Ciencia y Tecnología
Secretaría de Ciencia, Humanidades, Tecnología e Innovación

Innovative Ways of Using Solar Thermal Technologies in Sunbelt Countries

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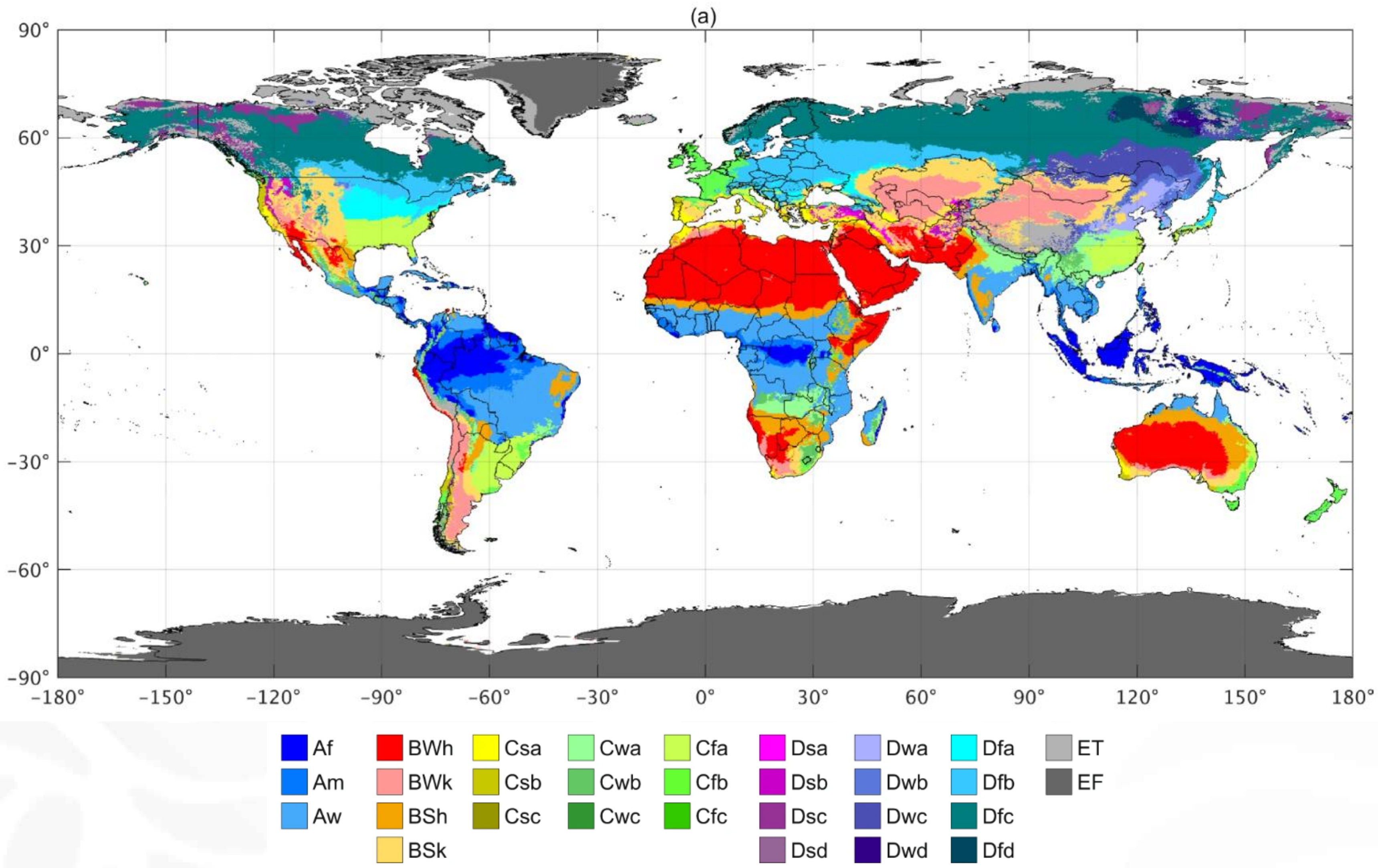
2025 Año de La Mujer Indígena

Köppen-Geiger Climate Classification

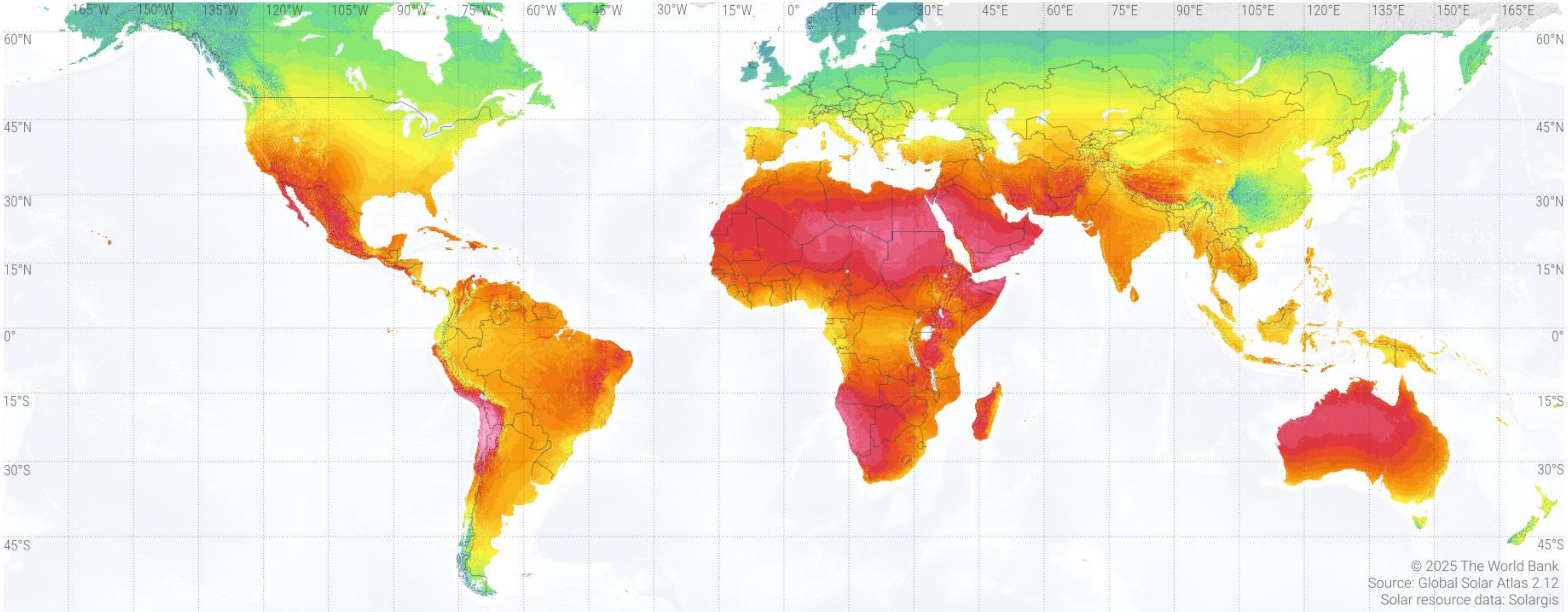


A – tropical
B – arid
C – temperate
D – cold
E – polar

Beck, H.E., N.E. Zimmermann, T.R. McVicar, N. Vergopolan, A. Berg, E.F. Wood: Present and future Köppen-Geiger climate classification maps at 1-km resolution, Scientific Data 5:180214, doi:10.1038/sdata.2018.214 (2018).

SOLAR RESOURCE MAP

GLOBAL HORIZONTAL IRRADIATION



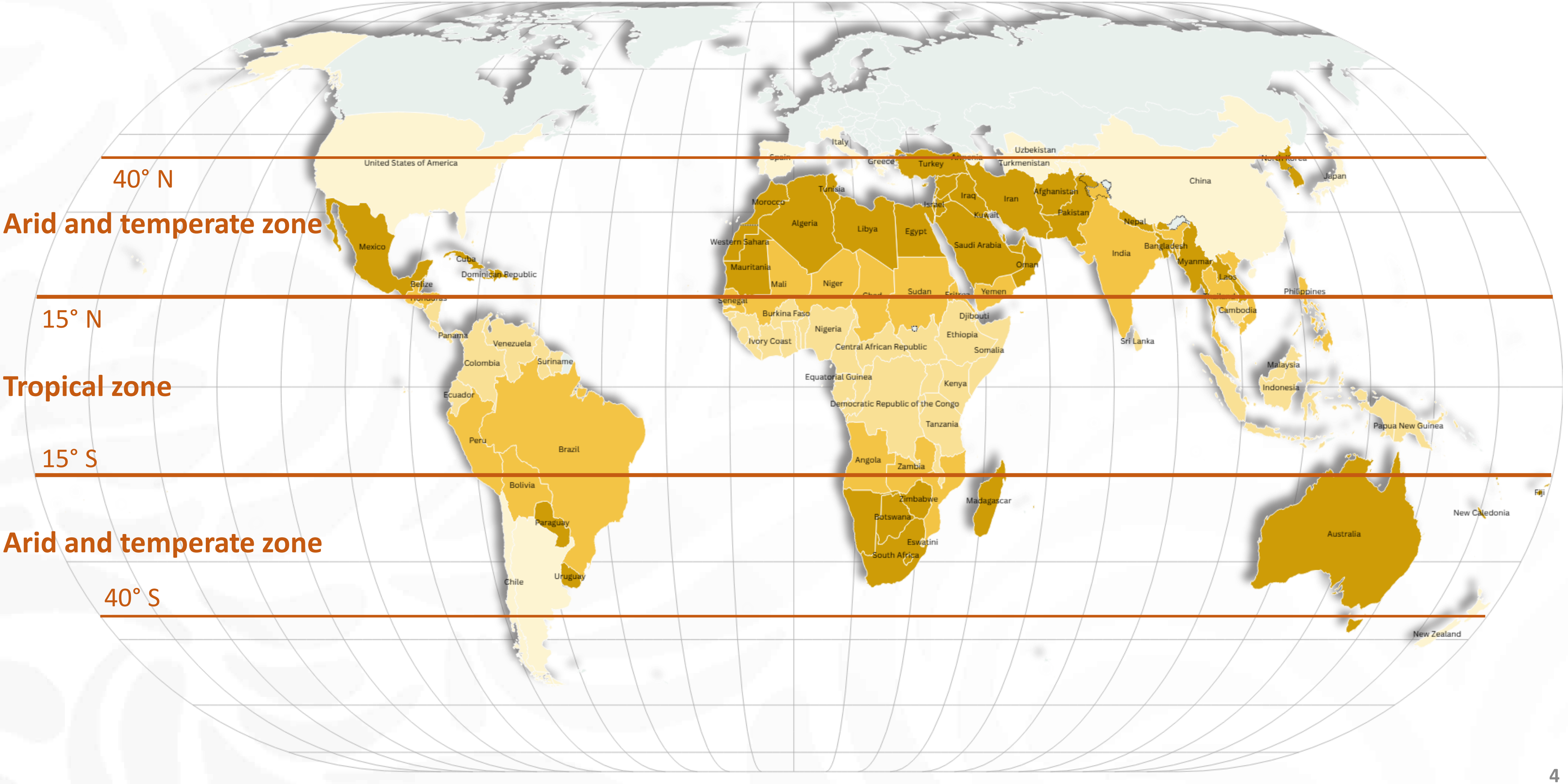
Long-term average of global horizontal irradiation (GHI)

Daily totals:	2.2	2.6	3.0	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.6	7.0	7.4
Yearly totals:	803	949	1095	1241	1387	1534	1680	1826	1972	2118	2264	2410	2556	2702

