COST TRENDS OF SOLAR ENERGY FOR **HEAT IN INDUSTRY**

Supply chain maturity and **economies of scale** are driving costs down in key markets across the globe.

Solar Payback

Large solar heat plants show cost reductions in three market segments

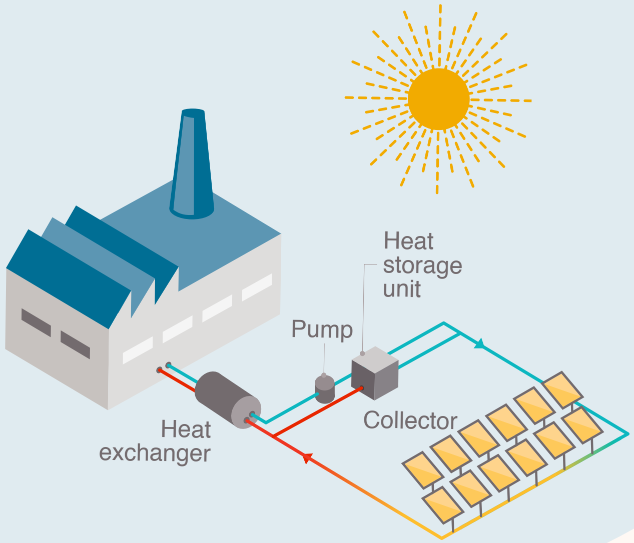
In the category of large solar heat plants, there are three main types of clients: **industries** with a high energy demand for heat, **utilities** running district heating networks and buildings from the **service sector** (hospitals, hotels, sport centres, multi-family houses etc.).

“Large” is set at 35 kW thermal capacity of the collector field, a threshold used by the IEA SHC Programme to count installations for the solar industrial heat world market.

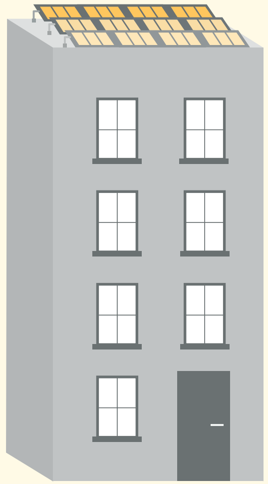
This report is a result of a comprehensive industry survey and the analysis of a unique dataset of costs and performance indicators of several hundred large solar heat systems constructed worldwide in the last ten years.

To identify cost trends either installed costs in USD per kW or levelized costs of heat (LCOH) are plotted over time or averaged for regions or countries which represent major solar thermal markets.

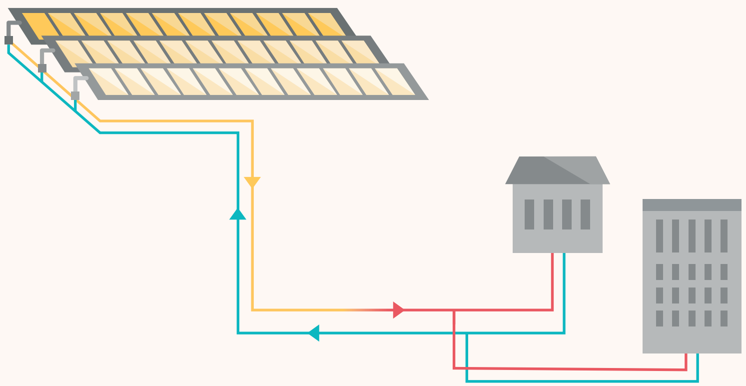
SHIP
Solar Heat
for Industrial Processes



