IRENA
International Renewable Energy Agency

RENEWABLE POWER GENERATION COSTS IN 2020

Citation: IRENA (2021), *Renewable Power Generation Costs in 2020*, International Renewable Energy Agency, Abu Dhabi.

ISBN 978-92-9260-348-9

About IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. An intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. **www.irena.org**

Acknowledgements

IRENA is grateful for the valuable contributions of Dolf Gielen, Elizabeth Press, Ahmed Badr, Simon Benmarraze, Herib Blanco, Francisco Boshell, Yong Chen, Imen Gherboudj, Barbara Jinks, Mohammed Nababa and Binu Parthan (IRENA) in the preparation of this study. This report benefited from the reviews and comments of numerous experts, including Pietro Altermatt (Trina Solar), Alain Dollet (CNRS / PROMES), Alejandro Labanda (UNEF), Alex Barrows (exa-watt), Amelie Ancelle (ESTELA), Christoph Richter (DLR), Daniel Gudopp (deea Solutions), David Moser (Eurac Research), Eero Vartiainen (Fortum Growth Oy), Elvira Lopez Prados (Acciona), Eric Lantz (NREL), Florian Egli (ETH Zurich), Jose Donoso (UNEF), Jose Luis Martinez Dalmau (ESTELA), Jürgen Dersch (DLR), Keiji Kimura (Renewable Energy Institute), Lena Kitzing (DTU), Manuel Quero (Sunntics), Marcel Bial (ESTELA), Mark Mehos (NREL), Marta Martinez Sanchez (Iberdrola), Miguel Mendez Trigo (ESTELA), Molly Morgan (exa-watt), Nikolai Orgland (ETH Zurich), Paul Komor (University of Colorado at Boulder), Pedro Dias (Solar Heat Europe), Phillip Beiter (IEA Wind), Simon Price (exa-watt) and Rina Bohle Zeller (Vestas).

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IRENA would like to thank:

- The International Climate Initiative (IKI) as part of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety for supporting the analysis of commercial and industrial solar thermal heat within the project Solar Payback.
- The German Federal Ministry for Economic Affairs and Energy for supporting the benchmarking and survey of the cost of capital for renewable power generation projects.
- The European Commission for supporting the collection of renewable energy cost and performance data to help track innovation output trends.

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FOREWORD

Francesco La Camera

Director-General
International Renewable Energy Agency

Renewables are becoming more and more competitive in the energy landscape. The data from the IRENA Renewable Cost Database shows cost declines continued in 2020, with the cost of electricity from utility-scale solar photovoltaics (PV) falling 7% year-on-year, offshore wind fell by 9%, onshore wind by 13% and that of concentrating solar power (CSP) by 16%.

The decade 2010 to 2020 saw dramatic improvement in the competitiveness of solar and wind power technologies. Between 2010 and 2020, the cost of electricity from utility-scale solar photovoltaics (PV) fell 85%, followed by concentrating solar power (CSP; 68%), onshore wind (56%) and offshore wind (48%). The last decade has seen CSP, offshore wind and utility-scale solar PV all join onshore wind in the cost range for new capacity fired by fossil fuels, when calculated without the benefit of financial support. Indeed, the trend is not only one of renewables competing with fossil fuels, but significantly undercutting them.

This is not just the case where new generating capacity is required. The analysis in this report shines a spotlight on how even existing coal plants are increasingly vulnerable to being undercut by new renewables. Indeed, our analysis suggests that up to 800 gigawatts (GW) of existing coal-fired capacity could be economically replaced by new renewables capacity, saving the electricity system up to USD 32 billion per year and reducing carbon-dioxide (CO_2) emissions by up to 3 gigatonnes (Gt) CO_2. This would provide 20% of the emissions reduction needed by 2030 for the 1.5°C climate pathway outlined in IRENA's *World Energy Transitions Outlook*. There is no room for these coal assets to be part of the energy future, retrofitting with carbon capture and storage would only increase costs. While the flexibility to integrate very high shares of renewables will come from other, cheaper sources, with IRENA having identified 30 options that can be combined into comprehensive solutions in the report *Innovation landscape for a renewable powered future*.