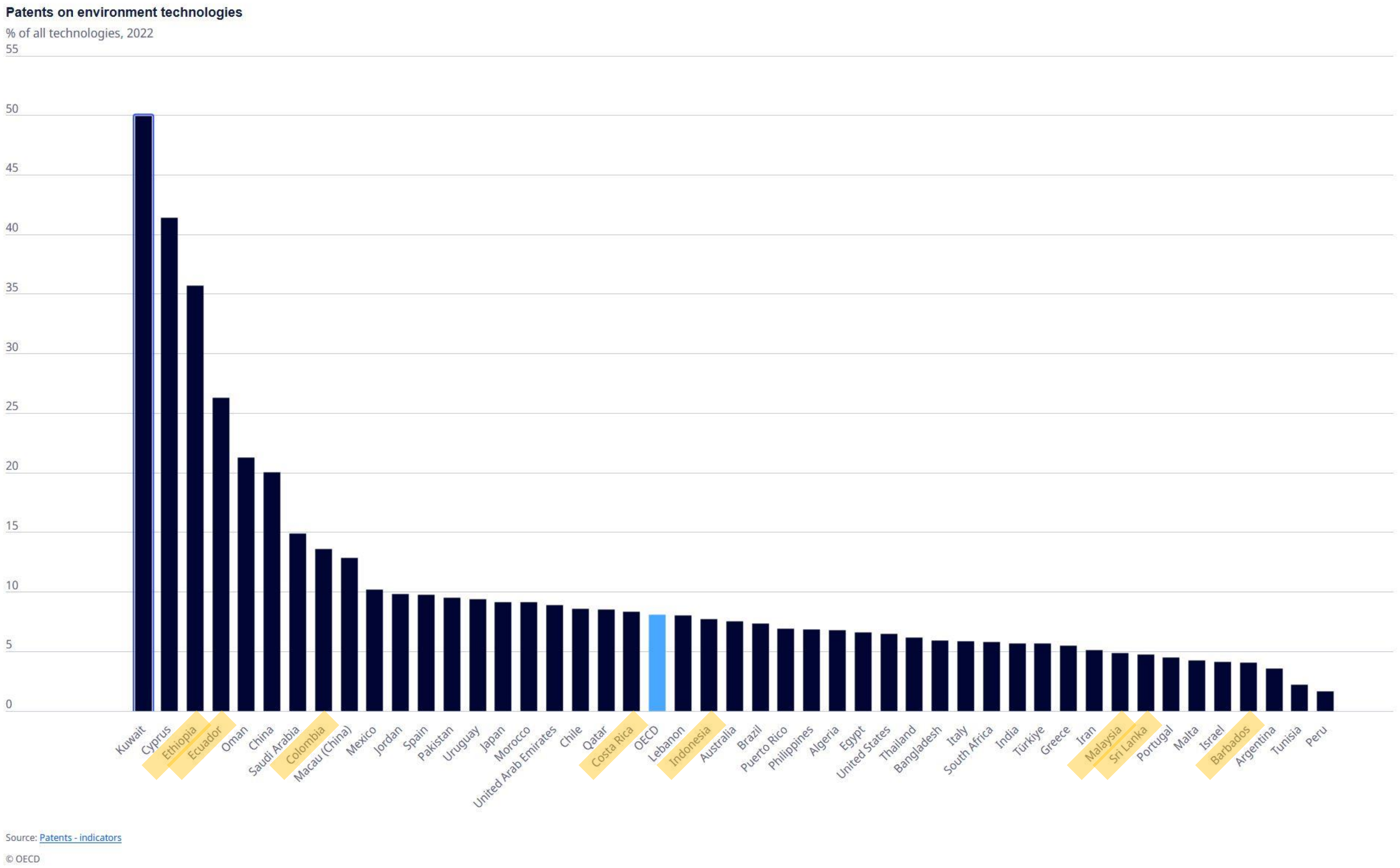
kWh/m²

This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit http://globalsolaratlas.info.

Sunbelt region



Patents on environment technologies



This indicator is measured as a percentage of all domestic inventions in all technologies

https://www.oecd.org/en/data/indicators/patents-on-environment-technologies.html

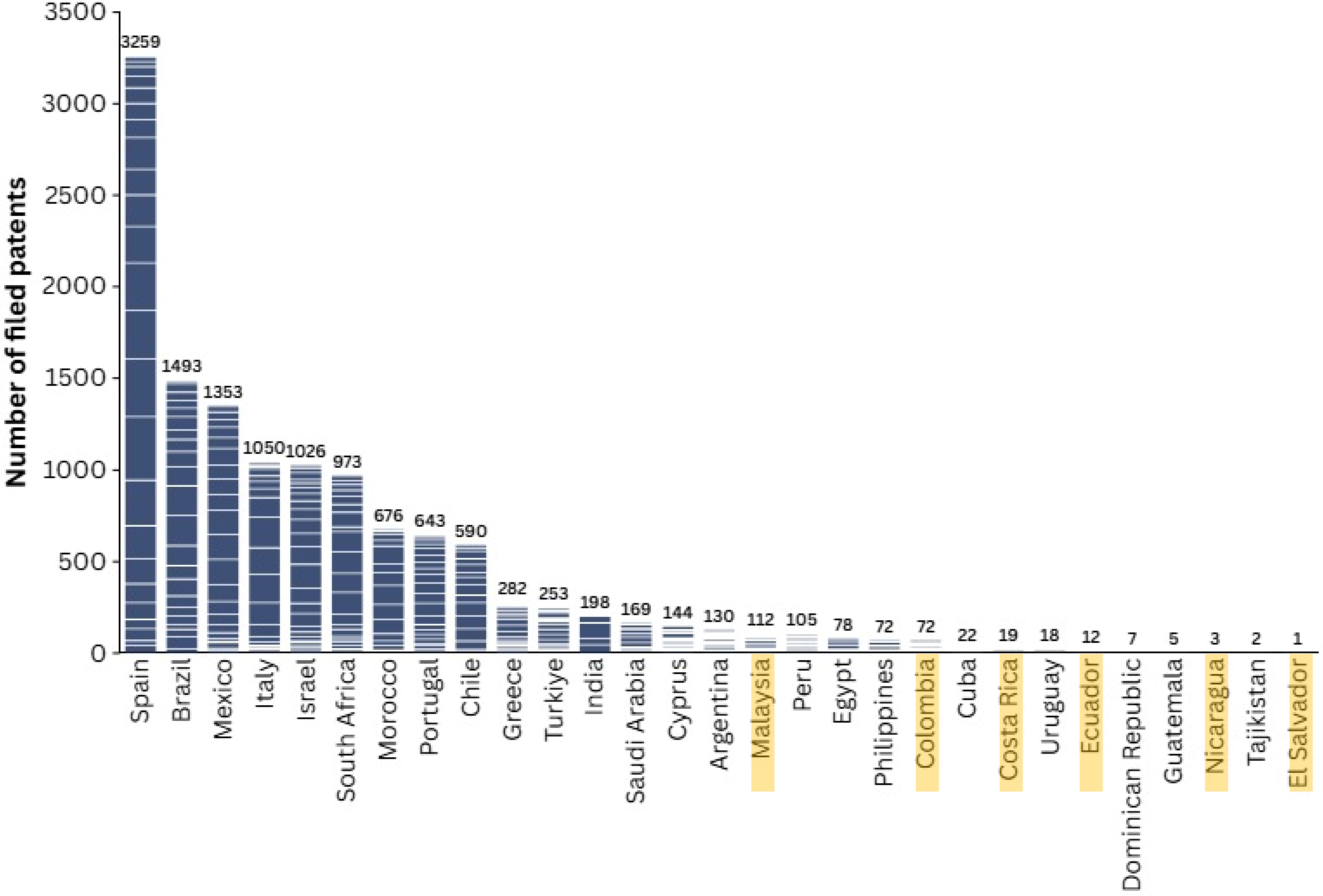
Patents on solar thermal technologies by country (2000 – 2024)

Top three:

China 92,181

USA 16,458

Japan 7,449

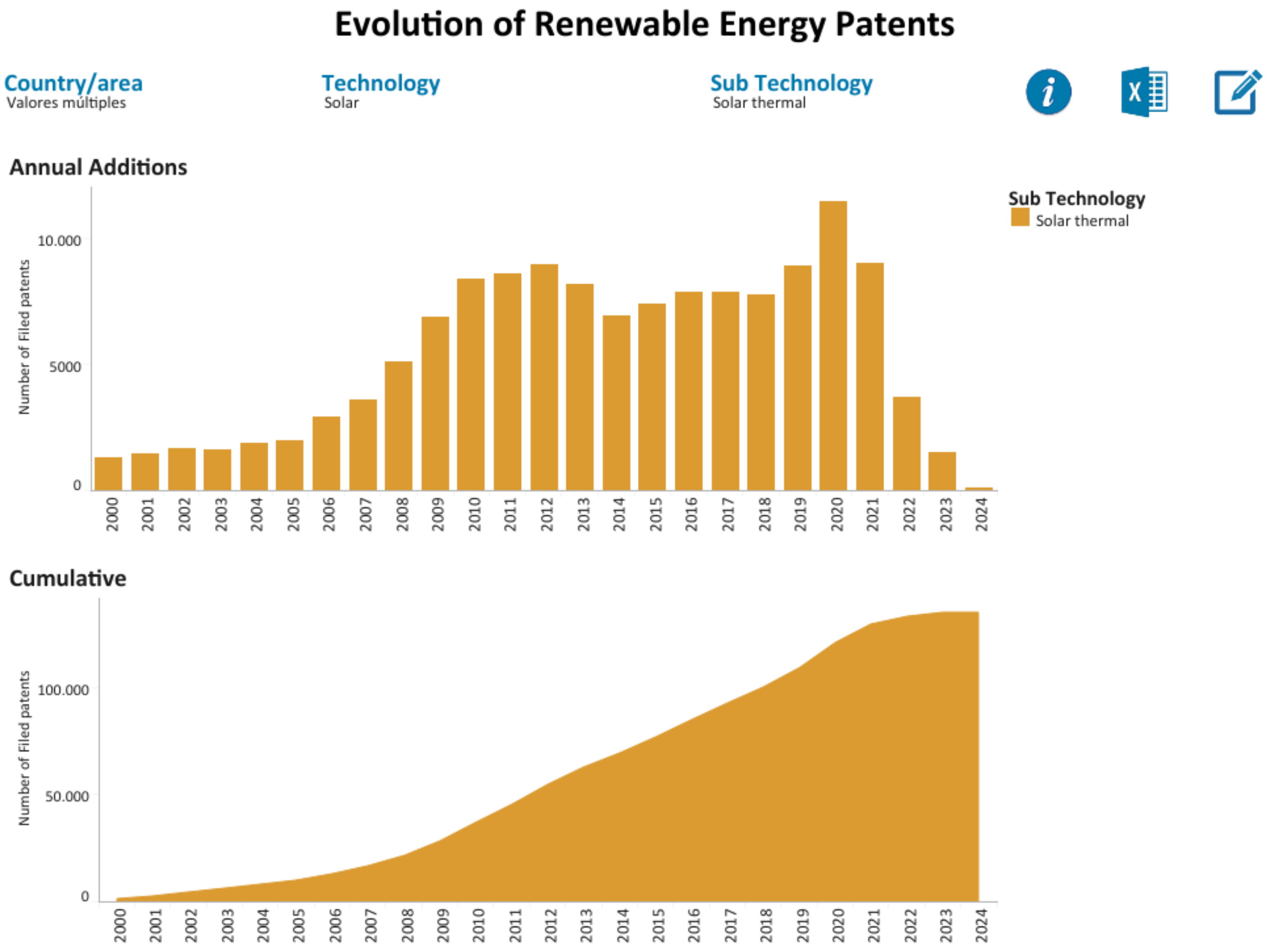


IRENA (2025) INSPIRE Platform. Available at: www.irena.org/INSPIRE

Evolution of renewable energy patents – Solar thermal

Countries:

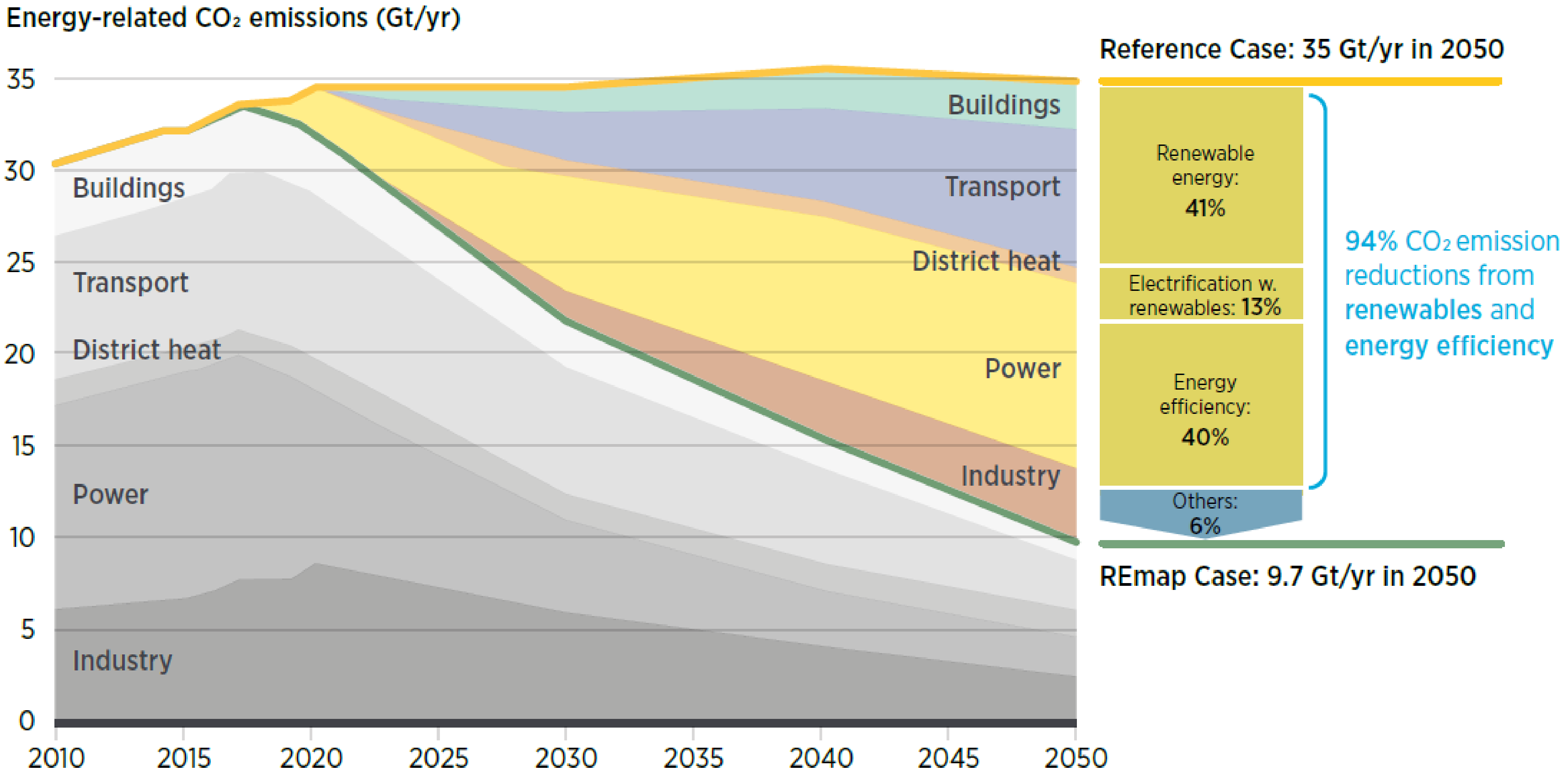
Algeria
Argentina
Australia
Brazil
Chile
China
Colombia
Costa Rica
Cuba
Cyprus
Dominican Republic
Ecuador
Egypt
El Salvador
Greece
Guatemala
Honduras
India
Indonesia
Israel
Italy
Japan
Jordan
Maylasia
Malta
Mexico
Morocco
New Zealand
Nicaragua
Panama
Peru
Philippines
Portugal
Saudi Arabia
South Africa
Spain
Tajikistan
Tunisia
Türkiye
United Arab Emirates
USA
Uruguay
Uzbekistan
Vietnam



Source IRENA INSPIRE (www.irena.org/Inspire) based on EPO PATSTAT 2024 Autumn edition, and on the Climate Change Mitigation Technologies (Y02) classification by EPO. It provides comprehensive, but by no means exhaustive information on patents filed for renewable energy worldwide.©IRENA

https://inspire.irena.org/Partners/Create-and-costumise-patent-data-charts

Carbon dioxide (CO_2) emission reductions needed by 2050, compared to 2017



Gt = gigatonne; yr = year.

Figures derived by IRENA REMap modelling.

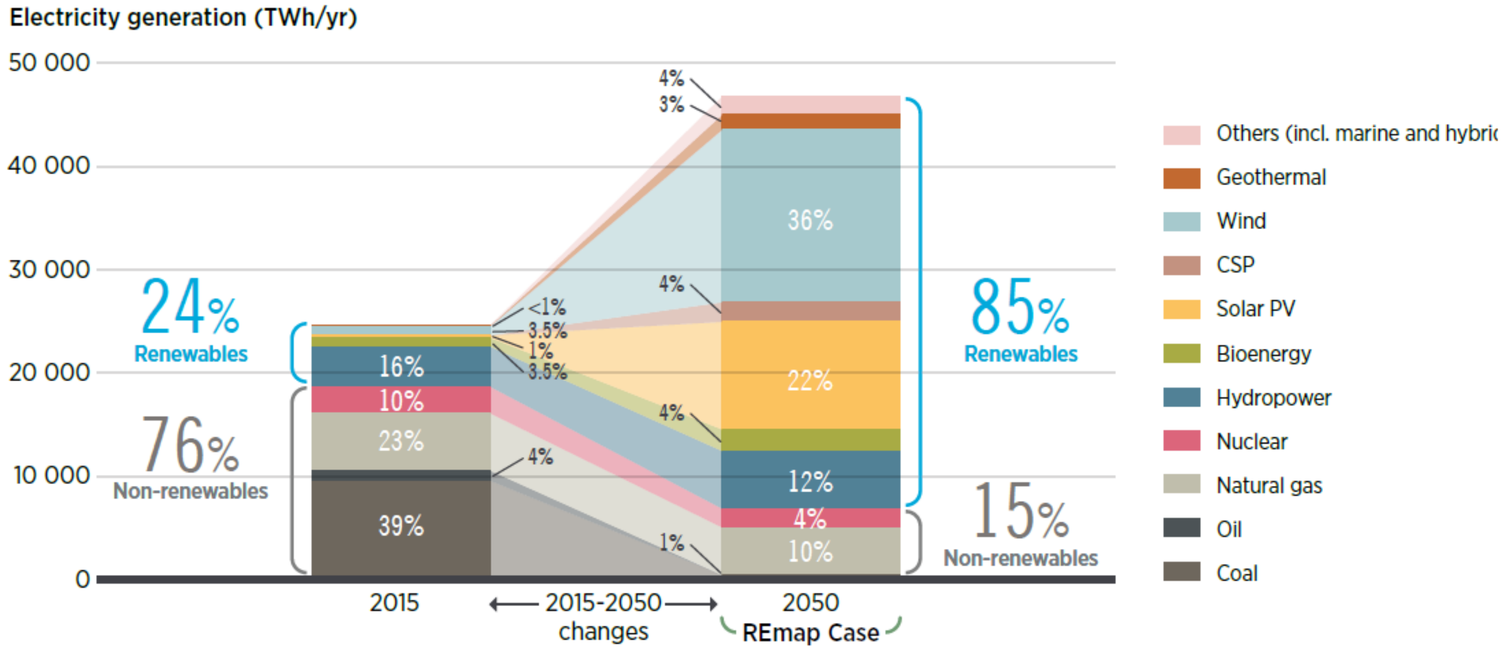
Source: IRENA (2018), Global Energy Transformation: A roadmap to 2050, International Renewable Energy Agency, Abu Dhabi.

Innovation is needed to affordably decarbonize industrial activities, such as iron and steel making, cement production, and chemical and petrochemical production.

Priority innovations needs in power generation

By 2050 the global power sector will need to have transitioned from fossil fuels to renewables. Gross power generation should almost double, with renewable energy providing 85% of electricity.

Power accounted for 37% of CO_2 emissions in 2015. That needs to fall by around 90% by 2050.



*Breakdown of electricity generation, by source (TWh/yr), taken from IRENA (2018), **Global energy transformation: A roadmap to 2050**, International Renewable Energy Agency, Abu Dhabi.*

IRENA (2018), Innovation priorities to transform the energy system, International Renewable Energy Agency, Abu Dhabi.

Priority innovations needs in power generation

- "The focus of innovation support must shift towards enabling the **integration of higher shares of variable renewables such as solar and wind electricity**. This will require supporting wider systemic innovations that can increase flexibility, as well as innovation that helps **electrify end-use sectors**.
- Further innovation in technologies that are becoming established, such as **solar and wind power**, may still be beneficial – particularly innovations in **the ways that these technologies are manufactured, deployed and used**. Such innovations can be driven mainly by competition in the private sector, but governments could highlight specific innovation needs and new applications and, where needed, facilitate collaborations to **address gaps in capability**.
- Broad government support should focus on **accelerating progress in under-deployed solutions such as concentrated solar power (CSP)** and geothermal energy, which could play valuable roles in some locations as part of the future global energy mix."

Strategy	Innovation	Scale-up*	Priorities for support
Push	Battery storage	–	Support R&D for cost reduction and enhanced performance
	Smart grids	–	Support R&D and piloting for a wide range of smart technologies Standardise some components e.g. smart meters Alongside technology, support innovation in business models and market design
	Concentrated Solar Power (CSP)	130x	Support targeted RD&D for cost reduction including thermal storage solutions Establish multiple projects and share learning
	Geothermal	22x	Support innovations to reduce costs and risks for deep geothermal drilling
	Bio-power	3.2x	Develop sustainable, reliable, affordable supplies of biomass feedstock Support RD&D for more flexible operation.
Nurture	Novel energy storage solutions	–	Increase the scale and diversity of R&D including cross-border collaborations.
	Wave or tidal	–	Support R&D and share learning (wave). Establish demonstration projects and share learning (tidal flow).
Facilitate	Hydropower	1.5x	Enhance processes for modernising existing plant Establish trials for responsive uses of pumped hydro Improve river basin planning techniques Increase use of floating solar PV on reservoirs
	Solar PV	32x	Support RD&D for new PV materials, novel PV designs and techniques for deploying PV e.g. building integrated solutions.
	Onshore wind	12x	Encourage collaborative RD&D to enhance manufacturing and refine designs e.g. for hostile weather conditions.
	Offshore wind	43x	Encourage national (and international) collaborative RD&D that enables larger turbine use and makes installation and maintenance more efficient Fund RD&D for cost reduction of floating foundations, establish multiple commercial projects and share learning Support R&D into novel approaches, e.g., kites

*An indication of the growth in capacity or activity needed between 2015 and 2050. Based on IRENA's REmap analysis.

IRENA (2018), Innovation priorities to transform the energy system, International Renewable Energy Agency, Abu Dhabi.

Innovations in power generation – Solar thermal electricity

Parabolic trough

- Parabolic troughs systems accounted in 2022:
  - 44 in Spain (2200 MW)
  - 7 in USA (1009 MW)
  - 5 in South Africa (450 MW)
  - 4 in Morocco (383 MW)
  - 1 in Israel (110 MW)
  - 3 in India (101 MW)
  - 1 in United Arab Emirates (100 MW)
  - 1 in China (50 MW)
  - 1 in Kuwait (50 MW)
  - 1 in Saudi Arabia (50 MW)
  - 1 in Algeria (20 MW)
  - 1 in Egypt (20 MW)
  - 1 in Mexico (12 MW)
  - 1 in Thailand (5 MW)
  - 1 in Italy (4.7 MW)

https://unfccc.int/climate-action/un-global-climate-action-awards/financing-for-climate-friendly-investment/kaxu-solar-one-i-south-africa

https://solarpaces.nrel.gov/by-technology/parabolic-trough

- TRL 9 (commercial operation in relevant environment)
- Relevance for net zero
  - High in regions with good Direct Normal Irradiation (DNI) resources, as solar thermal electricity (STE) plants in combination with thermal storage can be a dispatchable generation source, providing system services, e.g. inertia, and supporting the integration of solar PV.

