



BIOENERGY

KEY FACTS FOR 2024

- Modern bioenergy use grew across nearly all sectors in 2022, with the largest increases observed in agriculture and transport, underscoring the rising role of bioenergy in sectors that are traditionally harder to decarbonise.
- Solid bioenergy remained the most-used modern renewable fuel in 2023, making up 3.5% of total final energy consumption and 8.3% of global heat consumption.
- Sustainable aviation fuel (SAF) production tripled between 2023 and 2024, driven by new mandates and technological advances, yet still accounted for only 0.53% of global aviation fuel demand – highlighting both progress and the scale of the challenge.
- Global biopower generation continued to expand in 2024, driven by stronger investment, technological improvements, and growing interest in waste-to-energy and co-firing solutions across multiple regions.

175.2
billion litres

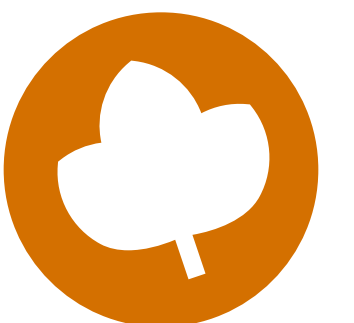
Global liquid biofuel production in 2023, a 7% increase from the previous year.

1.8
billion litres

Global SAF production in 2024, up from 600 million litres in 2023, marking a 200% increase in one year.

150.8 ^{GW}

Total global biopower capacity in 2024, following a record annual increase of 4.6 GW, driven largely by new installations in China and France.




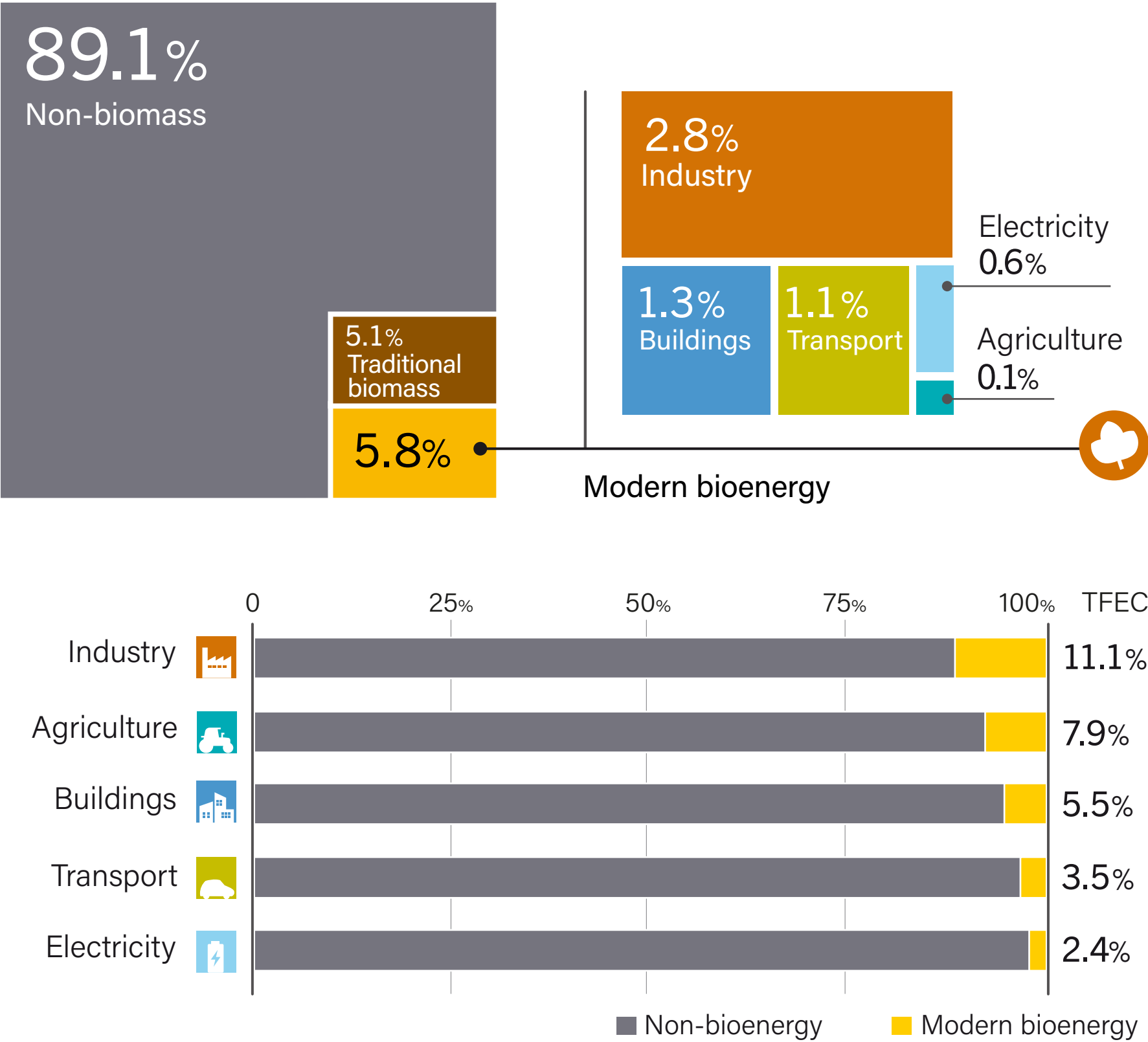
Globally, modern bioenergy represented 5.8% of **total final energy consumption** (TFEC) in 2022, up from 5.7% in 2021.¹ (→ See *Figure BIO-1*.) In absolute terms, the use of modern bioenergy grew 2.8% in total, due to increases in all sectors except buildings. The highest growth rates were in agriculture (+12.6%), followed by transport (+5.7%), power (+3.6%) and industry (+3.4%). In the buildings sector, the use of modern bioenergy decreased by 2.3%.²