SERVICE SECTOR
Central Solar
Water Heating

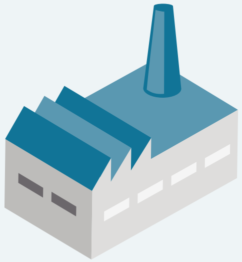


SDH
Solar District Heating

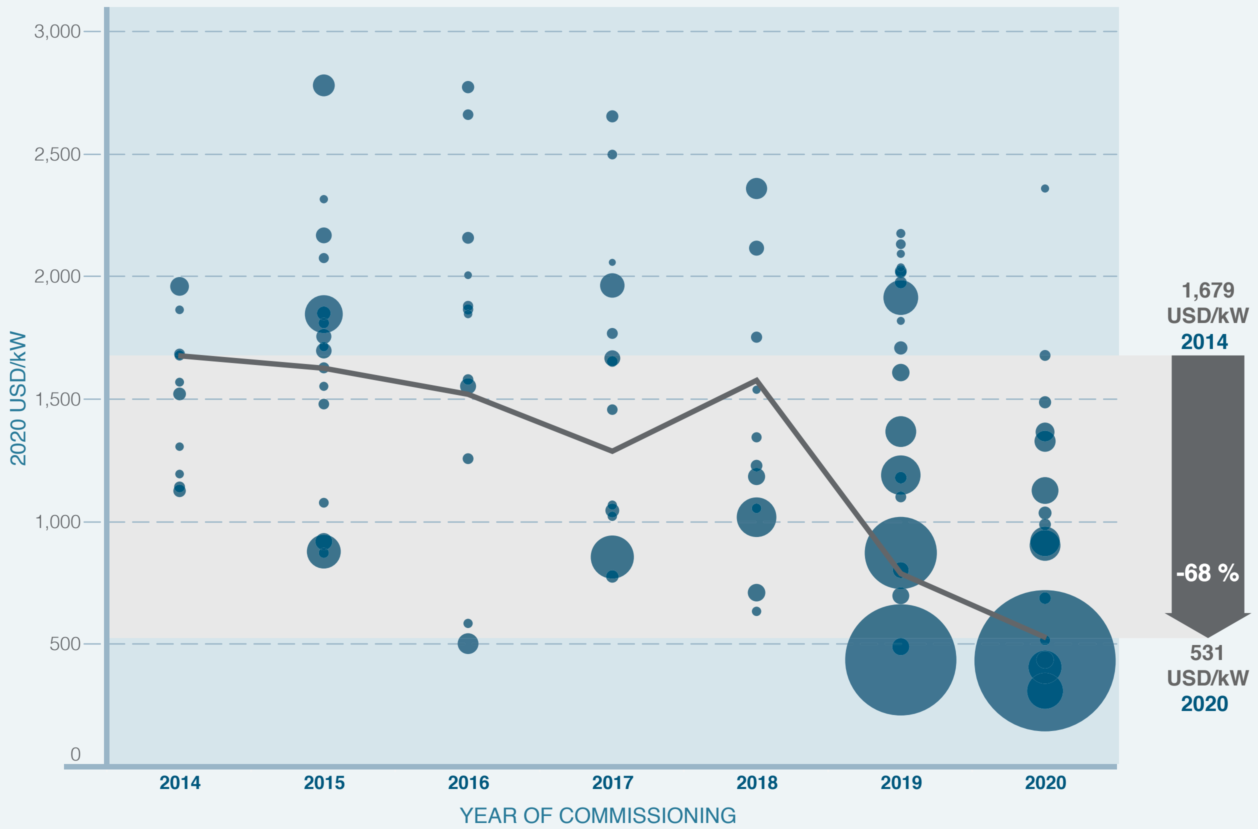


Solar
Payback

Economies of scale drive down SHIP costs in Europe



Weighted-average, total installed costs of 101 SHIP plants in Europe



The projects in this chart include stationary and concentrating collector technologies and are commissioned in Austria, Belgium, Cyprus, France, Germany, Greece, Italy, Netherlands and Spain. Total installed costs shown as real USD values in 2020 (taking inflation into account).

How to read this chart:

The diameter of each circle denotes project capacity in kW and the centre the total installed cost in USD 2020 on the Y-axis.

The bold line represents the weighted-average installed costs by year.

The arrow marks the reduction between the weighted-average costs of all projects in the first and the last year of the examined period.

Support policies were a key factor for a larger deployment of SHIP projects, resulting in cost reductions.

Examples: the investment grants in France and the solar heat tariff in the Netherlands have allowed for the commissioning of more multi-MW SHIP plants over the last few years.

Conclusion: the costs decreased by two-thirds in six years.

