世界市场的 5%，不包括中国）		1,244	1,449,131	50	28,983	519
总计			283,930,124		6,984,809	
AVG		1,535		45		638

Figure 56 shows the hydraulic scheme of the domestic hot water reference system for multi-family houses used for the simulations of the solar energy yields. Unlike small-scale domestic hot water systems, all large-scale systems are assumed to be

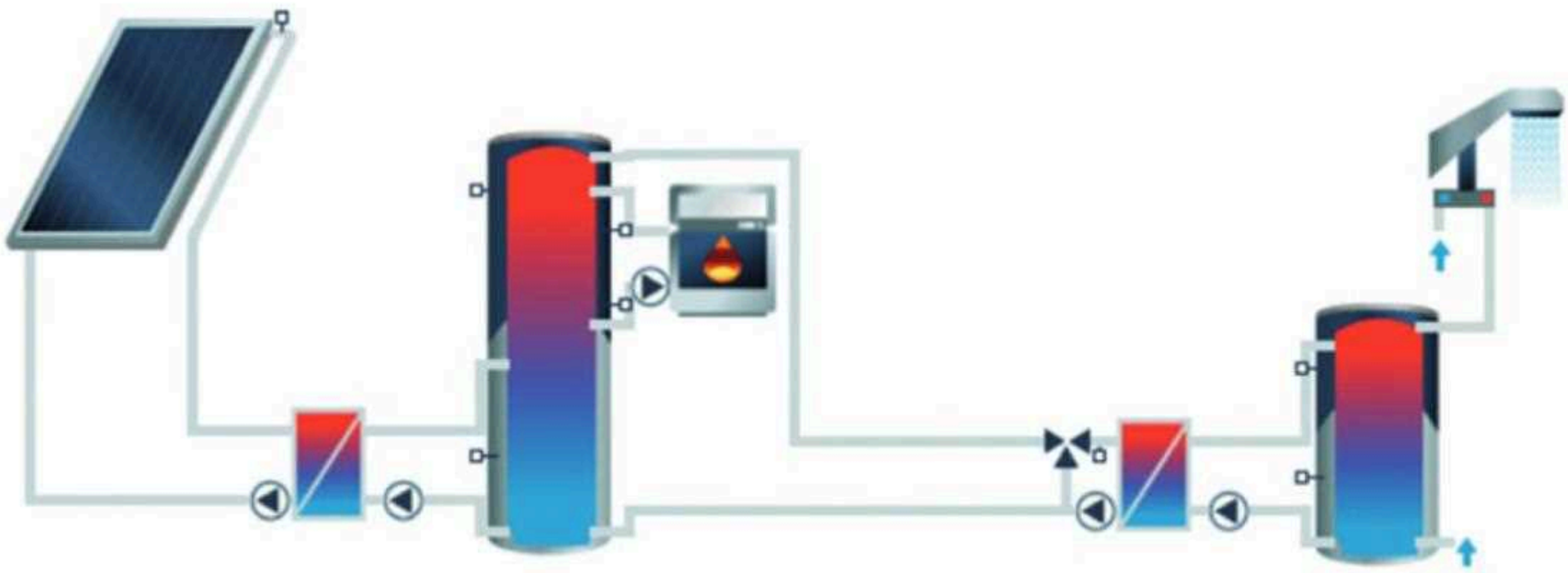

Figure 56: Hydraulic scheme of the domestic hot water pumped reference system for multi-family houses

9.1.4
Reference systems for domestic hot water preparation and space heating in single-family and multi-family houses (solar combi-systems)

The information in Table 17 refers to the total capacity of water collectors used for domestic hot water and space heating in single-family and multi-family houses at the end of 2022, as reported by each country.

图 56 显示了用于模拟太阳能产量的多户住宅生活热水参考系统的水力方案。与小型生活热水系统不同，所有大型系统均假定为泵式太阳能热系统。

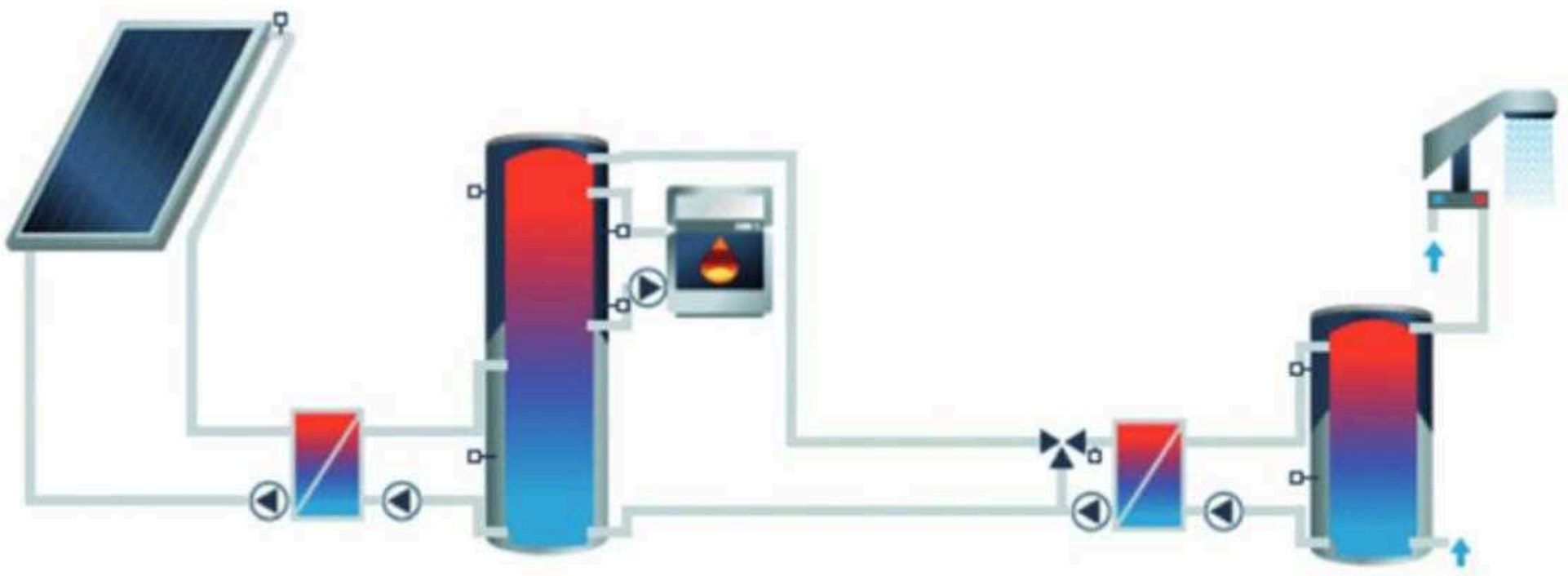

图 56：多户住宅生活热水抽水参考系统的水力方案

9.1.4 独户住宅和多户住宅的生活热水制备和空间供暖参考系统（太阳能组合系统）

表 17 中的信息指的是各国报告的 2022 年底独户住宅和多户住宅用于生活热水和空间供暖的集热器总容量。

Table 17: Solar combisystem reference for single-family and multi-family houses and the total collector area in operation in 2022

Energy calculation DHW-combi-systems						
Solar combi-systems - Total						
Country/Region/ Economy	Reference climate	Horizontal irradiation [kWh/m²*a]	Total collector area (DHW-combi-systems) [m²]	Collector area per system [m²]	Total number of systems [-]	Specific solar yield (DHW-combi-systems) [kWh/m²*a]
Argentina	Buenos Aires	1,748	43,271	12	3,606	615
Australia	Sydney	1,674	9,494	12	791	589
Austria	Graz	1,126	1,963,747	14	140,268	369
Belgium	Brussels	971	146,317	12	12,193	342
Bulgaria	Sofia	1,188	44,680	12	3,723	418
Canada	Montreal	1,351	82	12	7	476
China	Shanghai	1,282	11,323,758	12	943,647	388
Croatia	Zagreb	1,212	58,423	12	4,869	426
Cyprus	Nicosia	1,886	14,125	12	1,177	663
Czech Republic	Praha	998	246,677	8.5	29,021	351
Denmark	Copenhagen	989	63,506	8	7,938	348
Estonia	Tallin	960	4,675	12	390	338
Finland	Helsinki	948	15,616	12	1,301	334
France (mainland)	Paris	1,112	1,003	11	91	370
Germany	Würzburg	1,091	9,424,615	11.5	819,532	378
Greece	Athens	1,585	1,097,228	12	91,436	558
Hungary	Budapest	1,199	79,015	10	7,901	422
Ireland	Dublin	949	29,181	12	2,432	364
Italy	Bologna	1,419	1,078,964	12	89,914	499
Japan	Tokyo	1,175	134,138	12	11,178	414
Latvia	Riga	991	8,714	12	726	349
Lebanon	Beirut	1,935	5,454	12	455	681
Lesotho	Maseru	2,050	21	12	2	721
Lithuania	Vilnius	1,001	5,159	12	430	352
Luxembourg	Luxembourg	1,037	15,173	12	1,264	365
Morocco	Rabat	2,000	10,813	12	901	704
Netherlands	Amsterdam	999	42,850	6	7,142	352
New Zealand	Wellington	1,401	4,923	12	410	493
North Macedonia	Skopje	1,381	1,480	10	148	486
Norway	Oslo	971	23,252	15	1,550	342
Palestinian Territories	Jerusalem	2,198	20,634	12	1,720	773
Poland	Warsaw	1,024	340,569	12	28,381	365
Romania	Bucharest	1,324	53,656	12	4,471	466
Russia	Moscow	996	2,277	15	152	350
Slovakia	Bratislava	1,214	41,924	12	3,494	427
Slovenia	Ljubjana	1,115	10,617	12	885	362
South Korea	Seoul	1,161	21,118	12	1,760	409
Spain	Madrid	1,644	406,594	10	40,659	619
Sweden	Gothenburg	934	255,199	10	25,520	389
Switzerland	Zürich	1,094	383,417	11	34,856	385
Thailand	Bangkok	1,765	1,722	12	143	621
Other (5% of world market excluding China)		1,131	845,940	12	70,495	398
TOTAL			28,280,022		2,396,977	
AVG		1,295		12		454

combi-system: system for the supply of domestic hot water and space heating

表 17：2022 年独户住宅和多户住宅太阳能组合系统参考值及运行中的总集热器面积

DHW 混合系统的能耗计算						
太阳能组合系统 - 总计						
国家/地区/经济	参考资料气候	横向照射 [千瓦时/平方米*a]	收集器总数区域（DHW-组合系统） [m²]	集电区每个系统 [m²]	总数系统 [-]	特定太阳能产量（DHW-组合系统） [千瓦时/平方米*a]
阿根廷	布宜诺斯艾利斯	1,748	43,271	12	3,606	615
澳大利亚	悉尼	1,674	9,494	12	791	589
奥地利	Graz	1,126	1,963,747	14	140,268	369
比利时	布鲁塞尔	971	146,317	12	12,193	342
保加利亚	索菲亚	1,188	44,680	12	3,723	418
加拿大	蒙特利尔	1,351	82	12	7	476
中国	上海	1,282	11,323,758	12	943,647	388
克罗地亚	萨格勒布	1,212	58,423	12	4,869	426
塞浦路斯	尼科西亚	1,886	14,125	12	1,177	663
捷克共和国	普拉亚	998	246,677	8.5	29,021	351
丹麦	哥本哈根	989	63,506	8	7,938	348
爱沙尼亚	塔林	960	4,675	12	390	338
芬兰	赫尔辛基	948	15,616	12	1,301	334
法国（本土）	巴黎	1,112	1,003	11	91	370
德国	维尔茨堡	1,091	9,424,615	11.5	819,532	378
希腊	雅典	1,585	1,097,228	12	91,436	558
匈牙利	布达佩斯	1,199	79,015	10	7,901	422
爱尔兰	都柏林	949	29,181	12	2,432	364
意大利	博洛尼亚	1,419	1,078,964	12	89,914	499
日本	东京	1,175	134,138	12	11,178	414
拉脱维亚	Riga	991	8,714	12	726	349
黎巴嫩	贝鲁特	1,935	5,454	12	455	681
莱索托	马塞卢	2,050	21	12	2	721
立陶宛	维尔纽斯	1,001	5,159	12	430	352
卢森堡	卢森堡	1,037	15,173	12	1,264	365
摩洛哥	拉巴特	2,000	10,813	12	901	704
荷兰	阿姆斯特丹	999	42,850	6	7,142	352
新西兰	惠灵顿	1,401	4,923	12	410	493
北马其顿	斯科普里	1,381	1,480	10	148	486
挪威	Oslo	971	23,252	15	1,550	342
巴勒斯坦领土	耶路撒冷	2,198	20,634	12	1,720	773
波兰	华沙	1,024	340,569	12	28,381	365
罗马尼亚	布加勒斯特	1,324	53,656	12	4,471	466
俄罗斯	莫斯科	996	2,277	15	152	350
斯洛伐克	布拉迪斯拉发	1,214	41,924	12	3,494	427
斯洛文尼亚	卢布尔雅那	1,115	10,617	12	885	362
韩国	首尔	1,161	21,118	12	1,760	409
西班牙	马德里	1,644	406,594	10	40,659	619
瑞典	哥德堡	934	255,199	10	25,520	389
瑞士	苏黎世	1,094	383,417	11	34,856	385
泰国	曼谷	1,765	1,722	12	143	621
其他（占世界的 5 市场不包括中国）		1,131	845,940	12	70,495	398
总计			28,280,022		2,396,977	
AVG		1,295		12		454

组合系统：供应生活热水和空间供暖的系统

Figure 57 shows the hydraulic scheme of the domestic hot water reference system for multifamily houses used for the simulations of the solar energy yields.

