Introduction to Renewable Energy Development

Source REN21

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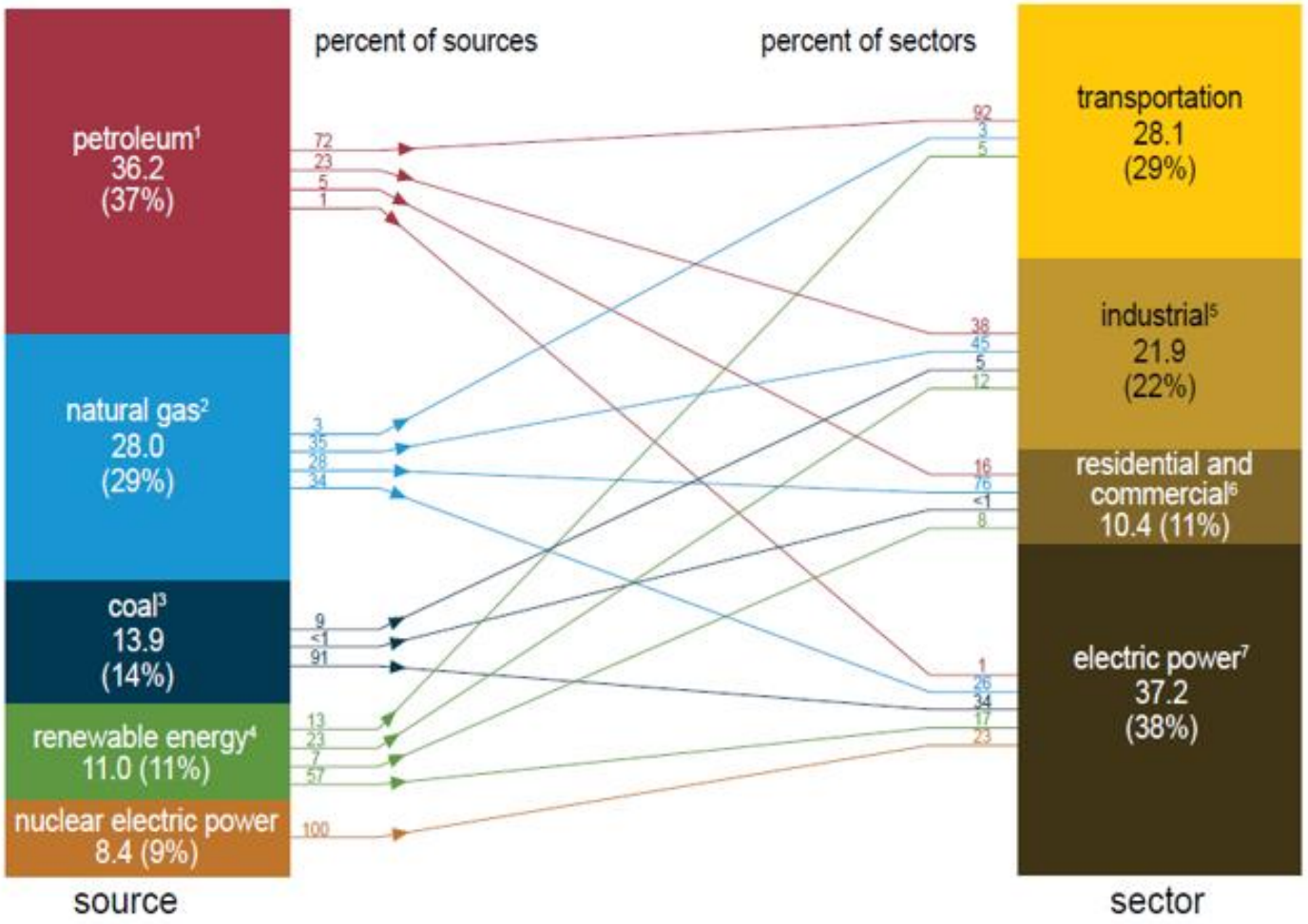
U.S. primary energy consumption by source and sector, 2017

Total = 97.7 quadrillion British thermal units (Btu)



[1] Does not include biofuels that have been blended with petroleum—biofuels are included in "Renewable Energy."
[2] Excludes supplemental gaseous fuels.
[3] Includes -0.03 quadrillion Btu of coal coke net imports.
[4] Conventional hydroelectric power, geothermal, solar, wind, and biomass.
[5] Includes industrial combined-heat-and-power (CHP) and industrial electricity-only plants.
[6] Includes commercial combined-heat-and-power (CHP) and commercial electricity-only plants.
[7] Electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public. Includes 0.17 quadrillion Btu of electricity net imports not shown under "source."

Notes: • Primary energy is energy in the form that it is accounted for in a statistical energy balance, before any transformation to secondary or tertiary forms of energy occurs (for example, coal is used to generate electricity). • The source total may not equal the sector total because of differences in the heat contents of total, end-use, and electric power sector consumption of natural gas. • Data are preliminary. • Values are derived from source data prior to rounding. • Sum of components may not equal total due to independent rounding.

Sources: U.S. Energy Information Administration, *Monthly Energy Review* (April 2018), Tables 1.3, 1.4a, 1.4b, and 2.1-2.6.

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ONGOING CHALLENGES TOWARDS A RENEWABLES-BASED WORLD

The developments during 2020 highlighted some of the key **ongoing challenges** impeding the widespread adoption of renewable energy;

- The **slow increase** of renewables in total final energy consumption (TFEC),
- The need for **more innovation** in some sectors,
- The need for infrastructure development and increased **affordability** in some markets,
- The **lack of sufficient policy** support and enforcement, and persistent support for fossil fuels.

The share of renewables in TFEC has increased only moderately due to:

• Rising global energy demand;

• Continuing consumption of and investment in new fossil fuels, resulting in fossil fuels meeting most of the increasing demand,

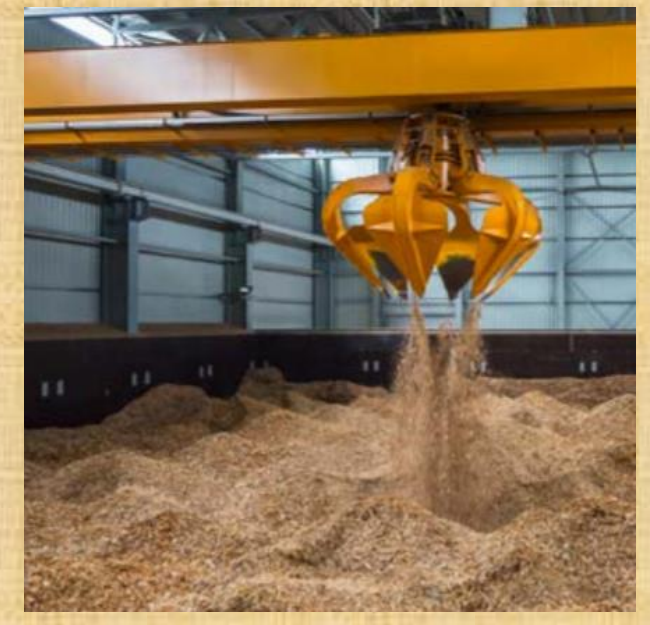
• Declining traditional use of biomass, which although a positive development due to sustainability and health concerns has meant that as people shift towards modern sources of energy, much of this is via fossil fuels.

BUILDINGS

Renewable energy meets a growing portion of final energy demand in buildings, although its share is still less than 15%.
Renewables remained the fastest growing source of energy in buildings, increasing 4.1% annually on average between 2009 and 2019.
The highest growth was in electricity use, whereas heating with renewable energy rose more slowly.
Modern bioenergy (such as the use of wood-based fuel in efficient stoves) still represented the largest source of renewables in the buildings sector, especially in providing heat, although its growth has been roughly stagnant.

INDUSTRY

The share of renewables in industrial energy demand remains small, particularly in sectors that require high temperatures for processing.
Renewable energy accounts for only around 14.8% of total industrial energy demand and is used mainly in industries with low temperature requirements for process heat.
In heavy industries – iron and steel, cement, and chemicals – renewables accounted for less than 1% of the combined energy demand in 2018.



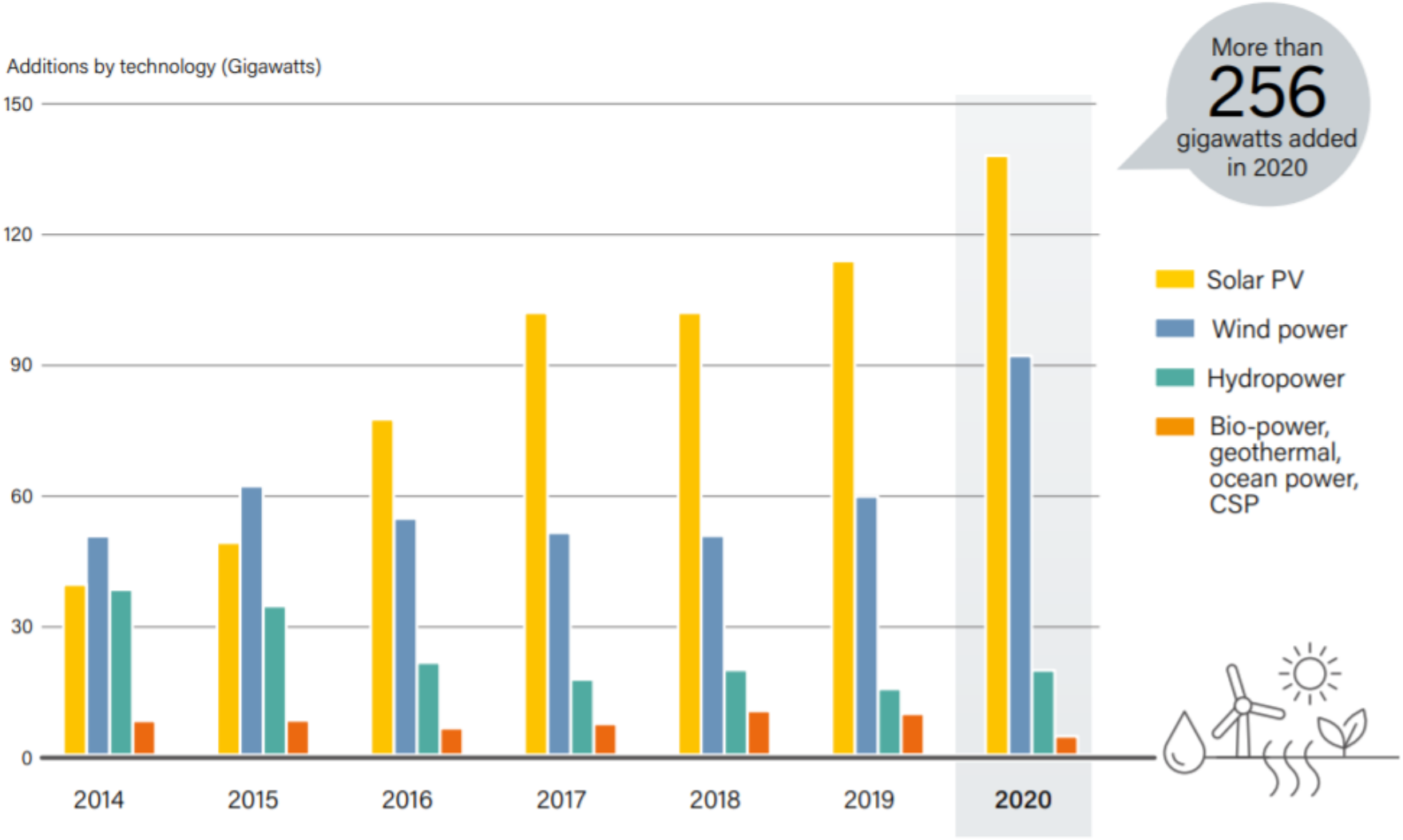
TRANSPORT

Transport remains the sector with the lowest share of renewables, as oil and petroleum products (and 0.8% nonrenewable electricity) continue to meet nearly all global transport energy needs (95.8%).
Biofuels and renewable electricity met small shares of those needs (3.1% and 0.3%, respectively).

