

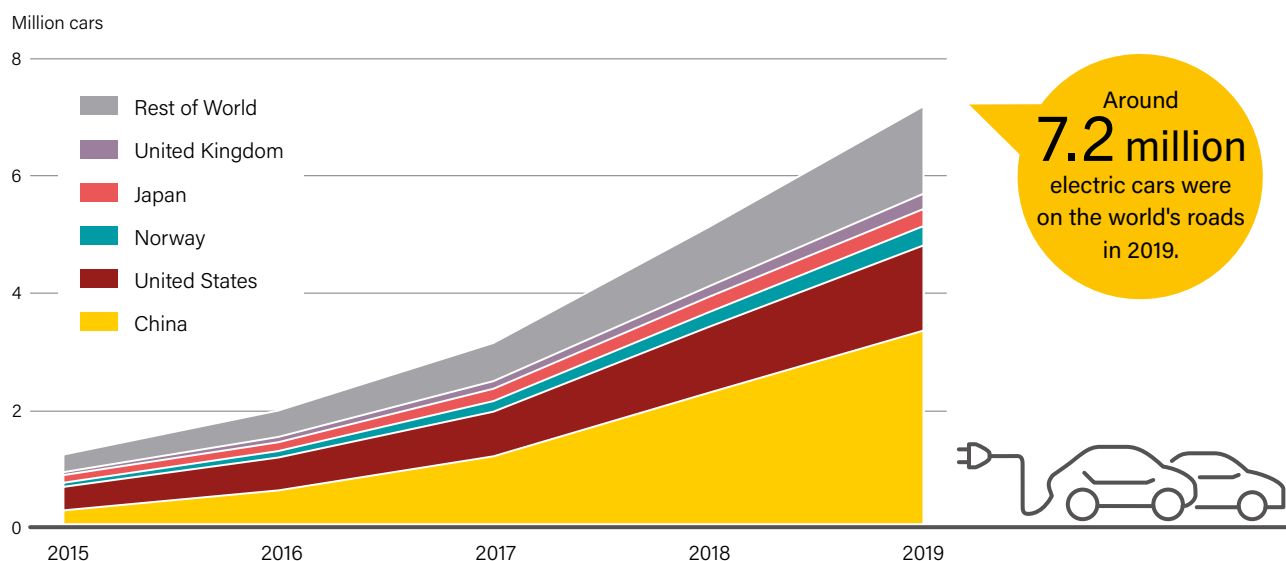
The global stock of electric two- and three-wheelers reached around 251 million in 2019.<sup>94</sup> Virtually all of these vehicles were in China.<sup>95</sup>

Sales of electric buses declined for the fourth consecutive year.<sup>96</sup> This drop reflected a 20% decrease in year-on-year sales in China – where some 71,000 new electric buses were registered, or 95% of the global total.<sup>97</sup> Growth was strong in other regions, but with much lower numbers.<sup>98</sup> India increased its stock of electric buses to around 800 units, and Europe's stock increased 60% compared with 2018, to around 4,500 units.<sup>99</sup> In North America,

some 2,200 electric buses were in operation at the end of 2019.<sup>100</sup> (→ See Figure 55.)

Public procurement by local and national governments helped boost EV markets in 2019. In India, the government of the Delhi region approved the purchase of 1,000 electric buses, the largest such commitment outside of China.<sup>101</sup> A range of other policies supported EV markets during the year, including e-mobility targets, financial incentives and indirect incentives (such as free parking and preferred access). (→ See *Policy Landscape* chapter.)