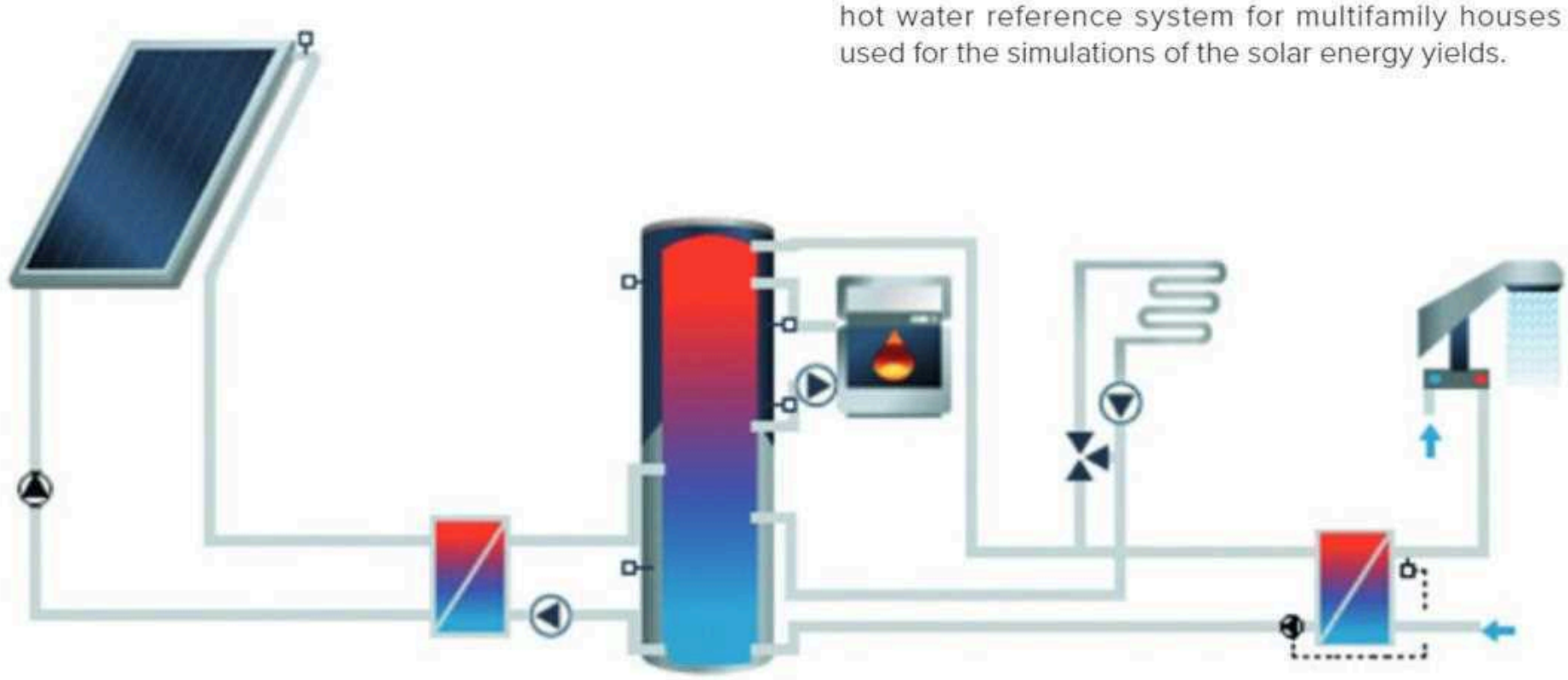

Figure 57: Hydraulic scheme of the solar-combi reference system for single and multi-family houses

9.2 Reference collectors

9.2.1 Data of the reference unglazed water collector for swimming pool heating

η = 0.85
a_1 = 20 [W/m²K]
a_2 = 0.1 [W/m² K²]

9.2.2 Data of the reference collector for all other applications except for China

η = 0.8
a_1 = 3.69 [W/m²K]
a_2 = 0.007 [W/m² K²]

9.2.3 Data of the Chinese reference vacuum tube collector

η = 0.74
a_1 = 2.5 [W/m²K]
a_2 = 0.013 [W/m² K²]

9.3 Methodological approach for the job calculation

The job calculation is based on a comprehensive literature study, information provided by the China National Renewable Energy Centre and IRENA, and data collected from different country market reports. Based on this information, the following assumptions were taken to calculate the number of full-time jobs:

- Countries with high labor costs. Advanced automated production of flat plate or evacuated tube collectors and heat storages – pumped systems with an average 133 m² solar collector area installed per full-time job.
- Countries with low labor costs. Advanced automated production of evacuated tube collectors and heat storages – thermosiphon systems with an average 87 m² solar collector area installed per full-time job.
- Countries with low labor costs. Mainly manual flat plate collector production – thermosiphon systems with an average 87 m² solar collector area installed per full-time job.
- Swimming pool systems with unglazed polymeric collectors or air collectors – around 200 m² solar collector area installed per full-time job.

The numbers presented are full-time jobs and consider the production, installation and maintenance of solar thermal systems.

图 57 显示了用于模拟太阳能产量的多户住宅生活热水参考系统的水力方案。

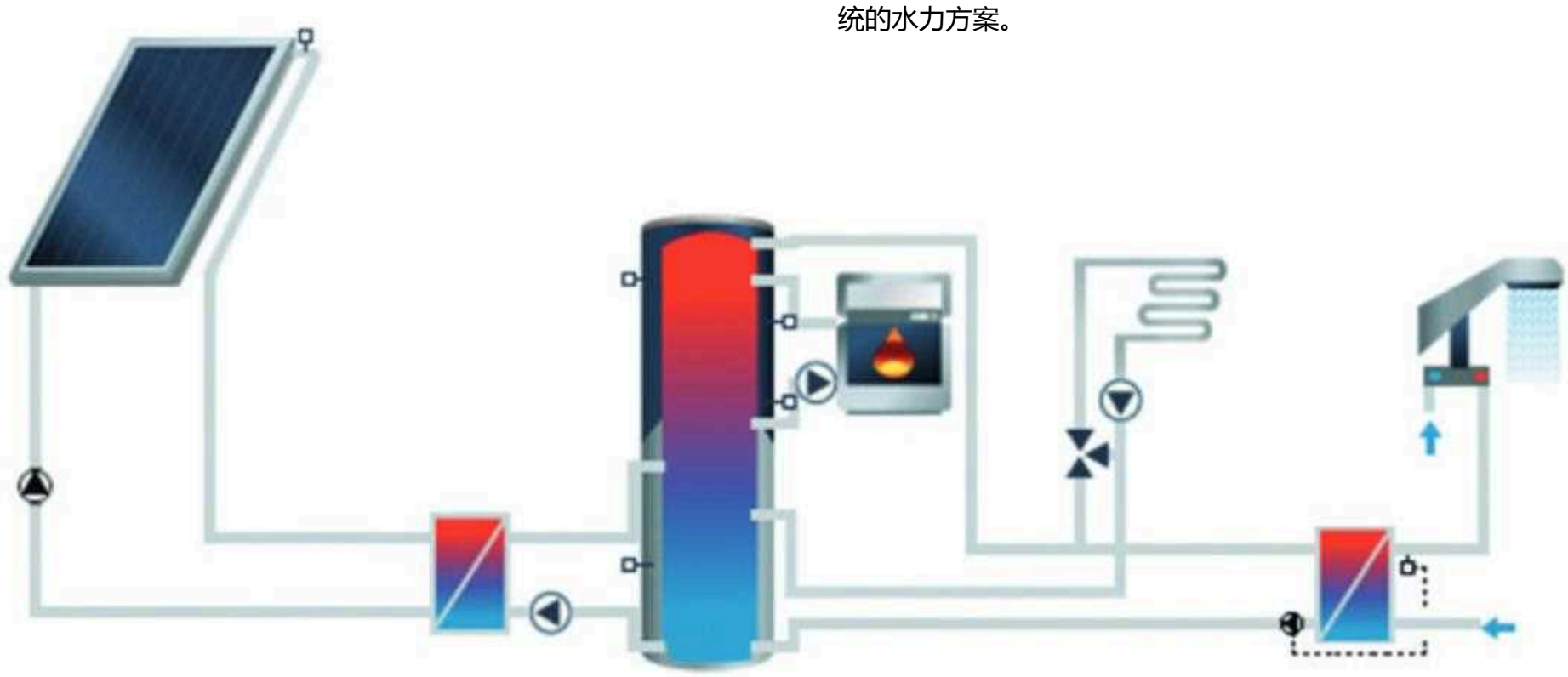

图 57：单户和多户住宅太阳能混合参考系统的水力方案

9.2 参考收集器

9.2.1 用于游泳池加热的无釉集热器参考数据

ŋ = 0.85
a = 20 [W/m²K]
a = 0.1 [W/m² K²] （瓦/平方米 K²

9.2.2 除中国外所有其他应用的参考采集器数据

ŋ = 0.8
a = 3.69 [W/m²K] （瓦/米²K
a = 0.007 [W/m² K²] （瓦/平方米 K²

9.2.3 中国参考真空管收集器的数据

ŋ = 0.74
a = 2.5 [W/m²K] （瓦/米²K
a = 0.013 [W/m² K²] （瓦/平方米 K²

9.3 工作计算方法

工作岗位的计算基于全面的文献研究、中国国家可再生能源中心和国际可再生能源机构提供的信息，以及从不同国家市场报告中收集的数据。根据这些信息，在计算全职工作岗位数量时采用了以下假设：

- 平板或真空管集热器和蓄热器的先进自动化生产--泵送系统，每个全职工作岗位平均安装 133 平方米的太阳能集热器。
- 实现了真空管集热器和蓄热器的自动化生产 - 热虹吸系统，每个全职工作岗位平均安装 87 平方米的太阳能集热器。
- 劳动力成本低的国家。主要是手动平板集热器生产 - 热虹吸系统，每个全职工作平均安装 87 平方米的太阳能集热器。
- 配备无釉聚合集热器或空气集热器的游泳池系统--每项全职工作安装的太阳能集热器面积约为 200 平方米。

所列数字均为全职工作，包括太阳能热系统的生产、安装和维护。

9.4 Reference climates

Table 18: Reference climates for the 72 countries surveyed

No.	Country/Region/ Economy	Reference climate	Horizontal irradiation [kWh/m²*a]	Inclined irradiation [kWh/m²*a]	Avg. outside air temp. [°C]
1	Albania	Tirana	1,604	1,835	13.5
2	Argentina	Buenos Aires	1,748	1,971	17.5
3	Australia	Sydney	1,674	1,841	18.1
4	Austria	Graz	1,126	1,280	9.2
5	Barbados	Grantley Adams	2,016	2,048	27.4
6	Belgium	Brussels	971	1,095	10.0
7	Bhutan	Thimphu	1,623	1,790	11.0
8	Botswana	Gaborone	2,161	2,365	18.0
9	Brazil	Brasília	1,793	1,838	22.0
10	Bulgaria	Sofia	1,188	1,304	10.1
11	Burkina Faso	Ouagadougou	2,212	2,270	25.0
12	Canada	Montreal	1,351	1,568	6.9
13	Cape Verde	Praia	2,096	2,168	23.6
14	Chile	Santiago de Chile	1,753	1,850	14.5
15	China	Shanghai	1,282	1,343	17.1
16	Croatia	Zagreb	1,212	1,352	11.3
17	Cyprus	Nicosia	1,886	2,098	19.9
18	Czech Republic	Praha	998	1,111	7.9
19	Denmark	Copenhagen	989	1,164	8.1
20	Estonia	Tallin	960	1,126	5.3
21	Finland	Helsinki	948	1,134	4.6
22	France (mainland)	Paris	1,112	1,246	11.0
23	France (overseas departments)	Basse-Terre, Papeete, Saint Pierre (Miquelon), Cayenne, Noumea	1,834	1,925	21.7
24	Germany	Würzburg	1,091	1,225	9.5
25	Ghana	Accra	2,146	2,161	23.7
26	Greece	Athens	1,585	1,744	18.5
27	Hungary	Budapest	1,199	1,346	11.0
28	India	Neu-Delhi	1,961	2,275	24.7
29	Ireland	Dublin	949	1,091	9.5
30	Israel	Jerusalem	2,198	2,400	17.3
31	Italy	Bologna	1,419	1,592	14.3
32	Japan	Tokyo	1,175	1,287	16.7
33	Jordan	Amman	2,145	2,341	17.9
34	Kenya	Nairobi	1,931	1,932	19.4
35	Latvia	Riga	991	1,187	6.3
36	Lebanon	Beirut	1,935	2,132	19.9
37	Lesotho	Maseru	2,050	2,290	15.2
38	Lithuania	Vilnius	1,001	1,161	6.2
39	Luxembourg	Luxembourg	1,037	1,158	8.4
40	Malta	Luqa	1,902	2,115	18.7
41	Mauritius	Port Louis	1,920	2,010	23.3
42	Mexico	Mexico City	1,706	1,759	16.6
43	Morocco	Rabat	2,000	2,250	17.2
44	Mozambique	Maputo	1,910	2,100	22.8
45	Namibia	Windhoek	2,363	2,499	21.0
46	Nepal	Kathmandu	1,771	1,960	18.6
47	Netherlands	Amsterdam	999	1,131	10.0
48	New Zealand	Wellington	1,401	1,542	13.6
49	Nigeria	Abuja	2,007	2,051	25.7
50	North Macedonia	Skopje	1,381	1,521	12.5
51	Norway	Oslo	971	1,208	5.8
52	Palestinian Territories	Jerusalem	2,198	2,400	17.3
53	Panama	Panama City	1,787	1,813	26.8
54	Poland	Warsaw	1,024	1,156	8.1
55	Portugal	Lisbon	1,686	1,875	17.4
56	Romania	Bucharest	1,324	1,473	10.6
57	Russia	Moscow	996	1,181	5.9
58	Senegal	Dakar	2,197	2,259	24.9
59	Slovakia	Bratislava	1,214	1,374	10.3
60	Slovenia	Ljubjana	1,115	1,231	9.8
61	South Africa	Johannesburg	2,075	2,232	15.6
62	South Korea	Seoul	1,161	1,280	12.7
63	Spain	Madrid	1,644	1,844	15.5
64	Sweden	Gothenburg	934	1,105	7.2
65	Switzerland	Zürich	1,094	1,218	9.6
66	Chinese Teipei	Taipei	1,372	1,398	20.8
67	Thailand	Bangkok	1,765	1,898	29.1
68	Tunisia	Tunis	1,808	2,038	19.3
69	Turkey	Antalya	1,795	1,958	18.4
70	United Kingdom	London	943	1,062	12.0
71	United States	LA, Indianapolis	1,646	1,816	14.3
72	Uruguay	Montevideo	1,534	1,647	15.9
73	Zimbabwe	Harare	2,017	2,087	18.9

Source: T-Sol expert version 4.5, Meteonorm version 6.1 and Global Solar Atlas (https://globalsolaratlas.info/map).

