
ELECTRICITY

N° 2 Renewable electricity generation continues to rise… but carbon-intense generation is not falling

- Emissions from electricity generation have followed a constant upward trend since 2015, except for the fall triggered by the pandemic in 2020.
- Since 2015, renewable capacity additions have outstripped fossil capacity additions (respectively accounting for three quarters and one quarter of the capacity added between 2019 and 2022). But on average, three times as much renewable capacity is needed to replace one unit of fossil capacity.
- The average carbon intensity of electricity generation has therefore fallen overall since 2015, but the rise in global demand is outstripping the decarbonization of the mix. Where it is taking place, the transition away from coal is benefiting renewables as much as gas.
- Government subsidies are keeping coal alive in China, India and Indonesia, while oil companies are still investing far too little in renewables to begin a genuine transition away from oil.

KEY FIGURES

Increase in emissions, decrease in carbon intensity

- **+10.91% emissions from electricity generation** from 2015 to 2022 – 15.95 $GtCO_2$ (Enerdata, 2023).
- **+10.11% primary energy consumed** from 2015 to 2022 – 14,951 Mtoe (*ibid.*).
- **+21.7% final electricity consumption** from 2015 to 2022 – 24,598 TWh (*ibid.*).
- **-8.08% average carbon intensity of global electricity generation** from 2015 to 2022 – 439.78 gCO_2/kWh (*ibid.*).
- **20.5% share of electricity** in final energy consumption, vs. 18% in 2015 (*ibid.*).

Growth in renewables, fossils persist

- **+82% renewable capacities** from 2015 (1,853 GW) to 2022 (**3,372 GW**) (IRENA, 2023).
- **40.2% of global generation capacity** was renewable in 2022, vs. 29.5% in 2015 (*ibid.*).
- **63.2% of fossils** in the electricity mix in 2022, vs. 68% in 2015. From 2015-22, solar went from 1% to 4.5%, and wind from 3.4% to 7.3% (Enerdata, 2023).

Investments and transition plans are insufficient

- **1,241 mergers and acquisitions** in 2022 in the energy sector, **+117%** compared to 2015 (White & Case, 2023).
- **13/100**, average ACT score of oil companies' transition plans. **37/100** for electric utilities (WBA, 2023).
- **+680% power purchase agreements (PPAs)** from 2015 (4.7 GW) to 2022 (**36.7 GW**) (BNEF, 2023).
- **1.3%** of the investments of 9 Oil Majors are "low-carbon" (Energy Monitor, 2023).

FURTHER READING

TRENDS

- The growth of renewables is still not enough to feed the insatiable energy appetite of the economic recovery (2022)
- From Big Oil to Big Power? At the heart of the renewable energy boom, oil producers are dreaming of a low-carbon future (2021)
- With PPAs, businesses and cities are securing the production and supply of low-carbon electricity (2021)

CASE STUDIES

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VIETNAM • A boom in solar energy (2021)

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TRENDS
ELECTRICITY

In a market under pressure, soaring consumption is eclipsing the energy transition

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The energy sector has been in a state of constant transformation since 2015. Subject to fluctuating prices and market concentration around dominant players, the sector has been hit hard by the pandemic and the war in Ukraine. Decarbonization and the penetration of renewables in the electricity mix, which were initially driven by the energy industry, now integrate the supply strategies of companies and local governments. Despite the increasing share of renewables in the mix, fossil fuels are still required to feed the global economy's voracious appetite for energy, creating a trend of accumulation rather than transition.

In the global energy landscape, consumption is moving faster than the transition

Decarbonization of the mix is too slow to compensate rising demand

In 2022, global CO_2 emissions (excluding land use) amounted to 38.1 $GtCO_2$ – a record, and a 7.02% rise compared to 2015, despite a historical drop in 2020 following the pandemic, which was rapidly wiped out by the economic recovery of 2021.[a, 1] The leading growth factor in emissions, global consumption of primary energy rose by 10.11% from 2015 to 2022. According to Enerdata's analyses, this increase is driven by the growth of the global population and per capita GDP, despite a weak reduction in the carbon intensity of the global energy mix.[2] Global emissions related to electricity production – which represented 20.4% of the final energy consumed in the world – amounted to 15.95 $GtCO_2$ in 2022, a rise of 10.91% since 2015 (**FIGURE 1**).