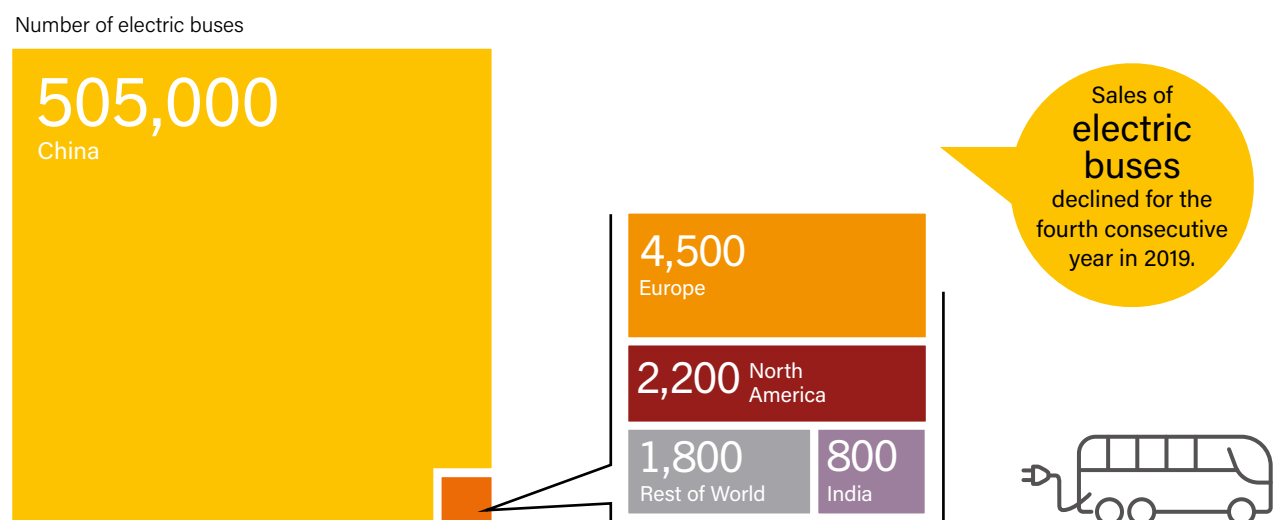
**FIGURE 54.** Electric Car Global Stock, Top Countries and Rest of World, 2015-2019



Note: Includes battery electric vehicles and plug-in hybrid electric vehicles. Shows countries among the top 5 according to the best available data at the time of publication.

Source: IEA. See endnote 85 for this chapter.

**FIGURE 55.** Electric Bus Global Stock, China and Selected Regions, 2019



Source: IEA. See endnote 100 for this chapter.

Around 2 million EV charging points were installed in 2019, increasing the global stock 40% to 7.5 million.<sup>102</sup> This includes both private and public, and fast and slow chargers, although nearly 90% of the total is private slow chargers.<sup>103</sup> The number of private chargers grew just under 40% in 2019, while the number of public chargers increased 60%.<sup>104</sup> China accounted for 80% of the new public fast chargers that entered the global market in 2019 and for just over half of the new public slow chargers.<sup>105</sup>

Passenger rail is the only form of transport that is widely electrified, and the share of electrification in the sector increased from 60% in 2000 to around 75% in early 2019.<sup>106</sup> The highest rates of passenger rail electrification are in Europe and Japan.<sup>107</sup> In the Americas, rail remains predominantly diesel-powered, and in most world markets freight rail is much less electrified than passenger rail.<sup>108</sup>

Electric rail can only be considered as a partially renewable form of transport depending on the prevailing shares of renewable energy in a given power supply system. Efforts have been made to directly electrify rail transport using VRE. In the United Kingdom, a trial project launched in 2019 connects solar panels to the direct current network of a rail system in south-east England.<sup>109</sup> Similar systems have been implemented at a small scale in several other countries.<sup>110</sup>

## Variable renewable electricity

was increasingly supplied to EV charging networks in 2019.



## Electric Vehicle Industry

The electric vehicle industry in 2019 was characterised by diverse commitments and investments from both dedicated EV manufacturers and traditional automakers. The industry also was bolstered by investments from non-automotive companies and by large corporate orders for EV fleets.

In 2019, the leading manufacturers of passenger EVs (including BEVs and PHEVs) were (in order of number of units produced) Tesla (United States); BYD, BAIC and SAIC (all China); BMW and Volkswagen (both Germany), Nissan (Japan), Geely (China), Hyundai (Republic of Korea) and Toyota (Japan).<sup>111</sup> Tesla surpassed BYD as the global EV sales leader after it recorded strong growth in the European and Chinese markets.<sup>112</sup>

Many traditional vehicle manufacturers announced plans to expand their EV offerings.<sup>113</sup> Toyota intends to offer electric versions of all of its vehicles by 2025, and Hyundai aims to offer 44 EV models by 2025.<sup>114</sup> In Europe, Volvo (Sweden) plans to launch new EVs every year until 2025, and Volkswagen intends to build 22 million EVs over the next 10 years.<sup>115</sup> Several other traditional auto manufacturers planned to release new models in 2020 and beyond.<sup>116</sup>