9.4
参考气候

表 18：接受调查的 72 个国家的参考气候

No.	国家/地区/经济	参考气候	横向照射 [千瓦时/平方米*a]	倾斜照射 [千瓦时/平方米*a]	室外平均值空气温度 [°C]
1	阿尔巴尼亚	地拉那	1,604	1,835	13.5
2	阿根廷	布宜诺斯艾利斯	1,748	1,971	17.5
3	澳大利亚	悉尼	1,674	1,841	18.1
4	奥地利	Graz	1,126	1,280	9.2
5	巴巴多斯	格兰特利-亚当斯	2,016	2,048	27.4
6	比利时	布鲁塞尔	971	1,095	10.0
7	不丹	廷布	1,623	1,790	11.0
8	博茨瓦纳	哈博罗内	2,161	2,365	18.0
9	巴西	巴西利亚	1,793	1,838	22.0
10	保加利亚	索菲亚	1,188	1,304	10.1
11	布基纳法索	瓦加杜古	2,212	2,270	25.0
12	加拿大	蒙特利尔	1,351	1,568	6.9
13	佛得角	普拉亚	2,096	2,168	23.6
14	智利	智利圣地亚哥	1,753	1,850	14.5
15	中国	上海	1,282	1,343	17.1
16	克罗地亚	萨格勒布	1,212	1,352	11.3
17	塞浦路斯	尼科西亚	1,886	2,098	19.9
18	捷克共和国	普拉亚	998	1,111	7.9
19	丹麦	哥本哈根	989	1,164	8.1
20	爱沙尼亚	塔林	960	1,126	5.3
21	芬兰	赫尔辛基	948	1,134	4.6
22	法国（本土）	巴黎	1,112	1,246	11.0
23	法国（海外部门)	下特雷岛、帕皮提、圣皮埃尔（密克隆）、卡宴、努美阿	1,834	1,925	21.7
24	德国	维尔茨堡	1,091	1,225	9.5
25	加纳	阿克拉	2,146	2,161	23.7
26	希腊	雅典	1,585	1,744	18.5
27	匈牙利	布达佩斯	1,199	1,346	11.0
28	印度	新德里	1,961	2,275	24.7
29	爱尔兰	都柏林	949	1,091	9.5
30	以色列	耶路撒冷	2,198	2,400	17.3
31	意大利	博洛尼亚	1,419	1,592	14.3
32	日本	东京	1,175	1,287	16.7
33	约旦	安曼	2,145	2,341	17.9
34	肯尼亚	内罗毕	1,931	1,932	19.4
35	拉脱维亚	Riga	991	1,187	6.3
36	黎巴嫩	贝鲁特	1,935	2,132	19.9
37	莱索托	马塞卢	2,050	2,290	15.2
38	立陶宛	维尔纽斯	1,001	1,161	6.2
39	卢森堡	卢森堡	1,037	1,158	8.4
40	马耳他	Luqa	1,902	2,115	18.7
41	毛里求斯	路易港	1,920	2,010	23.3
42	墨西哥	墨西哥城	1,706	1,759	16.6
43	摩洛哥	拉巴特	2,000	2,250	17.2
44	莫桑比克	马普托	1,910	2,100	22.8
45	纳米比亚	温得和克	2,363	2,499	21.0
46	尼泊尔	加德满都	1,771	1,960	18.6
47	荷兰	阿姆斯特丹	999	1,131	10.0
48	新西兰	惠灵顿	1,401	1,542	13.6
49	尼日利亚	阿布贾	2,007	2,051	25.7
50	北马其顿	斯科普里	1,381	1,521	12.5
51	挪威	Oslo	971	1,208	5.8
52	巴勒斯坦领土	耶路撒冷	2,198	2,400	17.3
53	巴拿马	巴拿马城	1,787	1,813	26.8
54	波兰	华沙	1,024	1,156	8.1
55	葡萄牙	里斯本	1,686	1,875	17.4
56	罗马尼亚	布加勒斯特	1,324	1,473	10.6
57	俄罗斯	莫斯科	996	1,181	5.9
58	塞内加尔	达喀尔	2,197	2,259	24.9
59	斯洛伐克	布拉迪斯拉发	1,214	1,374	10.3
60	斯洛文尼亚	卢布尔雅那	1,115	1,231	9.8
61	南非	约翰内斯堡	2,075	2,232	15.6
62	韩国	首尔	1,161	1,280	12.7
63	西班牙	马德里	1,644	1,844	15.5
64	瑞典	哥德堡	934	1,105	7.2
65	瑞士	苏黎世	1,094	1,218	9.6
66	中国帝培	台北	1,372	1,398	20.8
67	泰国	曼谷	1,765	1,898	29.1
68	突尼斯	突尼斯	1,808	2,038	19.3
69	土耳其	安塔利亚	1,795	1,958	18.4
70	英国	伦敦	943	1,062	12.0
71	美国	洛杉矶、印第安纳波利斯	1,646	1,816	14.3
72	乌拉圭	蒙得维的亚	1,534	1,647	15.9
73	津巴布韦	哈拉雷	2,017	2,087	18.9

资料来源资料来源：T-Sol expert version 4.5、Meteonorm version 6.1 和 Global Solar Atlas (https://globalsolaratlas.info/map)。

9.5 Population data

Table 19: Inhabitants by the end of 2022 of the 72 surveyed countries in alphabetical order

No	Country/Region/ Economy	2022	Region Code
1	Albania	3,095,344	6
2	Argentina	46,245,668	4
3	Australia	26,141,369	3
4	Austria	8,913,088	6
5	Barbados	302,674	4
6	Belgium	11,847,338	6
7	Bhutan	867,775	2
8	Botswana	2,384,246	1
9	Brazil	217,240,060	4
10	Bulgaria	6,873,253	6
11	Burkina Faso	21,935,389	1
12	Canada	38,232,593	8
13	Cape Verde	596,707	1
14	Chile	18,430,408	4
15	China	1,410,539,758	5
16	Croatia	4,188,853	6
17	Cyprus	1,295,102	6
18	Czech Republic	10,816,746	6
19	Denmark	5,920,767	6
20	Estonia	1,211,524	6
21	Finland	5,601,547	6
22	France (mainland)	68,092,884	6
	France (overseas departments and regions)	3,378,669	6
23	Germany	84,316,622	6
24	Ghana	33,107,275	1
25	Greece	10,533,871	6
26	Hungary	9,920,415	6
27	India	1,389,637,446	2
28	Ireland	5,120,464	6
29	Israel	9,111,963	7
30	Italy	61,095,551	6
31	Japan	124,214,766	2
32	Jordan	10,998,531	7
33	Republic of Kenya	55,864,655	1
34	Latvia	1,842,226	6
35	Lebanon	5,296,814	7
36	Lesotho	2,193,970	1
37	Lithuania	2,683,546	6
38	Luxembourg	630,364	6
39	Malta	464,186	6
40	Mauritius	1,308,222	1
41	Mexico	129,150,971	4
42	Morocco	36,738,229	7
43	Mozambique	31,693,239	1
44	Namibia	2,712,364	1
45	Nepal	30,666,598	2
46	Netherlands	17,601,564	6
47	New Zealand	5,053,004	3
48	Nigeria	225,082,083	1
49	North Macedonia	2,130,936	6
50	Norway	5,443,828	6
51	Palestinian Territories	5,165,249	7
52	Panama	4,337,768	4
53	Poland	38,699,570	6
54	Portugal	10,242,081	6
55	Romania	18,519,899	6
56	Russia	142,183,583	6
57	Senegal	17,923,036	1
58	Slovakia	5,527,637	6
59	Slovenia	2,101,208	6
60	South Africa	59,150,970	1
61	South Korea	51,844,834	2
62	Spain	47,163,418	6
63	Sweden	10,483,647	6
64	Switzerland	8,724,310	6
65	Chinese Taipei	23,580,712	2
66	Thailand	69,648,117	2
67	Tunisia	11,896,972	7
68	Turkey	83,047,706	6
69	United Kingdom	67,791,400	6
70	United States	333,287,557	8
71	Uruguay	3,407,213	4
72	Zimbabwe	16,481,694	1
73	Other (5%)	2,666,728,749	9
∑ Solar Thermal World Statistics		**5,239,974,046**	**66%**
∑Inhabitants world		**7,906,702,795**	

Data source: International Data Base of the U.S. Census Bureau
http://www.census.gov/population/international/data/idb/informationGateway.php

Table 20: Inhabitants per economic region by the end of 2022

Region Code	Country/Region/ Economy	∑Inhabitants	Share
1	Sub-Sahara Africa	470,433,850	6%
2	Other Asia	1,690,460,248	21%
3	Australia	31,194,373	0.4%
4	Latin America and the Caribbean	419,114,762	5%
5	China	1,410,539,758	18%
6	Europe	767,503,147	10%
7	MENA Region	79,207,758	1%
8	United States / Canada	371,520,150	5%
9	Other countries	2,666,728,749	34%
Total		**7,906,702,795**	**100%**

Data source: International Data Base of the U.S. Census Bureau
http://www.census.gov/ipc/www/idb/country.php

Sub-Sahara Africa: Botswana, Burkina Faso, Cape Verde, Ghana, Kenya, Lesotho, Namibia, Nigeria, Mozambique, Senegal, South Africa, Zimbabwe
Other Asia: Bhutan, India, Japan, South Korea, Chinese Taipei, Thailand
Latin America: Argentina, Barbados, Brazil, Chile, Mexico, Uruguay
Europe: Albania, EU 27, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA Region: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

9.5 人口数据

表 19：按字母顺序排列的 72 个接受调查国家 2022 年底的居民情况

No	国家/地区/经济	2022	地区 Code
1	阿尔巴尼亚	3,095,344	6
2	阿根廷	46,245,668	4
3	澳大利亚	26,141,369	3
4	奥地利	8,913,088	6
5	巴巴多斯	302,674	4
6	比利时	11,847,338	6
7	不丹	867,775	2
8	博茨瓦纳	2,384,246	1
9	巴西	217,240,060	4
10	保加利亚	6,873,253	6
11	布基纳法索	21,935,389	1
12	加拿大	38,232,593	8
13	佛得角	596,707	1
14	智利	18,430,408	4
15	中国	1,410,539,758	5
16	克罗地亚	4,188,853	6
17	塞浦路斯	1,295,102	6
18	捷克共和国	10,816,746	6
19	丹麦	5,920,767	6
20	爱沙尼亚	1,211,524	6
21	芬兰	5,601,547	6
22	法国（本土）	68,092,884	6
	法国（海外省和大区）	3,378,669	6
23	德国	84,316,622	6
24	加纳	33,107,275	1
25	希腊	10,533,871	6
26	匈牙利	9,920,415	6
27	印度	1,389,637,446	2
28	爱尔兰	5,120,464	6
29	以色列	9,111,963	7
30	意大利	61,095,551	6
31	日本	124,214,766	2
32	约旦	10,998,531	7
33	肯尼亚共和国	55,864,655	1
34	拉脱维亚	1,842,226	6
35	黎巴嫩	5,296,814	7
36	莱索托	2,193,970	1
37	立陶宛	2,683,546	6
38	卢森堡	630,364	6
39	马耳他	464,186	6
40	毛里求斯	1,308,222	1
41	墨西哥	129,150,971	4
42	摩洛哥	36,738,229	7
43	莫桑比克	31,693,239	1
44	纳米比亚	2,712,364	1
45	尼泊尔	30,666,598	2
46	荷兰	17,601,564	6
47	新西兰	5,053,004	3
48	尼日利亚	225,082,083	1
49	北马其顿	2,130,936	6
50	挪威	5,443,828	6
51	巴勒斯坦领土	5,165,249	7
52	巴拿马	4,337,768	4
53	波兰	38,699,570	6
54	葡萄牙	10,242,081	6
55	罗马尼亚	18,519,899	6
56	俄罗斯	142,183,583	6
57	塞内加尔	17,923,036	1
58	斯洛伐克	5,527,637	6
59	斯洛文尼亚	2,101,208	6
60	南非	59,150,970	1
61	韩国	51,844,834	2
62	西班牙	47,163,418	6
63	瑞典	10,483,647	6
64	瑞士	8,724,310	6
65	中国台北	23,580,712	2
66	泰国	69,648,117	2
67	突尼斯	11,896,972	7
68	土耳其	83,047,706	6
69	英国	67,791,400	6
70	美国	333,287,557	8
71	乌拉圭	3,407,213	4
72	津巴布韦	16,481,694	1
73	其他 (5%)	2,666,728,749	9
∑ 太阳能热世界统计		5,239,974,046	66%
∑居民世界		7,906,702,795	

数据来源美国人口普查局国际数据库
http://www.census.gov/population/international/data/idb/informationGateway.php

表 20：到 2022 年底各经济区的居民人数

地区 Code	国家/地区/经济	∑ 居民	分享
1	撒哈拉以南非洲	470,433,850	6%
2	其他亚洲地区	1,690,460,248	21%
3	澳大利亚	31,194,373	0.4%
4	拉丁美洲和加勒比地区	419,114,762	5%
5	中国	1,410,539,758	18%
6	欧洲	767,503,147	10%
7	中东和北非地区	79,207,758	1%
8	美国加拿大	371,520,150	5%
9	其他国家	2,666,728,749	34%
总计		7,906,702,795	100%

撒哈拉以南非洲博茨瓦纳、布基纳法索、佛得角、加纳、肯尼亚、莱索托、纳米比亚、尼日利 亚、莫桑比克、塞内加尔、南非、津巴布韦 其他亚洲：不丹、印度、日本、韩国、中国台北、泰国 拉丁美洲：阿根廷、巴巴多斯、巴西、智利、墨西哥、乌拉圭 欧洲：阿尔巴尼亚、欧盟 27 国、北马其顿、挪威、俄罗斯、瑞士、土耳其、英国 中东和北非地区：以色列、约旦、黎巴嫩、摩洛哥、巴勒斯坦领土、突尼斯

数据来源美国人口普查局国际数据库
http://www.census.gov/ipc/www/idb/country.php

9.6 Definition of SHIP systems

In November 2019, the IEA Solar Heating and Cooling Programme defined solar heat for industrial processes (SHIP systems). This definition refers only to the collection and documentation of SHIP systems in this Solar Heat Worldwide report.

Applications considered as SHIP Systems

Industrial Process Applications
All solar thermal systems, direct or indirect (via heat storage) connected to an industrial process. Systems that, in addition to the industrial process, also supply the space heating for the production halls, offices or showers are also taken into account.

Agricultural Applications
Solar thermal systems used for drying wood chips, crops, fruits, etc. and heat for animal breeding.

Greenhouses
Solar thermal systems supplying heat for commercial food and flower production, nurseries and vegetable farming.

Service Sector
Solar thermal systems supplying commercial laundries, car/truck washing, and sewage sludge drying facilities with heat.

Solar cooling of industrial processes
This refers to all cooling processes in industrial plants.

Not considered in this definition:

- Solar air conditioning of office buildings or industry halls
- Tourism sector, like hotels (including laundries of hotels)
- Health sector: hospitals, clinics
- Boarding schools
- Military barracks
- Showers or canteens for workers

Minimum size of systems

For the worldwide survey, only installations larger than 50 m^2 are considered. The minimum size of the plants surveyed was determined since small plants in many countries are not recorded separately. This does not mean that there are no SHIP systems with smaller collector areas. In some countries (e.g., Germany), the number of SHIP plants with collector areas below 50 m^2 is significantly higher than the realized plants above that limit.

9.7 Methodological adjustments and market data of the previous years

Change in the method for estimating global installed capacity

Global solar thermal capacity is based on the latest market data from more than 20 of the largest solar thermal markets in terms of added capacity. These were the following countries for the year 2023 listed in order of their added capacity: China, Turkey, United States, Brazil, Germany, India, Australia, Mexico, Greece, Italy, Spain, Austria, Poland, South Africa, Denmark, Portugal, Switzerland, Lebanon, United Kingdom, Cyprus, Belgium, Mozambique and Bhutan which represented 94.9% of the cumulative installed capacity in operation in 2022. The added capacities in the other countries, for which new additions are available until 2022, were projected according to the trend over the past two years. The rest of the world, which means countries without detailed solar thermal market information in 2022 and previous years, was estimated to be 5% of the global market volume without China in 2022.

Until 2019, the "rest of the world" was considered 5% of the global market, including China, which overestimated its market share. This methodological change should be noted when comparing data from this year's edition of Solar Heat Worldwide with earlier editions.

Conversion from square meters to capacity

The data presented in Chapters 5 to 8 were initially collected in square meters. Through an agreement of international experts, the collector areas of these solar thermal applications have been converted and shown in installed capacity.

Making the installed capacity of solar thermal collectors comparable with that of other energy sources, solar thermal experts from seven countries agreed upon a methodology to convert installed collector area into solar thermal capacity.

The methodology was developed during a meeting with IEA SHC Programme officials and major solar thermal trade associations in Gleisdorf, Austria, in September 2004. The represented associations from Austria, Canada, Germany, the Netherlands, Sweden, and the United States, as well as the European Solar Thermal Industry Federation (ESTIF) and the IEA SHC Programme, agreed to use a factor of 0.7 kW_{th}/m^2 to derive the nominal capacity from the area of installed collectors.

Data from the previous years

The following tables provide data from the previous years to ensure consistency of the calculations within this report. If necessary, the numbers have been revised compared to the data published in earlier editions of this report due to changes in methodology or the origin of the data for each country.

In Table 21, Table 22, and Table 23, these countries are marked accordingly and the respective data source is cited in Chapter 9.8 (References).