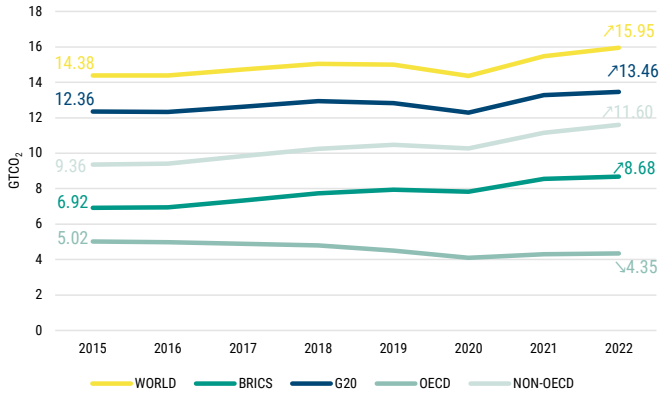
Two exogenous events bucked the trend one after the other. First, the Covid-19 pandemic provoked a drop in global energy demand (-3.88%), although at different levels depending on the country (**FIGURE 2**). The 2021 recovery saw consumption rise by 4.88% compared to its 2020 level, exceeding its 2019 level. Specifically, energy consumption is stagnating in industrialized countries (OECD), but has returned to rapid growth in non-OECD countries.[3] In 2022, this growth was driven by India (+7.36%), Indonesia (+9.24%), Saudi Arabia (+8.42%) and, to a smaller extent, China (+3.04%).

a The energy and emissions figures used in this analysis come from the Enerdata Global Energy and CO_2 Emissions database, unless otherwise indicated.

FIGURE 1

CO_2 EMISSIONS FROM ELECTRICITY GENERATION, 2015-2022

Source: Climate Chance, based on data from Enerdata

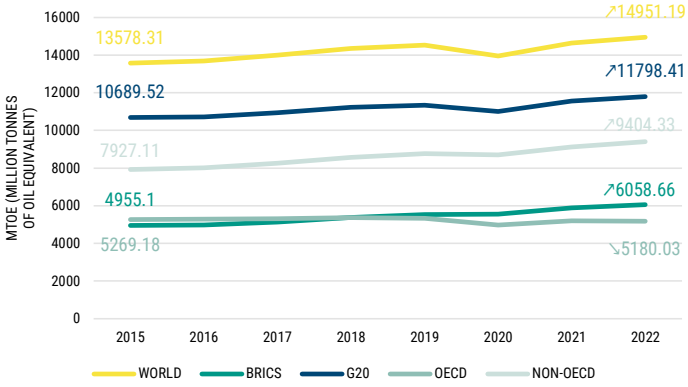


OECD countries, which have seen a constant drop in their emissions related to electricity reductions since 2015, and a more marked reduction in 2020, are the exception to the rule (**FIGURE 1**). The post-pandemic economic recovery led to a rise in emissions, but without exceeding 2019 levels. In contrast, emissions from non-OECD countries have pursued constant growth, with a less pronounced dip in 2020, and a very strong pickup in 2021, outstripping pre-pandemic figures.

FIGURE 2

GLOBAL CONSUMPTION OF PRIMARY ENERGY, 2015-2022

Source: Climate Chance, based on data from Enerdata



The war in Ukraine then accelerated the inflationary spiral triggered by the post-pandemic economic recovery, with a particularly strong impact in Europe. The combination of a warm winter and lower demand from industry saw energy consumption in Europe contract by 4% in 2022, well below its pre-Covid level.[4] Paradoxically, in 2022 the war and inflation generated a growth in emissions from the energy sector (+3.77%) in the European Union, due to the use of coal and oil to substitute Russian gas in the electricity mix.

Boom in renewable energies

The growth in global electricity production since the Paris Agreement also features a paradox. Although the volumes of CO_2 emitted by electricity production are increasing in absolute terms, its carbon intensity[b] has progressively decreased over the years: a

b The carbon intensity of electricity production is measured in grammes CO_2-equivalent emitted per kilowatt-hour of electricity produced.