POWER

Driven by solar photovoltaic (PV) and wind power, the renewable power sector surged in the second half of 2020 to overcome the pandemic's impacts.
Installed renewable power capacity grew by more than 256 gigawatts (GW) during the pandemic, the largest ever increase.
Continuing a trend dating back to 2012, net additions of renewable power generation capacity outpaced net installations of both fossil fuel and nuclear power capacity combined.
China again led the world in renewable capacity added, accounting for nearly half of all installations in 2020 and leading the global markets for concentrating solar thermal power (CSP), hydropower, solar PV and wind power.

FIGURE 7.
Annual Additions of Renewable Power Capacity, by Technology and Total, 2014-2020



Note: Solar PV capacity data are provided in direct current (DC). Data are not comparable against technology contributions to electricity generation.

Source: See endnote 311 for this chapter.

Bio-Energy

Bio-energy Key Facts

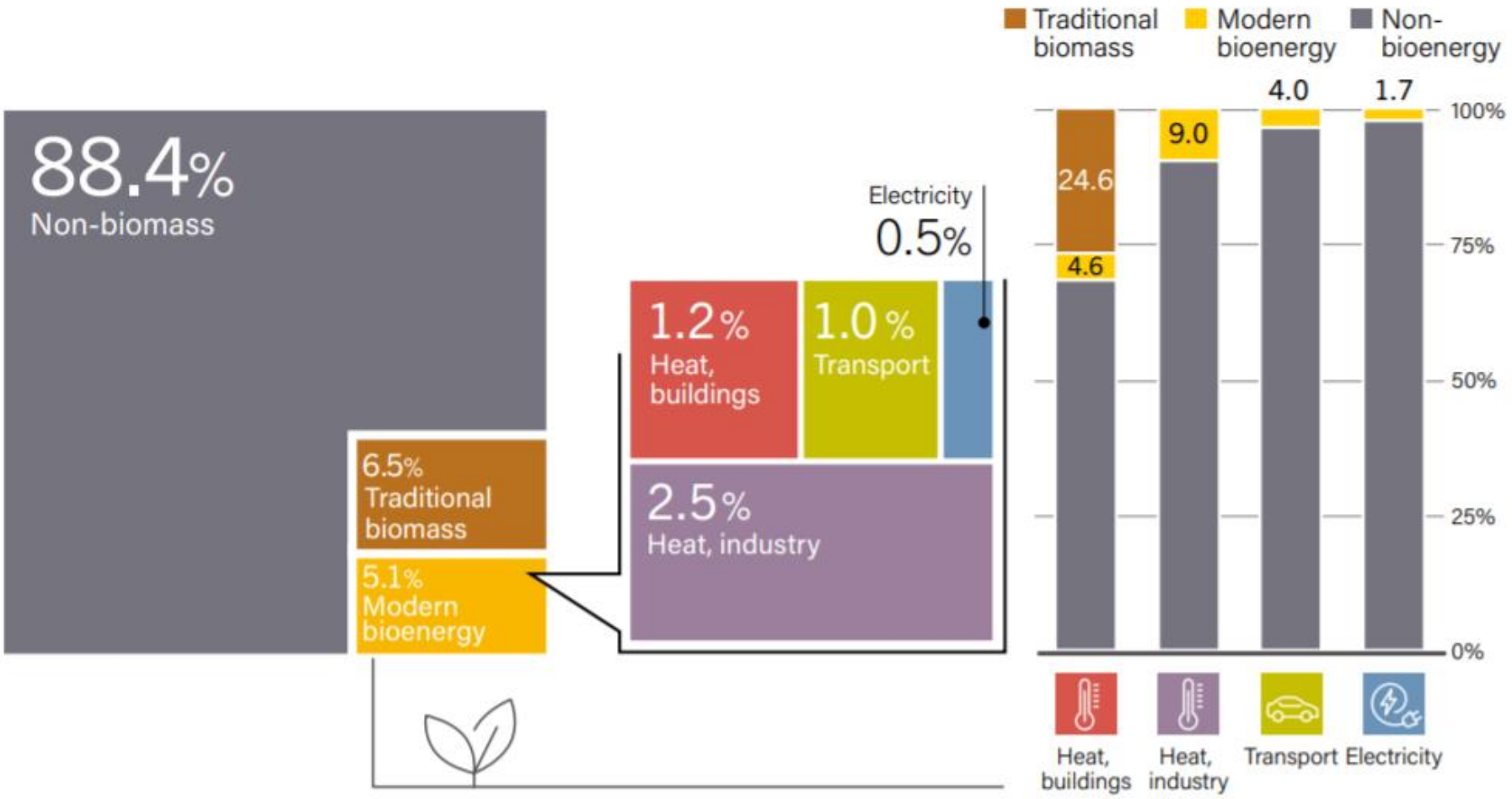
•Modern bioenergy provided 5.1% of total global final energy demand in 2019, accounting for around half of all renewable energy in final energy consumption.

•Modern bioenergy for industrial process heat grew around 16% between 2009 and 2019, while bio-heat demand in buildings grew 7% over the same period.

•In 2020, global biofuel production fell 5%, with ethanol production down 8%, while biodiesel production rose slightly to meet increased demand in Indonesia, the United States and Brazil.

•Bioelectricity production grew 6% in 2020, with China the major producer

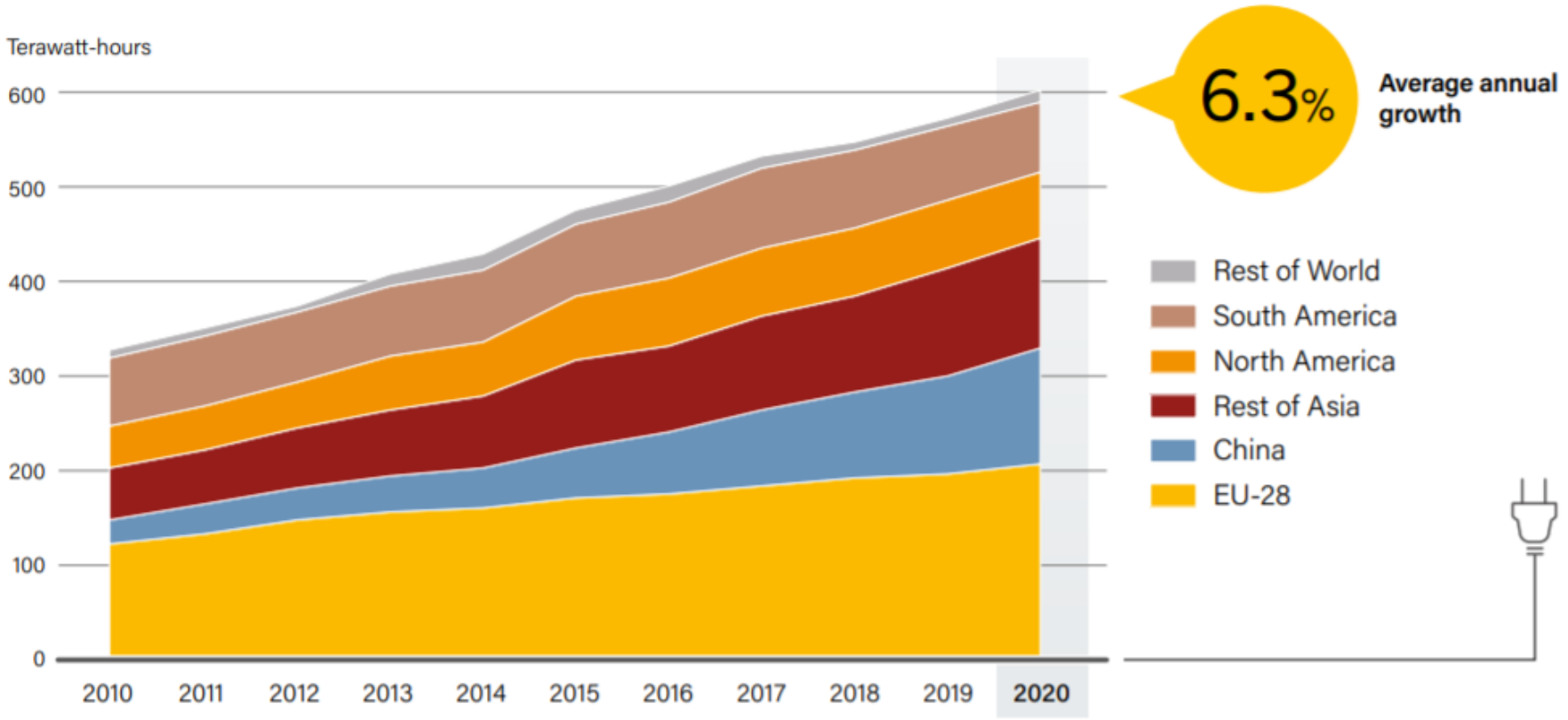
FIGURE 17.
Estimated Shares of Bioenergy in Total Final Energy Consumption, Overall and by End-Use Sector, 2019



Note: Data should not be compared with previous years because of revisions due to improved or adjusted data or methodology. Totals may not add up due to rounding. Buildings and industry categories include bioenergy supplied by district energy networks.

Source: Based on IEA. See endnote 5 for this section.

FIGURE 20.
Global Bioelectricity Generation, by Region, 2010-2020



Source: See endnote 105 for this section.