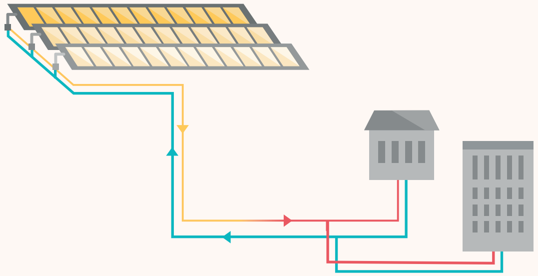
In 2014, the weighted-average installed costs of 11 SHIP projects were 1,679 USD/kW, while the average of 15 plants commissioned in 2020 dropped to 531 USD/kW, a decrease of 68 %.

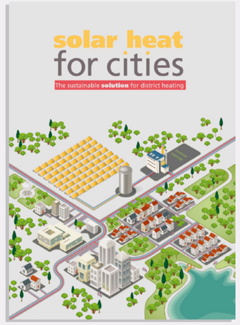
Large-scale SHIP plants benefit from “economies of scale” where larger projects tend to have lower costs, some of the drivers of these economies of scale are:

- Lower bill-of-materials for larger quantities
- Improved efficiency in manufacturing
- Lower fixed costs per kW for permissions, design and logistics
- Faster and more efficient installation

Solar Payback

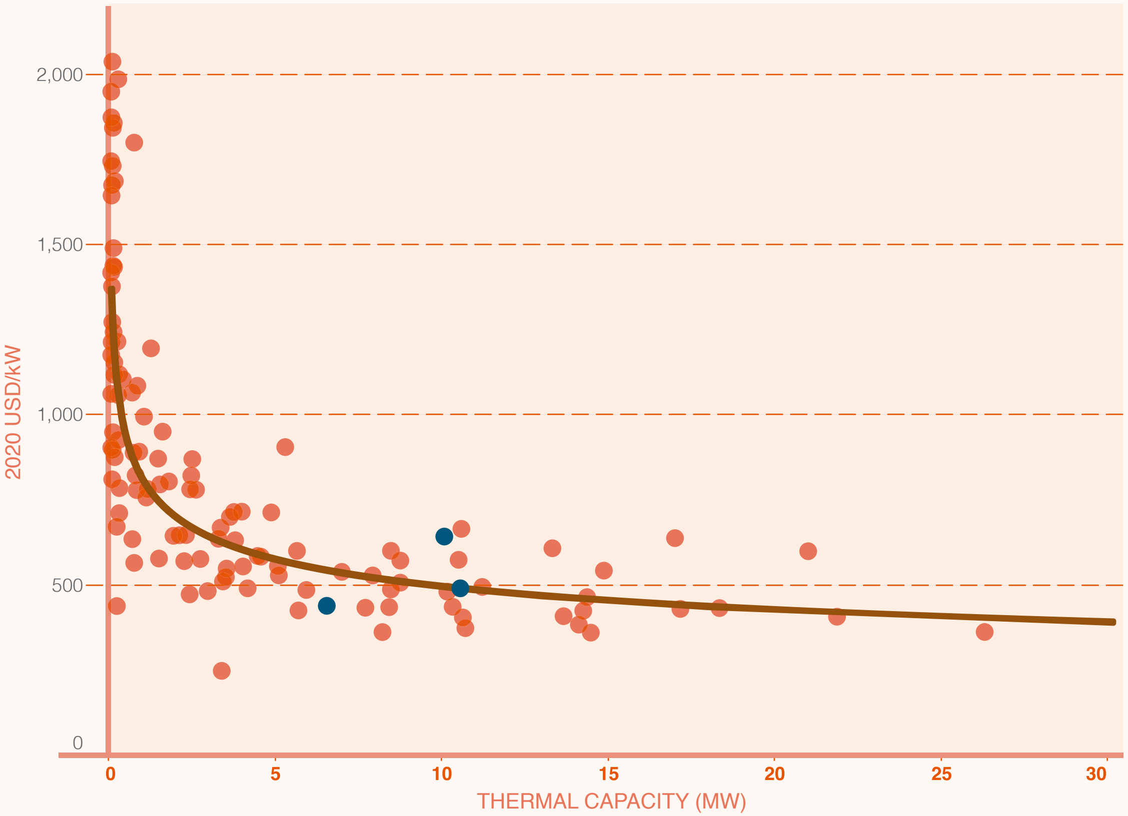
Denmark's SDH market: a role model for economies of scale





https://task55.iea-shc.org/

Weighted-average, total installed costs of large European plants



How to read this chart:

Each orange circle shows one SDH project and each blue circle shows one of the large multi-MW SHIP plants commissioned between 2010 and 2021 in Europe. 97 % of the SDH projects have been installed in three countries Austria, Germany and Denmark.

The fitted, trend line shows the cost degression for increased plant sizes in MW.

The European SDH market has achieved great economies of scale due to Denmark's leading role.

At least 110 Danish villages, towns and cities use solar heat in their networks already. Experienced suppliers and manufacturers have competed heavily to deliver competitive MW-scale projects in the last decade.

The three blue circles highlight the first multi-MW SHIP projects installed in France and the Netherlands. Their installed costs are close to the SDH cost trend line, indicating that SHIP plants can achieve economies of scale similar to those of SDH plants.

The trend curve suggests that for every doubling of the size of the plant, total installed costs will decline by 14 %. The curve results in costs of 296 USD/kW for a 110 MW plant. This is lower than the costs of the 110 MW installation in Silkeborg, Denmark, commissioned in 2016 which is part of the trend curve calculation, but off the chart.

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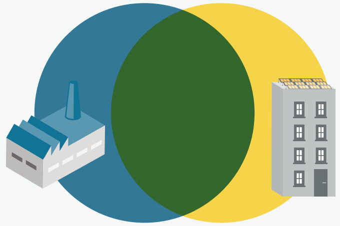
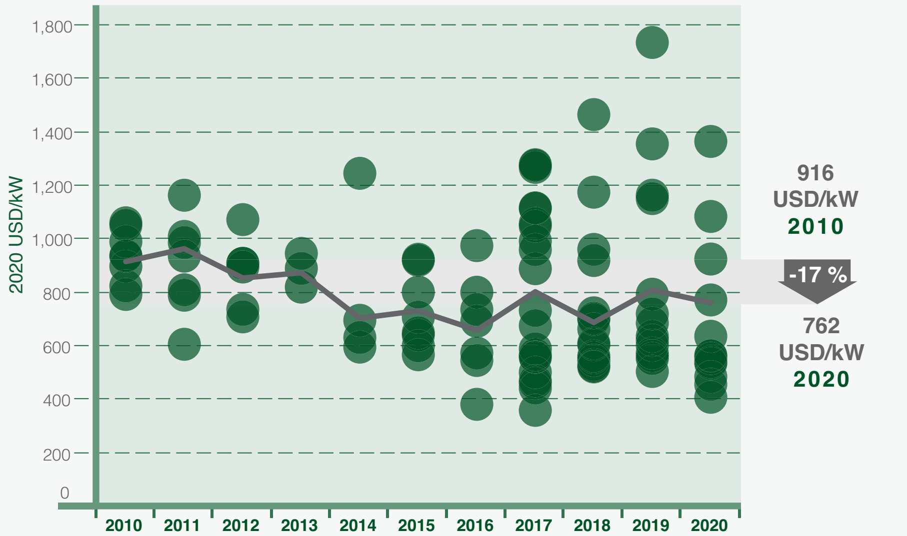
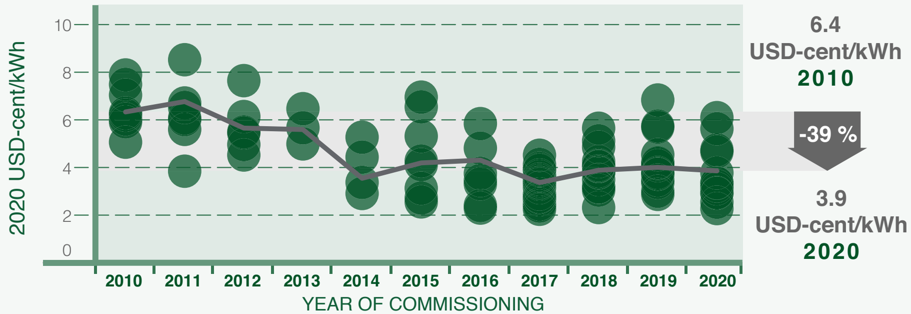
Mature markets accelerate cost reductions of large solar heat plants