IRENA has, for over a decade, highlighted the essential role renewable power generation will play in the energy transition, as the opportunities for cost reduction were time and again, demonstrated, and then, in many cases, exceeded as smart policy and the razor-sharp focus of industry combined to unlock better performance and lower costs. The insights from IRENA's data bear witness to the fruits of IRENA's pluriannual programme of work and its focus on providing our Member States with the facts they need to support the energy transition at home. With falling renewable power generation costs, updates to Nationally Determined Contributions (NDC) need to consider the opportunities that have emerged in recent years. Countries can be more ambitious, and IRENA is ready to support them in that process.

This report also reinforces one of the key messages of our *World Energy Transitions Outlook 2021*, that very low-cost renewables can not only form the backbone of a decarbonised electricity system, but support a radically different future energy system where renewable hydrogen – derived from very low-cost renewable electricity – and modern biomass provide the last key to unlocking an affordable pathway to a 1.5°C future for us all. Now is the time to seize that opportunity.

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09

RENEWABLE HEAT COSTS

COMMERCIAL AND INDUSTRIAL SOLAR THERMAL

Solar thermal technologies are used in all regions of the world to provide low and medium temperature heat in industry and buildings.

Solar thermal technologies are highly modular and can be installed on the rooftops of individual buildings for residential use, or in hospitals or hotels. They can also be found in large, MW-scale ground-mounted systems in industry, agriculture and district heating networks.

The market for solar thermal is still at an early stage of development, but at least 120 large-scale heat projects were added in 2020 in the commercial and industrial sectors. These feed renewable heat into district heating networks, or supply heat to processes in the manufacturing sector. Compared to what is needed to achieve the Paris Agreement goals, deployment rates remain woefully inadequate. For instance, IRENA's 1.5°C pathway requires global solar thermal capacity to increase from around 4 gigawatts thermal (GW_{th}) in 2018 to 890 GW_{th} in 2030 and 1290 GW_{th} in 2050.

Modest growth – total solar thermal heat capacity in Europe grew by only 3% in 2020 (Solar Heat Europe/ESTIF, 2021) – is therefore insufficient. Like many of the technologies necessary for decarbonising the building and industrial sectors, solar thermal is typically held back by the absence of co-ordinated and sustained policy support to decarbonise heat. The result of erratic and inconsistent support levels over time, has been insufficient market growth and the subsequent lack of scale that would otherwise stem from more consistent policy support and allow lower costs.

Solar thermal has also been held back by a lack of transparency regarding the cost and performance of systems and their potential for cost reduction. This raises information costs, introduces uncertainty and deters investors and policy makers from seriously investigating the opportunity that solar thermal represents in contributing to a 1.5°C pathway.

To fill this gap with accurate, timely, verifiable cost and performance data for solar heat technologies, IRENA has partnered with the Solar Payback to survey industry participants. The data collection process targeted the largest 32 project developers and technology suppliers for solar heat worldwide, as well as funding agencies in Europe.

The project has been successful in collecting comprehensive cost and performance data for large[1] solar thermal heat projects that have been commissioned in roughly the last 10 years. The database currently contains data for over 1 750 commercial and industrial solar heat projects, totalling 935 megawatts thermal (MW_{th}). The database contains 115 district heating projects, totalling 686 MW_{th}, 259 solar heat for industrial processes (SHIP) projects totaling 92 MW_{th}, with the remaining projects covering space heating and hot water.

The data come from 24 different countries, but the majority are from the major markets for commercial and industrial solar heat projects: Austria, China, Denmark, France, Germany, India, Mexico, Spain and the United States.