9.6 SHIP 系统的定义

2019 年 11 月，I E A 太阳能加热和冷却计划定义了工业流程太阳能热（SHIP 系统）。该定义仅指本《全球太阳能热利用报告》中收集和记录的 SHIP 系统。

被视为 SHIP 系统的应用程序

工业流程应用
所有直接或间接（通过蓄热）与工业流程相连的太阳能热系统。除工业生产过程外，还为生产车间、办公室或淋浴室提供空间供热的系统也在考虑之列。

农业应用
用于干燥木屑、农作物、水果等的太阳能热系统，以及用于动物饲养的热量。

温室
太阳能供热系统为社区、苗圃和蔬菜种植提供热能。

服务部门
为商业洗衣店、汽车/卡车清洗和污水污泥干燥设施供热的太阳能热系统。

太阳能冷却工业流程
这指的是工业厂房的所有冷却过程。

本定义中不予考虑：
"办公楼或工业厂房的太阳能空调＂旅游部门，如酒店（包括酒店的洗衣房）＂卫生部门：医院、诊所＂寄宿学校＂军营＂淋浴或工人食堂

系统的最小尺寸

在全球调查中，只考虑了面积大于 50 平方米的设备。由于许多国家的小型设备没有单独记录，因此确定了调查设备的最小尺寸。这并不意味着没有集热器面积较小的 SHIP 系统。在某些国家（如德国），集热器面积小于 50 平方米的 SHIP 发电站的数量远远高于超过该限制的发电站数量。

9.7 方法调整和往年的市场数据

全球装机容量估算方法的变化

全球太阳能热发电能力基于 20 多个最大的太阳能热发电市场的最新市场数据。这些国家在 2023 年的新增产能按顺序排列如下：中国、土耳其、美国、巴西、德国、印度、澳大利亚、墨西哥、希腊、意大利、西班牙、奥地利、波兰、南非、丹麦、葡萄牙、瑞士、黎巴嫩、英国、塞浦路斯、比利时、莫桑比克和不丹占2022年累计运行装机容量的94.9%。其他国家的新增装机容量是根据过去两年的趋势预测的，这些国家的新增装机容量将持续到 2022 年。世界其他地区，即 2022 年和前几年没有详细光热市场信息的国家，估计占 2022 年全球市场容量的 5%，中国除外。

在 2019 年之前，"世界其他地区 "被视为全球市场的 5%，其中包括高估了其市场份额的中国。在比较本年度《全球太阳能供热》与之前版本的数据时，应注意这一方法上的变化。

从平方米到容量的转换

第 5 章至第 8 章介绍的数据最初是以平方米为单位收集的。经过国际专家的商定，这些太阳能热应用的集热器面积已被换算成装机容量。

为了使太阳能集热器的已安装容量与其他能源相媲美，来自七个国家的太阳能热能专家商定了一种将已安装集热器面积转换为太阳能热能容量的方法。

该方法是 2004 年 9 月在奥地利 Gleisdorf 与国际能源机构 SHC 计划官员和主要太阳能热行业协会举行的一次会议上制定的。来自奥地利、加拿大、德国、荷兰、瑞典和美国的协会代表，以及欧洲太阳能热利用行业联合会 (ESTIF) 和国际能源机构 SHC 计划的代表，一致同意使用 0.7 kW/m 的系数，从已安装的集热器面积推导出额定容量。

往年数据

以下表格提供了前几年的数据，以确保本报告计算结果的一致性。必要时，由于方法或各国数据来源的变化，这些数字与本报告前几版公布的数据相比会有所修订。

在表 21、表 22 和表 23 中，这些国家都做了相应标记，并在第 9.8 章（参考文献）中引用了相应的数据来源。

Table 21: Newly installed collector area in 2020 [m²]

Newly installed collector area in 2020 [m²]						
Country/Region/Economy	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		10,680.0	968.0			11,648
Argentina	34,496.0	23,451.0	39,786.0	20.0	158.0	97,911
Australia	380,000.0	146,000.0	16,200.0			542,200
Austria	1,730.0	72,210.0	1,400.0		720.0	76,060
Barbados*		12,300.0				12,300
Belgium		18,200.0	4,300.0			22,500
Bhutan		460.0				460
Botswana		1,032.0	115.0			1,147
Brazil	710,810.0	673,600.0	32,360.0			1,416,770
Bulgaria		23,520.0	480.0			24,000
Burkina Faso*		100.0	310.0			410
Canada	1,475.0	261.0	321.0	7,000.0	1,000.0	10,057
Cape Verde		150.0				150
Chile*		25,183.0				25,183
China+		6,954,000.0	18,096,033.0			25,050,033
Croatia		15,968.0	1,055.0			17,023
Cyprus		74,193.0	0.0			74,193
Czech Republic		15,000.0	7,000.0			22,000
Denmark		14,613.0				14,613
Estonia		1,425.0				1,425
Finland		7,000.0				7,000
France (mainland)	600.0	45,807.0	330.0			46,737
France (overseas territories)++		91,425.0				91,425
Germany		544,564.0	98,888.0			643,452
Ghana		776.0	520.0			1,296
Greece		304,100.0	400.0			304,500
Hungary		21,000.0				21,000
India		207,209.0	1,451,524.0		150.0	1,658,883
Ireland		1,472.4	2,367.0			3,839
Israel		350,000.0				350,000
Italy		108,250.0	14,700.0			122,950
Japan		49,907.0	861.0		887.0	51,655
Kenya		8,364.0	4,182.0			12,546
Latvia		1,600.0				1,600
Lebanon		9,448.0	14,181.0			23,629
Lesotho**		286.0	1,103.0			1,389
Lithuania		700.0	1,000.0			1,700
Luxembourg		3,913.0	0.0			3,913
Malta		545.0	136.0			681
Mexico	106,400.0	130,080.0	141,000.0			377,480
Morocco*		71,700.0				71,700
Mozambique**			237.0			237
Namibia		3,807.0	8.1			3,815
Netherlands	2,620.0	21,430.0	8,330.0			32,380
Nigeria*		392.6	3,515.2			3,908
North Macedonia		4,274.0	6,948.0		12.0	11,234
Norway*		1,350.0	73.0			1,423
Palestinian Territories		46,401.0	0.0			46,401
Poland		159,270.0	1,830.0			161,100
Portugal		69,700.0				69,700
Romania		6,840.0	9,120.0			15,960
Russia		783.5	85.5			869
Senegal*		1,500.0	1,000.0			2,500
Slovakia		13,000.0				13,000
Slovenia		1,300.0	100.0		10.0	1,410
South Africa	56,629.0	28,967.0	74,180.0			159,776
South Korea*		3,552.0	16,918.0			20,470
Spain	2,798.0	177,103.0	7,539.0			187,440
Sweden		1,898.0	3,000.0			4,898
Switzerland	3,900.0	31,830.0	4,390.0			40,120
Chinese Taipei*		36,000.0				36,000
Tunisia		51,094.0				51,094
Turkey		988,000.0	939,000.0	2,500.0		1,929,500
United Kingdom++	4,261.0	4,153.0	3,121.0			11,535
United States	675,058.0	44,448.0		3,000.0	1,000.0	723,506
Uruguay*		10,418.0				10,418
Zimbabwe			4,050.0			4,050
Other (5% of the world market excluding China)	104,251.4	252,316.0	153,628.0	658.9	207.2	511,062
Total	**2,085,028.4**	**12,000,319.5**	**21,168,592.8**	**13,178.9**	**4,144.2**	**35,271,264**

* 0% growth assumed, ** revised 2022 according to new database
+ exports excluded, ++ revised 2024 according to new data base

表 21：2020 年新安装的集热器面积 [m]

国家/地区/经济	2020 年新安装的集热器面积[平方米]					
	集水池 [平方米]			空气收集器 [平方米]		总计 [m²]
	无釉	FPC	ETC	无釉	黄釉	
阿尔巴尼亚		10,680.0	968.0			11,648
阿根廷	34,496.0	23,451.0	39,786.0	20.0	158.0	97,911
澳大利亚	380,000.0	146,000.0	16,200.0			542,200
奥地利	1,730.0	72,210.0	1,400.0		720.0	76,060
巴巴多斯*		12,300.0				12,300
比利时		18,200.0	4,300.0			22,500
不丹		460.0				460
博茨瓦纳		1,032.0	115.0			1,147
巴西	710,810.0	673,600.0	32,360.0			1,416,770
保加利亚		23,520.0	480.0			24,000
布基纳法索*		100.0	310.0			410
加拿大	1,475.0	261.0	321.0	7,000.0	1,000.0	10,057
佛得角		150.0				150
智利*		25,183.0				25,183
中国+		6,954,000.0	18,096,033.0			25,050,033
克罗地亚		15,968.0	1,055.0			17,023
塞浦路斯		74,193.0	0.0			74,193
捷克共和国		15,000.0	7,000.0			22,000
丹麦		14,613.0				14,613
爱沙尼亚		1,425.0				1,425
芬兰		7,000.0				7,000
法国（本土）	600.0	45,807.0	330.0			46,737
法国（海外领地）++		91,425.0				91,425
德国		544,564.0	98,888.0			643,452
加纳		776.0	520.0			1,296
希腊		304,100.0	400.0			304,500
匈牙利		21,000.0				21,000
印度		207,209.0	1,451,524.0		150.0	1,658,883
爱尔兰		1,472.4	2,367.0			3,839
以色列		350,000.0				350,000
意大利		108,250.0	14,700.0			122,950
日本		49,907.0	861.0		887.0	51,655
肯尼亚		8,364.0	4,182.0			12,546
拉脱维亚		1,600.0				1,600
黎巴嫩		9,448.0	14,181.0			23,629
莱索托**		286.0	1,103.0			1,389
立陶宛		700.0	1,000.0			1,700
卢森堡		3,913.0	0.0			3,913
马耳他		545.0	136.0			681
墨西哥	106,400.0	130,080.0	141,000.0			377,480
摩洛哥*		71,700.0				71,700
莫桑比克**			237.0			237
纳米比亚		3,807.0	8.1			3,815
荷兰	2,620.0	21,430.0	8,330.0			32,380
尼日利亚*		392.6	3,515.2			3,908
北马其顿		4,274.0	6,948.0		12.0	11,234
挪威*		1,350.0	73.0			1,423
巴勒斯坦领土		46,401.0	0.0			46,401
波兰		159,270.0	1,830.0			161,100
葡萄牙		69,700.0				69,700
罗马尼亚		6,840.0	9,120.0			15,960
俄罗斯		783.5	85.5			869
塞内加尔*		1,500.0	1,000.0			2,500
斯洛伐克		13,000.0				13,000
斯洛文尼亚		1,300.0	100.0		10.0	1,410
南非	56,629.0	28,967.0	74,180.0			159,776
韩国*		3,552.0	16,918.0			20,470
西班牙	2,798.0	177,103.0	7,539.0			187,440
瑞典		1,898.0	3,000.0			4,898
瑞士	3,900.0	31,830.0	4,390.0			40,120
中国台北*		36,000.0				36,000
突尼斯		51,094.0				51,094
土耳其		988,000.0	939,000.0	2,500.0		1,929,500
联合王国++	4,261.0	4,153.0	3,121.0			11,535
美国	675,058.0	44,448.0		3,000.0	1,000.0	723,506
乌拉圭*		10,418.0				10,418
津巴布韦			4,050.0			4,050
其他（占世界市场的 5%，不包括中国）	104,251.4	252,316.0	153,628.0	658.9	207.2	511,062
总计	2,085,028.4	12,000,319.5	21,168,592.8	13,178.9	4,144.2	35,271,264

* 假定增长 0%，** 根据新数据库修订 2022 年 + 不包括出口，++ 根据新数据库修订 2024 年

Table 22: Newly installed collector area in 2021 [m²]

Newly installed collector area in 2020 [m²]						
Country/Region/Economy	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		14,840	1,360.0			16,200
Argentina	6,634.0	34,300	67,986.0	20.0	158.0	109,098
Australia	380,000.0	131,600	14,600.0			526,200
Austria	930.0	64,570	3,810.0		1,100.0	70,410
Belgium		13,600	3,000.0			16,600
Bhutan		460				460
Botswana		1,190	210.0			1,400
Brazil	948,931.0	831,223	38,509.0			1,818,663
Bulgaria		25,184				25,184
Canada*	1,475.0	261	321.0	6,000.0	1,000.0	9,057
Cape Verde		150				150
Chile*		25,183				25,183
China+		7,107,000	17,623,914.0	13,119.4	20,000.0	24,764,033
Croatia		12,912				12,912
Cyprus		70,360				70,360
Czech Republic		17,097	1,903.0			19,000
Denmark		8,013				8,013
Estonia		1,468				1,468
Finland		3,223				3,223
France (mainland)	600.0	63,910	1,760.0	200.0		66,470
France (overseas territories)		90,440				90,440
Germany		524,500	117,000.0			641,500
Ghana		700	450.0			1,150
Greece		358,600	400.0			359,000
Hungary		22,050				22,050
India		151,267	1,779,873.0		15.0	1,931,155
Ireland		3,898				3,898
Israel		350,000				350,000
Italy		207,548	17,452.0	120.0		225,120
Japan		49,736	610.0		887.0	51,233
Kenya*		8,364	4,182.0			12,546
Latvia		1,648				1,648
Lebanon		11,399	38,940.0			50,339
Lesotho		396	1,584.0			1,980
Lithuania		700	1,000.0			1,700
Luxembourg		3,574				3,574
Malta		1,051	263.0			1,314
Mexico	114,940.0	128,880	159,180.0			403,000
Morocco*		71,700				71,700
Mozambique			592.0			592
Namibia		4,201				4,201
Nepal		6,690	60,208.0			66,898
Netherlands	2,620.0	19,590	8,400.0			30,610
Nigeria		393	3,515.2			3,908
North Macedonia*		5,868	4,800.0		20.0	10,688
Palestinian Territories		53,453	0.0			53,453
Panama		665				665
Poland		186,100	3,000.0			189,100
Portugal		77,045				77,045
Romania	0.0	16,439				16,439
Russia	0.0	729	4.0			733
Slovakia	0.0	13,000				13,000
Slovenia		1,439				1,439
South Africa	57,483.0	16,117	66,351.0			139,951
South Korea+++				200.0	100.0	300
Spain	2,000.0	141,500	8,800.0	5,200.0		157,500
Sweden		1,955				1,955
Switzerland	4,090.0	22,630	4,470.0			31,190
Tunisia		52,340				52,340
Turkey		984,000	945,000.0	1,000.0		1,930,000
United Kingdom++	4,638.0	21,943	4,462.0			31,043
United States	808,417.0	50,274		3,000.0	1,000.0	862,691
Uruguay*		10,418				10,418
Zimbabwe			9,570.0			9,570
Other (5% excluding China)	122,776.7	262,778	177,556.1	828.4	225.3	564,165
TOTAL	**2,455,534.7**	**12,362,561.2**	**21,175,035.3**	**29,687.8**	**24,505.3**	**36,047,324**

* 0% growth assumed, ** revised 2022 due to new data base
+ exports excluded, ++ revised 2024 according to new data base, +++ only air collectors reported (provided by John Hollick)

表 22：2021 年新安装的集热器面积 [m]