Weighted-average, total installed cost trend in Mexico



Weighted-average LCOH trend in Mexico



The charts show costs for 108 Mexican plants installed in the industry and service sector between 2010 and 2020 with different collector types. LCOH is calculated with a standardised WACC of 5 % and 25 years lifetime.

In Mexico, the costs of large solar heat plants have come down 17 % in the last decade due to production output optimisations, more efficient logistics and high competition between well-established project developers.

Improved system efficiencies have driven down the LCOH by more (-39 %) than the decrease in installed costs. The low LCOH in 2020 of 3.9 USD-cent/kWh is also the result of superior solar resources compared with other major solar heat markets.

It is notable that these cost reductions have been achieved without the benefit of economies of scale, as the average plant size of the 108 projects illustrated in the charts is relatively small (139 kW).

A decade of decline

Mexico, Denmark and Germany are mature solar heat markets with an established, professional supply chain.

In these markets, the LCOH of large solar heat plants for industry, utilities and the service sector have fallen significantly.

GERMANY	DENMARK	MEXICO
18.2 USD-cent/kWh 2014	6.6 USD-cent/kWh 2010	6.4 USD-cent/kWh 2010
-21%	-32%	-39%
14.4 USD-cent/kWh 2020	4.5 USD-cent/kWh 2019	3.9 USD-cent/kWh 2020
209 projects: 34 % SHIP, 58 % service sector, remaining SDH	53 SDH projects	**108 projects:** 75 % SHIP, remaining service sector

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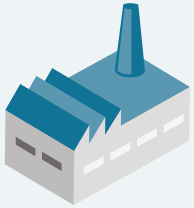
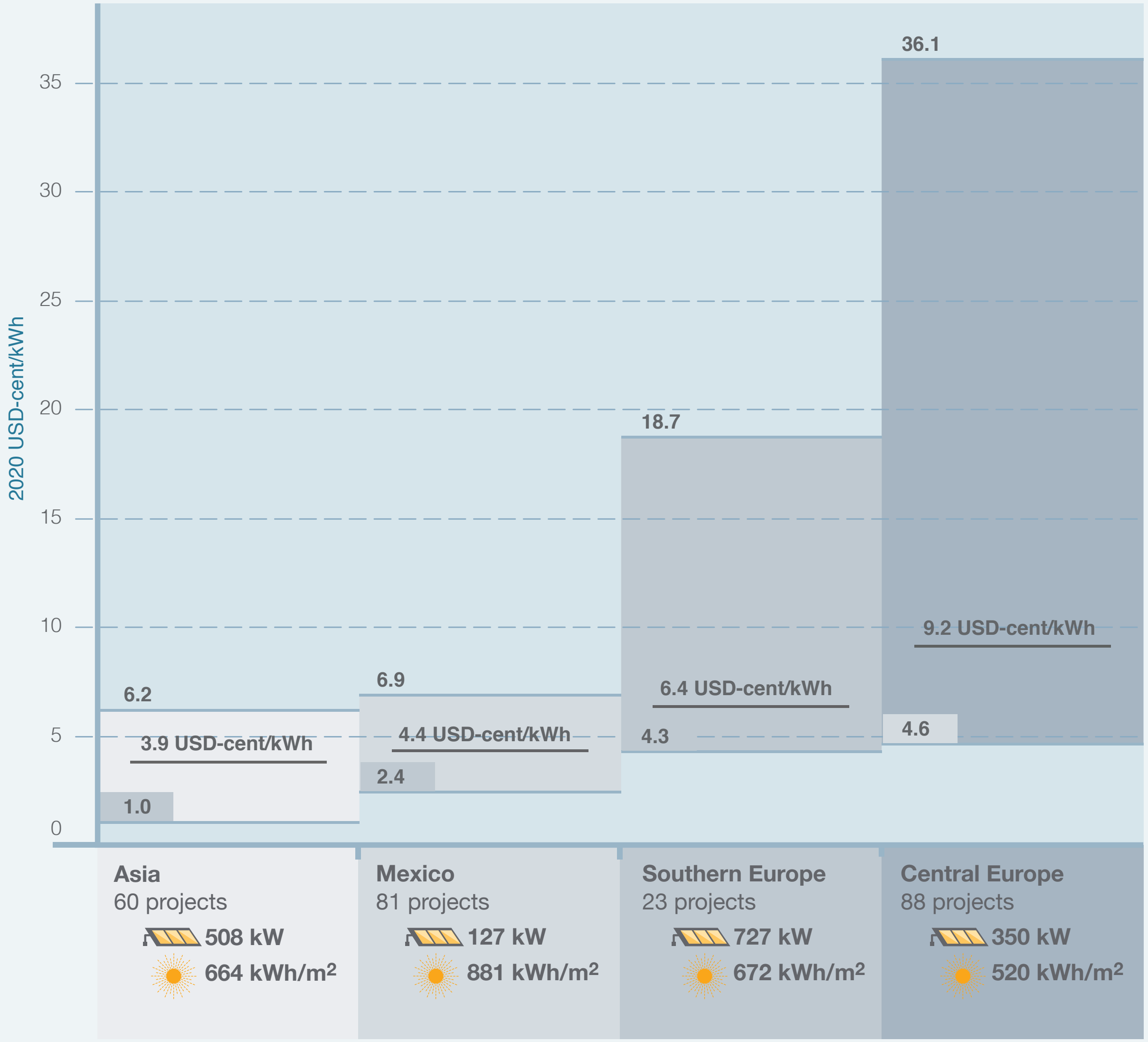
Asia and Mexico are the markets with the lowest industrial solar heat costs