In terms of collector technology, flat plate collectors represent 1 570 projects, totalling 776 MW_{th}, with 93 projects and 103 MW_{th} using concentrating collectors and 104 projects and 54 MW_{th} using vacuum tube collectors. To the best of the project partners' knowledge, this is the most comprehensive database of the cost and performance characteristics of large-scale solar thermal heat projects in existence.

The following section highlights some of the early findings from the data collection process. The full dataset will be presented and analysed in a forthcoming report by IRENA and Solar Payback in 2021. Next years Renewable Power Generation Cost report will include a more detailed discussion than presented here based on the full database, updated to include data for 2021 where possible.

SOLAR THERMAL FOR DISTRICT HEATING IN DENMARK

Denmark leads the world for total district heating capacity in operation, with more than 1 GW_{th} at the end of 2020. Around 120 villages, towns and cities use solar heat in their municipality-owned district heating networks.

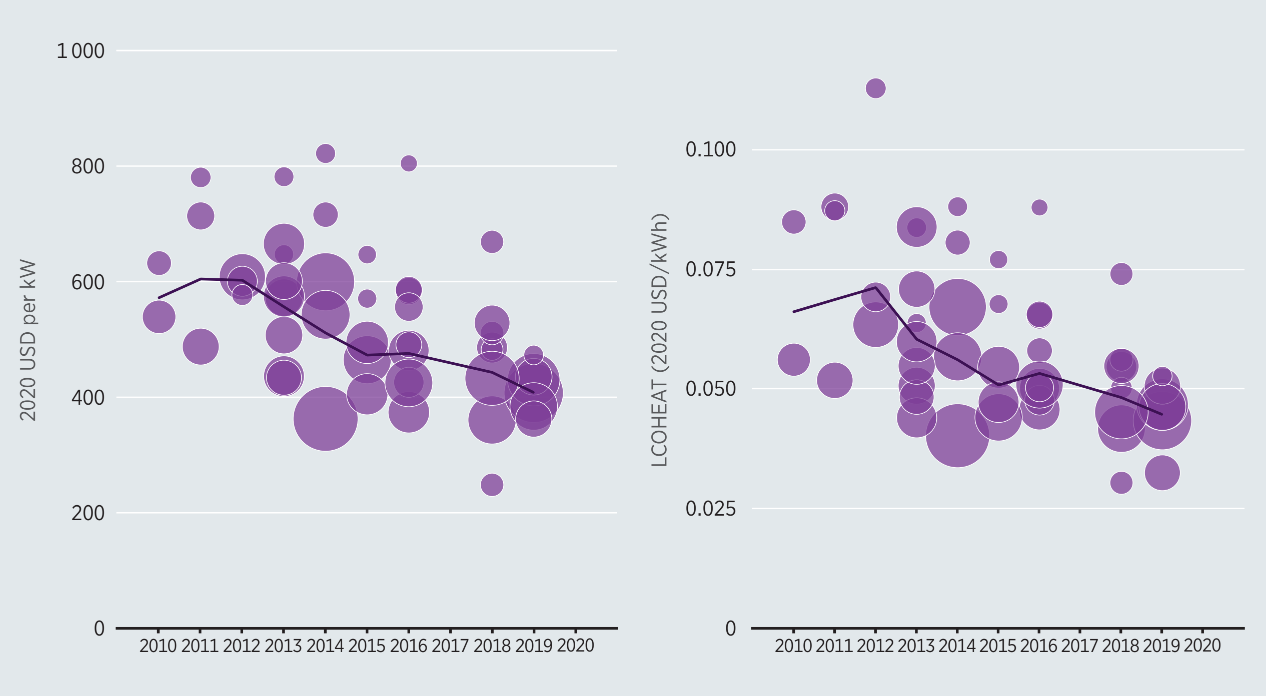
The total installed cost of district heating scale solar heat in Denmark fell from a weighted average of USD 573/kW in 2010 to USD 409/kW in 2019. This represents a learning rate for the period of around 17% – slightly higher than that of onshore wind for the period 2010 to 2020. These cost reductions have made solar thermal heating systems a competitive source of heat for district heating, as the weighted-average levelised cost of heat (LCOHEAT) fell from USD 0.066/kWh in 2010 to USD 0.045/kWh in 2019 (Figure 9.1).