2020 年新安装的集热器面积[平方米]						
国家/地区/经济	集水池 [平方米]			空气收集器 [平方米]		总计 [m²]
	无釉	FPC	ETC	无釉	黄釉	
阿尔巴尼亚		14,840	1,360.0			16,200
阿根廷	6,634.0	34,300	67,986.0	20.0	158.0	109,098
澳大利亚	380,000.0	131,600	14,600.0			526,200
奥地利	930.0	64,570	3,810.0		1,100.0	70,410
比利时		13,600	3,000.0			16,600
不丹		460				460
博茨瓦纳		1,190	210.0			1,400
巴西	948,931.0	831,223	38,509.0			1,818,663
保加利亚		25,184				25,184
加拿大*	1,475.0	261	321.0	6,000.0	1,000.0	9,057
佛得角		150				150
智利*		25,183				25,183
中国+		7,107,000	17,623,914.0	13,119.4	20,000.0	24,764,033
克罗地亚		12,912				12,912
塞浦路斯		70,360				70,360
捷克共和国		17,097	1,903.0			19,000
丹麦		8,013				8,013
爱沙尼亚		1,468				1,468
芬兰		3,223				3,223
法国（本土）	600.0	63,910	1,760.0	200.0		66,470
法国（海外领地）		90,440				90,440
德国		524,500	117,000.0			641,500
加纳		700	450.0			1,150
希腊		358,600	400.0			359,000
匈牙利		22,050				22,050
印度		151,267	1,779,873.0		15.0	1,931,155
爱尔兰		3,898				3,898
以色列		350,000				350,000
意大利		207,548	17,452.0	120.0		225,120
日本		49,736	610.0		887.0	51,233
肯尼亚		8,364	4,182.0			12,546
拉脱维亚		1,648				1,648
黎巴嫩		11,399	38,940.0			50,339
莱索托		396	1,584.0			1,980
立陶宛		700	1,000.0			1,700
卢森堡		3,574				3,574
马耳他		1,051	263.0			1,314
墨西哥	114,940.0	128,880	159,180.0			403,000
摩洛哥*		71,700				71,700
莫桑比克			592.0			592
纳米比亚		4,201				4,201
尼泊尔		6,690	60,208.0			66,898
荷兰	2,620.0	19,590	8,400.0			30,610
尼日利亚		393	3,515.2			3,908
北马其顿*		5,868	4,800.0		20.0	10,688
巴勒斯坦领土		53,453	0.0			53,453
巴拿马		665				665
波兰		186,100	3,000.0			189,100
葡萄牙		77,045				77,045
罗马尼亚	0.0	16,439				16,439
俄罗斯	0.0	729	4.0			733
斯洛伐克	0.0	13,000				13,000
斯洛文尼亚		1,439				1,439
南非	57,483.0	16,117	66,351.0			139,951
韩国++++				200.0	100.0	300
西班牙	2,000.0	141,500	8,800.0	5,200.0		157,500
瑞典		1,955				1,955
瑞士	4,090.0	22,630	4,470.0			31,190
突尼斯		52,340				52,340
土耳其		984,000	945,000.0	1,000.0		1,930,000
联合王国++	4,638.0	21,943	4,462.0			31,043
美国	808,417.0	50,274		3,000.0	1,000.0	862,691
乌拉圭*		10,418				10,418
津巴布韦			9,570.0			9,570
其他（5%，不包括中国）	122,776.7	262,778	177,556.1	828.4	225.3	564,165
总计	2,455,534.7	12,362,561.2	21,175,035.3	29,687.8	24,505.3	36,047,324

* 假定增长率为 0%，** 根据新的数据库修订为 2022 年 + 不包括出口，++ 根据新的数据库修订为 2024 年，+++ 仅报告了空气收集器（由约翰-霍利克提供）。

Table 23: Total collector area in operation by the end of 2021 [m²]

Country/Region/Economy	Total installed collector area in operation 2021 [m²]					
	Water Collectors [m²]			Air Collectors [m²]		TOTAL [m²]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		297,543	12,622			310,165
Argentina++	122,124	91,139	168,854	60	474	382,651
Australia	5,891,734	3,400,996	251,429	250,000	10,000	9,804,159
Austria	209,865	4,474,008	83,413		7,268	4,774,554
Barbados+++		258,192				258,192
Belgium	45,000	591,724	110,700			747,424
Bhutan		460				460
Botswana		16,061	2,614			18,675
Brazil	8,320,474	11,931,663	231,592			20,483,729
Bulgaria		193,811	5,850			199,661
Burkino Faso+++		3,282	1,399			4,681
Canada++	719,239	69,891	51,737	436,767	56,214	1,333,848
Cape Verde		2,613				2,613
Chile++	65,550	310,077	54,305		300	430,232
China+		67,338,000	477,412,430	20,819	23,000	544,794,250
Croatia		265,893	13,308			279,201
Cyprus	2,213	834,684	23,567			860,464
Czech Republic	450,000	479,677	158,826			1,088,503
Denmark	20,500	1,825,742	9,197	4,300	18,000	1,877,739
Estonia		13,358	8,360			21,718
Finland	11,800	49,998	20,788			82,586
France (mainland)	83,400	2,086,420	189,440	10,758	1,100	2,371,118
France (overseas territories)		1,100,620	43,980			1,144,600
Germany	443,726	19,308,064	2,471,388		19,200	22,242,378
Ghana		4,470	2,058			6,528
Greece		5,152,200	22,800			5,175,000
Hungary	18,300	286,294	79,850	3,418	2,300	390,162
India	0	4,093,789	13,648,251	0.00	12,400	17,754,440
Ireland		289,166	128,127			417,293
Israel++	39,000	4,968,434				5,007,434
Italy	43,800	4,354,211	686,455	120		5,084,586
Japan		2,872,248	42,587		230,888	3,145,723
Jordan**	5,940	982,482	272,084			1,260,506
Kenya++		309,984	154,992			464,975
Latvia		38,050	3,490			41,540
Lebanon		382,170	403,571			785,741
Lesotho		2,371	4,046			6,417
Lithuania		9,117	13,113			22,230
Luxembourg		63,706	8,900			72,606
Malta		60,318	15,079			75,397
Mauritius***		132,793				132,793
Mexico	1,758,293	2,019,282	1,735,322	752	8,773	5,522,422
Morocco++		967,000				967,000
Mozambique	136	48	2,949			3,133
Namibia	1,560	55,619	1,393			58,573
Netherlands	72,320	508,520	80,930			661,770
New Zealand*	7,025	142,975	9,644			159,645
Nigeria+++		1,866	10,782	0	1,670	14,318
North Macedonia		76,039	58,329		32	134,400
Norway++	1,849	36,394	4,422	200	4,106	46,972
Palestinian Territories		1,929,522				1,929,522
Panama		665				665
Poland		2,695,230	500,460			3,195,690
Portugal	2,130	1,284,064	30,570			1,316,764
Romania	340	134,519	114,590	800		250,249
Russia	137	23,919	3,876	2	64	27,998
Senegal+++		4,741	5,083	0	1,203	11,027
Slovakia	1,000	165,540	28,270			194,810
Slovenia		127,739	23,600		10	151,349
South Africa	1,408,585	719,089	505,359			2,633,033
South Korea+++		1,486,336	445,760	600	300	1,932,996
Spain	163,736	4,442,514	248,463	9,750	2,250	4,866,713
Sweden	171,000	255,937	72,578			499,515
Switzerland	169,800	1,402,900	145,800			1,718,500
Chinese Taipei+++	1,937	1,679,874	133,244			1,815,055
Thailand****		157,536				157,536
Tunisia		1,130,157	70,104			1,200,261
Turkey		16,941,182	10,100,454	13,570		27,055,206
United Kingdom	108,850	687,745	262,963	24,600		1,084,158
United States	22,757,856	2,997,722	177,100	129,595	72,000	26,134,273
Uruguay++		107,255				107,255
Zimbabwe		21,848	65,290			87,138
Other (5% excluding China)	2,263,704	6,002,980	1,806,608	46,594	23,608	10,143,494
TOTAL	**45,382,923**	**187,152,477**	**513,455,144**	**952,706**	**495,160**	**747,438,411**

*cumulated collector area by end of 2009, ** cumulated collector area by end of 2014, *** cumulated collector area by end of 2015
**** cumulated collector area by end of 2017, ***** new 2023 + exports excluded ++ calculated based on 0% growth
+++ cumulated collector area by end of 2020, ++++ revised 2024 according to new data base+ exports excluded

表 23：到 2021 年底投入使用的集电极总面积[m]。

2021 年运行中的集热器总安装面积 [m²]						
国家/地区/经济	集水池 [平方米]			空气收集器 [平方米]		总计 [m²]
	无釉	FPC	ETC	无釉	黄釉	
阿尔巴尼亚		297,543	12,622			310,165
阿根廷++	122,124	91,139	168,854	60	474	382,651
澳大利亚	5,891,734	3,400,996	251,429	250,000	10,000	9,804,159
奥地利	209,865	4,474,008	83,413		7,268	4,774,554
巴巴多斯+++		258,192				258,192
比利时	45,000	591,724	110,700			747,424
不丹		460				460
博茨瓦纳		16,061	2,614			18,675
巴西	8,320,474	11,931,663	231,592			20,483,729
保加利亚		193,811	5,850			199,661
布基纳法索++++		3,282	1,399			4,681
加拿大++	719,239	69,891	51,737	436,767	56,214	1,333,848
佛得角		2,613				2,613
智利++	65,550	310,077	54,305		300	430,232
中国+		67,338,000	477,412,430	20,819	23,000	544,794,250
克罗地亚		265,893	13,308			279,201
塞浦路斯	2,213	834,684	23,567			860,464
捷克共和国	450,000	479,677	158,826			1,088,503
丹麦	20,500	1,825,742	9,197	4,300	18,000	1,877,739
爱沙尼亚		13,358	8,360			21,718
芬兰	11,800	49,998	20,788			82,586
法国（本土）	83,400	2,086,420	189,440	10,758	1,100	2,371,118
法国（海外领地）		1,100,620	43,980			1,144,600
德国	443,726	19,308,064	2,471,388		19,200	22,242,378
加纳		4,470	2,058			6,528
希腊		5,152,200	22,800			5,175,000
匈牙利	18,300	286,294	79,850	3,418	2,300	390,162
印度	0	4,093,789	13,648,251	0.00	12,400	17,754,440
爱尔兰		289,166	128,127			417,293
以色列++	39,000	4,968,434				5,007,434
意大利	43,800	4,354,211	686,455	120		5,084,586
日本		2,872,248	42,587		230,888	3,145,723
约旦**	5,940	982,482	272,084			1,260,506
肯尼亚++++。		309,984	154,992			464,975
拉脱维亚		38,050	3,490			41,540
黎巴嫩		382,170	403,571			785,741
莱索托		2,371	4,046			6,417
立陶宛		9,117	13,113			22,230
卢森堡		63,706	8,900			72,606
马耳他		60,318	15,079			75,397
毛里求斯****		132,793				132,793
墨西哥	1,758,293	2,019,282	1,735,322	752	8,773	5,522,422
摩洛哥++		967,000				967,000
莫桑比克	136	48	2,949			3,133
纳米比亚	1,560	55,619	1,393			58,573
荷兰	72,320	508,520	80,930			661,770
新西兰*	7,025	142,975	9,644			159,645
尼日利亚+++		1,866	10,782	0	1,670	14,318
北马其顿		76,039	58,329		32	134,400
挪威++	1,849	36,394	4,422	200	4,106	46,972
巴勒斯坦领土		1,929,522				1,929,522
巴拿马		665				665
波兰		2,695,230	500,460			3,195,690
葡萄牙	2,130	1,284,064	30,570			1,316,764
罗马尼亚	340	134,519	114,590	800		250,249
俄罗斯	137	23,919	3,876	2	64	27,998
塞内加尔+++		4,741	5,083	0	1,203	11,027
斯洛伐克	1,000	165,540	28,270			194,810
斯洛文尼亚		127,739	23,600		10	151,349
南非	1,408,585	719,089	505,359			2,633,033
韩国++++		1,486,336	445,760	600	300	1,932,996
西班牙	163,736	4,442,514	248,463	9,750	2,250	4,866,713
瑞典	171,000	255,937	72,578			499,515
瑞士	169,800	1,402,900	145,800			1,718,500
中国台北+++	1,937	1,679,874	133,244			1,815,055
泰国****		157,536				157,536
突尼斯		1,130,157	70,104			1,200,261
土耳其		16,941,182	10,100,454	13,570		27,055,206
英国	108,850	687,745	262,963	24,600		1,084,158
美国	22,757,856	2,997,722	177,100	129,595	72,000	26,134,273
乌拉圭++		107,255				107,255
津巴布韦		21,848	65,290			87,138
其他（5%，不包括中国）	2,263,704	6,002,980	1,806,608	46,594	23,608	10,143,494
共计	45,382,923	187,152,477	513,455,144	952,706	495,160	747,438,411

*2009 年底累计集电面积，** 2014 年底累计集电面积，*** 2015 年底累计集电面积 **** 2017 年底累计集电面积，***** 新的 2023 年 + 不包括出口 ++ 根据 0% 增长率计算 +++ 2020 年底累计集电面积，++++ 根据新的数据基础修订的 2024 年 + 不包括出口

9.8 References to reports and persons who have supplied the data

The production of the report, Solar Heat Worldwide – Edition 2024, was kindly supported by national representatives of the recorded countries or other official sources of information as cited below.

Country	Contact	Source	Remarks
Albania	**Dr. Eng. Edmond M. HIDO** Interlogistic SHPK	Interlogistic SHPK	
Argentina	**Dr. Christian Navntoft** Solarmate SA https://www.solarmate.com.ar	Censo Nacional de Energía Solar Térmica (baja temperatura) Instituto Nacional de Tecnología Industrial (INTI)	Cumulated calculated by AEE INTEC based on newly installed,
Australia	**Dr. David Ferrari** Exemplary Energy, Melbourne, Victoria	UN ESCAP, with data from the Clean Energy Regulator and industry surveys / interviews	Out of operation systems calculated by UN ESCAP
Austria	**Werner Weiss** AEE - Institute for Sustainable Technologies	Biermayr et al, 2024: Innovative Energietechnologien in Österreich – Marktentwicklung 2023 (Report in German)	Out of operation systems calculated by AEE INTEC
Barbados	**James Husbands** Solardynamics Ltd.	Timeline based on Solar Water Heating Techscope Market Readiness Assessment – Reports, UNEP 2015	No new data reported; cumulated data by end of 2020
Belgium	**Leopoldo Mico** Head of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation AEE INTEC	Belsolar 2024	
Bhutan	**Ms. Dawa Zam** Ministry of Economic Affairs Department of Renewable Energy Alternate Energy Division	Ministry of Economic Affairs Department of Renewable Energy Installations by companies 2022 and 2023	New in edition 2022
Botswana	**Karen Gibson** SIAB Solar Industries Association Botswana		0% growth assumed
Brazil	**Dr. Danielle Johann** Diretora Executiva ABRASOL Associção Brasileira de Energia Solar Térmica	ABRASOL	Out of operation systems calculated based on ABRASOL long time recordings
Bulgaria	**Leopoldo Mico** Head of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Euroserv'ER July 2023	Newly installed: Euroserv'ER July 2023; cumulated calculated by AEE INTEC based on average out of operation (2013 to 2021)
Burkina Faso	**Kokouvi Edem N'Tsoukpoe** International Institute for Water and Environmental Engineering Ouagadougou, Burkina Faso	Rapport de l'étude de marché du solaire thermique: production d'eau chaude et de séchage de produits agricoles, 2015	No new data 2022; cumulated by end of 2020
Canada	**Lucio Mesquita, PhD** Natural Resources Canada	2022 Solar Thermal Market Survey	Out of operation systems considered by NRC air collectors provided by Bärbel Epp, Solrico
Cape Verde	**Antúnio Barbosa**	Country Market Report on solar thermal heating systems, solar drying and solar cooling, September 2015	No new data 2022; cumulated by end of 2021
Chile	**Andrés Véliz Araya** Sustainable Energy Division, Ministry of Energy, Chile Government;	Minvu Program, Law 20365 (Tax Benefit) www.minenergia.cl/sst/	no information about pumped systems as law 20,365 ended its validity