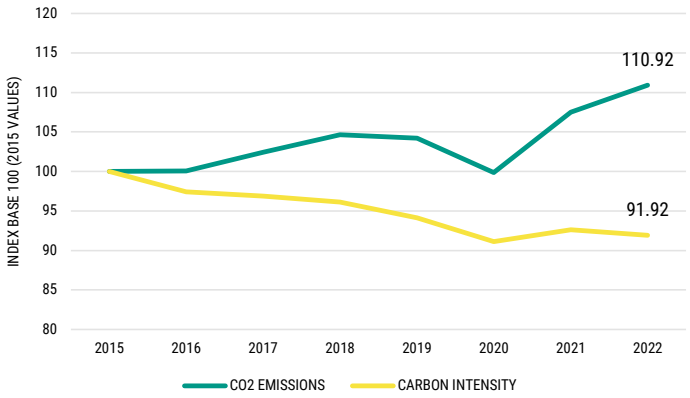
sign that electricity consumption, pushed by rising demand from end-uses is rising faster than the decarbonization of production (**FIGURE 3**). Even in end-uses with rising electricity demand, the rate of electrification remains low (**CF. "TRANSPORT" TRENDS**).

The trend therefore reveals an accumulation of low- and high-carbon sources of electricity generation rather than a genuine transition, which would involve substituting high-carbon sources with renewables.

FIGURE 3

EVOLUTION OF CARBON INTENSITY AND CO_2 EMISSIONS FROM ELECTRICITY GENERATION

Source: Climate Chance, based on data from Enerdata

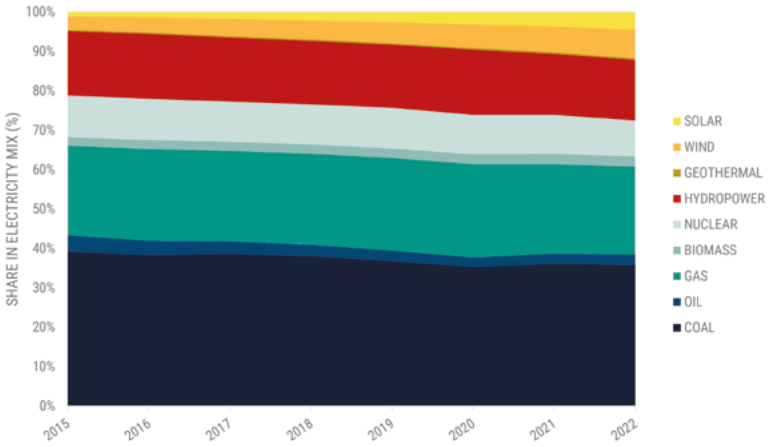


The place of renewable energy in the electricity mix is growing: the share of wind power more than doubled from 2015 (3.43%) to 2022 (7.27%) and the share of solar quadrupled (from 1.04% to 4.48%). Despite the strong growth of renewable energy compared to their initial share, the share of thermal fuel in the electricity mix only went down from 68.15% in 2015 to 63.8% in 2020, since when it has remained relatively stable (**FIGURE 4**).