5.8%
 share of modern bioenergy in
 total final energy consumption
 in 2022.



Ethanol production plant near Nysa, Poland


FIGURE BIO-1
 Shares of Modern Bioenergy in Total Final Energy Consumption by End-use Sector, 2022



Source: See endnote 1 for this section.

LIQUID BIOFUELS

Liquid biofuel production rose 7% in 2023, reaching a total of 175.2 billion litres.³ (→ See *Figure BIO-2*.)This growth was driven primarily by Brazil, India, Indonesia and the United States, which together accounted for 90% of the increase.

In October 2024, **Brazil** enacted the Fuel of the Future law, introducing a series of ambitious measures: it raised the ethanol blending requirement in gasoline to 30% with the potential to increase it to 35%; set biodiesel blending requirements, to be raised by one percent per year from 2025 to 20% (B20) by March 2030; mandated biomethane blending; established greenhouse gas (GHG) emissions reduction targets for the aviation sector; and launched a national programme for Green Diesel.⁴ Brazil also remained a key biodiesel producer, ranking third globally behind the United States and Indonesia, with an output of 8.9 billion litres in 2024 and a current blending requirement of 14%, set to rise to B15 in March 2025.⁵ In 2024, Brazil was the world’s second-largest producer of **ethanol**, with a total production of 32.5 billion litres (including 6.5 billion litres of corn-based ethanol).⁶

In **Indonesia**, 2024 marked the first full year of B35 (35% biodiesel blending) implementation. Final production of palm oil-based biodiesel reached 13 billion litres, with domestic consumption at 12.6 billion litres. Strong regulatory mandates in the United States and European Union made China, the Netherlands and the Philippines into key export destinations.⁷

In the **United States**, biofuel trends showed a mixed picture. Biodiesel production and consumption declined

by 1% compared to 2023, falling to 6.3 billion litres and 7.3 billion litres respectively.⁸ Meanwhile, ethanol production reached an all-time high of 61.4 billion litres, driven by strong domestic demand and export growth. Domestic consumption rose to nearly 54 billion litres, exceeding pre-pandemic levels, while exports increased by 37% compared to 2023.⁹

In 2024, **India** produced 6.35 billion litres of ethanol, approximately 2% less than the previous year, as a result of lower sugar production and depleted rice stocks due to weather and environmental conditions. India’s ethanol consumption rose to 7.4 billion litres in 2024, driven by the E20 blending goal for 2025.¹⁰ However, only 12% blending had been achieved by 2023 and 15% by May 2024, so that the 20% target will be difficult to achieve in 2025. On January 17, 2024, the Indian government imposed a new 50% export tax on two biofuel feedstocks: B- and C-heavy molasses.¹¹ This duty aims to secure the supply of feedstock for the production of ethanol within the country.¹²