Richard Thonig, Alina Gilmanova & Johan Lilliestam. (2023). CSP.guru 2023-07-01 [Data set]. Zenodo. https://doi.org/10.5281/zenodo.1318151

https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide?layout=tree&selectedTechID=all

Innovations in power generation – Solar thermal electricity

Solar tower

- Solar towers plants accounted in 2022:
  - 3 in USA (492 MW)
  - 4 in China (160 MW)
  - 1 in Morocco (150 MW)
  - 2 in Israel (127 MW)
  - 1 in Chile (110 MW)
  - 1 United Arab Emirates (100 MW)
  - 4 in Spain (56 MW)
  - 1 South Africa (50 MW)
  - 1 in India (2.5 MW)
  - 1 in Turkey (1.4 MW)

https://www.cerrodominador.com/proyectos.html

https://solarpaces.nrel.gov/by-technology/power-tower

- TRL 9 (commercial operation in relevant environment)
- Relevance for net zero
  - High in regions with good Direct Normal Irradiation (DNI) resources, as solar thermal electricity (STE) plants in combination with thermal storage can provide electricity after sunset and support the integration of solar PV.

Richard Thonig, Alina Gilmanova & Johan Lilliestam. (2023). CSP.guru 2023-07-01 [Data set]. Zenodo. https://doi.org/10.5281/zenodo.1318151
https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide?layout=tree&selectedTechID=all

Innovations in power generation sector – Solar thermal electricity

Linear Fresnel reflector

- Linear Fresnel reflectors accounted in 2022:
  - 2 in India (139 MW)
  - 2 in Spain (31.4 MW)
  - 2 in Italy (5.26 MW)

https://solarpaces.nrel.gov/by-technology/linear-fresnel

Richard Thonig, Alina Gilmanova & Johan Lilliestam. (2023). CSP.guru 2023-07-01 [Data set]. Zenodo. https://doi.org/10.5281/zenodo.1318151

https://blogs.adb.org/blog/new-solar-power-plant-brings-clean-energy-rajasthan-india

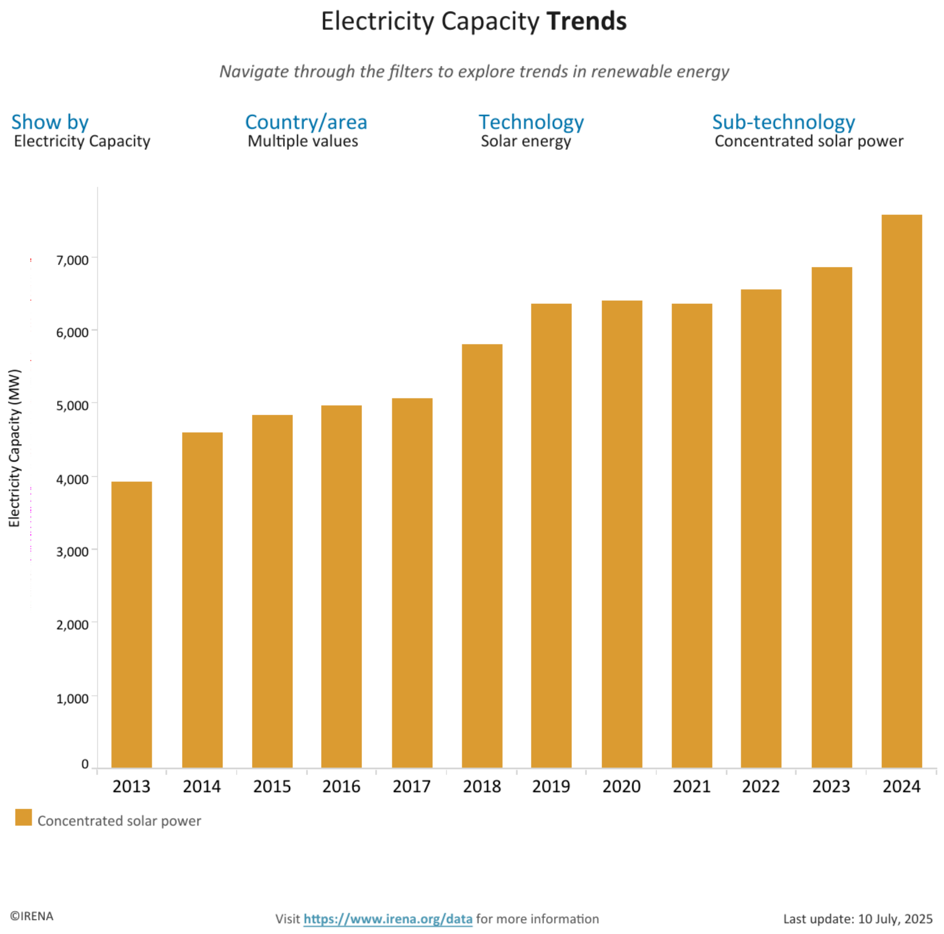
- TRL 7 (pre-commercial demonstration)
- The main advantage of LFR systems is that their simple design of flexibly bent mirrors and fixed receivers requires lower investment costs and facilitates direct steam generation, thereby eliminating the need for – and cost of – heat transfer fluids and heat exchangers.
- LFR plants are, however, less efficient than troughs in converting solar energy to electricity and it is more difficult to incorporate storage capacity into their design.
- Relevance for net zero
  - Potentially lower investment costs than parabolic troughs and solar towers, but also more difficult integration of thermal storage.

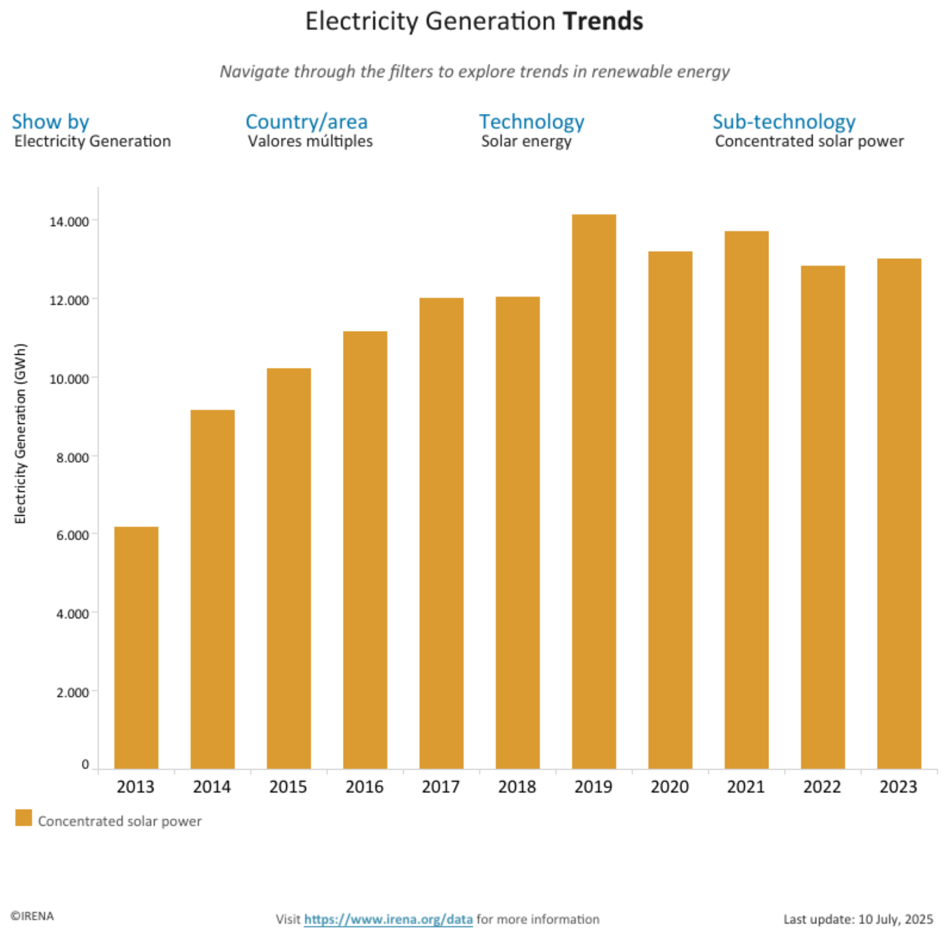
https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide?layout=tree&selectedTechID=all

Power capacity and generation trends – Concentrated solar power

Countries:

- Algeria
- Australia
- Chile
- China
- Egypt
- India
- Israel
- Italy
- Kuwait
- Mexico
- Morocco
- Portugal
- Saudi Arabia
- South Africa
- Spain
- Thailand
- Türkiye
- United Arab Emirates
- USA





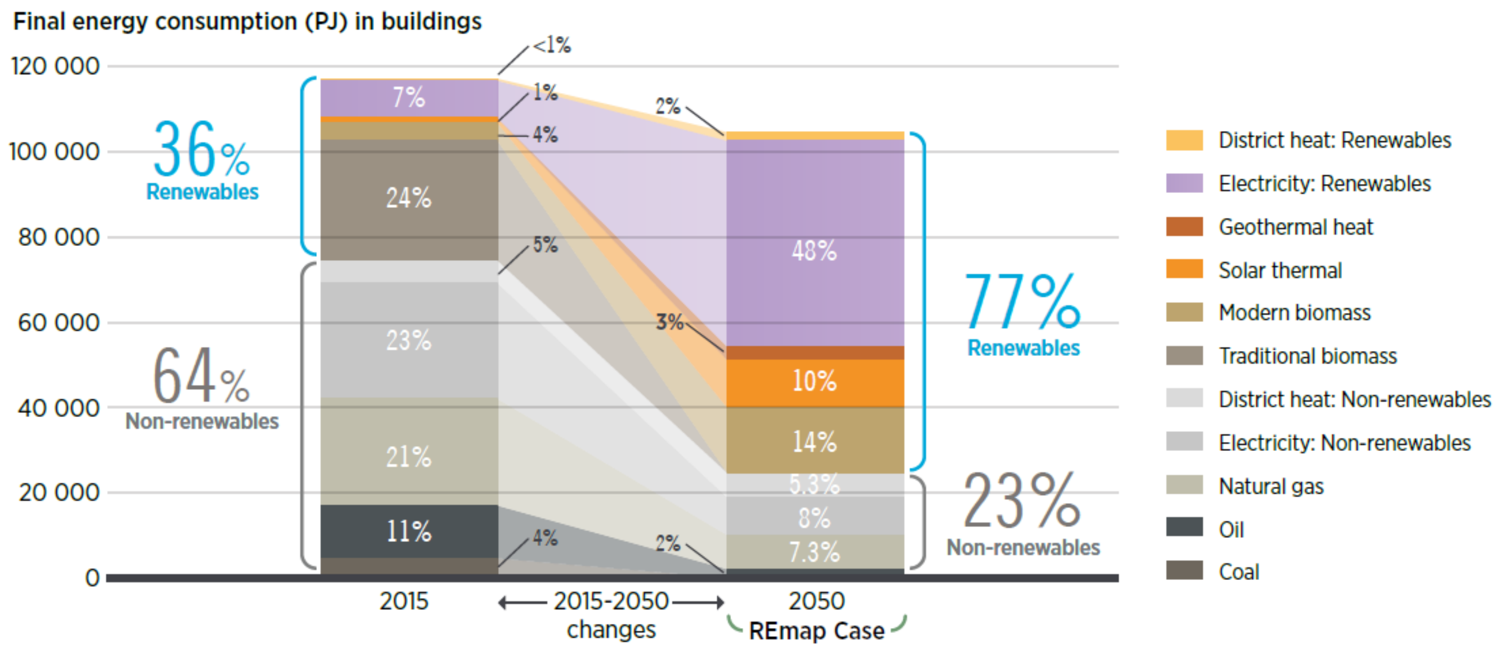
https://www.irena.org/Energy-Transition/Technology/Solar-energy

Priority innovations needs in buildings

Modern renewable energy in the buildings sector needs to increase significantly. Up to three-quarters of total energy consumption in buildings could be supplied by renewables. Electricity should supply almost 60% of the sector's energy demand.

Buildings accounted for 12% of global CO_2 emissions in 2015.

Emissions need to fall by over 80% by 2050 compared to current and planned policies.



*Breakdown of final energy consumption in the buildings sector, by source (PJ/yr), taken from IRENA (2018), **Global energy transformation: A roadmap to 2050**, International Renewable Energy Agency, Abu Dhabi.*

IRENA (2018), Innovation priorities to transform the energy system, International Renewable Energy Agency, Abu Dhabi.