FIGURE 4

EVOLUTION OF THE GLOBAL ELECTRICITY MIX, 2015-2022

Source: Climate Chance, based on data from Enerdata



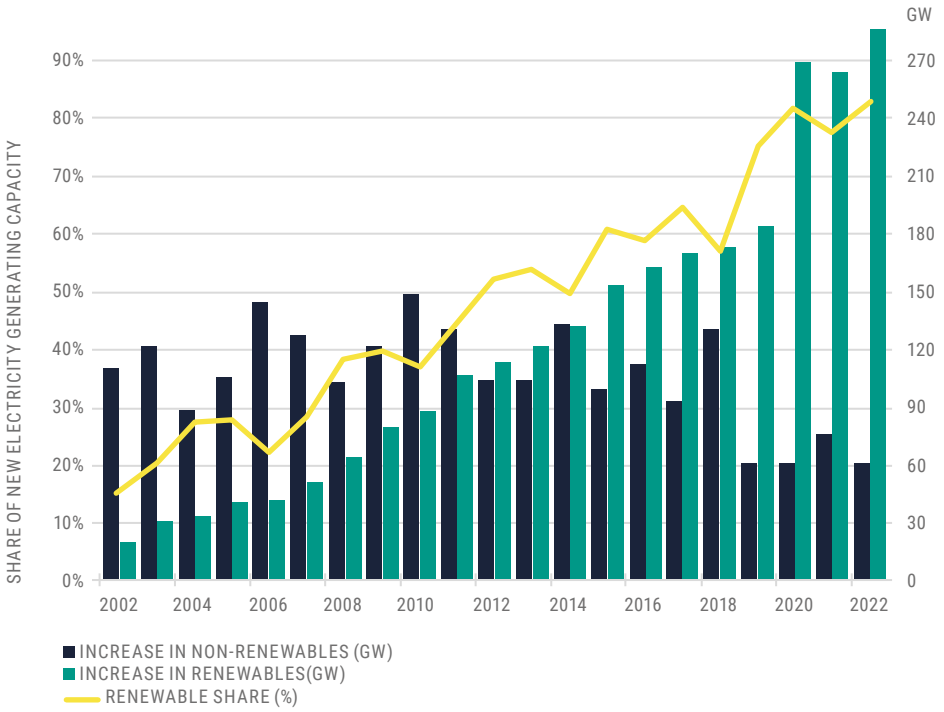
Annual additions of new electricity generation capacities from fossil and renewable sources follow crossed trajectories: renewable capacity additions have been at least three times higher than fossil capacity additions since 2019 (**FIGURE 5**). The total stock of renewable capacities installed rose by 82% from 2015 (1,853 GW) to 2022 (3,372 GW).[5] Nevertheless, the real impact of renewable capacity installations

on production needs to take capacity factors into account[c] – a recent study observed that, based on data for 2000-2017, to replace 1 W of fossil production capacity on average requires about 4 W of photovoltaic solar capacity or 2 W of wind capacity.[6]

FIGURE 5

ELECTRICITY GENERATION CAPACITY ADDITIONS, AND THE RELATIVE SHARE OF RENEWABLE CAPACITIES

Source: IRENA, 2023



Solar photovoltaic capacities have grown the most, rising from 224 GW in 2015 to 1,047 GW in 2022 (+367%). In 2021, solar installations overtook wind in terms of capacity.[7] Asia is the main driver of the solar sector, led by China followed by India. The pace of expansion of wind capacities has in fact slowed down since 2020. The share of offshore wind remains low, representing just 7% of total installed wind capacity in 2022, most of it in China, ahead of the United States.[8]

Hydropower is the biggest provider of renewable energy in the global electricity mix (15.44% in 2022, **FIGURE 4**), although hydro capacity additions have followed a much slower pace than other energies (2% per year). China is the leader in installed capacity, while hydropower makes up over two-thirds of the electricity mix in Brazil, Colombia, Canada, New Zealand, Sweden and Norway. This partly explains why the latter two countries have some of the highest rates of electrification of end-uses in the world, particularly mobility.[9]

Following a year of decline in 2018, investments in renewable energy picked up again to reach a new record of $495.4 billion in 2022[d] (**FIGURE 6**). The particularly rapid acceleration of investments in renewable energy observed since 2020 was initially driven by post-Covid recovery policies and public investments, strengthened by energy sovereignty strategies in reaction to the war in Ukraine, like the Inflation Reduction Act in the United States, the RePowerEU strategy in Europe, and the GX Green Transformation

c The capacity factor of an electric power plant is a measure of actual production compared to the plant's maximum production capacity. While it is about 50% for fossil fuel plants and almost 80% for nuclear power plants, for renewable energies it is much more variable and depends on the location, ranging from about 12% to 25% for solar, and almost 30% for wind.

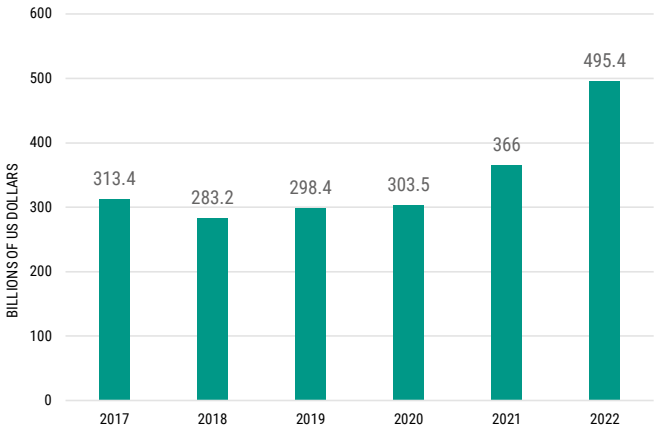
d Although these figures are higher partly due to inflation, the impact of inflation only presents a fraction of the total increase in investments.