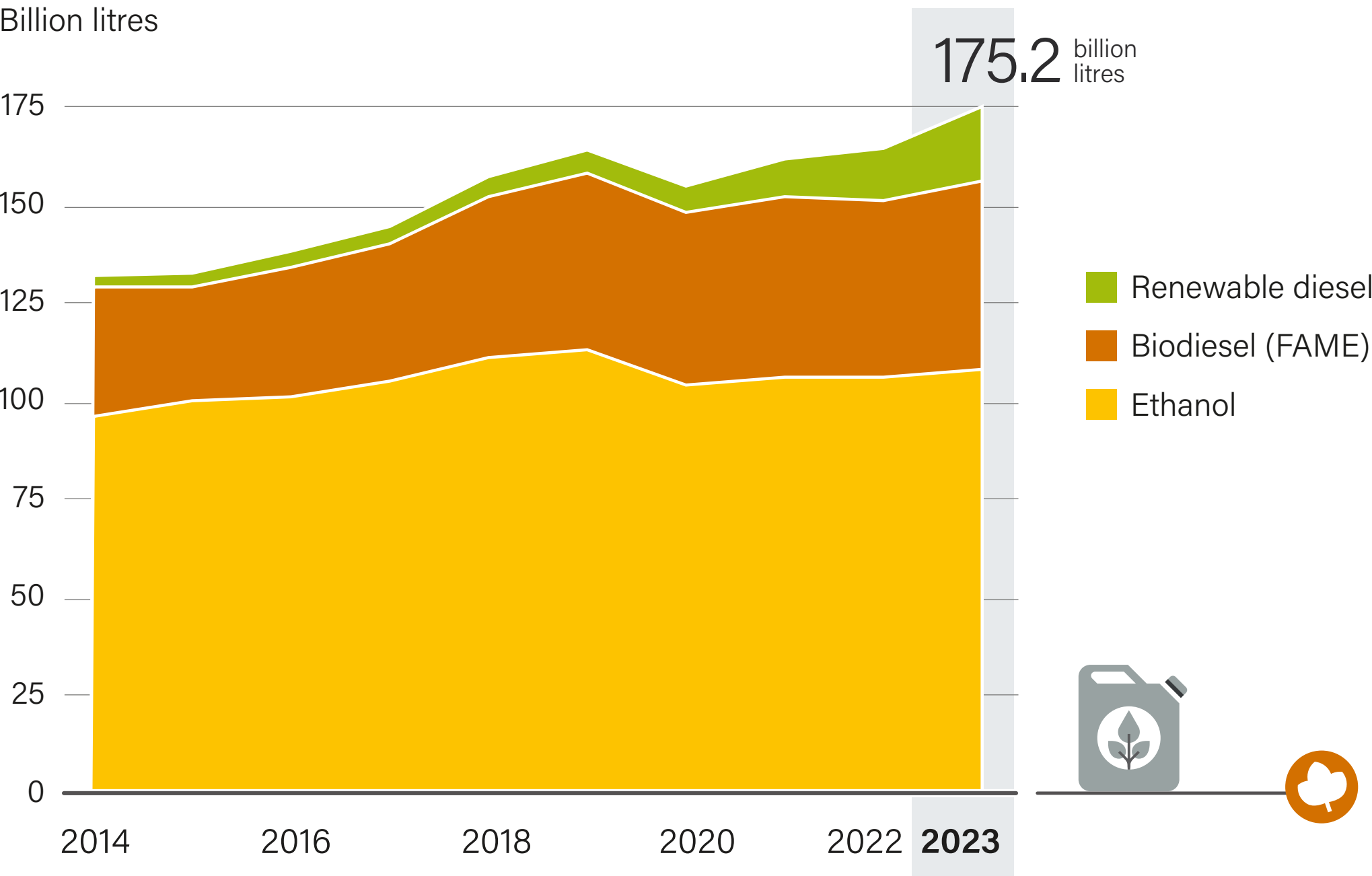
+7%

increase in global liquid
biofuel production in 2023
compared to 2022.



FIGURE BIO-2

Global demand of Bioethanol, Biodiesel and Renewable Diesel, 2014-2023



Source: See endnote 3 for this section.