9.8 参考报告和提供数据者

本报告《全球太阳能供热--2024 年版》的编制得到了以下记录国家的国家代表或其他官方信息来源的大力支持。

国家	联系方式	资料来源	备注
阿尔巴尼亚	Dr. Eng.Edmond M. HIDO 英特罗吉斯特SHPK	英特罗吉斯特SHPK	
阿根廷	克里斯蒂安-纳文托夫特博士 Solarmate SA https://www.solarmate.com.ar	Censo Nacional de Energía Solar Térmica (baja temperatura) Instituto Nacional de Tecnología Industrial (INTI)	由 AEE INTEC 根据新安装的设备计算得出、
澳大利亚	戴维-法拉利博士 典范能源公司，维多利亚州墨尔本市	联合国亚太经社会，数据来自清洁能源监管机构和行业调查/访谈	联合国亚太经社会计算的业务系统外
奥地利	维尔纳-魏斯 AEE - 可持续技术研究所	Biermayr 等人，《2024 年：奥地利的创新能源技术--2023 年的市场发展》（报告语言为德语）	由 AEE INTEC 计算的停运系统
巴巴多斯	詹姆斯-赫斯本兹 Solardynamics Ltd.	时间表基于《太阳能热水技术范围市场准备情况评估--报告》，联合国环境规划署，2015 年	未报告新数据；到 2020 年底累计数据
比利时	莱奥波尔多-米科 运营与欧盟项目负责人 欧洲太阳能热利用协会（ESTIF）--欧洲太阳能热利用行业联合会 AEE INTEC	Belsolar 2024	
不丹	达瓦-扎姆女士 经济事务部 可再生能源司 替代能源处	经济部可再生能源司各公司 2022 年和 2020 年的安装情况。 2023	2022 年新版
博茨瓦纳	卡伦-吉布森 SIAB 博茨瓦纳太阳能产业协会		假定增长率为 0
巴西	Danielle Johann 博士 执行董事 ABRASOL Associção Brasileira de Energia Solar Térmica	ABRASOL	根据 ABRASOL 长时间记录计算的停运系统
保加利亚	莱奥波尔多-米科 欧洲太阳能热利用行业联合会（ESTIF）运营与欧盟项目负责人	Euroserv'ER 2023 年 7 月	新安装：Euroserv'ER 2023 年 7 月；AEE INTEC 根据平均停运时间（2013 年至 2021 年）计算的累计数
布基纳法索	Kokouvi Edem N'Tsoukpoe 国际水与环境工程研究所 布基纳法索瓦加杜古	2015 年太阳能热利用市场研究报告：热水生产和农产品干燥	2022 年无新数据；2020 年底累计
加拿大	卢西奥-梅斯基塔，博士 加拿大自然资源部	2022 年太阳能热利用市场调查	NRC 考虑的停用系统 Solrico 公司 Bärbel Epp 提供的空气收集器
佛得角	安图尼奥-巴尔博萨	2015 年 9 月关于太阳能热供暖系统、太阳能干燥和太阳能制冷的国家市场报告	2022 年无新数据；2021 年底累计
智利	安德烈斯-韦利斯-阿拉亚 智利政府能源部可持续能源处；	Minvu 计划，第 20365 号法律（税收优惠） www.minenergia.cl/sst/	由于第 20365 号法律失效，没有关于抽水系统的信息

Country	Contact	Source	Remarks
China	**Ruicheng Zheng** China Academy of Building Research **He Tao** China Academy of Building Research CSTIF - Chinese Solar Thermal Industry Federation	China Renewable Energy Society, CSTIF - Chinese Solar Thermal Industry Federation	Exports excluded, out of operation systems calculated by AEE INTEC (2022 14 years lifetime considered)
Croatia	**DiasLeopoldo Mico** Head of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Euroserv'ER July 2023Solar	Cumulated calculated by AEE INTEC, out of operation considered (average 2020/2021)
Cyprus	**Panayiotis Kastanias** Cyprus Employers and Industrialists Federation	FPC Cyprus Union of Solar Thermal Industrialists (EBHEK) and the Cyprus Employers & Industrialists Federation (OEB)	Cumulated calculated by AEE INTEC based on replacement figures provided by Panayiotis Kastanias
Czech Republic	**Leopoldo Mico** Head of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation AEE INTEC	Euroserv'ER July 2023	Unglazed water collectors: AEE INTEC recordings
Denmark	**Daniel Trier** Planenergi		DH plants only; unglazed water collectors: AEE INTEC recordings
Estonia	**Leopoldo Mico** Secretary General Head of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Euroserv'ER July 2023	estimation according to the trend
Finland	**Leopoldo Mico** Head of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry FederationPedro	Euroserv'ER July 2023	estimation according to the trend
France	**Paul Kaaijik** ADEME - Agence de l'Environnement et de la Maîtrise de l'Énergie **Frédéric Tuillé** Research Manager Observ'ER **John Hollick** SAHWIA - Solar Air Heating World Industry Association	EurObserv'ER 2023 Air collectors: John Hollick France overseas: Eurobser'Er 2023	Data provided by Frédéric Tuillé
Germany	**Dr. Andrea Liesen** BSW - Bundesverband Solarwirtschaft e.V., **John Hollick** SAHWIA - Solar Air Heating World Industry Association **Dirk Mangold**, Executive Director, Solites Steinbeis Research Institute for Solar and Sustainable Thermal Energy Systems **Magdalena Berberich**, Solites Steinbeis Research Institute for Solar and Sustainable Thermal Energy Systems	BSW - Bundesverband Solarwirtschaft e.V. Air collectors: John Hollick Solar district heating: Solites Steinbeis Research Institute for Solar and Sustainable Thermal Energy Systems	Data provided by Charlotte Brauns, BSW; FPC/ETC: BSW solar long time recordings; unglazed water collectors & glazed air collectors: AEE INTEC recordings SDH data provided by Dirk Mangold and Magdalena Berberich
Ghana	**Divine Atsu** Koforidua Polytechnic Department of Energy Systems Engineering		0% growth assumed; cumulated calculated based on 0% growth
Greece	**Costas Travasaros** EBHE – Greek Solar Industry Association **Vassiliki Drosou** CRES – Center for Renewable Energy Sources		Data provided by Costas Travasaros (EBHE)
Hungary	**Leopoldo Mico** Head of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry FederationPedro **John Hollick** SAHWIA - Solar Air Heating World Industry Association	Eurobserv'ER2023Air collectors: John Hollick	Cumulated calculated by AEE INTEC based on new installed 2022 from Eurobserv'ER 2023; shares FPC/ETC AEE INTEC

国家	联系方式	资料来源	备注
中国	Ruicheng Zheng 中国建筑科学研究院 何涛 中国建筑科学研究院 CSTIF - 中国太阳能热利用产业联盟	中国可再生能源学会，CSTIF - 中国太阳能热利用产业联盟	不包括出口，停运系统由 AEE INTEC 计算（考虑 2022 年的 14 年寿命）。
克罗地亚	迪亚斯-莱奥波尔多-米科 欧洲太阳能热利用行业联合会（ESTIF）运营与欧盟项目负责人	Euroserv'ER 2023 年 7 月太阳能	由 AEE INTEC 计算得出的累计数，已考虑停运（2020/2021 年平均值）
塞浦路斯	Panayiotis Kastanias 塞浦路斯雇主和实业家联合会	FPC 塞浦路斯太阳能热能工业家联盟 (EBHEK) 和塞浦路斯雇主和工业家联合会 (OEB)	AEE INTEC 根据 Panayiotis Kastanias 提供的替换数字计算得出的累计数
捷克共和国	莱奥波尔多-米科 运营与欧盟项目负责人 欧洲太阳能热利用协会（ESTIF）--欧洲太阳能热利用行业联合会 AEE INTEC	Euroserv'ER 2023 年 7 月	无釉集热器：AEE INTEC 记录
丹麦	丹尼尔-特里尔 Planenergi		仅限于 DH 设备；无釉集热器：AEE INTEC 记录
爱沙尼亚	莱奥波尔多-米科 秘书长 运营与欧盟项目主管 欧洲太阳能热利用行业联合会 (ESTIF)	Euroserv'ER 2023 年 7 月	根据趋势进行估算
芬兰	莱奥波尔多-米科 运营与欧盟项目负责人 欧洲太阳能热利用行业联合会（ESTIF）Pedro	Euroserv'ER 2023 年 7 月	根据趋势进行估算
法国	保罗-卡艾吉克 ADEME - 法国环境与能源管理局 Frédéric Tuillé 研究经理 观察 约翰-霍利克 SAHWIA - 世界太阳能空气加热工业协会	EurObserv'ER 2023 航空收藏家：John Hollick 法国海外：Eurobser'Er 2023	数据由 Frédéric Tuillé 提供
德国	安德烈娅-利森博士 BSW - Bundesverband Solarwirtschaft e.V.、 约翰-霍利克 SAHWIA - 世界太阳能空气加热工业协会 Dirk Mangold，Solites Steinbeis 太阳能和可持续热能系统研究所执行主任 Magdalena Berberich，Solites Steinbeis 太阳能和可持续热能系统研究所	BSW - Bundesverband Solarwirtschaft e.V. 空气集热器：John Hollick 太阳能区域供热：Solites Steinbeis 太阳能和可持续热能系统研究所	数据由 BSW 的 Charlotte Brauns 提供；FPC/ETC：BSW 太阳能长时间记录；无釉水集热器和有釉空气集热器：AEE INTEC 记录 SDH 数据由 Dirk Mangold 和 Magdalena Berberich 提供
加纳	神圣的阿特苏 科福里杜亚理工学院能源系统工程系		假定增长率为 0%；累计数按 0%计算
希腊	科斯塔斯-特拉瓦萨罗斯 EBHE - 希腊太阳能产业协会 瓦西里基-德罗苏 CRES - 可再生能源中心		数据由 Costas Travasaros（欧洲高等教育局）提供
匈牙利	莱奥波尔多-米科 运营与欧盟项目负责人 欧洲太阳能热利用行业联合会（ESTIF）Pedro 约翰-霍利克 SAHWIA - 世界太阳能空气加热工业协会	Eurobserv'ER2023Air 收藏者：约翰-霍利克	由 AEE INTEC 根据 Eurobserv'ER 2023 年新增装机 2022 计算得出的累积值；FPC/ETC AEE INTEC 的份额

Country	Contact	Source	Remarks
India	**Jaideep N. Malaviya** Malaviya Solar Energy Consultancy	Malaviya Solar Energy Consultancy (based on market survey)	New and cumulated installations based on survey from Malaviya Solar Energy Consultancy
Ireland	**Leopoldo Mico** Secretary GeneralHead of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Eurobserv'ER July 2023	Cumulated calculated by AEE INTEC based on newly installed collector areas; shares FPC/ETC AEE INTEC
Israel	**Eli Shilton** ELSOL **Bärbel Epp** Solrico – Solar market research		0% growth assumed; cumulated calculated by AEE INTEC based on 0% growth (replacement rate as of 2020 used for the calculation)
Italy	**Leopoldo Mico** Secretary GeneralHead of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation AEE INTEC	Solar Thermal Market Survey	Cumulated area: Solar Heat Europe 2021/ share FPC-ETC: AEE INTEC unglazed water collectors: AEE INTEC
Japan	**Manami Mizutani** Japan Solar System Development Association	Japan Solar System Development Association Long time series	
Jordan	AEE INTEC	AEE INTEC	No data for 2022; Cumulated installations by end of 2014
Kenya	East African Centre of Excellence for Renewable Energy and Efficiency (EACREEE)	Study of the Solar Water Heating Industry in Kenya, Energy Regulatory Commission of Kenya, Nairobi 2017	0% growth assumed
Latvia	**Leopoldo Mico** Secretary GeneralHead of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Eurobserv'ER 2023	Eurobserv'ER 2023 (estimation)
Lebanon	**Dr. Sorina Mortada** **Ammar Fadlallah** Lebanese Center for Energy Conservation (LCEC)	Lebanese Center for Energy Conservation (LCEC)	Data provided by Ammar Fadlallah
Lesotho	**Ivan Yaholnitsky** **Puleng Mosothoane** Bethel Business and Community Development Center (BBCDC)	SOLTRAIN Study, data provided by Puleng Mosothoane	
Lithuania	**Leopoldo Mico** Secretary GeneralHead of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Eurobserv'ER 2023	Newly installed Eurobserv'ER 2023 (estimation); cumulated calculated by AEE INTEC based on newly installed
Luxembourg	**Leopoldo Mico** Secretary GeneralHead of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry Federation	Eurobserv'ER 2023	Eurobserv'ER 2023 (estimation)
Malta	**Mark Anthony Callus** Sustainable Energy and Water Conservation Unit (SEWCU) Ministry for Energy and Health	Sustainable Energy and Water Conservation Unit (SEWCU) based on data provided by the Regulator for Energy and Water Services (REWS)	
Mauritius	**Devika Balgobin** Statistician Environment Statistics Unit Ministry of Environment and Sustainable Development	Statistics Mauritius	No new collector area 2022; cumulated collector area by end of 2015
Mexico	**David Garcia** FAMERAC **Bärbel Epp** Solrico – Solar market research	Glazed and unglazed water collectors: FAMERAC - Renewable Energy Industry Association Air collectors: SAHWIA - Solar Air Heating World Industry Association	Cumulated installations: calculated by AEE INTEC
Morocco	**Bärbel Epp** Solrico - Solar market research AEE INTEC	"A New Project for a Much More Diverse Moroccan Strategic Version: The Generalization of Solar Water Heater" by Fatima Zohra Gargab, Amine Allouhi, Tarik Kousksou, Haytham El-Houari, Abdelmajid Jamil; MDPI Switzerland 2021	0% growth assumed 2022