Programme in Japan. China is the biggest investor in renewable energies. Brazil and India have also increased their investments since 2020, while Europe and the United States have followed a downward trend since 2020 due to uncertainties on the market despite public support.[10, 11]

FIGURE 6

GLOBAL INVESTMENTS IN RENEWABLE ENERGY (2017-2022)

Source: Climate Chance, based on REN21, 2023



Fossil fuels prove tenacious

Although the use of fossil energy to produce electricity has dropped slightly since 2015, its share in the global energy mix has remained stable at around 80% for decades.[12] Renewable energy only partly compensates the structural decline of coal, which also works to the benefit of gas, despite the negative impact of geopolitical events since 2020.

Oil demand shot up following the eruption of American shale oil on the market in 2016,[13] until the historical break caused by Covid-19 in 2020 (-9.2%). The pickup in demand in 2021 and 2022 was mainly driven by the recovery of the transport sector, and by the gas-to-oil shift in electricity generation, in a period of global economic downturn and gas price inflation.[14]

Touted as a bridge fuel for the transition, gas benefited from the coal-to-gas shift in the 2010s, but its place in global electricity generation plateaued at an average 23% between 2015 and 2022. Regional trends vary: gas represents a relatively high share of the mix in OECD countries (30% in 2022, a rise since 2015) – in particular when they are planning to phase out coal. The United Kingdom is a good example here: the share of gas went up from 29% to 38% of the electricity mix from 2015 to 2022, while coal – the primary source of electricity in the early 2010s – plummeted from 23% to under 2% over the same period. A similar trend can be observed in Spain, and in the United States during the shale oil boom.[15] In comparison, the major emerging BRICS economies use five times less gas – 6.6% in 2022, in constant decline since 2015. The majority of the 615 GW of gas power stations being developed in the world in 2022 are located in East Asia, the Middle East and North Africa.[16]

Although gas-fired electricity generation infrastructure can also be used for biogas or even renewable, less-emitting biomethane, the IEA estimated that in 2018 only 18 GW of the world's installed electricity generation capacity was biogas-fired.[17]

Electricity generation from coal has evolved erratically since 2015. Following two years of successive decreases in 2019 (-2.08 %) and 2020 (-4.91 %), the share of coal shot back by 8.1% in 2021. Coal power stations constituted half of the increase in global demand for electricity in 2021, a trend intensified by a rise in gas prices; this trend continued in 2022 with EU efforts to avoid using Russian gas.[18] Asia, in particular China, India and Indonesia, is the chief driver of coal growth, at the cost of huge public subsidies that keep the black mineral afloat in a market where renewable energies are nevertheless increasingly profitable and competitive.[19]

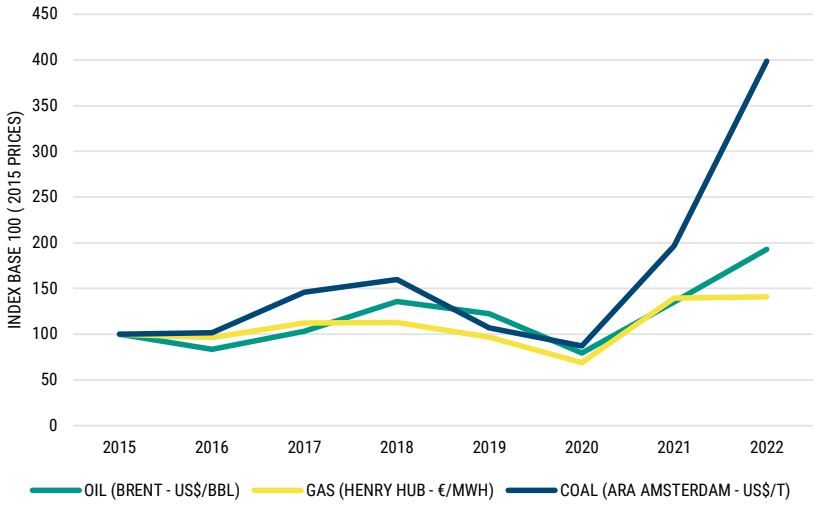
Faced with increasingly affordable renewable technologies, the relative and absolute cost of producing fossil fuels has tended to rise structurally (more ex-