In the European Union, the use of sustainable biofuels compliant with the Renewable Energy Directive (RED II) increased by 4.9%, with the consumption of advanced biofuels surging by 50.9% due to significant industry investment. However, the use of biofuels from used cooking oils (UCO) and animal fats declined by 14.6%, reflecting changing feedstock dynamics and tightening supply chains.¹³ The European Union remained the world's largest market for **bio-based diesel (BBD)** – a category which includes biodiesel and renewable diesel – both in terms of production and consumption. In 2024, EU production of BBD

(including sustainable aviation fuel) totalled 16.8 billion litres. Despite this scale, overall BBD consumption in the European Union was projected to decline by 1.6% to 17.7 billion litres in 2025. The expected drop is largely driven by Sweden's lowering of its GHG mandate for diesel, from 30.5% in 2023 to just 6% in 2024, which is expected to cut national BBD use in half.¹⁴ **Sweden** also reduced the ambition of its blending mandate for ethanol at the beginning of 2024 (from 7.8% in 2023 to 6% during 2024–2026). The new government of **Finland** lowered its ethanol blending target from 30% to 19.5% in 2030.¹⁵

SUSTAINABLE AVIATION FUEL

Sustainable Aviation Fuel (SAF) production reached 1.8 billion litres in 2024.¹⁶ Though this covers just 0.53% of global aviation fuel demand, it represents a significant increase from 600 million litres in 2023. Growth in production has been driven by supportive policies and the Alcohol-to-Jet technology, which is currently used to produce 3% of all renewable fuels.¹⁷ New mandates announced in 2023-2024 in Indonesia, South Korea and India signal an increasing commitment to scaling up SAF use in international aviation. **Indonesia** announced its SAF roadmap in September 2024, which requires

international flights to use 1% SAF in their fuel mix from 2027, and 2.5% by 2030.¹⁸ China's removal of the UCO export tax rebate could disrupt global feedstock trade but boost domestic SAF production.¹⁹ In August 2024, South Korea, the world's largest exporter of jet fuel, implemented a SAF mandate, requiring all international flights to use at least 1% SAF starting in 2027.²⁰ In early 2024, India's Ministry of Petroleum and Natural Gas announced SAF blending goals for international flights of 1% by 2027 and 2% by 2028.²¹ To achieve its 1% target by 2027, India will need around 300 million litres of ethanol and 140 million litres of SAF.²²

BOX 1. NEW HRD & SAF FACILITY IN SWEDEN

In April 2024, St1 and SCA inaugurated a joint venture facility in Gothenburg, Sweden, with the capacity to produce up to 250 million litres of hydrotreated renewable diesel (HRD) and sustainable aviation fuel (SAF) annually. The facility sources its feedstocks from UCO, animal fats and tall oil fatty acids, the latter derived from SCA's paper and pulp operations. This marks a significant step in the expansion of Europe's advanced biofuel production capacity.²³



BOX 2. CORN STOVER TO SAF IN KANSAS

SAFFiRE Renewables, backed by the US Department of Energy, is building a pilot plant in Kansas to convert corn stover into SAF. Processing 10 tonnes daily, the project aims for an 83% reduction in GHG emissions compared to conventional jet fuel. Expected to be operational by Q4 2025, it will generate USD 83 million in economic impact and create 478 jobs. Partners include Southwest Airlines, Conestoga Energy, LanzaJet and NREL.²⁴



MARITIME BIOFUEL

In July 2024, the National Agency of Petroleum, Natural Gas and Biofuels in Brazil authorised the sale of **maritime** fuel oil (bunker) containing 24% biodiesel.²⁵ This marked Brazil's first approval of maritime bunker fuel with a renewable component. The authorisation was awarded to Petrobras, Brazil's state-owned oil and gas company.²⁶

BOX 3. BIOMASS-FUELLED CARGO SHIPS IN JAPAN

A consortium including the Japanese global shipping and logistics company NYK Line and the British power generation and biomass company Drax Group is developing the world's first biomass-fuelled cargo ship, targeting carbon-negative operations by 2030. The project aims to demonstrate the viability of biomass as a fuel for maritime transport and reduce the sector's reliance on fossil fuels. Delivery of the ships is expected by 2029.²⁷