In the first years of this period, prices were fairly stable. Then, there was a steep decline of LCOHEAT after 2014, driven by an increasingly competitive supply chain and growing developer experience amongst a small number of highly competitive project developers. Economies of scale are also evident in the most recent years.

The figure excludes a 110 MW_{th} project commissioned in 2016, as this project has lower costs and is something of an outlier in the database. Including this project in the chart would increase the learning rate to 19%. The other important point to note is that since 2016, 55% of the projects commissioned have included storage tanks to meet demand throughout the entire day.

1 Given the nascent nature of the market for these systems, the threshold is set as low as 50 square metres (m^2) of collector area for solar industrial heat systems. This is in order to collect as much relevant data as possible, particularly in Europe, where support schemes for these systems are an important source of data.

Figure 9.1 Total installed costs and LCOHEAT for solar thermal district heating plants in Denmark, 2010-2019



Source: IRENA and Solar Payback, 2021

Note: Data is for 50 projects commissioned between 2010 and 2019 ranging in size from 1.8 MW_{th} to 26 MW_{th}.

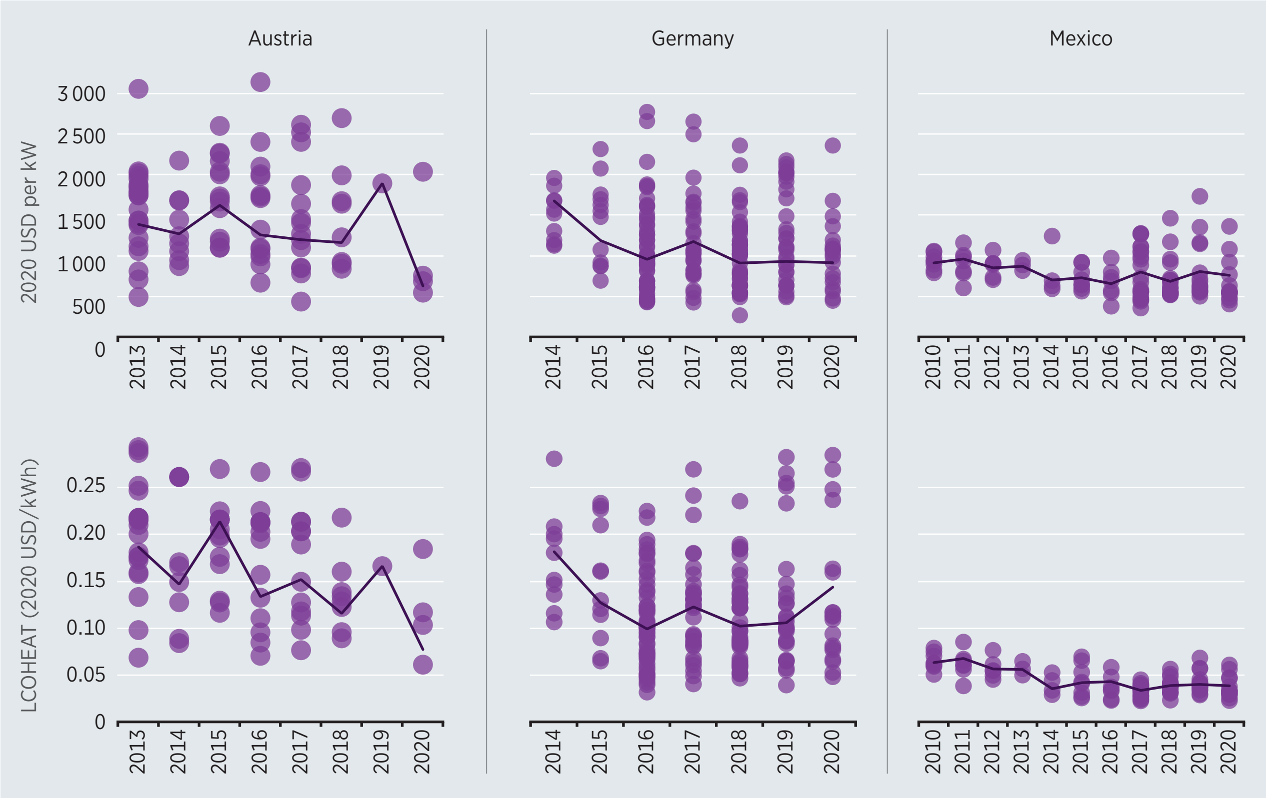
LARGE-SCALE SOLAR THERMAL IN AUSTRIA, GERMANY AND MEXICO

Figure 9.2 presents the data for all of the large-scale solar thermal heat projects in the database for Austria, Germany and Mexico. The data for Austria (89 projects) are a mix of all applications for which data was collected, including central space heating and hot water systems, process heat (air, liquid and steam), as well as for district heating systems.