Geothermal Energy

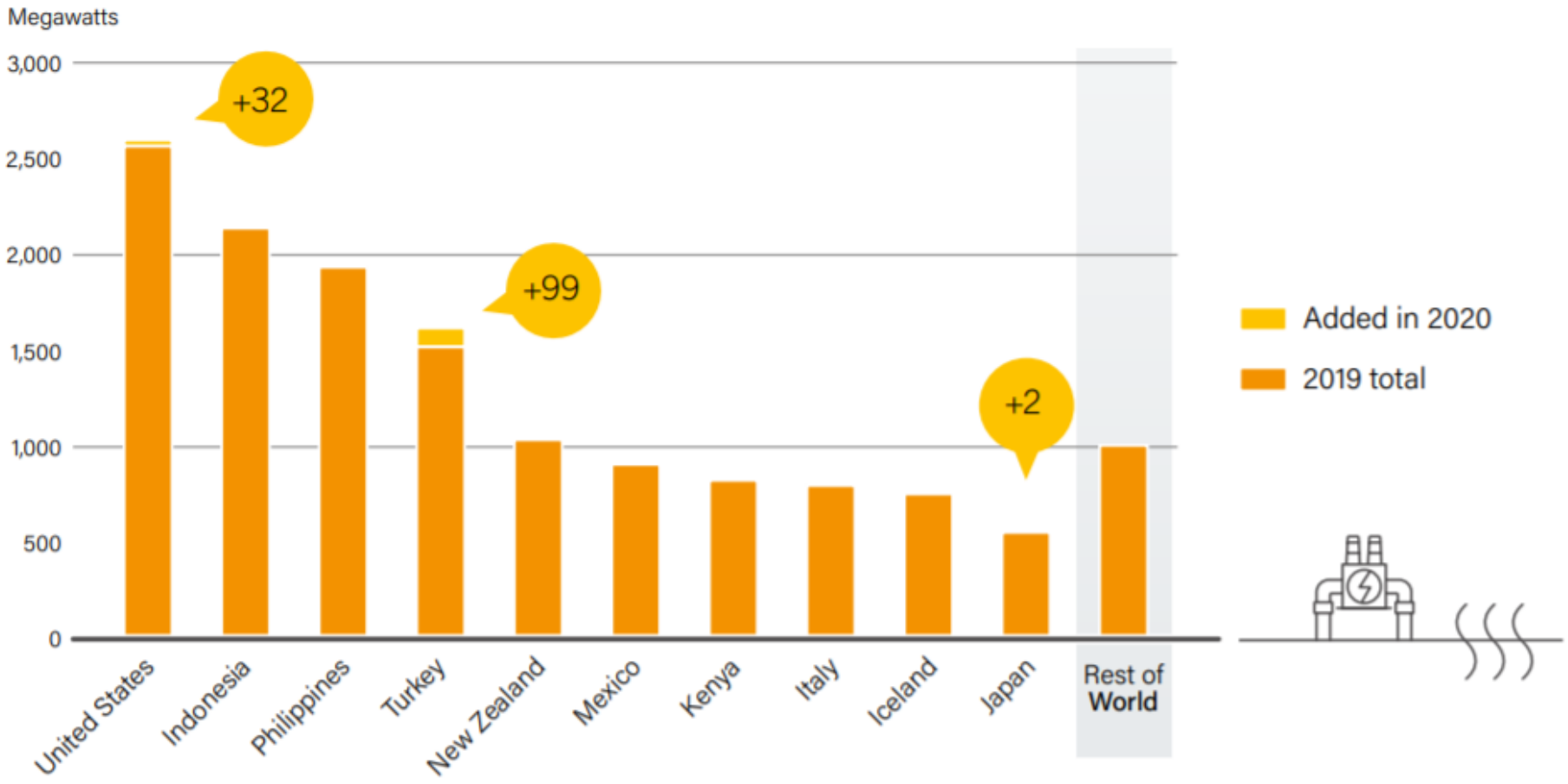
Geothermal Key Facts

•An estimated 0.1 GW of new geothermal power generating capacity came online in 2020 – significantly less than in recent years – with just one country (Turkey) representing the bulk of new installations.

•Direct use of geothermal energy for thermal applications continues to grow around 8% annually, but the market remains geographically concentrated, with only four countries (China, Turkey, Iceland and Japan) representing three-quarters of all direct geothermal use.

•The main focus continued to be on technological innovation, such as new resource recovery techniques and seismic risk mitigation, with the aim of improving the economics, lowering the development risk and strengthening prospects for expanded geothermal resource development.

FIGURE 21.
Geothermal Power Capacity and Additions, Top 10 Countries and Rest of World, 2020



Note: Figure shows known new capacity and capacity increases at existing facilities but does not indicate known capacity decommissioning or derating of existing facilities, although those may be reflected (at least partially) in total capacity values.

Hydropower

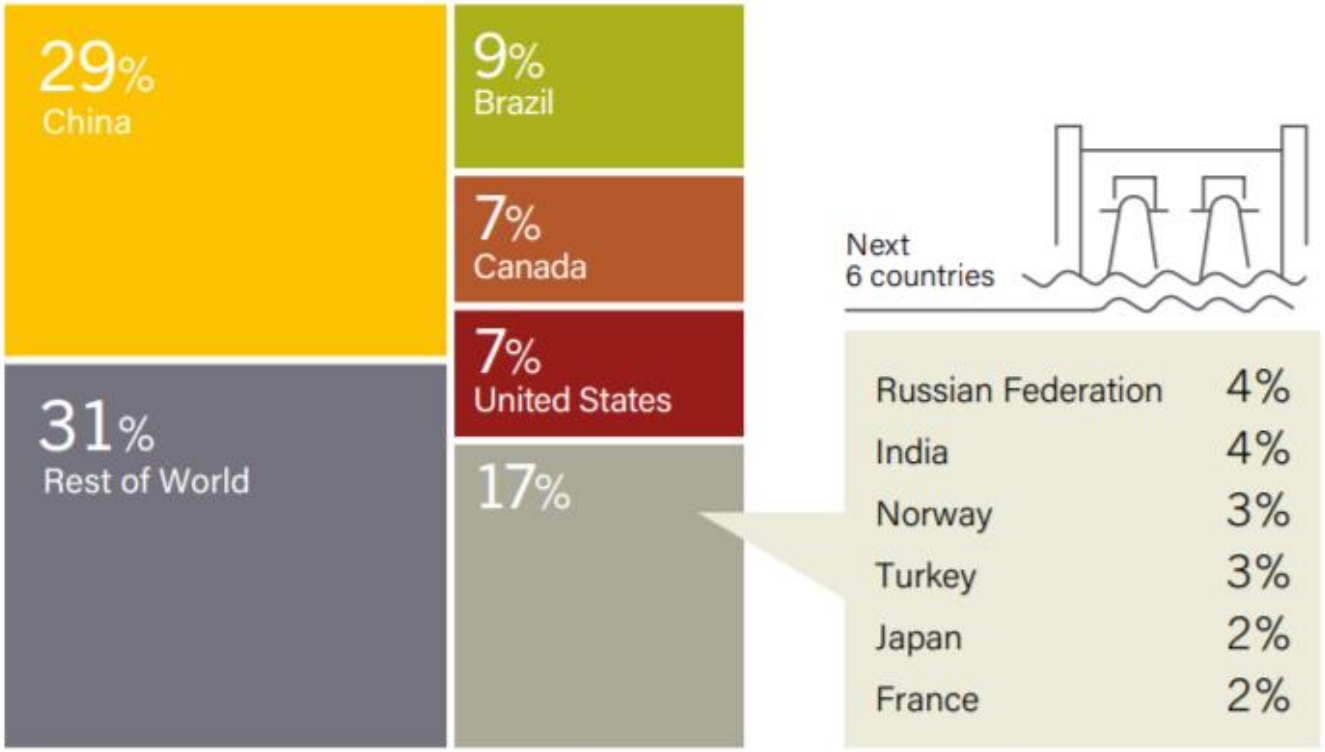
Hydropower Key facts

•The global hydropower market expanded in 2020 but did not recover from several years of deceleration.

•China added 12.6 GW of hydropower capacity in 2020, its largest addition of the previous five years, and regained the lead from Brazil in commissioning new hydropower capacity.

•Hydropower faced challenges including operational and technical factors, environmental and social acceptability, a global decline in wholesale electricity prices, and adverse climate impacts on hydropower production and infrastructure.

FIGURE 23.
Hydropower Global Capacity, Shares of Top 10 Countries and Rest of World, 2020



Photovoltaics

PV Key Facts

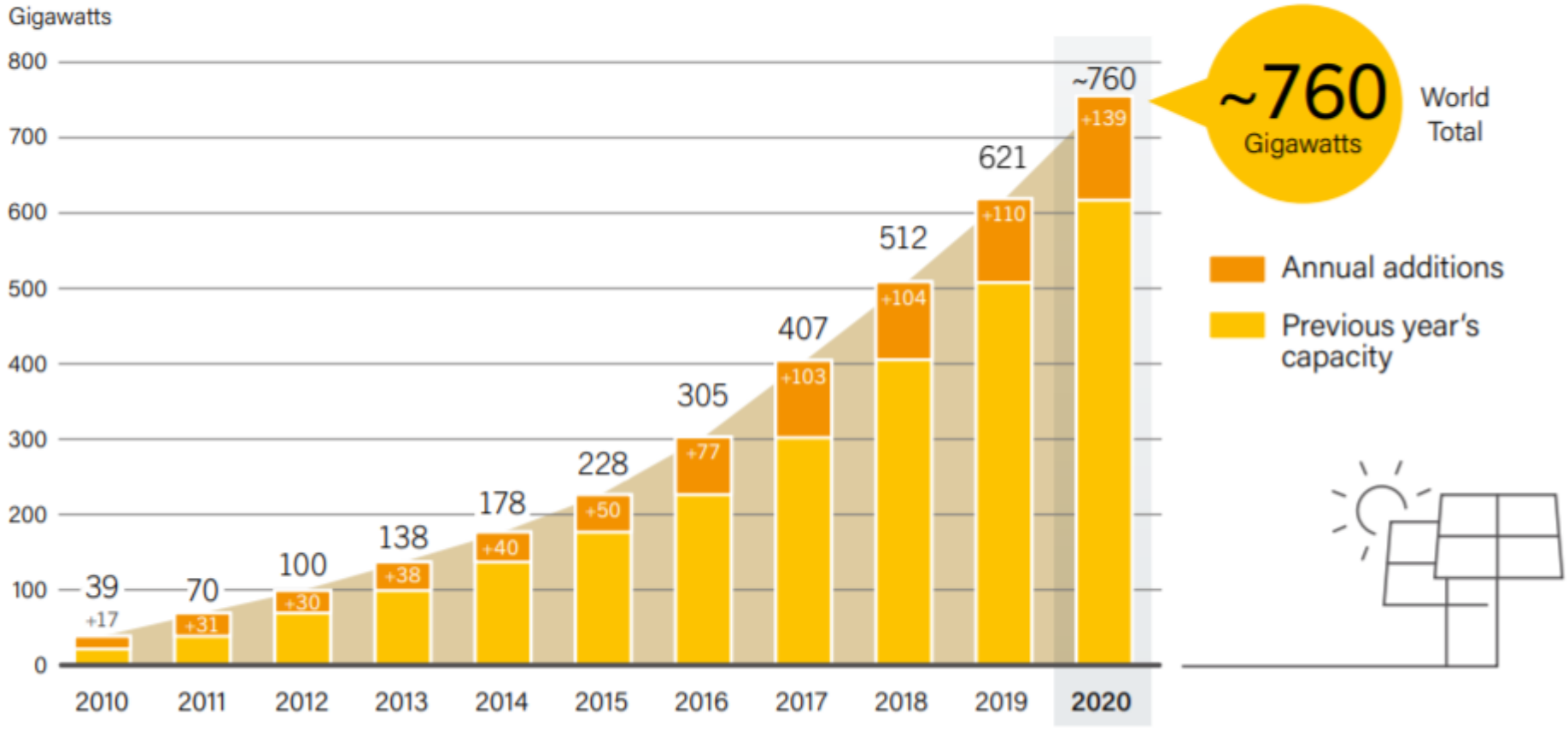
•Solar PV had another record-breaking year in 2020. Anticipated policy changes drove much of the growth in the top three markets – China, the United States and Vietnam – but several other countries saw noteworthy expansion.

•Favourable economics have boosted interest in distributed rooftop systems. In South Australia, the growth of distributed solar PV has made the state's power system the first large-scale system in the world to approach the point at which rooftop solar PV effectively eliminates demand for electricity from the grid.