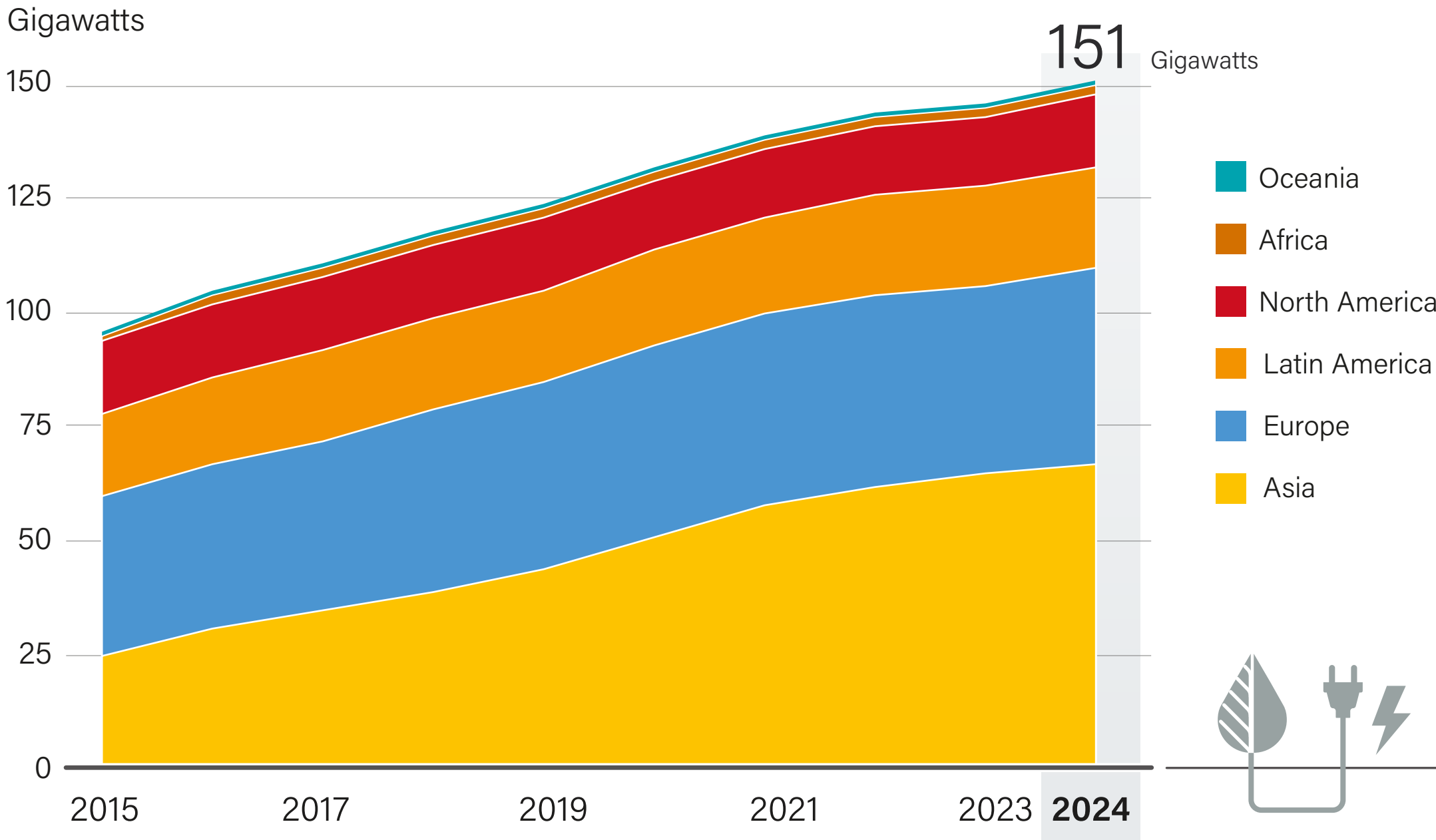
BIOGAS AND BIOWATER

In 2024, biopower and waste-to-power accounted for 3% of global **electricity generation**. Investment in biopower saw a strong recovery in 2024; global generation capacity expanded by 4.6 GW, up from 3.0 GW in 2023, bringing the total to 150.8 GW.²⁸ (→ See *Figure BIO-3*.) This growth was largely fuelled by China and France, which each added 1.3 GW of new capacity. In 2024, **China's** biopower capacity accounted for over half of Asia's total, growing at an annual rate of 4%.²⁹ **Japan** added 7% more biopower capacity in 2024 than in 2023, bringing its total to 6 GW, up from just 3 GW in 2019.³⁰ Between 2023 and 2024, **India's** biopower capacity increased by 4.51%. Since 2019, capacity in India has grown 10% and since 2014 it has more than doubled.³¹ Biopower generation capacity in **France** increased 60% in 2024, from 2.1 GW to 3.4 GW.³² Solid biomass electricity generation in the European Union plummeted in 2023, falling 11.3% to 78.4 TWh. This was a continuation of a trend that has seen the sector reduce its output by 15.4% since 2021. **Sweden** and **Finland** remain the largest producers, but both saw declines of around 10%. Meanwhile, in **Denmark** and **the Netherlands** – Europe's top wood pellet importers – production dropped even more steeply, with the Netherlands' output shrinking by 27.1%.³³