The data for Germany (209 projects) are predominantly for central hot water and space heating systems, but also include a number of district heating systems and process heat (air or liquid) systems. Mexico (108 projects) is somewhat different, with most of the large systems there being for process heat (liquid or process heat (steam), with some data for large central hot water systems. The data for Austria has a gap in 2019, for which data from the support scheme were not available.

In Austria, total installed costs fell by 55% between 2013 and 2020. In Germany, they fell by 45% between 2014 and 2020

Figure 9.2 Total installed costs and LCOHEAT for commercial and industrial-scale solar thermal plants in Austria, Germany and Mexico, 2010-2020



Source: IRENA and Solar Payback, 2021

In Austria, total installed costs fell by 55% between 2013 and 2020. In Germany, they fell by 45% between 2014 and 2020, while in Mexico, they fell by 17% between 2010 and 2020. Data for 2020 and 2021 is still sparse, while care must be taken interpreting the data – notably for Austria, where only a handful of data points is available. By 2020, however, total installed costs had converged somewhat, with, on average, larger projects in Austria having a slightly lower weighted average in those two years than in Germany and Mexico. When we come to LCOHEAT, however, the superior solar resources available in Mexico become readily apparent, as the weighted-average LCOHEAT of the solar thermal plants in Mexico in 2020 was USD 0.039/kWh. The increase in Germany in 2020 for LCOHEAT is due to one outlier, with very high installed costs, while the decline for Austria in the weighted-average LCOHEAT between 2018 and 2020 is predominantly due to the much larger average size of systems deployed in the latter period, compared to the period prior to 2018. This is a graphic illustration of the benefits of economies of scale.

ECONOMIES OF SCALE

Despite the small-scale of the market for solar thermal in Europe, the data for district heating projects in Europe helps to show the impact that economies of scale can have on project costs.