•The solar PV industry rode a roller coaster in 2020, driven largely by pandemic-related disruptions, as well as by accidents at polysilicon facilities in China and a shortage of solar glass. These disruptions, due in large part to heavy reliance on China as the world's dominant producer, combined with concerns about possible forced labour in polysilicon production, led to calls in many countries for the creation of local supply chains.

•New actors entered the sector. Competition and price pressures continued to motivate investment to improve efficiencies, reduce costs and improve margins.

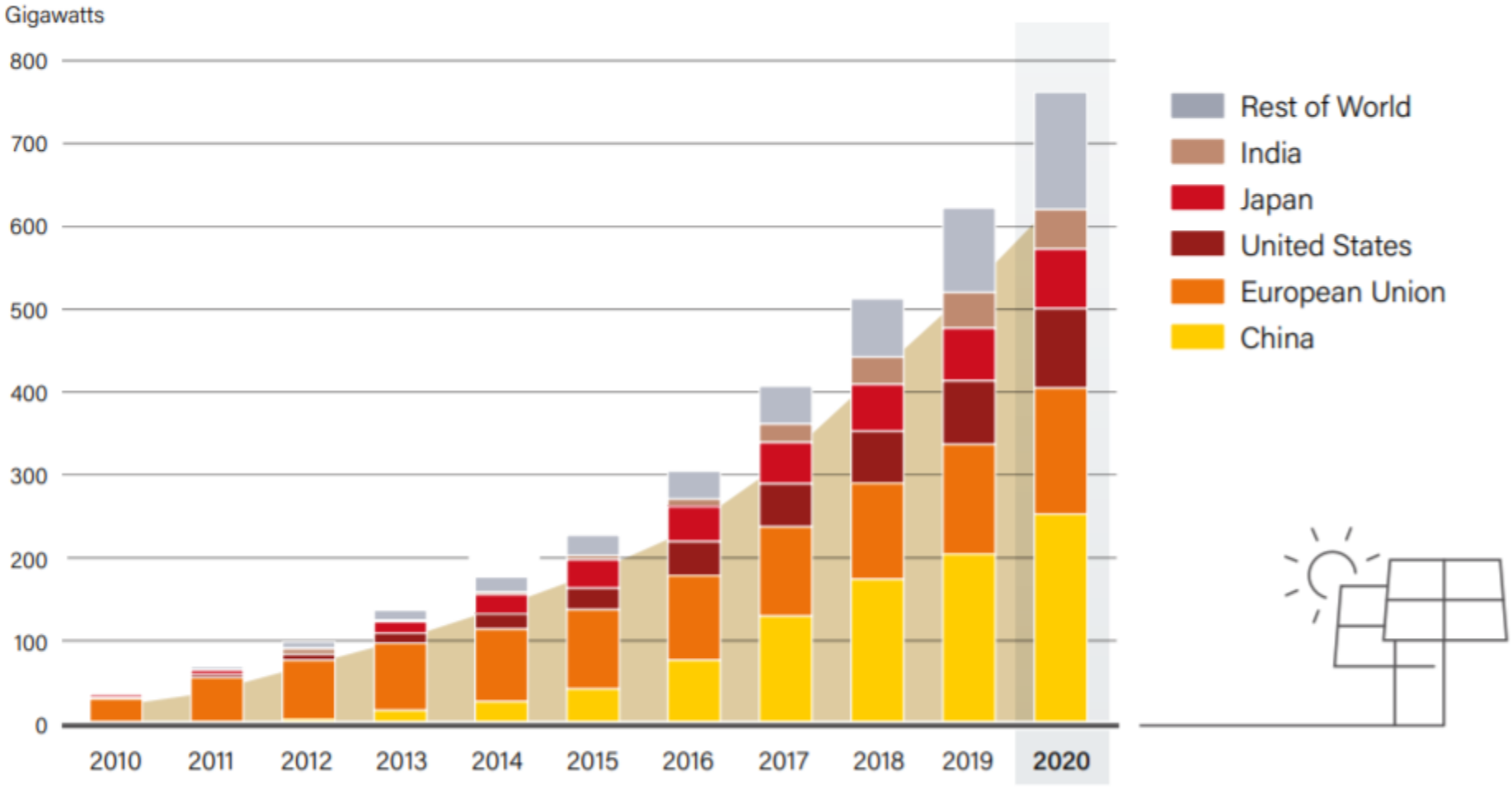
FIGURE 25.
Solar PV Global Capacity and Annual Additions, 2010-2020



Note: Data are provided in direct current (DC). Totals may not add up due to rounding.

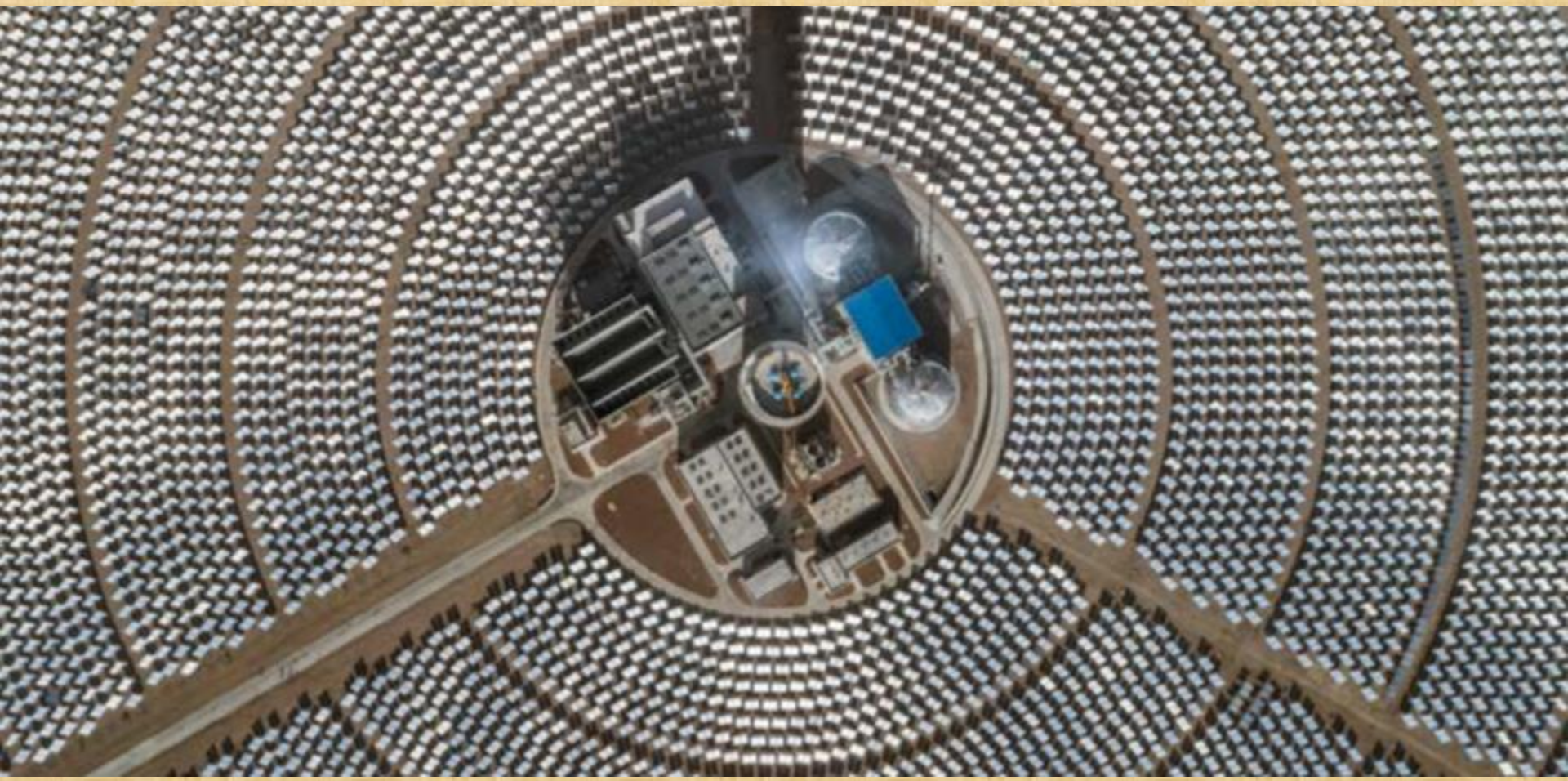
Source: Becquerel Institute and IEA PVPS. See endnote 6 for this section.

FIGURE 26.
Solar PV Global Capacity, by Country and Region, 2010-2020



Note: Data are provided in direct current (DC). European Union includes the United Kingdom throughout the 2010-2020 period. Germany's share of the EU total has declined from over 58% in 2010 to just under 36% in 2020 due to growth in other EU markets.

Solar Thermal Energy



CSP Key Facts

•CSP markets grew slowly in 2020 as a result of increasing cost competition from solar PV, the expiry of CSP incentive programmes and operational issues at existing facilities. Spain and the United States, the market leaders in cumulative installed CSP capacity, have not added new capacity in seven and five years, respectively

•More than 1 GW of new capacity was under construction in 2020 in the United Arab Emirates, China, Chile and India, although construction did not begin on any new projects. China was the only country to add new capacity during the year.

•CSP costs fell 50% during the 2010s, and there are several examples of CSP facilities with thermal energy storage co-located with solar PV to lower costs and increase capacity factors.

FIGURE 30.
Thermal Energy Storage Global Capacity and Annual Additions, 2010-2020