Priority innovations needs in buildings

- "**Reductions in existing emissions for heating and cooling homes and offices** in developed and emerging economies will likely best come from a **combination** of heat pumps, modern bioenergy, district heating and cooling, and **solar thermal heating**.
- These technologies exist and are used in many countries, but innovation is needed to further **improve performance**, **adapt to local conditions** and **simplify installation** to facilitate more widespread deployment.
- Progress in **low-carbon heating and cooling systems** must be underpinned by significant improvements in energy efficiency in both new and existing buildings. Solutions for this exist, but innovation is needed **to broaden their application** and **to make installation more affordable and practical**."

Strategy	Innovation	Scale-up*	Priorities for support
Push	Retrofit/renovate existing buildings	3x	Regulate for and enforce progressively higher standards Support RD&D into innovative solutions, including installation techniques, for 'hard-to-treat' properties
	District Heating and Cooling from renewable energy	5x	Support demonstration projects that use renewable energy and share learning
Nurture	Hydrogen as a heating fuel	–	Establish multiple demonstration projects and share learning
	Seasonal heat storage	–	Increase support for R&D Support demonstration projects and share learning
Facilitate	Heat Pumps	13x	Alongside support for up-take support RD&D to address deployment challenges, improve efficiency and integrate flexibly with the wider system
	Solar assisted water/space heating	10x	Alongside support for up-take encourage RD&D to address deployment challenges
	Zero energy new builds	>100x	Regulate for, verify and enforce stringent standards
	New super-efficient appliances	–	Alongside support for up-take encourage RD&D for cost reduction
	Clean cooking from renewable energy	18x	Alongside support for up-take encourage RD&D to improve suitability Develop enabling policy frameworks and business models

*An indication of the growth in capacity or activity needed between 2015 and 2050. Based on IRENA's REMap analysis.

IRENA (2018), Innovation priorities to transform the energy system, International Renewable Energy Agency, Abu Dhabi.

Innovations in building sector – Heat generation

Solar thermal district heating

- By the end of 2024, several solar district heating systems were in operation in sunbelt countries:
  - 76 systems in China* (535 MW_{th})
  - 1 system in Saudi Arabia* (25 MW_{th})
  - 5 systems in Greece** (7.1 MW_{th})
  - 1 system in Portugal** (1.1 MW_{th})
  - 1 system in Italy* (0.6 MW_{th})
- TRL 10 (integration needed at scale)

Saudi Arabia: Women's Princess Noura University with Solar District Heating

https://whoswhoinewe.com/project-sheet/princess-noura-university-25mwth

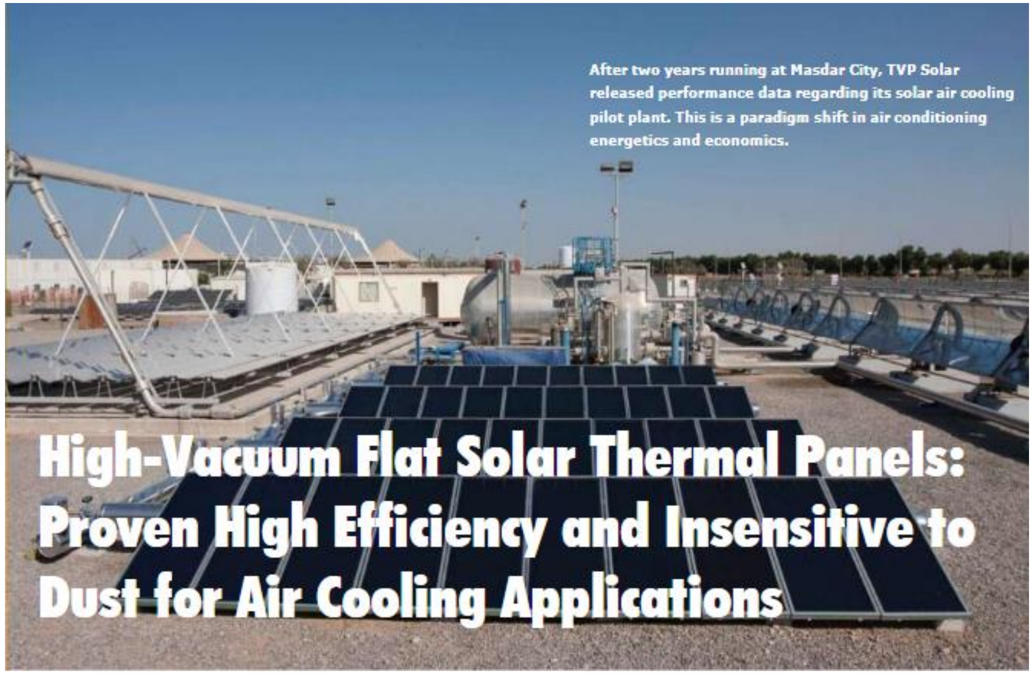
- Solar district heating plants employ sizeable fields of solar thermal collectors to supply or upgrade the heat in district heating networks.
- The technology necessary provides only a share of all heat, which typically hovers around 10-50% of system needs.
- A key constraint is the space required for renewable energy such as solar thermal.
- To keep costs to a minimum, they need to be installed close to the heat consumers, where land availability is the scarcest.

* Solar Heat Worldwide 2025
** https://www.solar-district-heating.eu/en/plant-database/
https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide?layout=tree&selectedTechID=all

Innovations in building sector – Solar thermal water heat pump

High vacuum flat plate collectors heat pump

- Masdar City Solar Air-Cooling Pilot, in the United Arab Emirates (2014)
  - 180 °C
  - 42 m^2
  - 29,082 kWh/yr
  - 50 % peak solar-to-thermal efficiency
- TRL 9 (Commercial operation in relevant environment)
- Heat exchanger that uses solar radiation to heat a water-based system, under high vacuum.
- Relevance for net zero:
  - Maximum temperature at 350 °C.
  - 450 °C with focusing mirrors.
  - Use of diffuse light.



https://www.tvpsolar.com/high-vacuum-flat-solar-thermal-panels-proven-high-efficiency-and-insensitive-to-dust-for-air-cooling-applications-en/

https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide?layout=tree&selectedTechID=all

Successful applications – Domestic hot water systems

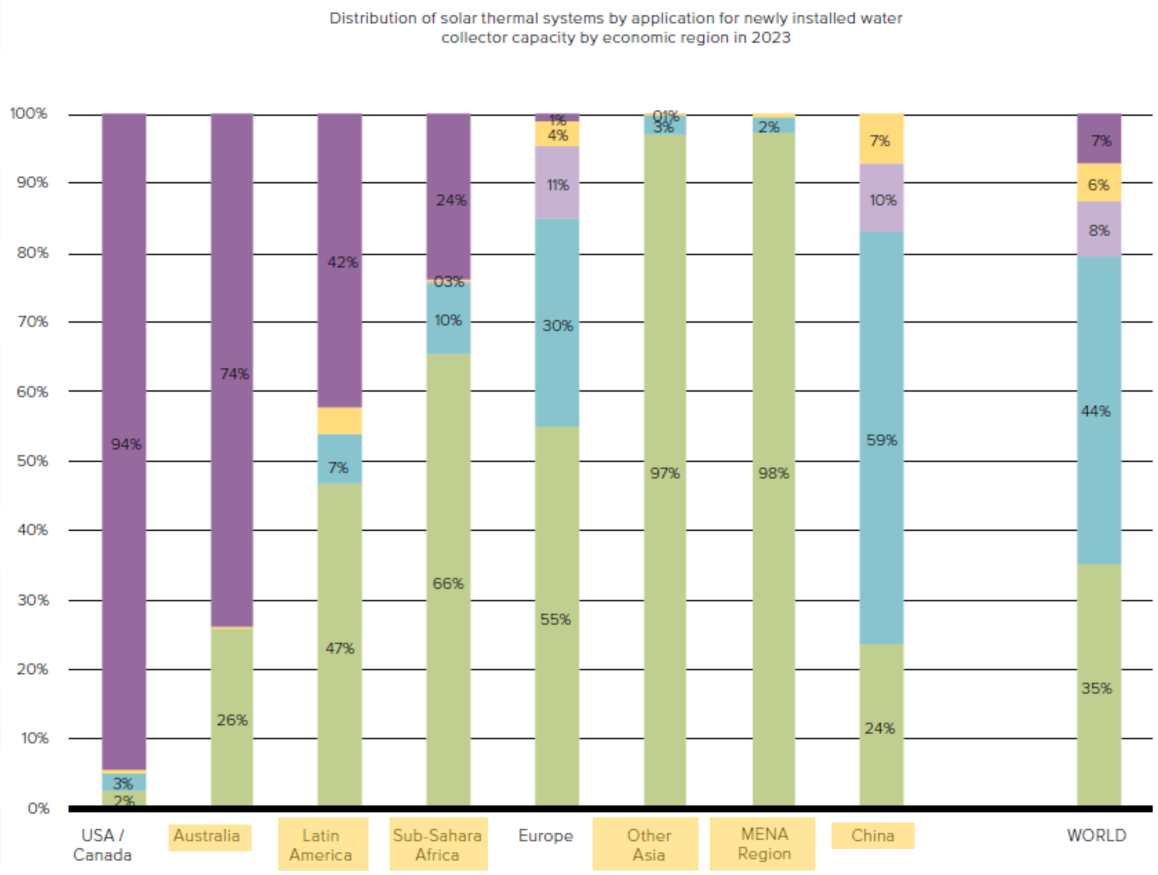


Figure 53: Distribution of solar thermal systems by application for newly installed water collector capacity by economic region in 2023

- Swimming pool heating
- Other (solar district heating, solar processheat, solar cooling)
- Solar combi-systems (DHW and space heating for single-family and multi-family houses)
- Large DHW systems (multi-family houses, tourism and public sector)
- Domestic hot water systems for single-family houses

➡ **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, Ecuador, Mexico, Panama, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
➡ **MENA countries:** Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

From: Solar Heat Worldwide 2025

From: https://modulosolar.com/mx/galeria/

From: https://soltrain.org/systems/associacao-salesianos-de-dom-bosco/detail

Successful applications – Domestic hot water systems

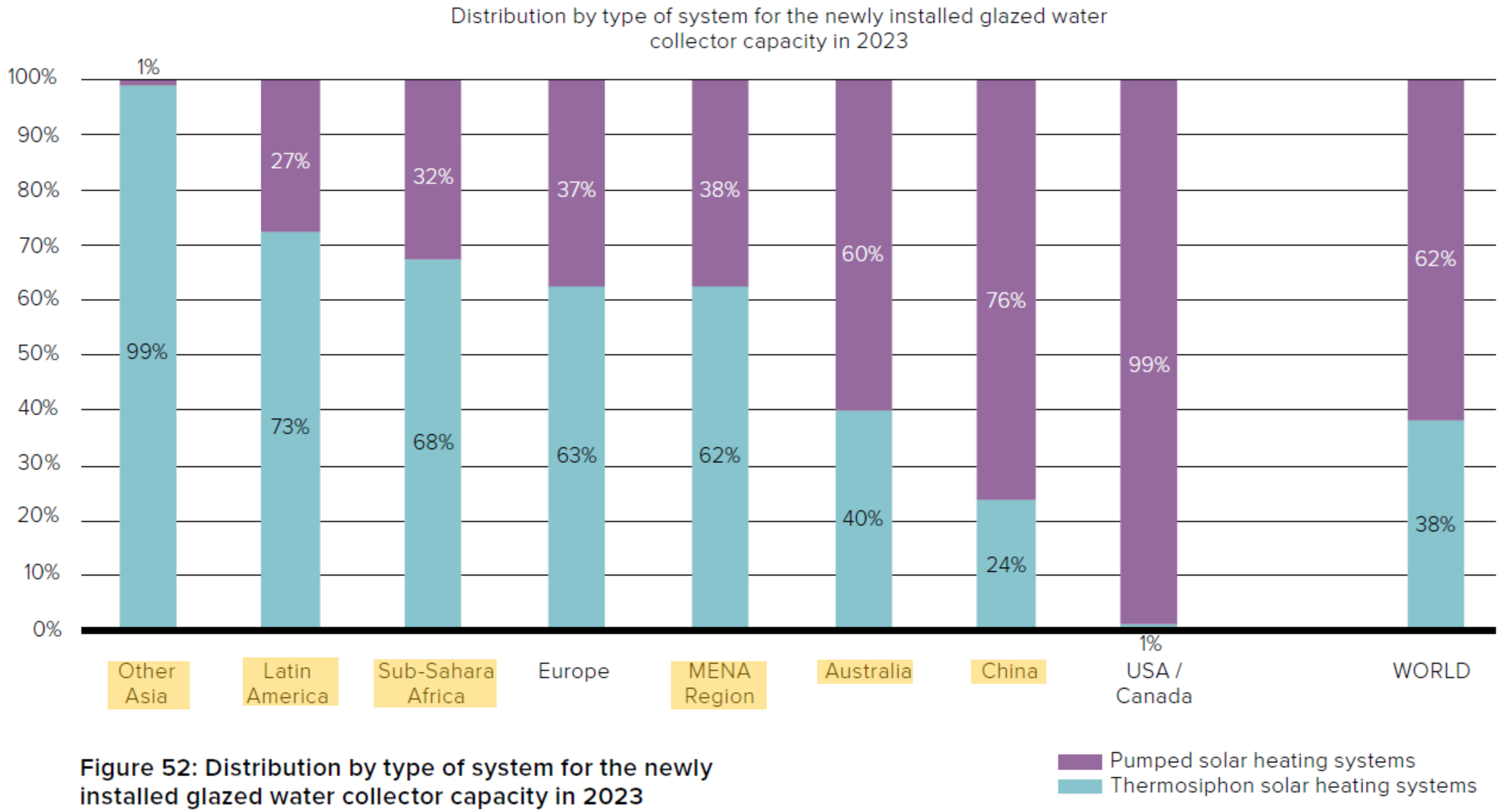


Figure 52: Distribution by type of system for the newly installed glazed water collector capacity in 2023