pensive exploration and drilling), especially as the instability of oil and gas prices (**FIGURE 7**) does not guarantee their profitability. However, the voluntary cuts in oil production decided by OPEC+ and the war in Ukraine have boosted producers' revenues in recent years. The trend for investments is mixed: according to IEA figures,[20] following a relatively stable period from 2016 to 2018, investments in fossil fuels decreased from 2019 to 2020, then picked up again, recently strengthened by the super profits made by oil and gas giants (**CF. BELOW**).

FIGURE 7

SPOT PRICE INDEX FOR COAL, OIL AND GAS (2015 INDEX)

Source: Climate Chance, based on data from Enerdata



Nuclear energy in slight decline over recent years

The share of nuclear power in the global electricity mix went down from 2015-2022, from 10.56% in 2015 to 9.1% in 2022. Installed capacity, spread over 32 countries, grew from 387 GW in 2015 to 405 GW in 2018, and then dropped to 398 GW in 2022. According to the IEA,[21] an average $40 billion were invested annually in nuclear energy from 2016 to 2022, an increase compared to the period 2011-2015. Investments in nuclear power went up in G7 countries and emerging economies, driven by national governments, but dropped in China. Since the Paris Agreement, only Belarus and the United Arab Emirates have joined the list of countries equipped with nuclear power stations.

In a concentrated market, security of supply is a plus point for renewables

Energy market concentrated around major energy operators

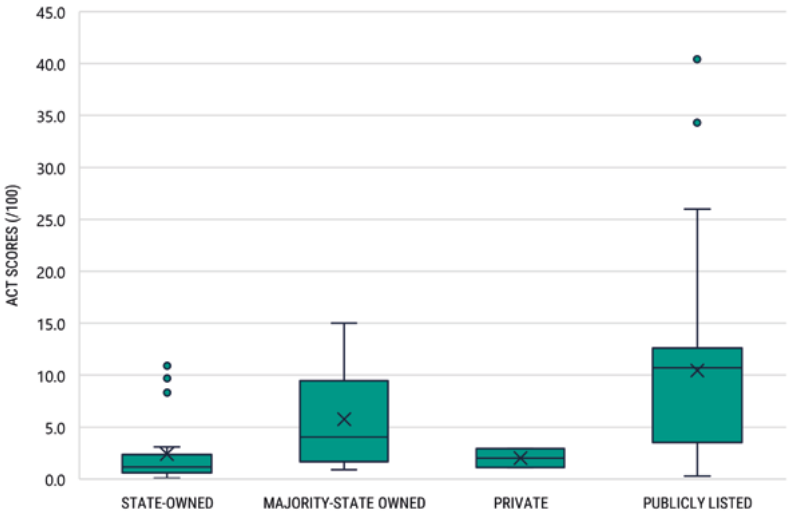
According to an analysis by the World Benchmarking Alliance (WBA),[22] most of the 100 biggest oil and gas companies did not have a credible transition plan in 2023. Their average ACT[e] score is 15/100 for their low-carbon and just transition plans. Of the fifty "net zero" targets stated, 32 in reality only cover operational emissions (Scopes 1 & 2), while emissions upstream and downstream in the value chain (Scope 3) represent close to 80% of the sector's emissions. State-run oil companies, which are responsible for two-thirds of the world's oil reserves, come out even worse: they are likely to exceed their carbon budget even faster, and their ACT scores are about three times lower than those of their competitors (**FIGURE 8**).

e The Assessing Low Carbon Transition (ACT) method, developed by Ademe and the CDP, evaluates the low-carbon transition plans of companies in a given sector, based on qualitative and quantitative indicators specific to that sector (**cf. "Companies" trends**)

FIGURE 8

2023 ACT SCORES OF 100 BIGGEST OIL & GAS COMPANIES

Source: WBA, 2023



Following a difficult financial period in 2020, the tide began to turn from late 2021 and the start of the war in Ukraine. In 2022, Saudi Aramco recorded profits of over $161 billion, a historical high,[23] similar to Shell,[24] Exxon,[25] and Chevron.[26] TotalEnergies[27] and BP[28] also doubled their profits.