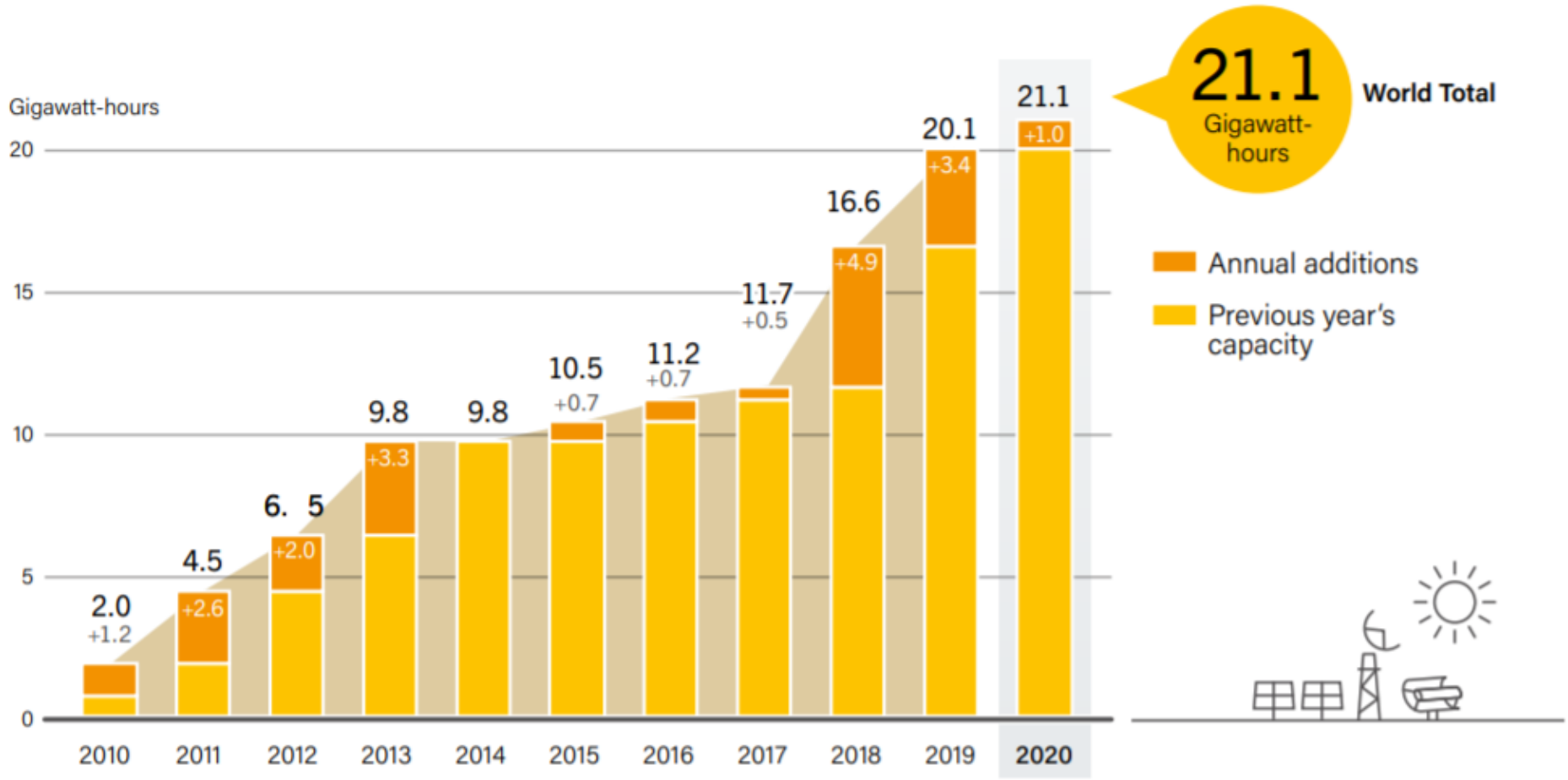


FIGURE 31.
Solar Water Heating Collectors Global Capacity, 2010-2020

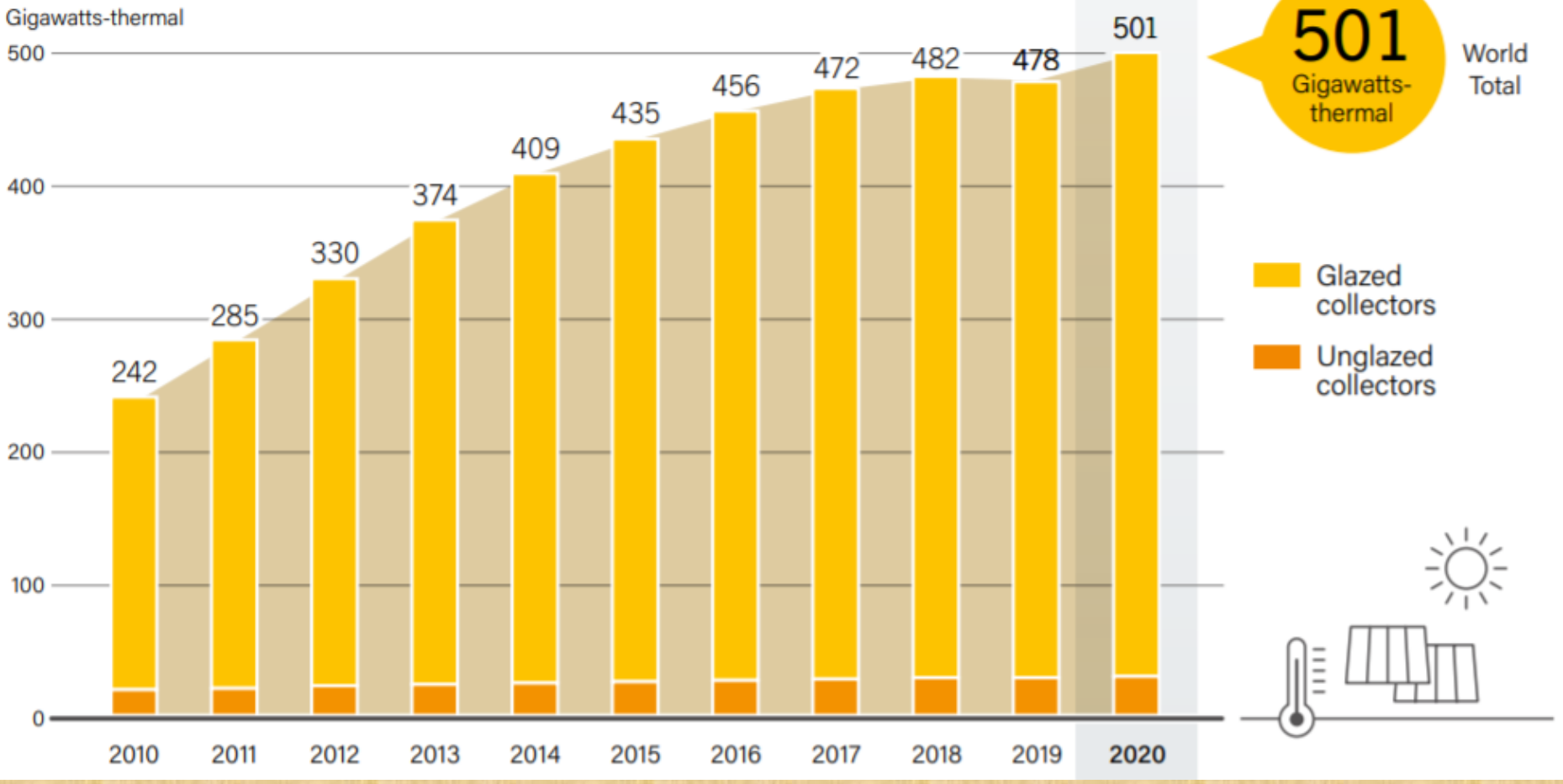
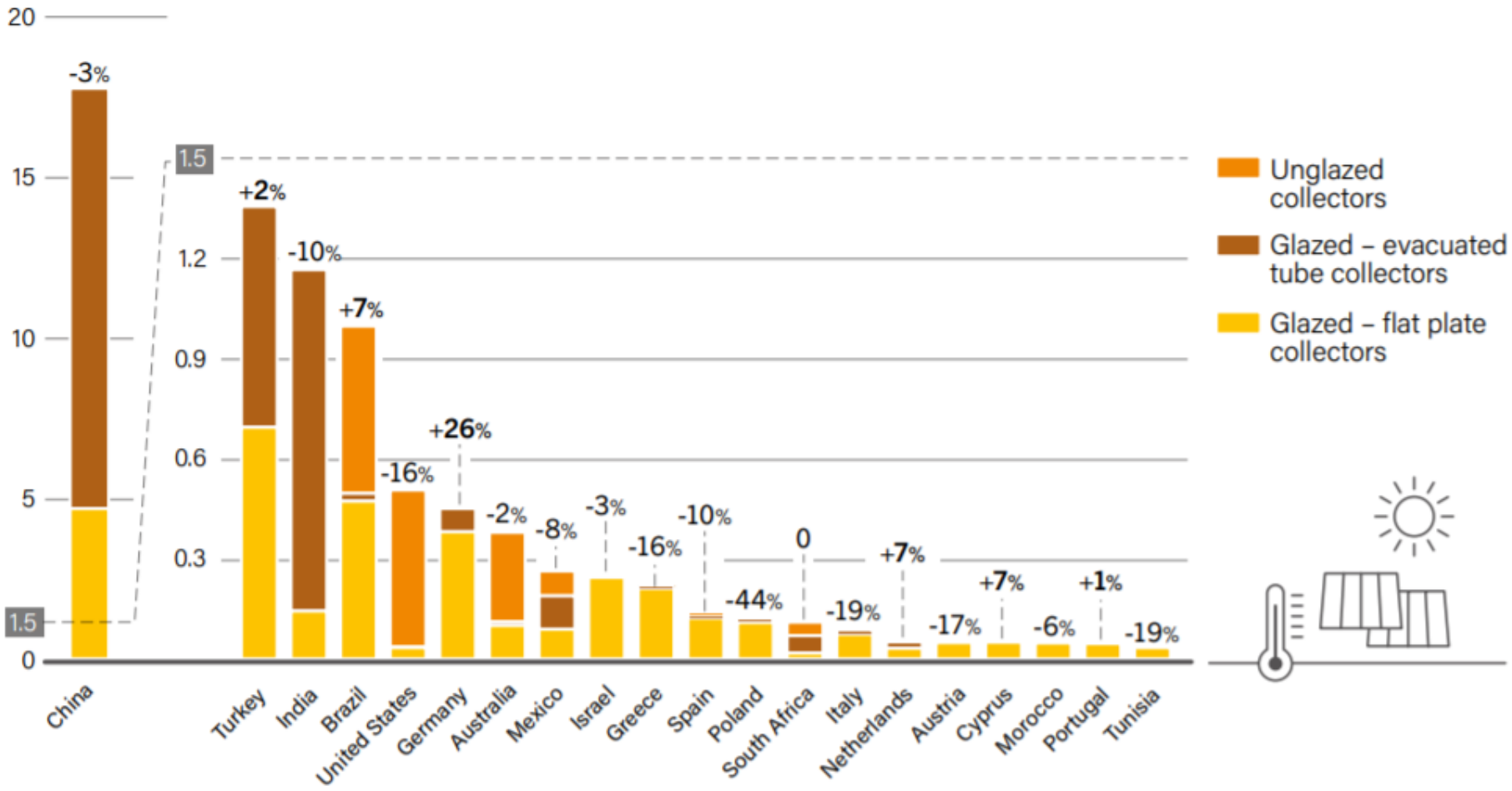


FIGURE 32.
Solar Water Heating Collector Additions, Top 20 Countries for Capacity Added, 2020

Gigawatts-thermal



Wind Energy

Wind Key Facts

•The world added a record 93 GW of wind power capacity in 2020, led by China and the United States. Both countries broke national records for new installations, driven in part by pending policy changes. The rest of the world commissioned about the same amount as in 2019, but several additional countries had record-breaking years.

•For the first time, global capital expenditures committed to offshore wind power in 2020 surpassed investments in offshore oil and gas.

•The industry continued to face perennial challenges exacerbated by the pandemic, but maintained momentum in technology innovation in continuous pursuit of an ever lower levelised cost of energy.

•Wind power accounted for a substantial share of electricity generation in several countries in 2020, including Denmark (over 58%), Uruguay (40.4%), Ireland (38%) and the United Kingdom (24.2%).