FIGURE BIO-3

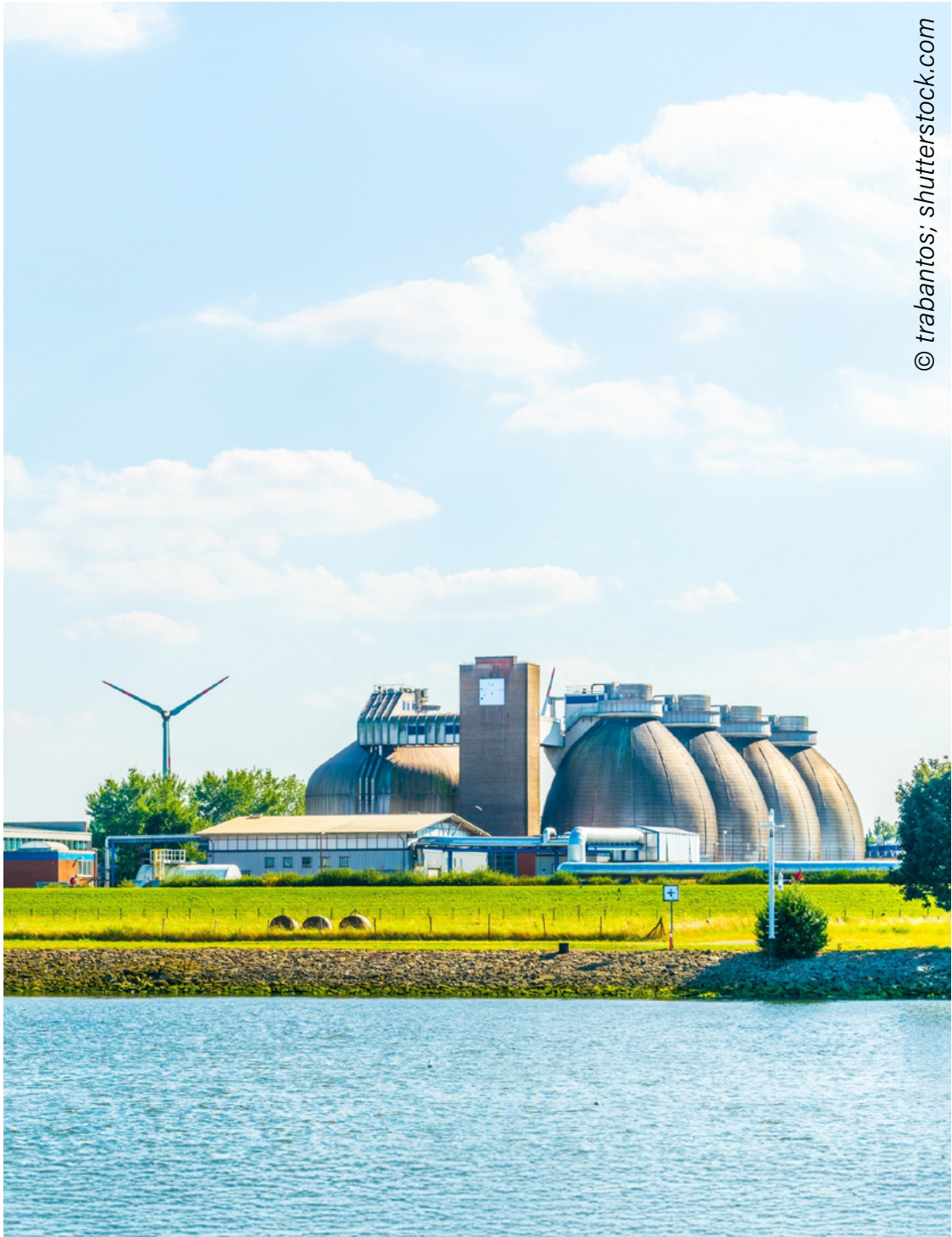
Global Bioelectricity Installed Capacity, by Region, 2015-2024



Source: See endnote 28 for this section.