This historic profitability of oil only marginally seeps into low-carbon activities. The lion's share of profits is primarily used to remunerate shareholders and finance the repurchase of shares. In 2022, the oil sector devoted $20 billion, or over 4% of its investments, to low-carbon industries, compared to barely 1% in 2020.[29] These investments are mainly a response to the clear ambition of several oil companies, most of them European, to diversify and become integrated energy companies. This translates into higher investments in the production of renewable energies and biofuels, along with storage batteries, green and blue hydrogen, carbon capture and storage (CCS) **(CF. "INDUSTRY" TRENDS)** and even charging stations for electric vehicles.

The volume of low-carbon investments is far removed from the sums devoted to fossil energies. According to Reclaim Finance, TotalEnergies invests three times more in fossil fuels than in low-carbon energies; this ratio is six for Shell, fourteen for BP and thirty-two for Equinor. The US oil & gas majors do not communicate any investments in renewable energy.[30] In 2023, Shell[31] and BP[32] even partially backtracked on their commitments by announcing new increases in their oil production.

In addition, these investments mainly take the form of mergers and acquisitions (M&A), pointing to another trend: the growing concentration of the energy market. M&As in the energy sector reached a record 1,186 operations in 2021, for $228 billion in transactions. This figure dropped by 15% in 2022, but the tendency remains strong, with 1,241 operations recorded.[33]

In parallel, the electricity market has been reshaped, involving a concentration to the detriment of the smallest actors, hit hardest by the pandemic and inflation, especially in Europe. In the United Kingdom, from 2021 to 2022, 31 energy companies stopped their activities due to rocketing gas prices. Many of them were bought out by existing giants like British Gas, Scottish Power and EDF.[34] In France, the number of electricity and gas suppliers dropped from 39 in summer 2021 to 14 in the final quarter of 2022.[35] In Germany, municipal electricity companies were hit hard by inflation,[36] while bigger companies like Uniper,[37] and EDF in France[38] were nationalized. Although electricity companies started decarbonization before other industries, 66% of the generation capacity of the 50 biggest utilities evaluated by the WBA were still supplied by fossil fuels, and 98% of these utilities are expected to exceed their carbon budget by 2035. Forty-seven of these 50 utilities did not have an emissions reduction target aligned with a 1.5 °C scenario.[39]

Power Purchase Agreements, a lever for low-carbon electricity supply

Since the late 2000s, renewable energy certificate[f] markets have played a key role in companies' energy sourcing – in Europe, the number of "guarantees of origin" almost doubled from 2014 to 2018.[40] While certificates represented over a quarter of the renewable energy supplied to companies in 2018, direct contracts involving the signature of a PPA (Power Purchase Agreement)[g] have become increasingly popular.

In 2021, 49% of electricity consumption reported by companies committing to increase their renewable energy consumption under the RE100 initiative – 367 TWh of electricity, or more than the consumption of the United Kingdom – was of renewable origin, compared to 32% in 2016. Thirty-five per cent of renewable energy supplies took the form of a PPA, not far behind renewable energy certificates (39%). Direct purchase agreements have gradually eaten away the share of contracts made with suppliers, which halved between 2016 (41%) and 2021 (19%), while self-generation remains marginal (2%).[41]

These figures illustrate a growing tendency for direct supply contracts for renewable electricity among major firms. Global volumes of corporate PPAs went from 4.7 GW in 2015 to 36.7 GW in 2022. Two-thirds of them are located in the Americas, led by the USA, ahead of Europe (22%) and the Asia-Pacific region (12.5%), in particular in India and Australia.[42] Although relatively more recent on the African continent, legislation is evolving to allow the conclusion of green PPAs.[43]

PPAs are particularly popular with the biggest companies, especially digital ones. In 2023, Amazon took first place, with cumulated purchases of 24.8 GW, following on from the previous two years. Meta and Microsoft came second and third.[44] Although most PPAs are drawn up off-site (geographically disconnected from the purchasers), on-site PPAs and production for self-consumption are also popular with retail chains like Ikea, Target and Decathlon, which own vast built areas.