FIGURE 34.
Wind Power Global Capacity and Annual Additions, 2010-2020

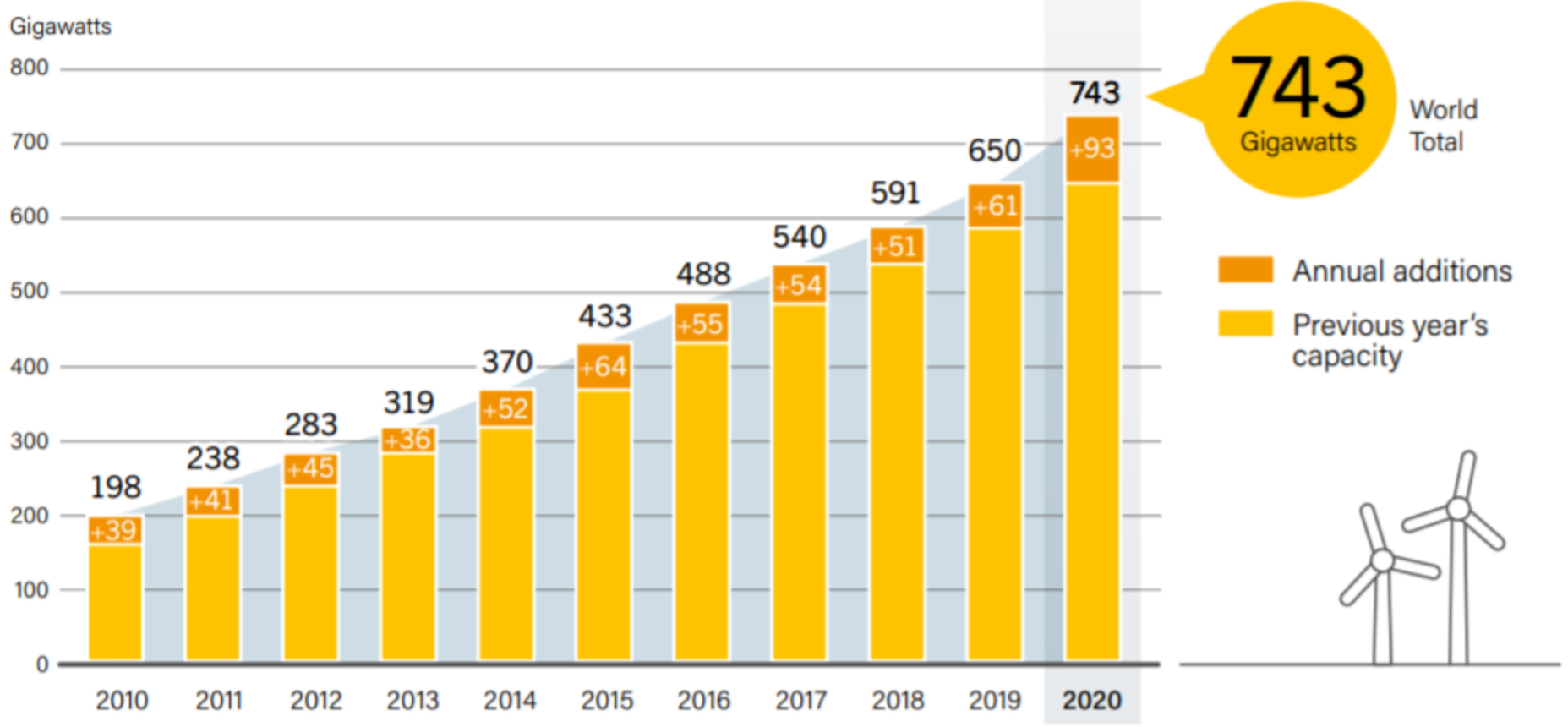


FIGURE 35.
Wind Power Capacity and Additions, Top 10 Countries for Capacity Added, 2020

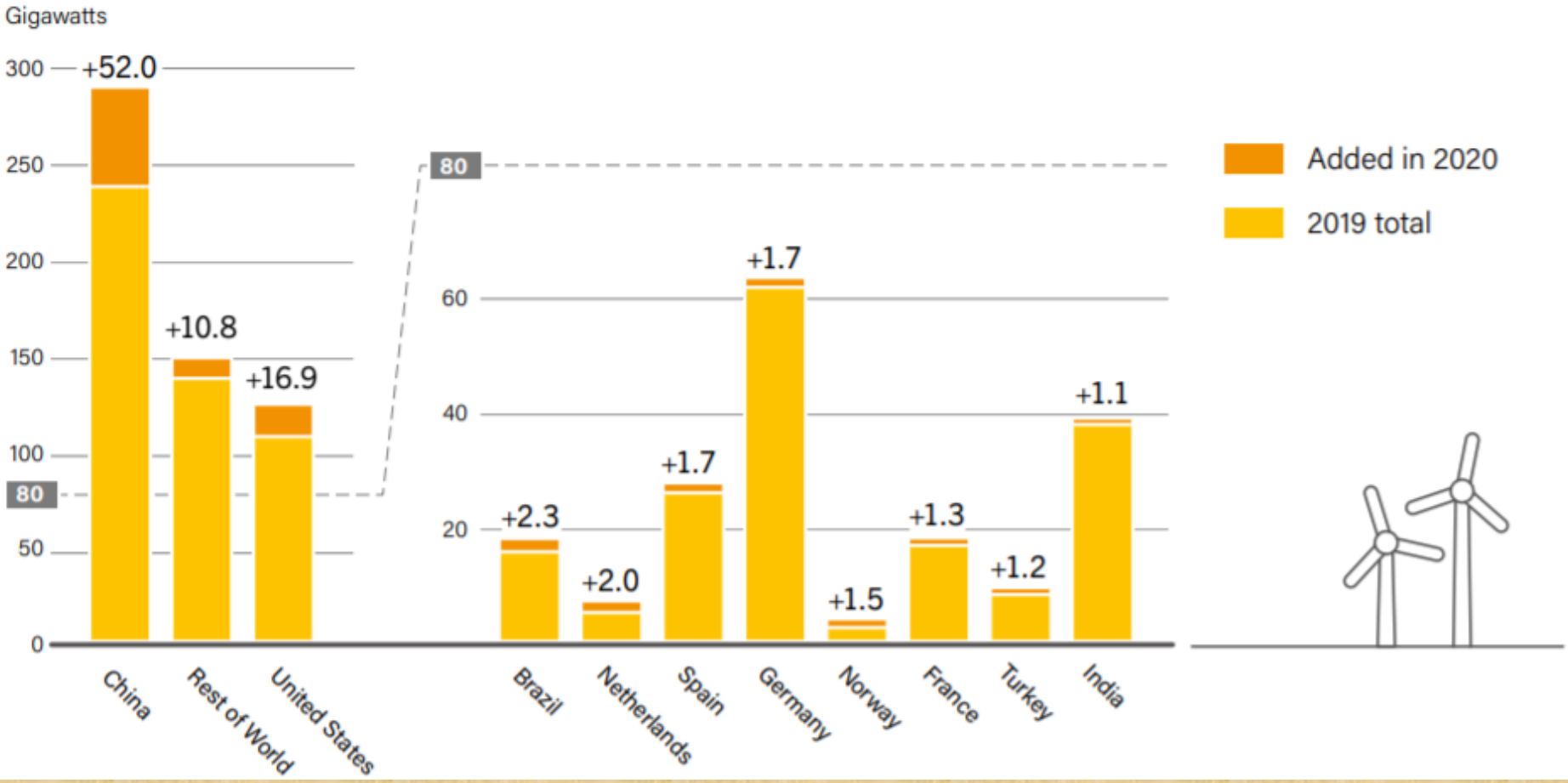
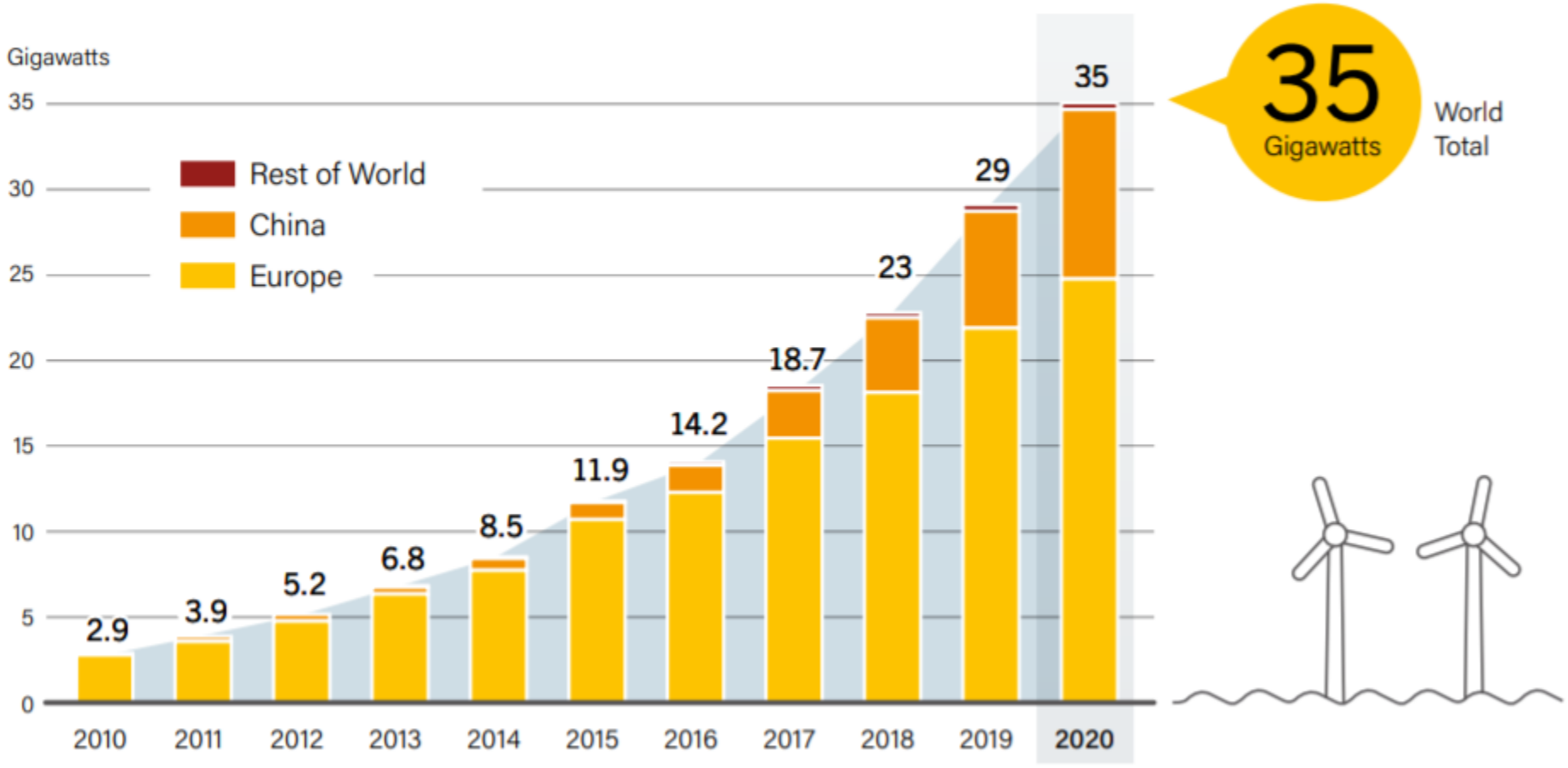


FIGURE 36.
Wind Power Offshore Global Capacity by Region, 2010-2020



Note: Totals above 20 GW are rounded to nearest GW. Rest of World includes the rest of Asia as well as North America.