In South America, **Brazil's** biopower capacity continues to grow at a steady pace, reaching 17.8 GW in 2024, or nearly 86% of South America's total.³⁴ In Thailand, renewable energy provided 16% of electricity generation in 2024, with biopower the leading source, accounting for more than 50% of the total.³⁵

Biogas production in Europe increased 6% in 2023, reaching 15,789 ktoe. This total includes pure biogas and biogas mixed into the grid, as well as biogas heat directly consumed or sold.³⁶ In 2023, **Germany** was the largest producer of biogas (7,743 ktoe) in the European Union, accounting for almost half of total EU production, followed by Italy and France. This was despite Germany's biogas output shrinking 4.3% in 2023, continuing a downward trend as the country prioritises injection into the national gas grid over biopower capacity expansion. Despite this, biogas electricity generation increased 1.3% due to the optimisation of existing plants.³⁷ In 2023, the share of biomethane in **Denmark's** gas system neared 40%, driven by a decade-long rise in biogas output from 105 to 758 ktoe. The country aims for 100% biogas consumption by 2030, with currently 80% of the biogas produced injected into the gas grid.³⁸



Biogas factory; Bremen, Germany

+3%

growth in global biopower capacity in 2024.

BOX 4. LAST COAL POWER PLANT SHUT DOWN BY ØRSTED

Ørsted, once a coal-intensive utility, has shut down its last coal plant, replacing fossil fuels with certified sustainable biomass. This transition eliminates 1.2 million tonnes of CO₂ emissions annually, equivalent to the emissions of 600,000 fossil-fuel cars in the European Union. By 2025, Ørsted's operations will run on 99% renewable energy, cutting scope 1-2 emissions by 92% compared to 2006.³⁹



BOX 5. BIOMASS POWER FOR THE OPITCIWAN FIRST NATION IN CANADA

Turboden has deployed a 4.8 MWe Organic Rankine Cycle (ORC) biomass power plant to support energy independence for the Opitciwan First Nation in Canada. Using local wood residues as fuel, the plant replaces diesel generators, reducing emissions while maintaining a stable electricity supply. The community has secured a 25-year Power Purchase Agreement with Hydro-Québec, with a possible extension, supported by provincial and federal grants.⁴⁰

SOLID BIOFUELS

In 2023, **solid bioenergy** was the most-used modern renewable fuel, delivering 3.5% (16 EJ) of TREC and 8.3% of **heat** consumed globally.⁴¹ Solid bioenergy is the main renewable fuel used in district heating, mainly in the form of municipal solid waste and biomass used for cogeneration. In 2023, over 30% of heat for district heating systems was generated from solid bioenergy; in some countries, this share exceeded 50% (e.g. Denmark, Estonia, Sweden, Lithuania, Latvia, Austria and Finland).

Global production of **wood pellets** was estimated at 46.94 billion tonnes in 2023.⁴² (→ See Figure BIO-4.) Europe is the top consumer of modern solid bioenergy in the buildings sector, responsible for over half of global consumption, with logs and wood chips as primary

fuels. The European Union accounted for 44% of pellet production and 50% of consumption (22 million tonnes) in 2023, mainly for residential use. After years of growth, production stagnated in 2023 because of rising input prices, falling industrial demand and a record warm winter.⁴³ Consumption of solid biofuels also decreased between 2022 and 2023, by 4.8%, for the same reasons, while consumption of wood pellets fell 3.3%.⁴⁴