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, Ecuador, Mexico, Panama, Uruguay
Europe: EU 27, Albania, North Macedonia, Norway, Russia, Switzerland, Turkey, United Kingdom
MENA countries: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

From: Solar Heat Worldwide 2025

From: IEA SHC TASK 69, Solar Hot Water for 2030. Deliverable D1: Solar Hot Water Standards and Certifications – Pathways to 2030

Successful applications – Domestic hot water systems

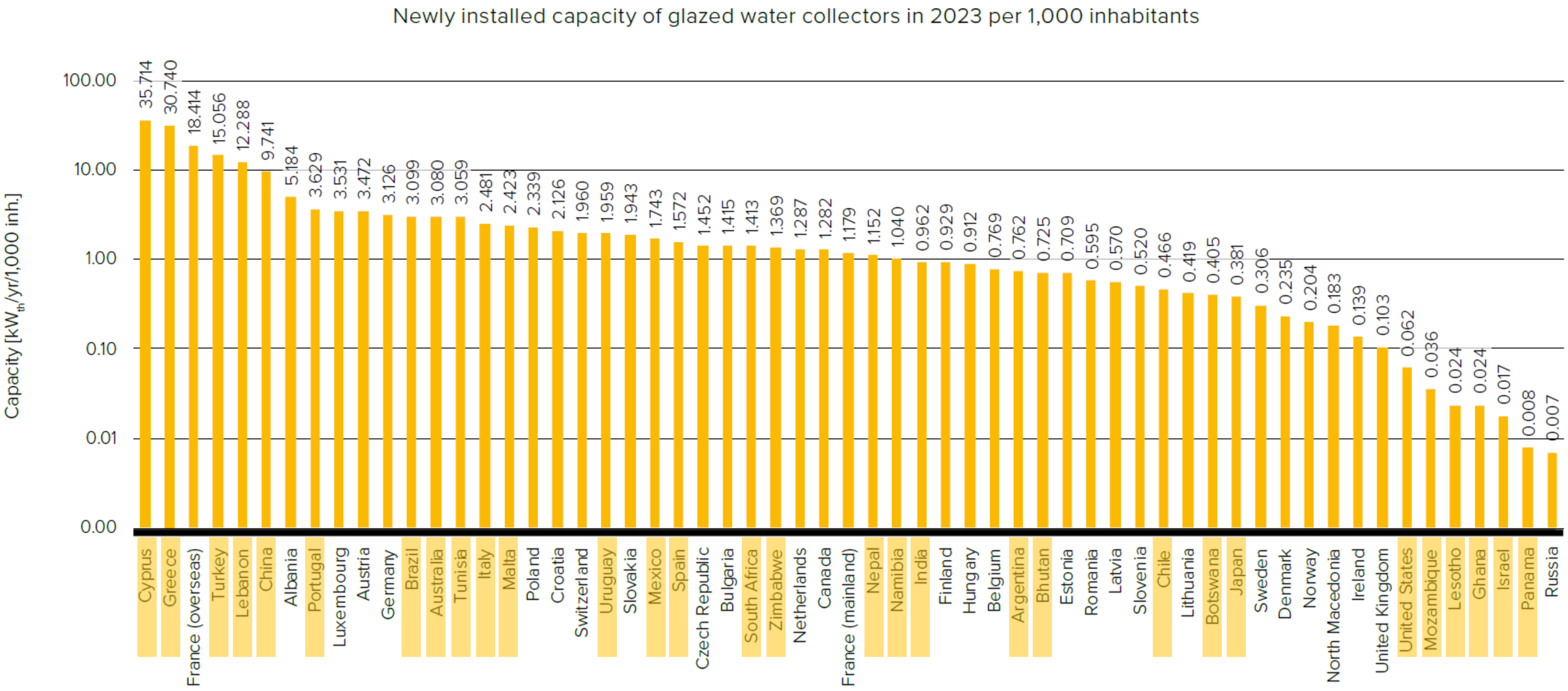


Figure 40: Newly installed capacity of glazed water collectors in 2023 in kW$_{th}$ per 1,000 inhabitants

From: Solar Heat Worldwide 2025

Successful applications – Domestic hot water systems

Standards for solar heating

- Argentina
- Australia
- Brazil
- China
- Mexico
- Namibia
- South Africa
- Uruguay
- USA
- Zimbabwe
- *Barbados*
- *Colombia*
- *Ghana*
- *Tanzania*
- *Uganda*

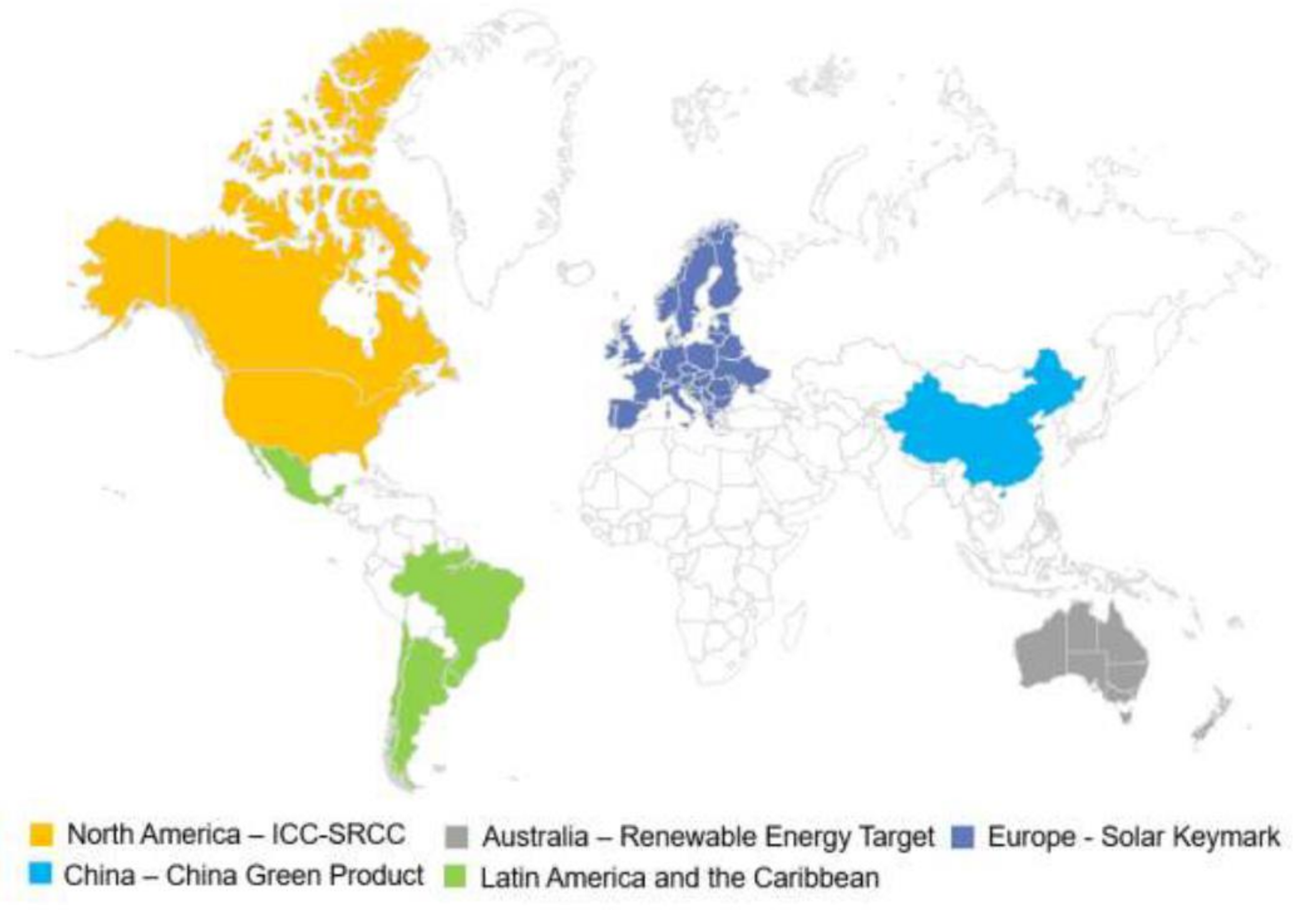


Figure 2: Quality Certification Programs of the participating countries.

Promoting or certification

- Argentina
- Australia
- Brazil
- Chile
- China
- Mexico
- Uruguay
- USA
- *Colombia*
- *Panamá **

* https://www.thegef.org/projects-operations/projects/5287

IEA SHC TASK 69, Solar Hot Water for 2030. Deliverable D1: Solar Hot Water Standards and Certifications – Pathways to 2030

Successful applications – Solar cooking

Solar Cookers International

https://solarcooking.fandom.com/wiki/File:Cocineros_Solares_January_2020_San_Miguel_Del_Valle,_Mexico.jpg

- Approximately 1 in 4 people today lack modern fuel to cook food.
- One solar cooker preserves more than 1 ton of wood every year.
- 4.8+ million solar cookers in the world.

From: **https://www.solarcookers.org/**

Successful applications – Solar cooling

Figure 1: Flat plate, evacuated tube, parabolic trough and Fresnel collectors (from left to right below), Sources: JER.

Heat-driven cooling systems utilize solar thermal collectors to capture sunlight and convert it into heat energy:

- absorption chillers
- adsorption chillers
- desiccant-evaporative systems

Lithium bromide absorption chiller with a cooling capacity of 348 kW

Figure 2: Lithium bromide absorption chiller with closed circuit cooler and vacuum tube solar collector field (from left to right), Sources: SolarNext.