国家	联系方式	资料来源	备注
印度	Jaideep N. Malaviya 马拉维亚太阳能咨询公司	马拉维亚太阳能咨询公司（基于市场调查）	根据马拉维亚太阳能咨询公司的调查，新增和累计安装量
爱尔兰	莱奥波尔多-米科 秘书长运营与欧盟项目主管 欧洲太阳能热利用行业联合会 (ESTIF) - 欧洲太阳能热利用行业联合会	Eurobserv'ER 2023 年 7 月	AEE INTEC 根据新安装的集热器面积计算得出的累积值；FPC/ETC AEE INTEC 的份额
以色列	伊莱-希尔顿 ELSOL 巴贝尔-埃普 Solrico - 太阳能市场研究		假定增长率为 0%；AEE INTEC 根据 0%的增长率计算出累计数（计算时采用了 2020 年的替代率）。
意大利	莱奥波尔多-米科 秘书长运营与欧盟项目负责人 欧洲太阳能热利用协会 (ESTIF) - 欧洲太阳能热利用行业联合会 AEE INTEC	太阳能热利用市场调查	累计面积：欧洲太阳能供热 2021 年/份额 FPC-ETC：AEE INTEC 无釉水收集器：AEE INTEC
日本	水谷真奈美 日本太阳能系统开发协会	日本太阳能系统开发协会 长期序列	
约旦	AEE INTEC	AEE INTEC	2022 年无数据；2014 年底累计安装量
肯尼亚	东非可再生能源和效率高级研究中心（EACREEE）	《肯尼亚太阳能热水器行业研究》，肯尼亚能源管理委员会，内罗毕，2017 年	假定增长率为 0
拉脱维亚	莱奥波尔多-米科 秘书长运营与欧盟项目主管 欧洲太阳能热利用行业联合会 (ESTIF) - 欧洲太阳能热利用行业联合会	Eurobserv'ER 2023	Eurobserv'ER 2023（估计值）
黎巴嫩	Sorina Mortada 博士 阿马尔-法德拉拉赫 黎巴嫩节能中心（LCEC）	黎巴嫩节能中心（LCEC）	数据由 Ammar Fadlallah 提供
莱索托	Ivan Yaholnitsky Puleng Mosothoane 贝瑟尔商业与社区发展中心（BBCDC）	SOLTRAIN 研究，数据由 Puleng Mosothoane 提供	
立陶宛	莱奥波尔多-米科 秘书长运营与欧盟项目主管 欧洲太阳能热利用行业联合会 (ESTIF) - 欧洲太阳能热利用行业联合会	Eurobserv'ER 2023	2023 年新安装的 Eurobserv'ER（估计值）；AEE INTEC 根据新安装的 Eurobserv'ER 计算得出的累积值。
卢森堡	莱奥波尔多-米科 秘书长运营与欧盟项目主管 欧洲太阳能热利用行业联合会 (ESTIF) - 欧洲太阳能热利用行业联合会	Eurobserv'ER 2023	Eurobserv'ER 2023（估计值）
马耳他	马克-安东尼-卡卢斯 能源和卫生部可持续能源和节水股（SEWCU）	可持续能源和节水单位（SEWCU），基于能源和水服务监管机构（REWS）提供的数据	
毛里求斯	德维卡-巴尔戈宾 环境与可持续发展部 环境统计股统计员	毛里求斯统计局	2022 年不新增集电区；2015 年底前累计集电区面积
墨西哥	戴维-加西亚 FAMERAC 巴贝尔-埃普 Solrico - 太阳能市场研究	有釉和无釉集热器：FAMERAC - 可再生能源工业协会空气集热器：SAHWIA - 世界太阳能空气加热工业协会	累计安装量：由 AEE INTEC 计算
摩洛哥	巴贝尔-埃普 Solrico - 太阳能市场研究 AEE INTEC	"摩洛哥战略版本更加多样化的新项目：Fatima Zohra Gargab、Amine Allouhi、Tarik Kousksou、Haytham El-Houari、Abdelmajid Jamil 撰写的 "太阳能热水器的普及"；MDPI 瑞士，2021 年。	假定增长率为 0% 2022 年

Country	Contact	Source	Remarks
Mozambique	**Alberto Pondeca** Sunpower Engineering https://www.sunpowermz.com/	Market sales	Cumulated installations calculated by AEE INTEC
Namibia	**Fenni Shidhika** Namibia Energy Institute Namibia University of Science and Technology	Namibia Energy Institute-Solar Water Heaters-Survey 2022	
Nepal	**Avishek Malla** International Centre for Integrated Mountain Development	Solar Water Heating System Database https://www.researchgate.net/publication/299487583_Solar_Water_Heating_System_Database_in_Nepal/figures (07/05/2024)	New 2024
Netherlands	**Reinoud Segers** **Maria José Linders** **Laura Geurts** Statistics Netherlands (CBS) The Hague	Statistics Netherlands (CBS)	Newly installed areas: Statistics Netherlands based on survey of sales. Market Shares: Expert estimates Netherlands Enterprise Agency and Holland Solar. Data provided by Laura Geurts
New Zealand			No data available since 2010 Cumulated area by end of 2009
Nigeria	**Okala Nwoke** National Centre for Energy Research and Development, University of Nigeria, Nsukka		No new data 2022; cumulated by end of 2020
North Macedonia	**Prof. Dr. Ilja Nasov** National University St. Kiril and Metodij, Faculty for Natural Science, Institute of Physics, Solar Energy Department	Macedonian Solar Energy Association	Cumulated installations calculated by AEE INTEC based on new installation figures
Norway	**Dr. Michaela Meir** Aventasolar	Solvarmeanlegg i Norge 2019 commissioned by The Norwegian Solar Energy Cluster (Solenergiklyngen), provided by Michaela Meir	Cumulated calculated by AEE INTEC based on 12% growth for new installed collector area; 4 % out of operation considered
Palestinian Territories	**Mohammed Mobayyed** EEU Director Palestinian Energy Authority **Abdallah Azzam** Palestinian Central Bureau of Statics Natural Resource Statistics	Palestinian Energy Authority	
Poland	**Janusz Starościk** President Association of Heating Appliances Manufacturers and Importers in Poland (SPIUG)	SPIUG (Association of Heating Appliances Producers and Importers in Poland) – market research	
Portugal	**Jorge Facão** Laboratório de Energia Solar Laboratório Nacional de Energia e Geologia (LNEG) Lisboa	Data provided by Jorge Facão (2024)	
Romania	**Leopoldo Mico** Secretary GeneralHead of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry	Eurobserv'ER 2023	2021Eurobserv'ER 2023 (estimation)
Russia	**Prof. Vitaly Butuzov** Energotechnologies Service Ltd. Krasnodar **Dr. Semen Frid** JIHT RAS - Joint Institute for High Temperatures of Russian Academy of Sciences **Dr. Sophia Kiseleva** - Lomonosow Moscow State University	The source of information - Energotechnologies Service Ltd. (ETS)	
Senegal	**T. Ababacar** Université Cheikh Anta DIOP	Rapport de Marché du Solaire Thermique: Production d' Eau Chaude et Séchage de Produits Agricoles	No new data 2022
Slovakia	**Leopoldo Mico** Secretary GeneralHead of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal Industry	Eurobserv'ER 2023	
Slovenia	**Ciril Arkar** University of Ljubljana, Faculty of Mechanical Engineering	Eco Fund, Slovenian Environmental Public Fund	

国家	联系方式	资料来源	备注
莫桑比克	阿尔贝托-庞德卡 Sunpower Engineering https://www.sunpowermz.com/	市场销售	由 AEE INTEC 计算的累计安装量
纳米比亚	芬尼-希迪卡 纳米比亚能源研究所 纳米比亚科技大学	纳米比亚能源研究所--太阳能热水器--2022 年调查	
尼泊尔	阿维谢克-马拉 国际山区综合开发中心	太阳能热水系统数据库 https://www.researchgate.net/publication/299487583_Solar_Water_Heating_System_Database_in_Nepal/figures (07/05/2024)	新 2024
荷兰	Reinoud Segers 玛丽亚-何塞-林德斯 劳拉-格尔茨 荷兰统计局（CBS） 海牙	荷兰统计局（CBS）	新安装区域：荷兰统计数字基于销售调查。市场份额：荷兰企业局和荷兰太阳能公司专家估算。数据由 Laura Geurts 提供
新西兰			2010 年以来无数据 2009 年底累计面积
尼日利亚	奥卡拉-恩沃克 尼日利亚大学国家能源研究与发展中心，恩苏卡		2022 年无新数据；2020 年底累计
北马其顿	伊利亚-纳索夫博士教授 圣基里尔和梅托迪国立大学，自然科学学院，物理研究所，太阳能系	马其顿太阳能协会	AEE INTEC 根据新增安装量计算出的累计安装量
挪威	米凯拉-梅厄博士 Aventasolar	Solvarmeanlegg i Norge 2019 由挪威太阳能集群 (Solenergiklyngen) 委托制作，Michaela Meir 提供	AEE INTEC 根据新安装的集热器面积增长 12% 计算得出的累积值；考虑了 4% 的停运率
巴勒斯坦 领土	穆罕默德-穆巴耶德 EEU 主任 巴勒斯坦能源管理局 阿卜杜拉-阿扎姆 巴勒斯坦中央统计局 自然资源统计	巴勒斯坦能源管理局	
波兰	雅努什-斯塔诺希克 波兰供暖设备制造商和进口商协会主席 (SPIUG)	SPIUG（波兰暖气设备生产商和进口商协会）- 市场调研	
葡萄牙	豪尔赫-法康 太阳能实验室 里斯本国家能源与地质实验室（LNEG）	数据由 Jorge Facão 提供（2024 年）	
罗马尼亚	莱奥波尔多-米科 秘书长运营与欧盟项目负责人 欧洲太阳能热利用协会 (ESTIF) - 欧洲太阳能热利用行业	Eurobserv'ER 2023	2021Eurobserv'ER 2023（估计值）
俄罗斯	维塔利-布图佐夫教授 能源技术服务有限公司克拉斯诺达尔 塞门-弗里德博士 JIHT RAS - 俄罗斯科学院联合高温研究所 索菲亚-基塞列娃博士 - 罗蒙诺索夫 莫斯科国立大学	信息来源：Energotechnologies Service Ltd. (ETS)(ETS)	
塞内加尔	T.阿巴巴卡尔 谢赫-安塔-迪奥普大学	太阳能热利用市场报告：热水生产和农产品干燥	无新数据 2022
斯洛伐克	莱奥波尔多-米科 秘书长运营与欧盟项目负责人 欧洲太阳能热利用协会 (ESTIF) - 欧洲太阳能热利用行业	Eurobserv'ER 2023	
斯洛文尼亚	西里尔-阿尔卡尔 卢布尔雅那大学机械工程学院	生态基金，斯洛文尼亚环境公共基金	

Country	Contact	Source	Remarks
South Africa	**Karin Kritzinger** and **Lavhelesani Maluleke** Centre of Renewable and Sustainable Energy Studies Stellenbosch University	SWH manufacturer, SHW installers survey	
South Korea	**Ki-Young Choi** Korea Energy Management Corporation (KEMCO) **Kyoung-ho Lee** Solar Thermal and Geothermal Research Center New and Renewable Energy Research Division Korea Institute of Energy Research (KIER)	2018 New & Renewable Energy Statistics by the Korea New & Renewable Energy Center, KEA 2019;	No new data 2022; cumulated collector area by end of 2020
Spain	**Pascual Polo** ASIT - Asociación Solar de la Industria Térmica	ASIT (Solar Energy Industry Association of Spain)	Out of operation systems calculated by ASIT
Sweden	**Leopoldo Mico** Secretary GeneralHead of Operations & EU Projects Solar Heat Europe (ESTIF) – European Solar Thermal IndustryPedro	Eurobserv'ER 2023	Glazed water collectors: Solar Heat Europe 2021
Switzerland	http://www.swissolar.ch/	SWISSOLAR - Markterhebung Sonnenenergie 2022, Bundesamt für Energie 2023	Out of operation systems calculated by SWISSOLAR
Chinese Taipei	**K.M. Chung** Energy Research Center - National Cheng Kung University	Installers association	No new data 2022; cumulated collector area by end of 2020
Thailand	**Charuwan Phipatana-phuttapanta** Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy	GIZ study, Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy (Subsidized systems)	No new collector area in 2022; cumulated collector area by end of 2016
Tunisia	**Abdelkader Baccouche** Agence Nationale pour la Maîtrise de l'Energie (ANME)	ANME (National Agency of Energy Conservation)	0% growth assumed; cumulated calculated by AEE INTEC based on 0% growth
Turkey	**A. Kutay Ulke** Bural Heating Corporation Ltd. **John Hollick** SAHWIA - Solar Air Heating World Industry Association **Prof. Bulent Yesilata** GAP Renewable Energy and Energy Efficiency Center Harran University	Water collectors: A. Kutay Ulke, personal studies Air collectors: SAHWIA	New installations: A. Kutay Ulke, Bural Heating Corporation Ltd.; cumulated installations calculated by AEE INTEC considering 15 years lifetime
United Kingdom	**Elizabeth Waters** Renewables, Heat and Consumption BEIS - Department for Business, Energy & Industrial Strategy **John Hollick** SAHWIA - Solar Air Heating World Industry Association	MSC (microgeneration certification scheme) data used Air collectors provided by John Hollick	Revised timeline (2024)
United States	**Brad Heavner** California Solar and Storage Association (CALSSA) **Pam Murphey** IEA SHC Technology Program **John Hollick** SAHWIA - Solar Air Heating World Industry Association	Unglazed and FPC provided by Brad Heavner Air collectors: SAHWIA provided by John Hollick	New installations: CALSSA No new ETC data available 2022 Totals: calculated by AEE INTEC considering 25 years lifetime
Uruguay	**Dr. Luis Christian Navntoft** Solarmate SA https://www.solarmate.com.ar	Analysis of imported equipment under category 8419.12.00 NCM (assuming a total area of 2,2m2 per imported unit) Proportions of each type of collector and system obtained from the latest pool of solar thermal and PV equipment performed by the government in 2018: https://www.gub.uy/ministerio-industria-energia-mineria/sites/ministerio-industria-energia-mineria/files/2020-07/Equipamiento%20Solar%202017-2018.pdf	Cumulated calculated by AEE INTEC based on newly installed
Zimbabwe	**Samson Mhlanga** National University of Science and Technology, Bulawayo	Dr. Anton Schwarzlmüller Domestic Solar Heating unpublished statistics; SOLTRAIN survey 2022 (unpublished sources)	Cumulated calculated by AEE INTEC based on newly installed

国家	联系方式	资料来源	备注
南非	Karin Kritzinger 和 Lavhelesani Maluleke 斯泰伦博斯大学可再生和可持续能源研究中心	SWH 制造商、SHW 安装商调查	
韩国	Ki-Young Choi 韩国能源管理公司（KEMCO） Kyoung-ho Lee 太阳热能和地热研究中心 新能源和可再生能源研究部 韩国能源研究所（KIER）	韩国新能源与可再生能源中心 2018 年新能源与可再生能源统计数据，KEA 2019；	2022 年无新数据；到 2020 年底累计集电区面积
西班牙	帕斯夸尔-波罗 ASIT - 太阳能热能工业协会	西班牙太阳能行业协会（ASIT）	由 ASIT 计算的停止运行系统
瑞典	莱奥波尔多-米科 秘书长 运营与欧盟项目负责人 欧洲太阳能热利用行业（ESTIF）Pedro	Eurobserv'ER 2023	玻璃集热器：2021 年欧洲太阳能供热
瑞士	http://www.swissolar.ch/	SWISSOLAR - 2022 年太阳能市场调查，瑞士联邦能源办公室，2023 年	SWISSOLAR 计算的停止运行系统
中国台北	K.M. Chung 能源研究中心 - 国立成功大学	安装协会	2022 年无新数据；到 2020 年底累计集电区面积
泰国	Charuwan Phipatana-phuttapanta 能源部替代能源开发和效率司（DEDE）	德国国际合作机构的研究，能源部替代能源开发和效率司（DEDE）（补贴系统）	2022 年不新增集电区；2016 年底前累计集电区面积
突尼斯	Abdelkader Baccouche 国家能源管理局（ANME）	国家节能署（ANME）	假定增长率为 0%；AEE INTEC 根据 0% 的增长率计算出累计数
土耳其	A.库泰-乌尔克 布拉尔供热有限公司 约翰-霍利克 SAHWIA - 世界太阳能空气加热工业协会 Bulent Yesilata 教授 GAP 可再生能源和能源效率中心 哈兰大学	水收集器A. Kutay Ulke，个人研究 空气收集器：SAHWIA	新安装：A. Kutay Ulke，Bural Heating Corporation Ltd.；AEE INTEC 计算的累计安装量，考虑 15 年使用寿命
英国	伊丽莎白-沃特斯 可再生能源、供热和消费 BEIS - 商业、能源和工业战略部 约翰-霍利克 SAHWIA - 世界太阳能空气加热工业协会	使用的 MSC（微型发电认证计划）数据 John Hollick 提供的空气收集器	修订后的时间表（2024 年）
美国	布拉德-希夫纳 加州太阳能与储能协会（CALSSA） 帕姆-默菲 国际能源机构（IEA）SHC 技术计划 约翰-霍利克 SAHWIA - 世界太阳能空气加热工业协会	Unglazed 和 FPC 由 Brad Heavner 提供 空气收集器：SAHWIA 由 John Hollick 提供	新安装：CALSSA 无新的 ETC 数据 2022 总计：由 AEE INTEC 计算，考虑 25 年使用寿命
乌拉圭	路易斯-克里斯蒂安-纳文托夫特博士 Solarmate SA https://www.solarmate.com.ar	8419.12.00 NCM 类别下的进口设备分析（假设每台进口设备的总面积为 2.2 平方米） 各类集热器和系统的比例来自 2018 年政府进行的最新太阳能光热和光伏设备库： https://www.gub.uy/ministeriodeindustria-energia-mineria/sites/ ministerio-industria-energia-mineria/ files/2020-07/Equipamiento%20%20 Solar%202017-2018.pdf	AEE INTEC 根据新安装的设备计算出的累计数
津巴布韦	萨姆森-姆兰加 国立科技大学，布拉瓦约	Anton Schwarzlmüller 博士 家用太阳能供暖未公布的统计数据；2022 年 SOLTRAIN 调查（未公布的资料来源）	AEE INTEC 根据新安装的设备计算出的累计数

9.9 Additional literature and web sources used

The following reports and statistics were used in this report.