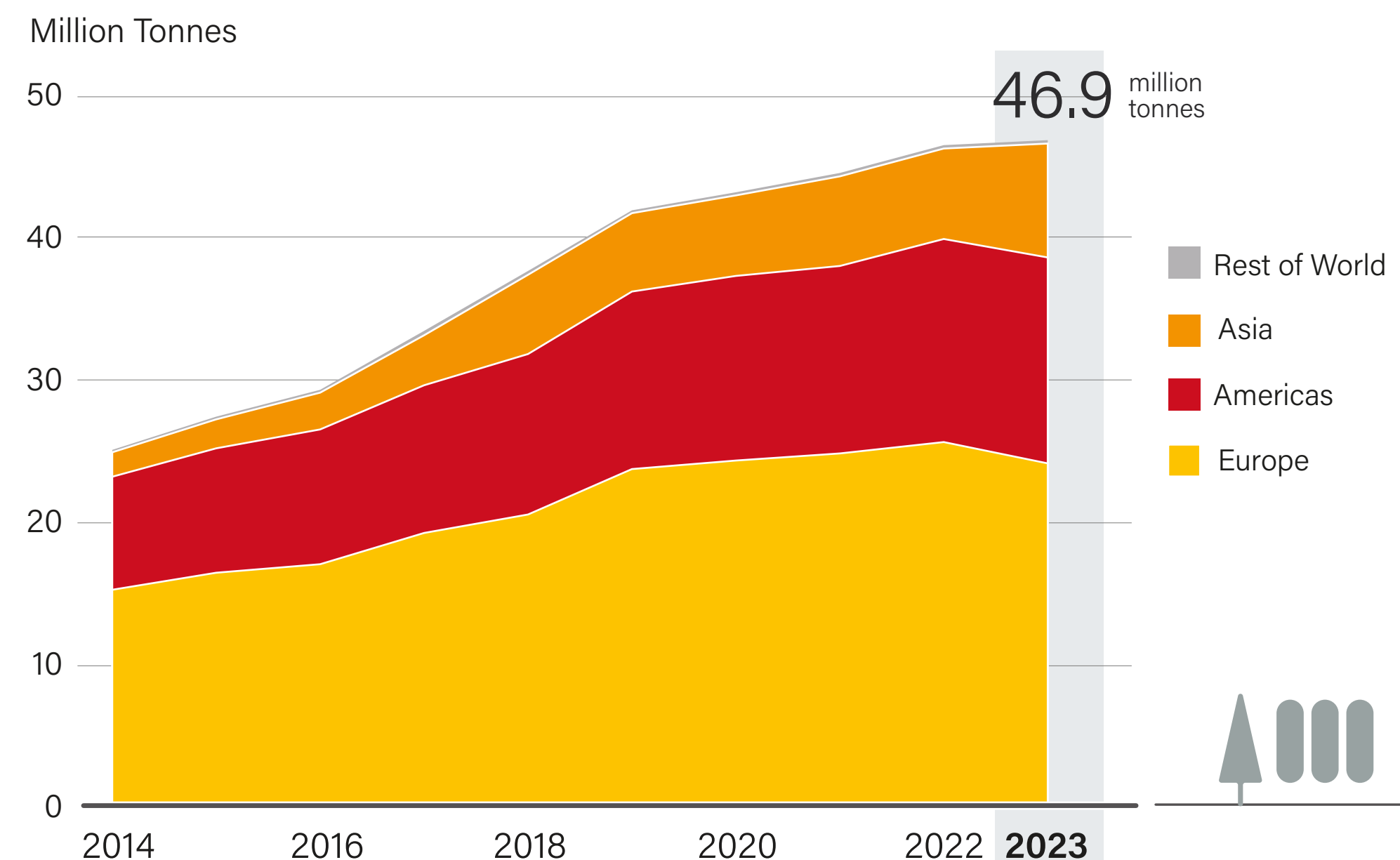
Germany recorded the largest drop at 13.8%. Sweden, a key bioenergy user, experienced a 14.9% decline in heat sales to district heating networks, largely due to rising wood pellet prices after the European Union banned biomass imports from Russia and Belarus following the invasion of Ukraine. In contrast, Finland increased its heat output by 7.3%, partially offsetting regional declines.⁴⁵

BOX 6. WOOD WASTE IN COAL POWER PLANT IN GHENT

ArcelorMittal has commissioned a bio-coal plant at its Ghent steel mill, converting 88,000 tonnes of waste wood into 37,500 tonnes of bio-coal annually. This initiative aims to cut fossil coal use in blast furnaces, reducing carbon emissions by 112,500 tonnes per year. The project, part of the EU-supported TORERO initiative, aligns with ArcelorMittal's goal of reducing CO₂ emissions by 35% by 2030 and achieving climate neutrality by 2050. By replacing fossil coal in the blast furnace, the use of bio-coal also enables the capture and fermentation of furnace off-gases for ethanol production at the adjacent Steelanol facility. This ethanol, produced via carbon capture and utilisation (CCU), supports decarbonisation efforts in the chemical sector.⁴⁶



FIGURE BIO-4
Global Wood Pellet Production, by Region, 2014-2023



Source: See endnote 42 for this section.



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For the 2025 edition of the Renewables Global Status Report, REN21 updated the methodology and classification system of its Policy Database to improve clarity and better capture current policy developments. Consequently, some figures in this edition may not be directly comparable with data from previous reports.



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