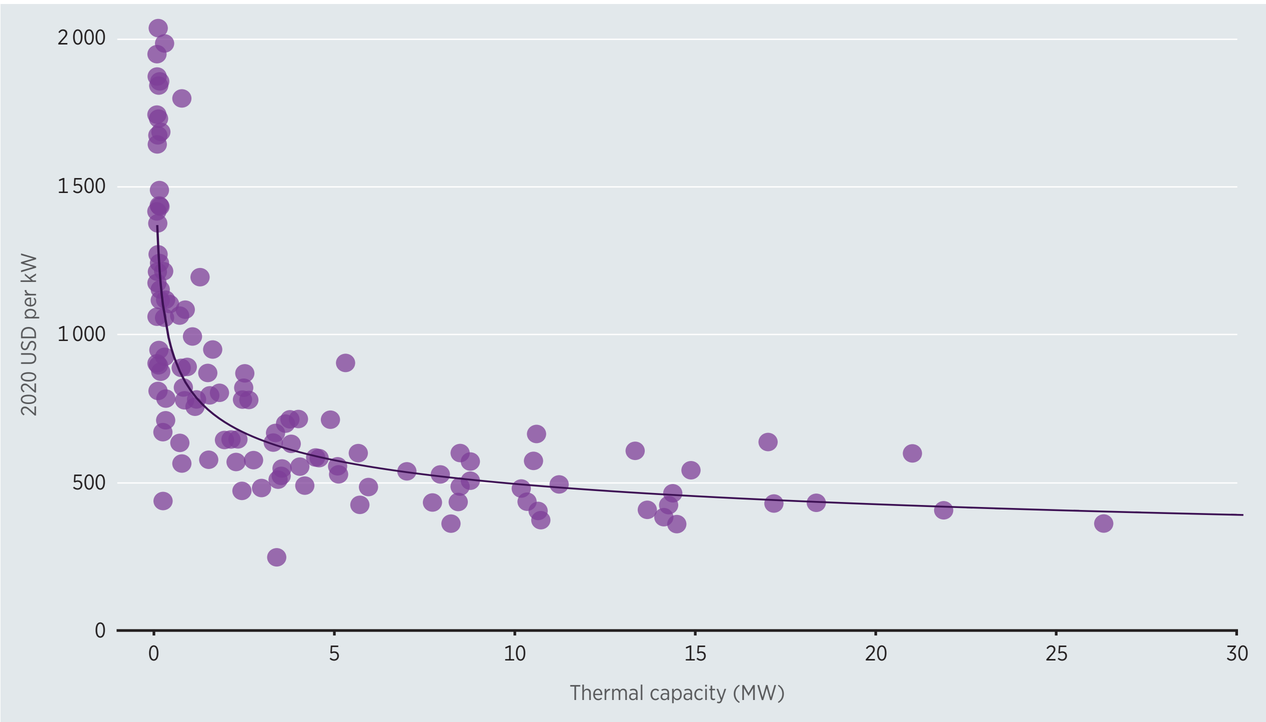
The Danish district heating market has been marked by experienced suppliers and manufacturers, competing to deliver competitive MW-scale projects to district heating schemes. Between 2010 and 2020, the weighted-average project size for those in our database ranged from a low of 5.4 MW_{th} in 2010 to a high of 17 MW_{th} in 2016 and was 12 MW_{th} in 2019. For Europe, these are large project sizes and as can be seen from Figures 9.1 and 9.2, the result is that Denmark has a very competitive LCOHEAT.

Costs are higher in Austria and Germany and this is directly related to project size, although other factors no doubt also play a role. In Austria, the weighted-average size of district heating projects ranged from a low of 0.1 MW_{th} in 2012 to a high of 0.4 MW_{th} in 2017. Germany's district heating schemes sit in between Austria and Denmark, ranging from a low of 0.8 MW in 2017 to a high of 2.1 MW_{th} achieved in the previous year, 2016.

Figure 9.3 shows the total installed cost data for 118 district heating projects, plotted against the project capacity in MW. Austria, Denmark and Germany account for 97% of the district heating projects in the database, and the clear economies of scale in project size are quite evident. Austrian district heating projects lie almost exclusively in the range up to 1 MW_{th}, while most German projects are situated between 0.4 MW_{th} and 1.9 MW_{th}. Denmark dominates the far right of the figure, with most projects in the 2 MW_{th} to 15 MW_{th} range. Not shown on the chart is the 110 MW_{th} plant from Denmark, but it is included for the calculation of the trend line. The fitted line for economies of scale suggests that for every doubling in the size of the plant, total installed costs will decline by 14%.

Policies to support larger-scale projects would likely have immediate benefits for consumers in terms of lower renewable heat costs in most of Europe, as the example of Denmark demonstrates. This is before considering the benefits to economies of scale in manufacturing that would occur if a more ambitious programme of support for renewable heat was pursued.

Figure 9.3 Total installed costs for district heating projects by installed capacity in Europe, 2010-2020



Source: IRENA and Solar Payback, 2021