- ABRASOL, Producao e Vendas de Sistemas de Aquecimento Solar 2023, April 2024
- Bundesamt für Energie BFE, Sektion Analysen und Perspektiven, Statistik Sonnenenergie, Referenzjahr 2022; Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation UVEK, Juli 2023
- Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK), Austria – Innovative Energy Technologies - Market Development 2022; Ed. Peter Biermayr et al, Vienna, Austria June 2023
- Bundesverband Solarwirtschaft e.V. (BSW), Statistische Zahlen der deutschen Solarwärmebranche (Solarthermie) - BSW Faktenblatt Solarwärme, Februar 2024
- Eurobserv'ER 2023, The State of Renewable Energies in Europe, Edition July 2023
- Global Market Outlook for Solar Power / 2019-2023, Solar Power Europe, 2019
- GWEC / Global Wind Report 2023, Global Wind Energy Council, March 2023
- GWEC / Global Wind Report 2024, Global Wind Energy Council, April 2024
- IEA PVPS Snapshot 2021
- IRENA (2024) Renewable Capacities Statistics 2024, International Renewable Energy Agency, Abu Dhabi
- IRENA Renewable Energy and Jobs: Annual Review 2020
- IRENA Photovoltaic Systems Programme, Snapshot of Global PV Markets 2024, Report IEA-PVSP T1-42: 2024
- Lehr, U. et.al (2015), Beschäftigung durch erneuerbare Energien in Deutschland: Ausbau und Betrieb, heute und morgen
- Navntovt, L.C. et al., Análisis del potencial solar térmico en Argentina, Ministerio Economía Argentina, November 2022
- Photovoltaics Report, Fraunhofer Institute for Solar Energy Systems - ISE, with support from PSE Projects GmbH, February 2023
- Solar Heat Europe (ESTIF), Decarbonising Heat with Solar Thermal - Market Outlook 2022/2023
- Solar Power Europe (2021): Global Market Outlook for Solar Power 2021-2025
- Study of the Solar Water Heating Industry in Kenya, Energy Regulatory Commission of Kenya (ERC), Nairobi 2017
- Weiss, W. (2003) Wirtschaftsfaktor Solarenergie, Wien
- Weiss, W., Biermayr, P. (2006) Potential of Solar Thermal in Europe, published by ESTIF
- Wimmer, L. et al. (2019), Monitoring renewable process heat plants within the gas sector.

The following online sources were used in this report:

https://abrasol.org.br/wp-content/uploads/2024/05/Solar-Heating-Systems-Production-and-Sales-2024.pdf

https://www.amee.ma/

http://www.asit-solar.com/

https://helioscsp.com

https://www.solarpowereurope.org/

http://www.giz.de/

http://www.iea-shc.org/

http://www.irena.org/

http://www.olade.org/

http://www.ren21.net/

http://sahwia.org/

http://www.solar-district-heating.eu/

http://www.solarwirtschaft.de/

http://www.solrico.com/

http://www.solarthermalworld.org/

http://www.swissolar.ch/

9.9 使用的其他文献和网络来源

本报告使用了以下报告和统计数据。

› ABRASOL, Producao e Vendas de Sistemas de Aquecimento Solar 2023, April 2024

› 瑞士联邦能源办公室 SFOE，分析和展望科，太阳能统计，参考年份 2022 年；联邦环境、交通、能源和通信部 DETEC，7 月。

2023

› 联邦气候行动、环境、能源、交通、创新和技术部 (BMK)，奥地利 - 创新能源技术 - 2022 年市场开发；Peter Biermayr 等人编辑，奥地利维也纳，2023 年 6 月

› Bundesverband Solarwirtschaft e.V. (BSW)，德国太阳能供热行业（太阳能热能）统计数字 - BSW 太阳能供热概况介绍，2024 年 2 月

› Eurobserv'ER 2023，欧洲可再生能源状况，2023 年 7 月版

› 2019-2023年全球太阳能市场展望》，欧洲太阳能协会，2019年

› 全球风能理事会/《2023 年全球风能报告》，全球风能理事会，2023 年 3 月

› 全球风能理事会/《2024 年全球风能报告》，全球风能理事会，2024 年 4 月

› 国际能源署 2021 年光伏发电站快照

› 国际可再生能源机构（2024 年）《2024 年可再生能源能力统计》，国际可再生能源机构，阿布扎比

› 国际可再生能源机构《可再生能源与就业》：年度回顾 2020

› 国际可再生能源机构光伏系统计划，《2024 年全球光伏市场快照》，IEA-PVSP T1-42 报告：2024

› Lehr, U. et.al (2015)，《德国可再生能源带来的就业：今天和明天的扩张与运营》（Employment through renewable energies in Germany: Expansion and

› Navntovt, L.C. et al., Análisis del potencial solar térmico en Argentina, Ministerio Economía Argentina, November 2022

› 《光伏报告》，弗劳恩霍夫太阳能系统研究所 - ISE，PSE Projects GmbH 支持，2023 年 2 月

› 欧洲太阳能供热公司（ESTIF），《利用太阳能供热实现供热脱碳--2022/2023 年市场展望》（Solar Heat Europe (ESTIF), Decarbonising Heat with Solar Thermal - Market Outlook 2022/2023

› 欧洲太阳能发电（2021 年）：2021-2025 年全球太阳能市场展望

› 《肯尼亚太阳能热水器行业研究》，肯尼亚能源管理委员会（ERC），内罗毕，2017 年

› Weiss, W. (2003) Wirtschaftsfaktor Solarenergie, Vienna

› Weiss, W., Biermayr, P. (2006) Potential of Solar Thermal in Europe, published by ESTIF

› Wimmer, L. et al. (2019)，《监测天然气行业中的可再生工艺热电厂》。

本报告使用了以下在线资料来源：

https://abrasol.org.br/wp-content/uploads/2024/05/Solar-Heating-Systems-Production and-Sales-2024.pdf

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http://www.asit-solar.com/

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https://www.solarpowereurope.org/

http://www.giz.de/

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http://www.irena.org/

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http://www.solarwirtschaft.de/

http://www.solrico.com/

http://www.solarthermalworld.org/

http://www.swissolar.ch/

9.10 List of Figures

9.10 图表目录

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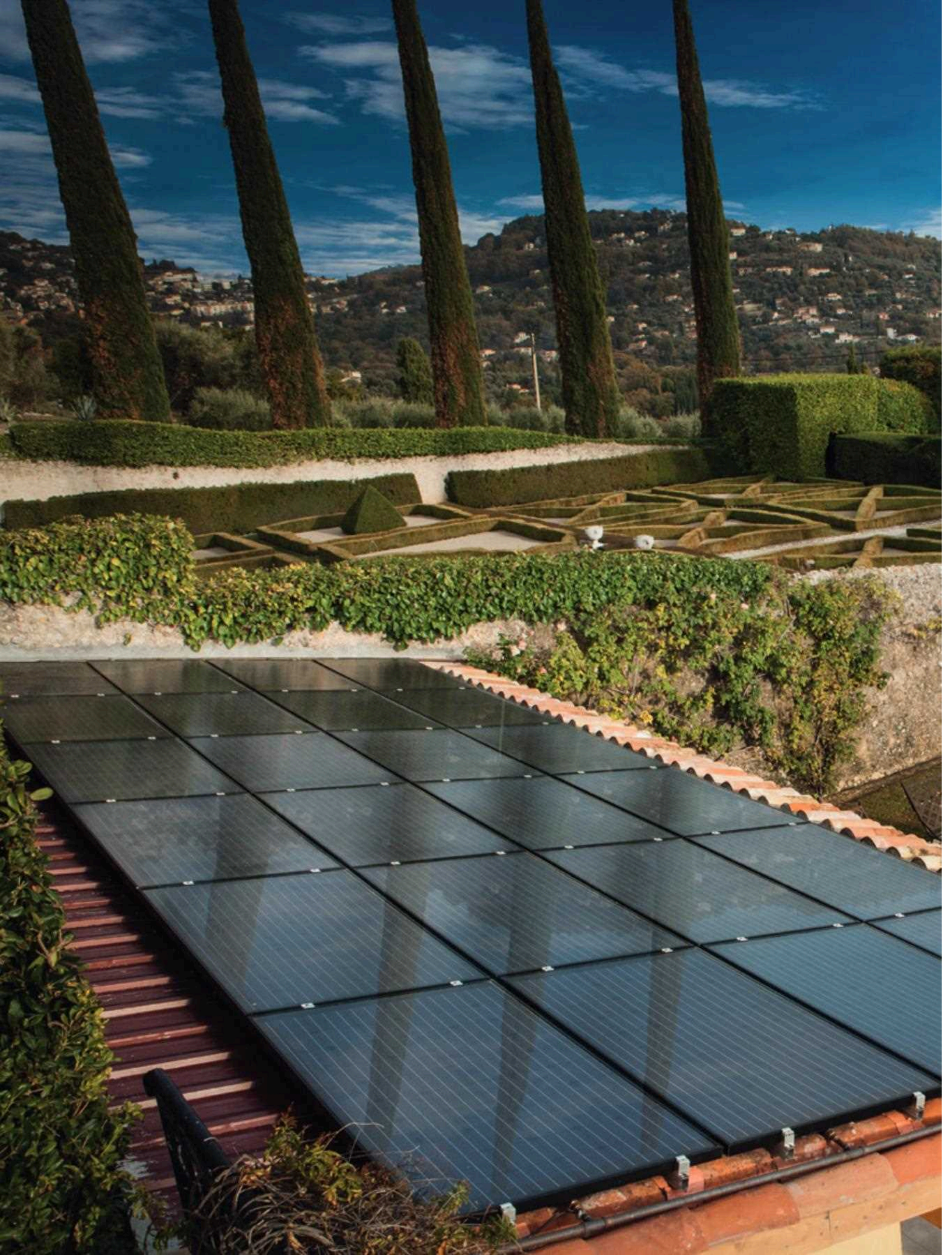

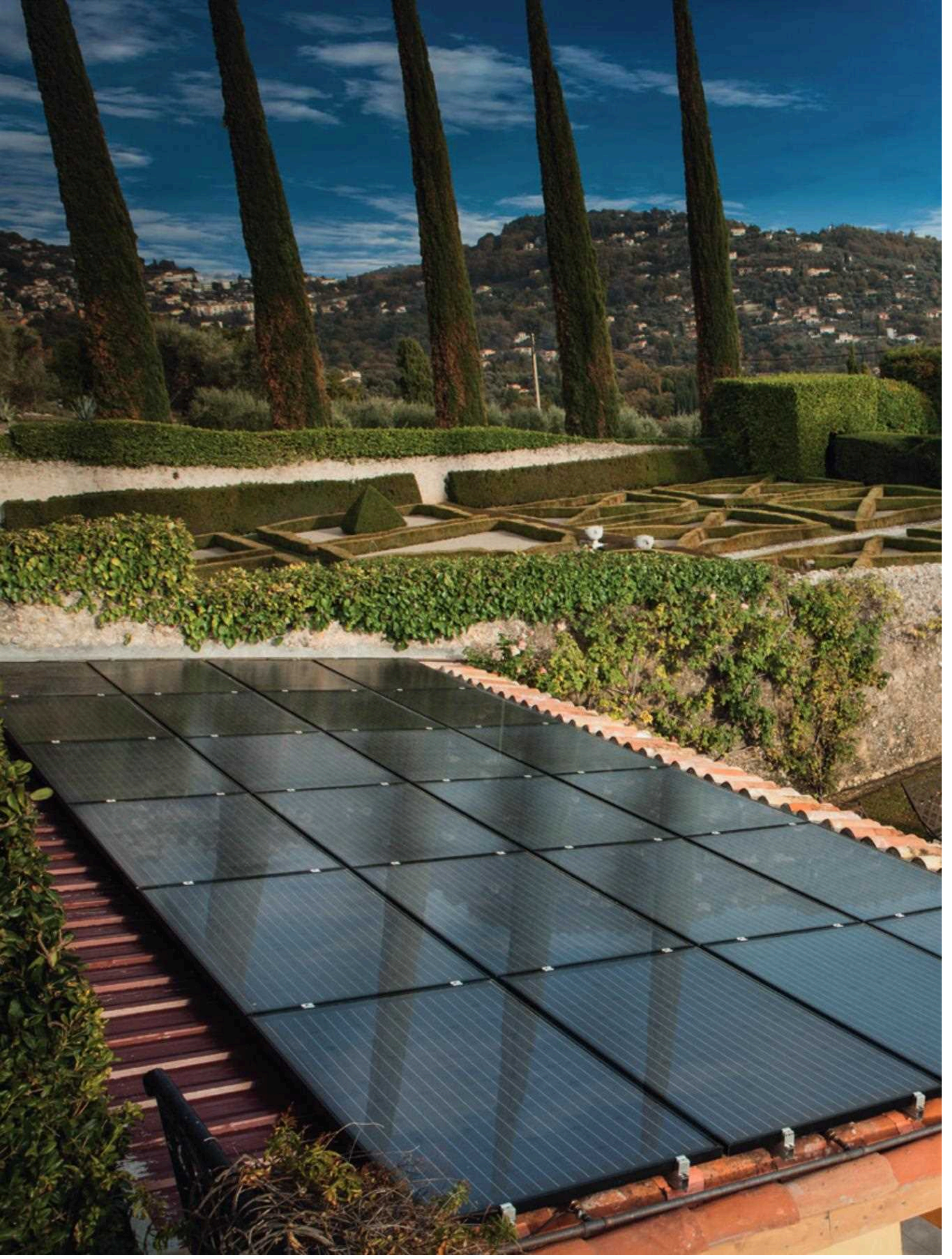

Photo: DualSun, France

照片法国 DualSun 公司