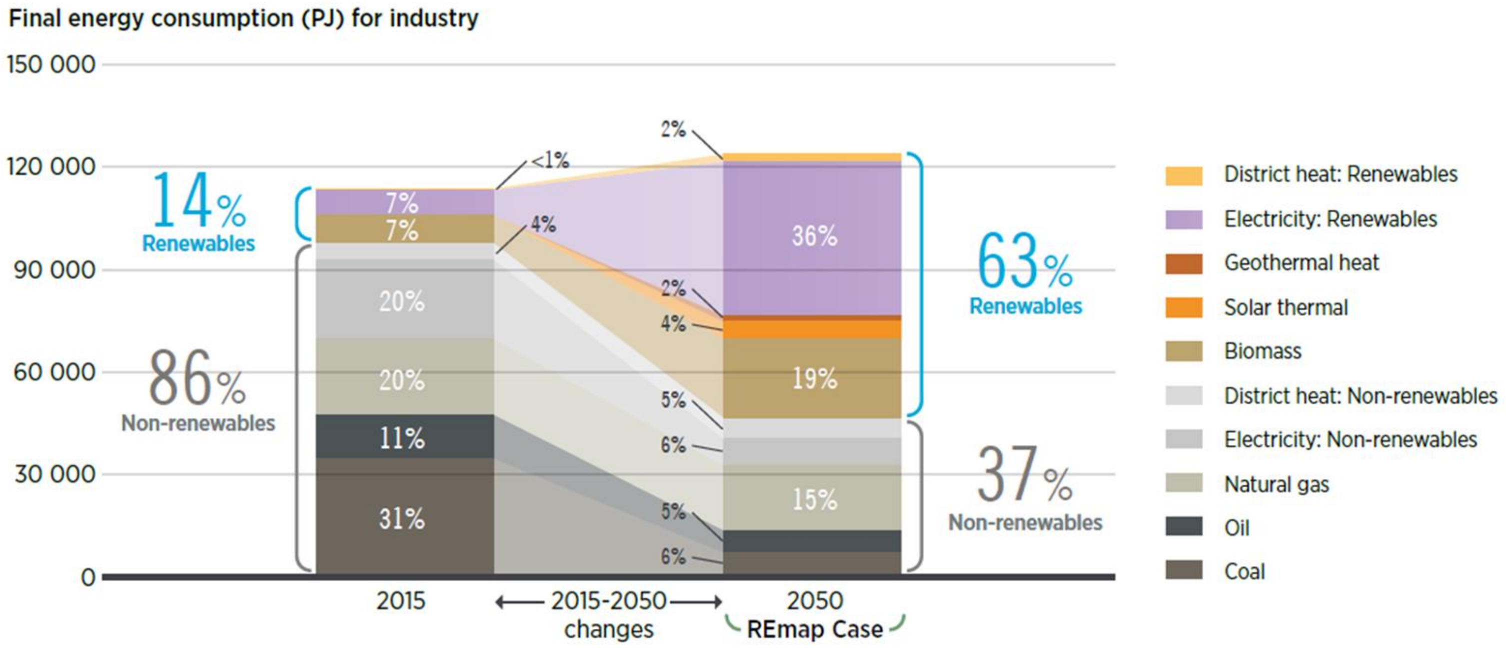
- System installed at a German Army Camp in Mali in 2022 to provide air-conditioning for a new cafeteria and kitchen spanning 3,500 square meters.
- Thermal energy was provided by 700 square meters of evacuated tube collectors with a capacity of 450 kW.
- The system incorporated two hot water buffers, each with a volume of 10,000 liters, to ensure efficient operation.

From: IEA SHC Task 65, "Solar Cooling for the Sunbelt Regions". Standardized Solar Cooling Kits

Priority innovations needs in industry

By 2050, renewable energy use in industry needs to grow to more than four times present levels. Biomass and renewable electrification are expected to play a prominent role.

Industry accounted for 28% of global CO_2 emissions in 2015.
That needs to fall by around 50% by 2050.



*Breakdown of final energy consumption in the buildings sector, by source (PJ/yr), taken from IRENA (2018), **Global energy transformation: A roadmap to 2050**, International Renewable Energy Agency, Abu Dhabi.*

IRENA (2018), Innovation priorities to transform the energy system, International Renewable Energy Agency, Abu Dhabi.

Priority innovations needs in industry

- "Significant innovation is needed **in the most energy- or carbon-intensive industries** in order to decrease costs, increase industry acceptance and inform policy. **Co-ordinated international policy and regulatory action** will be essential to overcome competitiveness concerns.
- In the **iron and steel sector** – focus on both **enhancing the efficiency** of existing processes and **demonstrating new technologies** and fuels such as renewable hydrogen and carbon capture and storage (CCS).
- **In the cement sector** – focus on demonstration projects to explore the **blending or replacement of clinker with lower-carbon substitutes**; demonstrate the use of biomass and alternative fuels; and utilize CCS.
- In the chemical and petrochemical sector – focus on increasing recycling of chemicals and utilizing biomass as both a feedstock and a fuel for plastics production."

Strategy	Innovation	Scale-up*	Priorities for support
Push	Lower carbon processes for cement making e.g. alternatives to clinker, use of biomass or CCS	>100x	Establish multiple demonstration projects and share learning internationally Support R&D, international sectoral agreements and business models to secure affordable, sustainable biomass supply at scale.
	Direct use of renewable energy in industrial heat	4x	Support RD&D for cost reduction Support sustainable biomass supply (see above)
	Hydrogen use in direct reduced Iron making	10x	Establish multiple demonstration projects and share learning.
	Hydrogen used in ammonium production	11x	Establish multiple demonstration projects and share learning.
Nurture	Biomass used in blast furnaces	10x	Extend application from small- to large-capacity blast furnaces Support sustainable bio-mass supply (see above)
	Chemicals from recycling and biomass feedstock	13x	Support sustainable biomass supply (see above)
	CCS applied to iron-making	12x	Establish multiple demonstration projects and share learning.
Facilitate	Material efficiency	2x	Enforce regulation to promote circular economy in industries
	Energy management systems	3x	Broaden ISO50001 adoption and ensure that it is enforced

*An indication of the growth in capacity or activity needed between 2015 and 2050.

Source: IRENA (2018), ***Global energy transformation: A roadmap to 2050,*** International Renewable Energy Agency, Abu Dhabi.

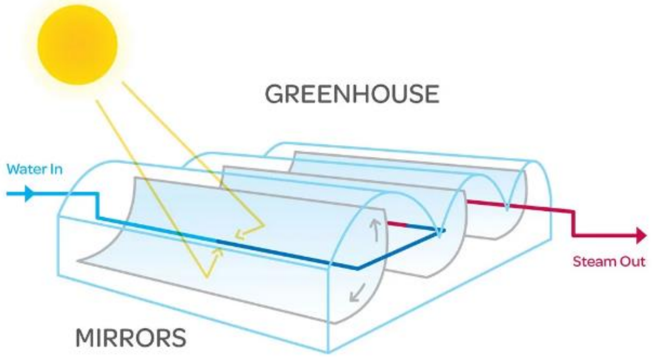
IRENA (2018), Innovation priorities to transform the energy system, International Renewable Energy Agency, Abu Dhabi.

Innovations in industry sector – Alumina refining

Concentrated solar thermal in the Bayer process

- In 2024, Ma'aden mining company in Saudi Arabia started developing a solar steam facility to supply steam for alumina refining, for use in digestion heat:
  - 1,500 MW_{th} solar steam facility.
  - 6 km^2 concentrated solar field.
  - 600,000 tons annually of CO_2 emissions will be saved.
- TRL 6-7 (Full prototype at scale, Pre-commercial demonstration)
- The Bayer process - the main method to refine bauxite into alumina (the input to aluminum smelting) - requires 100 to 250 °C heat and steam for digestion and 1000 °C heat for calcination, which are currently delivered using fossil fuels. Testing is underway to use concentrated solar thermal as heat input into alumina refining.
- Relevance for net zero
  - Alternative fuels provide a good prospect for reducing alumina refining emissions.
  - Alumina refining is a key source of the sector's emissions, so it will be important to develop technologies to reduce them in moving towards net zero emissions.
  - Concentrated solar thermal potentially has lower applicability compared to alternatives.

https://www.glasspoint.com/projects/maaden-solar



How enclosed troughs work

https://www.glasspoint.com/technology

https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide?layout=tree&selectedTechID=all

Innovations in industry sector – Cement kiln (Solar thermal calciner)

Direct heat from variable renewables

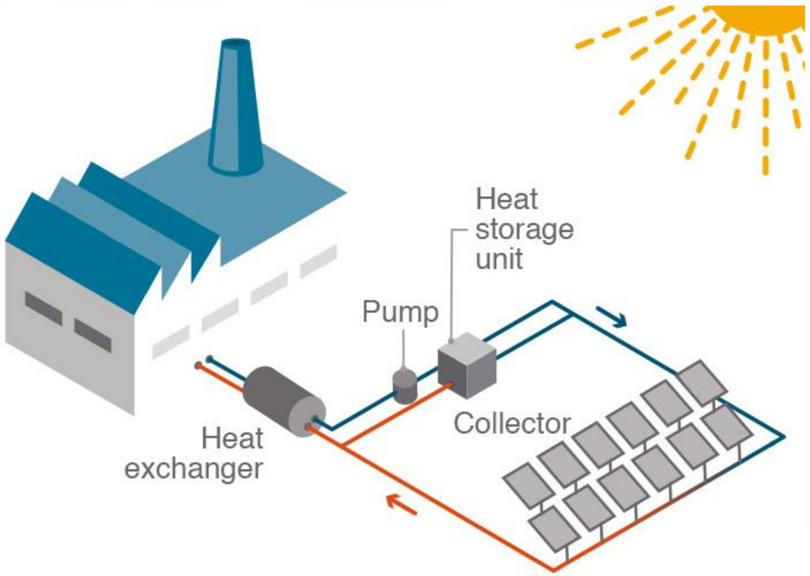
- In October 2022, Heliogen received USD 4.1 million from the United States Department of Energy to accelerate large-scale development of CSP for the decarbonization of limestone heating:
  - New concentrating solar-thermal power (CSP) technique that has proven capable of generating heat above 1000 °C.
  - The robotic heliostats use an AI algorithm to position and redirect all the sunlight to a single point.
- TRL 6 (full prototype at scale)

https://helioscsp.com/heliogen-and-nantg-power-announce-strategic-collaboration-to-innovate-solar-thermal-calcination-design/#

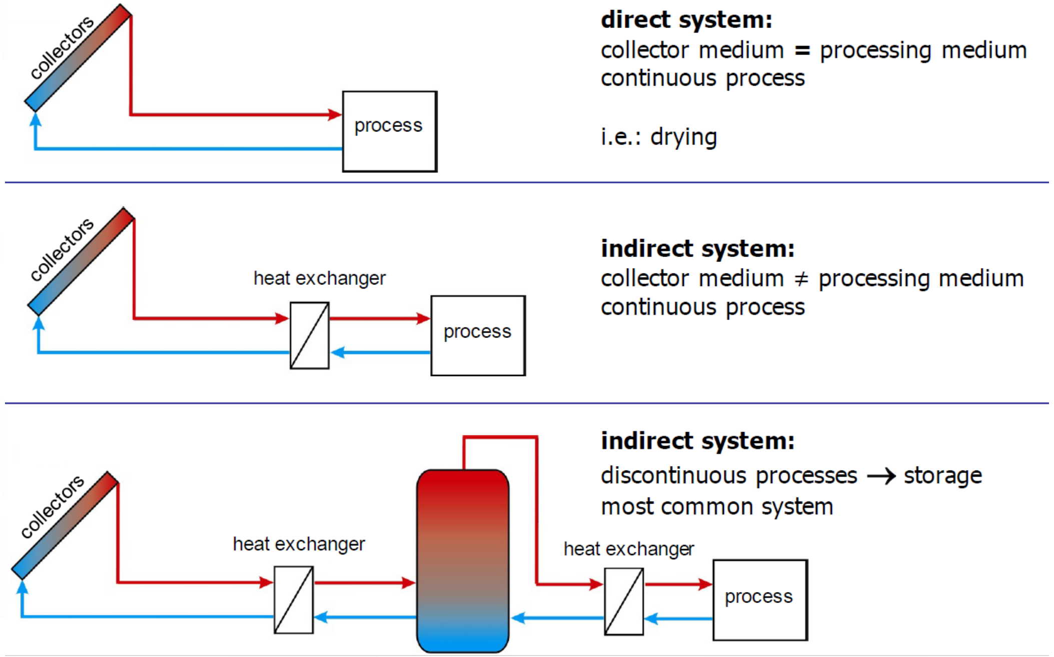
- The CSP plant can be used in processes that need high temperature, such as non-metallic particles treatment and clinker production.
- Over 80 % of the energy used in cement production is consumed by calcination.
- Challenges:
  - It is still at a relatively early stage of development and would require considerable cost reductions to be competitive.
  - Its application may be limited to areas with peak solar potential.
  - Replacing all process heat (as opposed to a part) with solar thermal will likely be challenging.

https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide?layout=tree&selectedTechID=all

Successful applications – Solar heat for industrial processes (SHIP)



From: https://www.solar-payback.com/technology/



- According to the IEA, industrial heat accounts for two-thirds of industrial energy demand and almost one-fifth of global energy consumption.
- Temperature levels for different processes and end applications vary in a wide range.
- For industrial low-temperature process heat up to 400°C, solar thermal systems are an excellent option.
- According to Solrico in February 2025, there are at least 1,315 systems in operation with 1.531 million square meters collector area related to a capacity of 1,071 MW_{th}.
- On average 100 new SHIP systems with an average capacity of 1.1 MW_{th} have been commissioned each year between 2017 and 2024.