FIGURE 37.
Global Levelised Costs of Electricity from Newly Commissioned Utility-scale Renewable Power Generation Technologies, 2010 and 2020

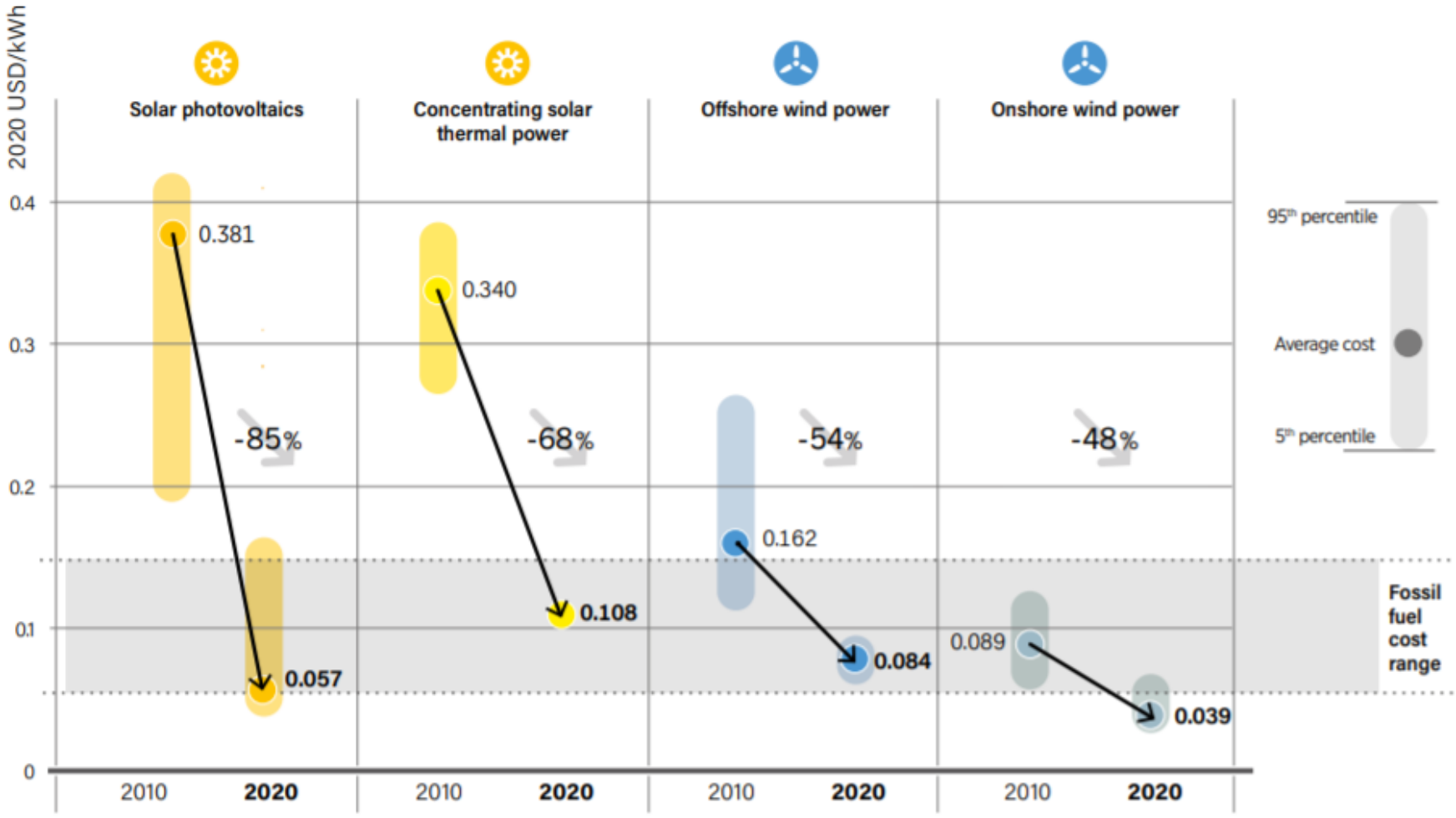
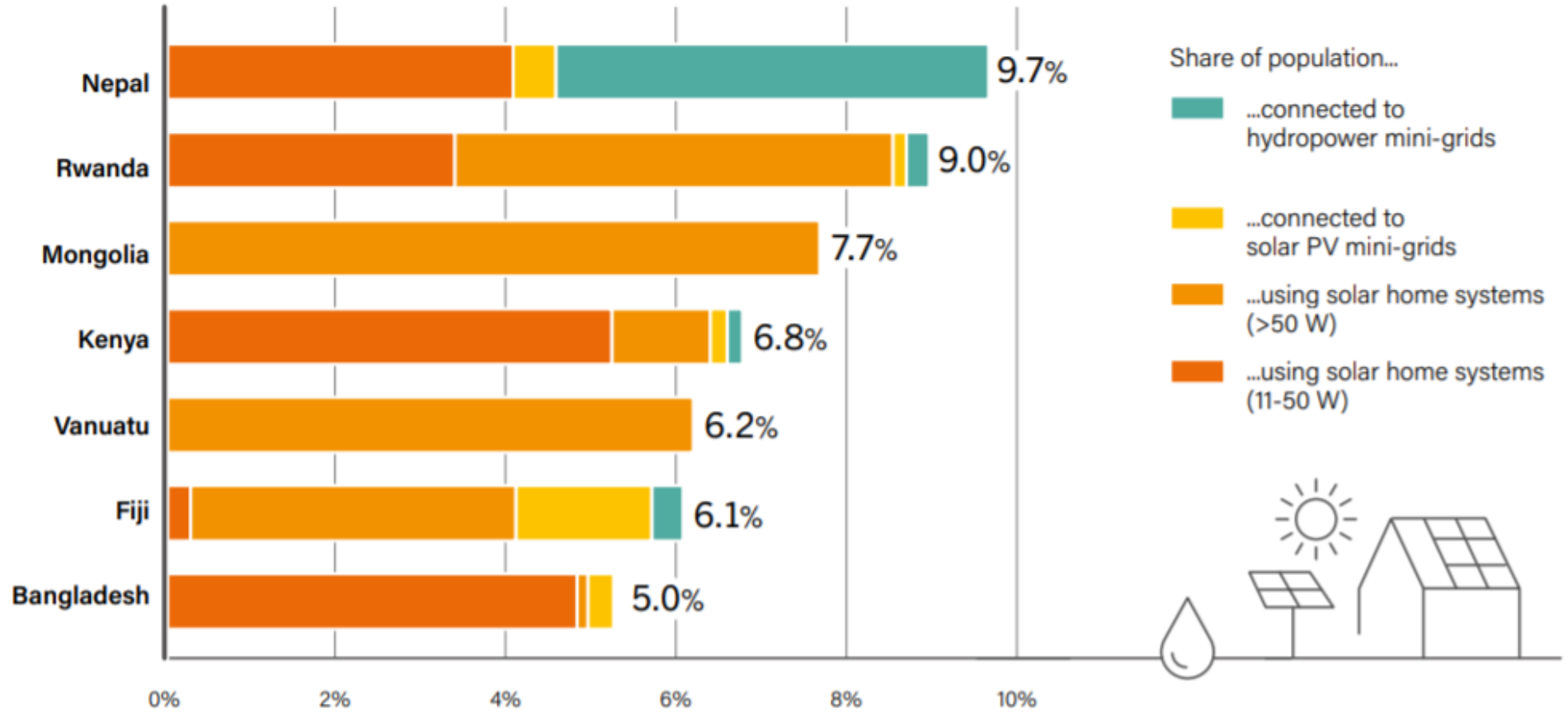


FIGURE 38.
Top 7 Countries with the Highest Electricity Access Rate from Distributed Renewable Energy Solutions, 2019



Note: Data in figure include solar home systems and mini-grids but exclude solar lights.

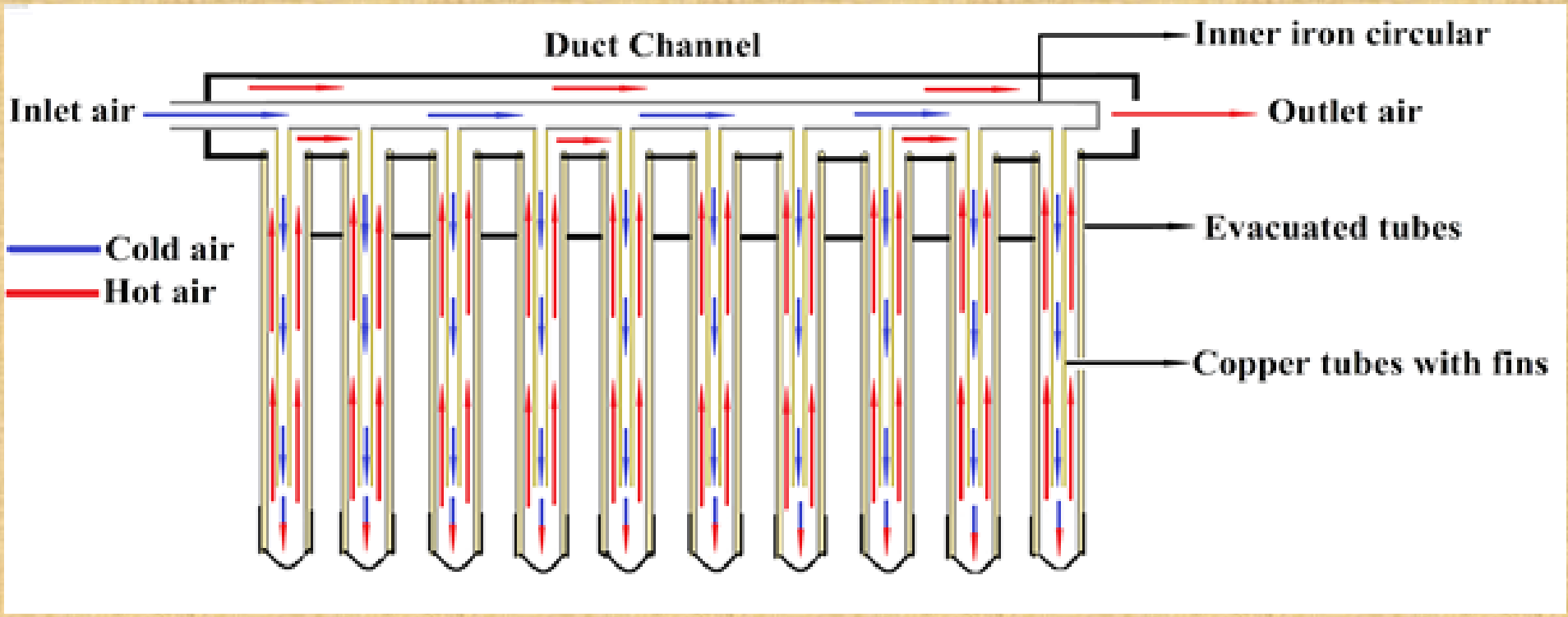
Solar Air Heaters and Crop Dryers

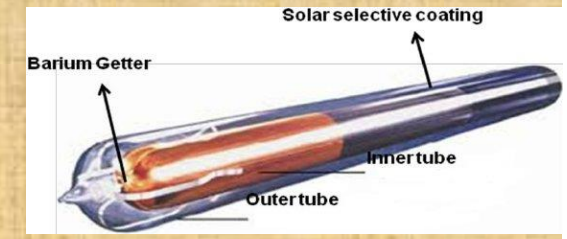
Solar air heating is a solar thermal technology in which the solar radiation from the sun is captured by a medium and converted into heat. Solar air heating is a renewable energy technology used to heat or condition air for buildings or process heat applications.