Weighted-average LCOH of SHIP plants in different regions



The regional average LCOH for SHIP plants ranges from a low 3.9 USD-cent/kWh in Asia to a high 9.2 USD-cent/kWh in Western Europe. Besides economies of scale, variations in cost structure and irradiation levels also impact the LCOH.

- **Costs structure:** the level of material costs together with the labour costs for acquisition, planning, design, installation and commissioning explain most of the large differences in installed costs at regional and country level. Total installed costs in Southern Europe for example are 84 % higher than in Asia.

- **Irradiation levels:** more sunshine on the collector area increases the solar heat harvested from the same area. For instance, Mexican plants achieve on average a 70 % higher yield than those in Central Europe.

Project costs in Central Europe show the widest range (grey band), because the SHIP market has matured significantly in the last decade, while new markets have also emerged, and small projects with relatively high costs at the beginning of the period have given way to large projects with lower costs at the end.

How to read this chart:

The grey bands show the 5th and 95th percentiles of LCOH by project for a region / country. Projects with various collector technologies are included all commissioned in the period 2010 to 2020. The LCOH is calculated with a standardised WACC of 5 % and 25 years lifetime.

The bold line represents the weighted-average installed costs for that country/region.

Average collector field size

Average annual solar yield

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High potential of SHIP in the lower temperature range

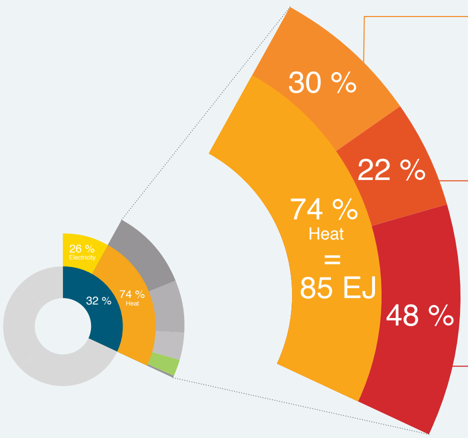
The most popular applications for SHIP plants globally are processes that need heat up to 150 °C. This segment makes up 30 % of the global industrial heat demand and solar heat costs are generally lower in this segment. The lowest weighted-average LCOH values of 3.8 USD-cent/kWh for solar heat up to 150 °C are achieved in the service of factories in Asia and Mexico.