From: Solar Heat Worldwide 2025

Successful applications – Solar heat for industrial processes (SHIP)

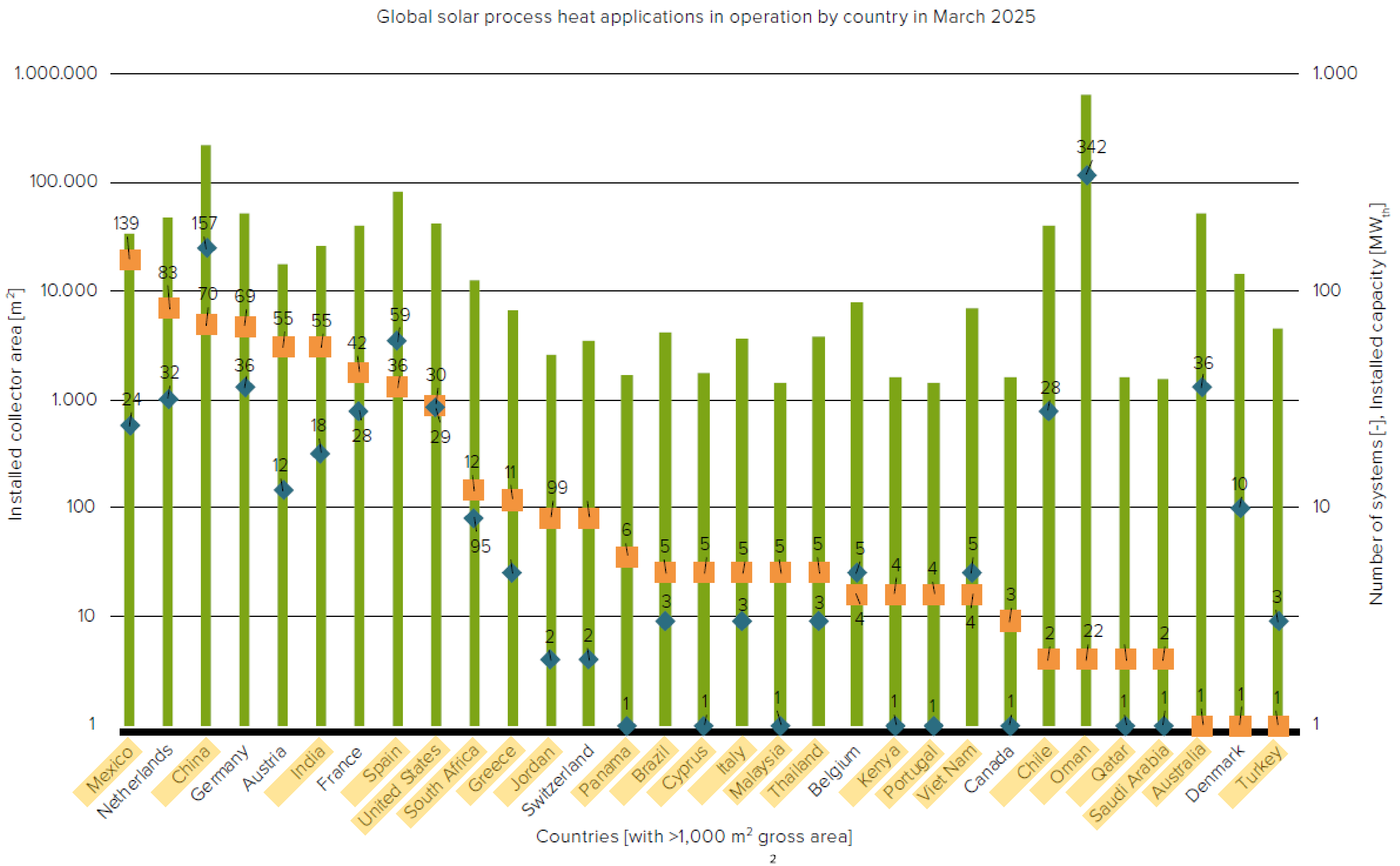
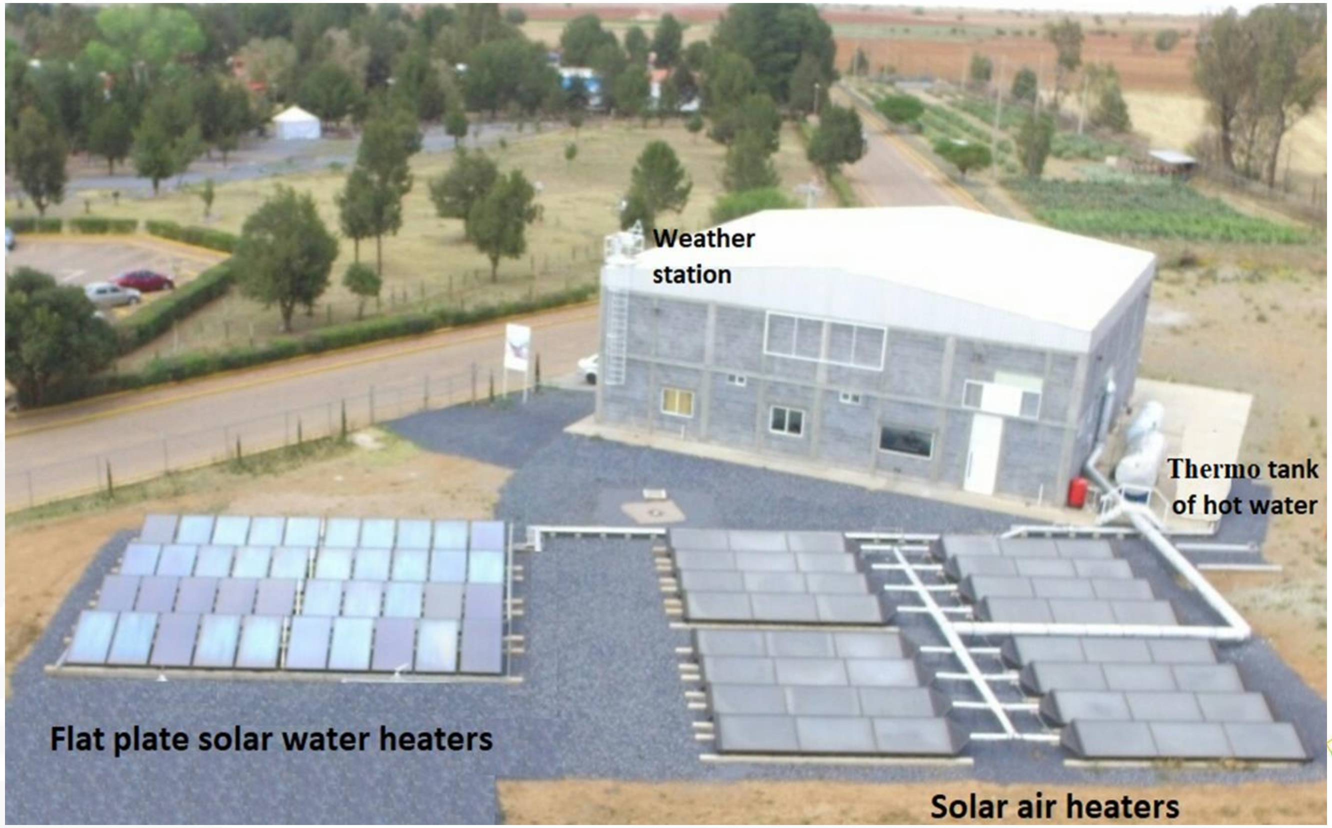


Figure 14: Global solar process heat applications in operation by country in March 2025
Source: SHIP database

From: Solar Heat Worldwide 2025

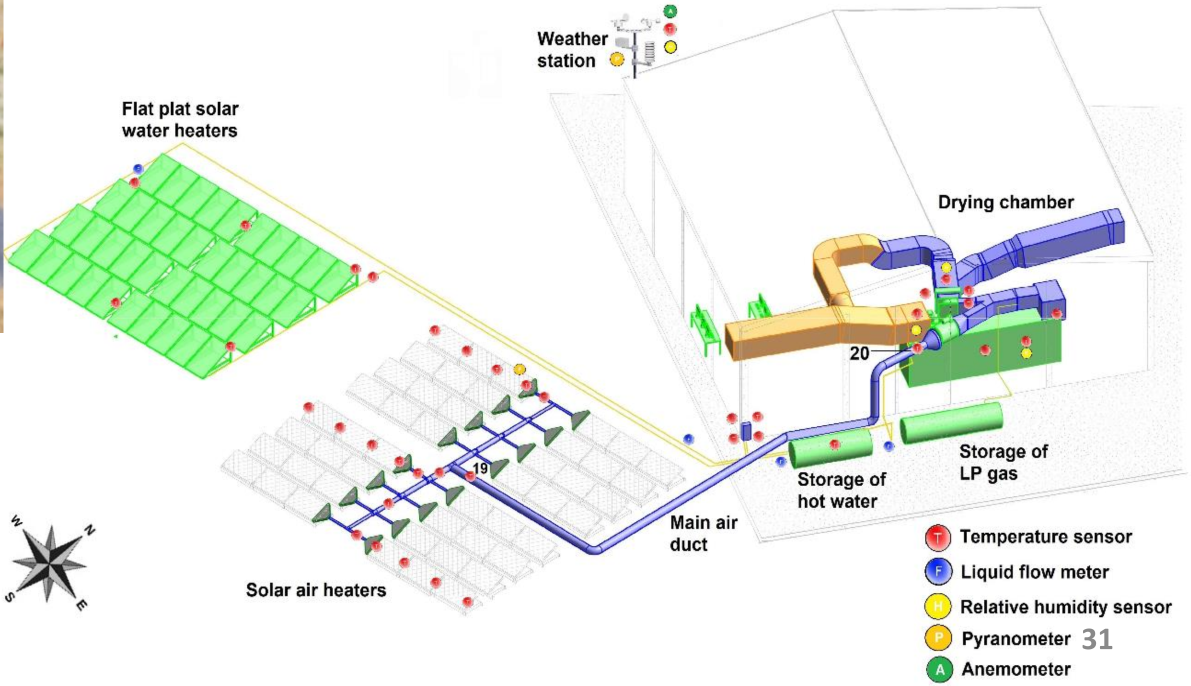
Successful applications – Solar drying

Solar-LP gas hybrid plant for dehydration of food - Mexico



The air heating system is integrated by:

- field of 40 flat plate solar water collectors (92.4 m^2)
  - liquid-liquid plate heat exchanger
  - thermal storage tank (6150 l)
  - water-air finned tube heat exchanger
  - centrifugal fan
  - auxiliary equipment
- field of 48 solar air heaters (111.1 m^2)



Summary

- The sunbelt includes more than 160 countries, which have optimal climatic conditions for the use of solar thermal energy, even in tropical areas with high rainfall.
- There has been significant growth in the number of patents related to solar thermal technologies, especially in countries such as China, the US, Japan, Spain, Brazil, and Mexico.
- There is an urgent need for innovation to achieve the 2050 decarbonization targets, especially in the power generation, buildings, and industry sectors.
- In power generation, technologies such as concentrated solar power (CSP), including parabolic troughs, central towers, and Fresnel reflectors, need to be scaled up, with an emphasis on thermal storage and cost reduction.
- In the buildings sector, opportunities for innovation have been identified in water heating with technologies such as thermosiphon systems, as well as in solar cooking, and solar cooling.
- In the industrial sector, the use of solar heat for industrial processes (SHIP) is being promoted, with more than 1,300 systems in operation, with Mexico leading in number of installations and Oman in installed capacity.
- The importance of standardization and certification of solar thermal technologies is emphasized to encourage their adoption and ensure quality.
- Although significant progress has been made, the current pace of growth is insufficient to achieve the 2050 emission reduction targets, requiring accelerated innovation, investment, and international collaboration.

Thank you

2025 Año de La Mujer Indígena

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