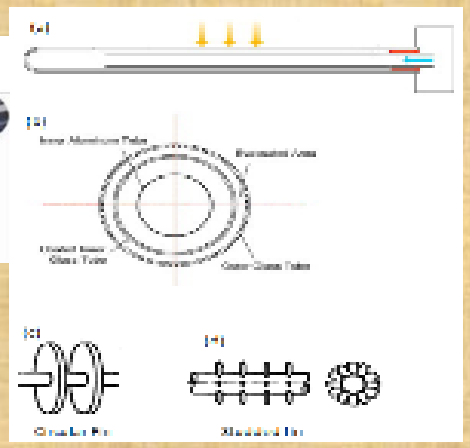
New Hingham Elementary School in Hingham, Massachusetts

Potential Significance of the Project

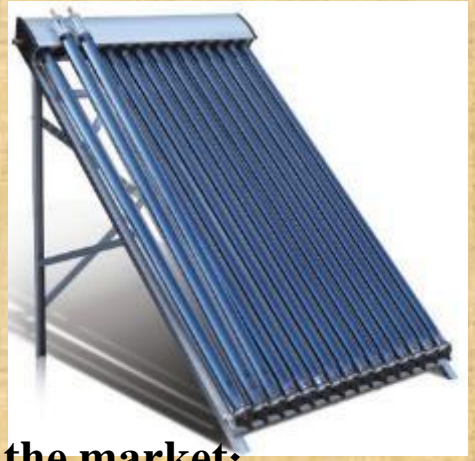
- The solar air collector is a simple technology that can significantly decrease buildings' energy consumption and increase buildings' energy efficiency
- The solar air collector can provide 50% of a building's heating, thus making the building more energy efficient and reducing total electric demand.
- 92% of Israelis use electricity for heating their houses.
- 30-50% of the Palestinians use electricity for heating their houses.


Duct Channel
Inner iron circular
Inlet air
Outlet air
Cold air
Hot air
Evacuated tubes
Copper tubes with fins


Solar selective coating
Barium Getter
Inner tube
Outer tube

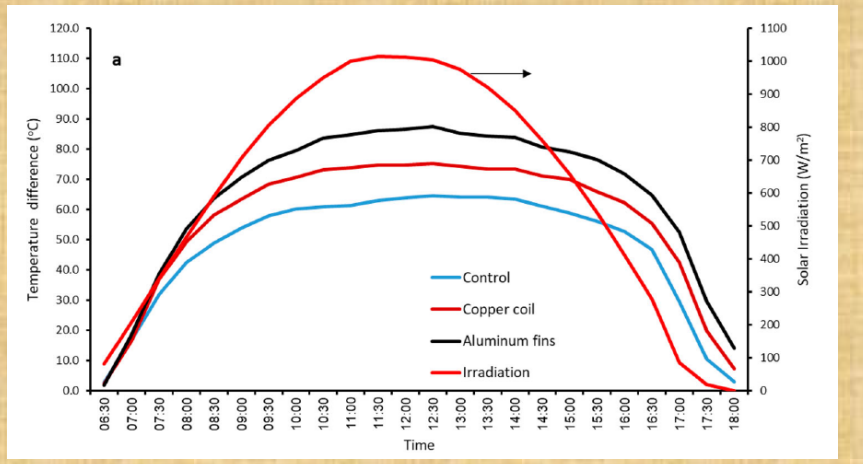


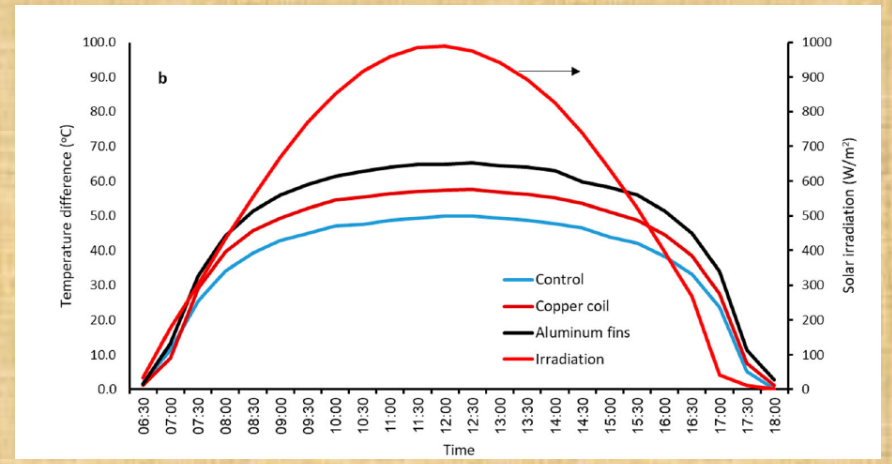
Evacuated tube solar collector

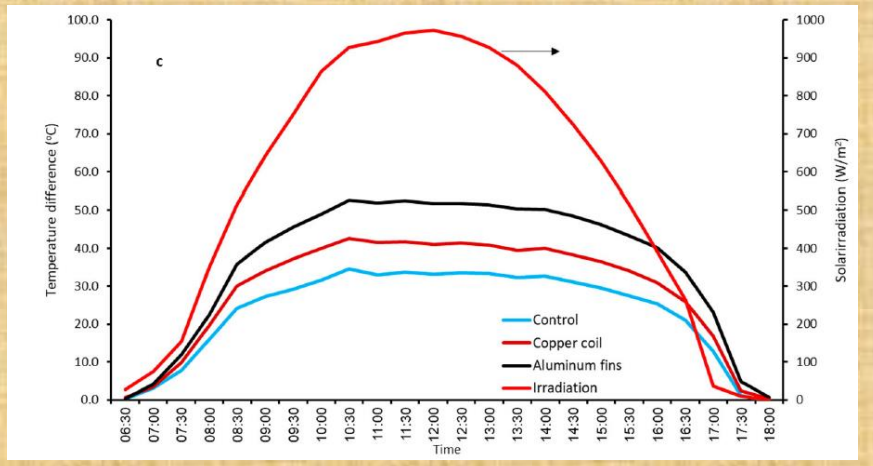


The advantages of the project compared to products available in the market:

- The curved shape of the tubes allows thermal absorption from a greater range of sun angles,
- The system can be easily scaled up or down and maintained.
- The cylindrical shape of the tubes provides lower aerodynamic drag, proving less wind-drag in some high wind locations
- Because of the vacuum, heat loss is minimal. Almost 94% of the radiation is captured.
- The worldwide market for solar vacuum tubes is growing exponentially and is expected to surpass flat plate collectors within the next 5-10 years. Currently, Asia uses 95% evacuated tubes in solar applications and Europe is quickly adopting vacuum tubes in areas such as water heating.



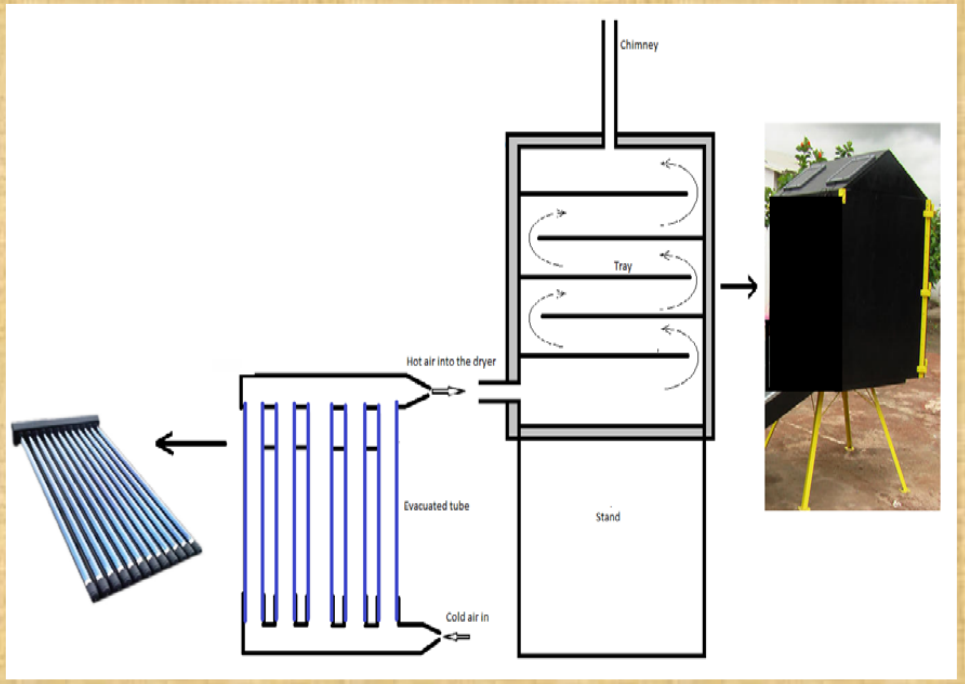




Temperature difference and solar irradiation with time for the three systems at various flow rates. a) air flow rate of 0.6 m^3/min, b) air flow rate of 0.9 m^3/min, c) air flow rate of 1.25 m^3/min.

The ETSH was able to heat the air up to 120 °C

Solar air collectors for crop drying



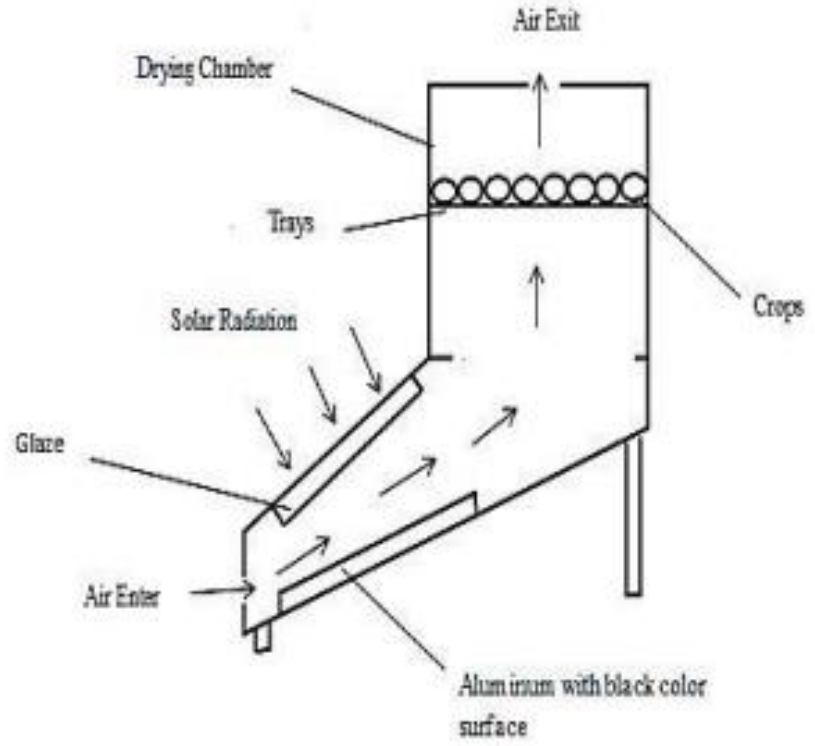


Figure 2: Schematic Diagram of the Solar Dryer used