Variations in solar potential between the regions also impacts the heat costs but cannot explain the whole difference. Asia and Mexico achieve 27 % more kilowatt hours from the same area but weighted-average LCOH for SHIP in Europe are still more than double due to higher installed costs.

SHIP systems providing heat with more than 150 °C typically have lower yields due to higher losses. As the majority of this sample operates in countries with high irradiation, however, the average specific yield (654 kWh/m²) is higher than that of the European SHIP projects (577 kWh/m²).

More than **890**
industrial manufacturers trust solar heat worldwide.

More than **791 MW**
of solar thermal capacity produce solar heat for industrial processes around the globe.



Low-temp heat
(below 150 °C)
Boiling, pasteurising, sterilising, cleaning, drying, washing, bleaching, steaming, pickling, cooking.

Medium-temp heat
(150 to 400 °C)
Distilling, nitrate melting, dyeing, compression.

High-temp heat
(above 400 °C)
Material transformation processes.

Weighted-average LCOH for SHIP plants

Asia and Mexico
3.8 USD-cent/kWh
140 projects
293 kW
731 kWh/m²

Europe
8.7 USD-cent/kWh
82 projects
400 kW
564 kWh/m²

Global
9.7 US-cent/kWh
11 projects
334 kW
654 kWh/m²

How to read this chart:

The average LCOH values consider SHIP projects commissioned between 2010 and 2020 with all collector types excluding air heating applications.
Given the relatively small number of projects providing heat or steam between 150 and 400 °C, the average is calculated on a global level.

Average collector field size.

Average annual solar yield.

32 % of the total final energy demand are consumed in the industry, of which **74 %** is heat and only **26 %** is electricity. **90%** of the heat is covered with fossil fuels.

Source: World Energy Statistics 2016 of IEA / Solar Payback

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About the database and the methodology

How are LCOH calculated?

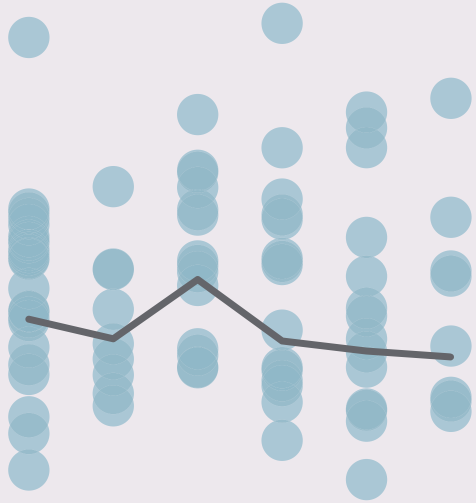
$$LCOH = \frac{I_0 + \sum_{t=1}^{n} \frac{M_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{Y_t}{(1+r)^t}}$$

LCOH = Levelised Cost of Heat and describes the heat costs averaged over the system lifetime of 25 years (n). **This methodology allows the comparison of costs in different countries and for different applications.**
As the equation uses a standardised **WACC** and lifetime for all projects, **LCOH** are different from solar heat prices that the individual plant owner reaches with its investment.

with

I_0 = investment expenditure in year zero
M_t = operation and maintenance expenditure estimated by IEA SHC Task 64 experts
- 1 % of total installed costs per year (≤ 1,000 m² aperture area of field)
- 0.5 % of total installed costs per year (>1,000 m² aperture area of field)

Y = project-specific annual heat generation [MWh/a]
r = discount rate (WACC) = 5 % (real)



How to read this chart?

Each circle illustrates a solar heat project for which the following data is available in the IRENA database:

- Year and country of commissioning
- Collector type
- Application
- Size in kW / aperture area
- **Total costs in local currency including installation without VAT/subsidies**
- **Calculated/simulated solar heat yield in MWh/year**

The bold line represents the weighted-average installed costs in a year. The weighted-average is calculated as a sum of costs of all commissioned projects in this year times thermal capacity, divided by the sum of the thermal capacity.

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Solar Payback

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