PPAs also increasingly attract public actors[45] even though volumes remain low compared to the private sector. In the United States, the volume of off-site PPAs concluded by US cities more than tripled, from 1,085 MW in 2015 to 3,974 MW in 2021, while on-site and virtual PPAs are also increasing.[46] This trend can also be found in Europe, where several cities, public services, universities and transport companies have signed PPAs.[47] In South Africa, Johannesburg recently entered into 92 MW of short-term PPAs with independent suppliers in order to make up for the difficulties encountered by Eksom, the national company.[48]

In the face of inflation, the resilience of decentralized energy systems is put to the test

In 2021, around 1,500 cities had established renewable energy targets or policies, covering almost 1.3 billion people, compared to 1,300 cities in the previous year, and over 1,000 cities in 2019.[49] Municipal policies are much more likely to go beyond the electricity sector and include renewable energy in building codes, heating and cooling, and transport – domains where local governments often have the most power to act (**CF. "LOCAL GOVERNMENTS" TRENDS**).

Cities play a role in the diversification of renewable electricity production models: by municipalizing all or part of production and electricity supply activities, as shown by the Observatory in the case of Cadiz,[50] they can direct these activities towards renewables. The European Commission listed about 9,000 active energy communities in Europe in late 2022,[51] including municipal enterprises and energy cooperatives, which are autonomous groups of citizens that get together to collectively consume and/or produce renewable energy. Cooperatives promote democracy, tackle the issue of energy poverty, and group local governments or consumers, making them increasingly popular in Europe. REScoop.eu, the European federation of citizen energy cooperatives, lists 1,900 cooperatives, representing 1,250,000 citizens.[52] The trend was nevertheless weakened by the pandemic, and especially by the 2022 energy crisis. Yet in a few exceptional cases, some cooperatives emerged from these crises even more resilient, as identified in Georgia.[53]

In parallel, there has been a growth of collective self-consumption – which in France refers to consumers located in the same geographic area and consuming renewable energy produced on-site[54] 187 collective self-consumption operations were

f These electronic documents are produced by renewable energy producers, certified by the applicable mandatory or voluntary market authority, then purchased by suppliers that want to certify the origin of their electricity.

g PPAs are long-term electricity purchase contracts at a fixed or variable price, negotiated directly between producers and consumers (purchasers) of renewable electricity, without involving an intermediate supplier.

observed in early 2023, over 100 of them driven by local authorities, compared to six in 2018, totalling 11 MW of power.[55]

Citizen involvement has had a positive effect on the local energy transition – a study of eleven countries in the Nordic and Baltic regions showed a strong correlation between citizen engagement and the share of renewable energy in the electricity mix.[56] This trend is also confirmed outside Europe: the Pan African Alliance for Climate Justice, for example, works with civil society organizations in Botswana, Cameroon, Kenya, Morocco and Nigeria to strengthen the implementation of renewable energy policies.[57]

Demonstrations by civil society have had a significant impact on the energy transition over recent years by holding back fossil or renewable energy projects (**CF. "CIVIL SOCIETY" TRENDS**), influencing commercial policy and strategies, defending and driving action for a just transition, and even organizing communities to be more resilient.

Conversely, the development of renewable energies can also come up against local resistance. In the USA, for example, in May 2023, 228 local restrictions in 35 states aimed to block or restrain renewable energy installations, along with nine restrictions at federal state level. In total, 293 renewable energy projects came up against significant opposition. This is an increase compared to 2021, when 100 local restrictions of this type existed, and 152 renewable installations were contested. Oppositions are most frequent in the states that have seen the biggest developments in terms of renewable energy (like Kansas, New York and Texas).[58, 59] A study of 649 cases of movements resisting fossil and renewable energy projects spanning 1997 to 2019 showed that over a quarter of projects coming up against resistance were cancelled, suspended or postponed. Among the renewable energy projects, hydropower was the most perturbed, while wind and solar projects were the least conflictual.[60]

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