Hydrogen fuel cell electric vehicles (FCEV) also advanced in 2019, although the upfront and running costs of the vehicles remain higher than for petrol or diesel equivalents.<sup>117</sup> Toyota, which launched the world's first commercial FCEV for the general market – the Mirai sedan – in 2014, unveiled a second version in 2019.<sup>118</sup> Hyundai planned to launch two new hydrogen FCEVs by 2025 and partnered with the diesel engine and generator manufacturer Cummins to supply hydrogen fuel cell systems to the transport and electricity sectors.<sup>119</sup>

Non-automotive companies have moved into the EV space, including the solar technology company SolarEdge (Israel), which announced plans to acquire SMRE, an Italian firm specialised in powertrain technology and electronics for EVs.<sup>120</sup> Numerous Chinese companies, including online retailer Alibaba, and the internet companies Tencent and Baidu, acquired or increased stakes in EV companies.<sup>121</sup>

VRE was increasingly available on EV charging networks in 2019. The largest US public fast-charging network, EVgo, was contracting 100% of its electricity from renewable sources during the year.<sup>122</sup> In the US state of Texas, the utility Austin Energy offered 100% electricity from wind power to EV users via its network of 800 charging points.<sup>123</sup> In Europe, BMW partnered with the Dutch grid operator TenneT to pilot an intelligent charging system that allows EVs to maximise their use of VRE.<sup>124</sup>

Numerous vehicle-to-grid initiatives were under way in 2019, enabling EVs to provide flexibility services to electric grids through the controlled export of electricity from their onboard batteries. By year's end, around 65 V2G projects and initiatives were in progress across 15 countries.<sup>125</sup> Several projects in the Netherlands, the Republic of Korea and the United Kingdom reached the pilot stage, and others had achieved or were nearing commercial operation in Denmark, Japan, the United Kingdom and the United States.<sup>126</sup>

## ENERGY STORAGE

Energy storage can allow for flexible dispatch of renewable electricity and thermal energy at times of demand, and also can enable surplus or otherwise curtailed VRE to be applied to end-uses such as heating and cooling, mobility (as in EVs) and electricity generation. Energy storage includes mechanical, electrical, electro-chemical, thermal and chemical technologies, all of which can play an important role in the system integration of renewables.

Widely commercialised storage technologies relevant to the integration of renewables include pumped storage, various forms of electro-chemical storage such as lithium-ion, lead-acid and flow batteries, and certain thermal energy storage systems (including molten salt storage and hot water or ice storage). Biofuels also are a form of renewable energy storage, but in this report they are addressed as a primary form of renewable energy rather than as an enabling technology. (→ See *Bioenergy section in Market and Industry chapter*.)

Much of the development of energy storage over the past decade has focused on short-duration<sup>i</sup> applications. Emerging long-term or long-duration technologies, such as renewable hydrogen, flow batteries and novel forms of mechanical storage, are supported by decreasing costs and rising shares of VRE in many power systems.<sup>127</sup> Mature storage technologies often are less viable for longer-duration storage because of limitations relating to cost, durability, energy density or resource availability (for example, pumped storage) – a characteristic that has potential importance for wider decarbonisation of the energy sector.<sup>128</sup>

### Energy Storage Markets

The global market for energy storage of all types reached 183 GW in 2019.<sup>129</sup> Mechanical storage in the form of **pumped (hydropower) storage** accounted for most of this capacity, at around 158 GW<sup>ii</sup>, with 0.3 GW of new pumped storage capacity added during the year.<sup>130</sup>

Several new pumped storage facilities were under development in 2019 to directly facilitate the integration of renewables through storage and dispatch of VRE – including in Greece, the United Arab Emirates, the United States and Zimbabwe.<sup>131</sup> In Australia, the public utility Hydro Tasmania planned to connect the electrical grid of Victoria with up to 2.5 GW of new pumped storage capacity on Tasmania, increasing grid flexibility on mainland Australia and enabling higher VRE shares in the national electricity market.<sup>132</sup>

The leading markets for **battery storage** saw mixed results in 2019.<sup>133</sup> The United States had a record year for new capacity, adding 523 MW and 1,113 megawatt-hours (MWh), although project delays impacted the market.<sup>134</sup> Regulatory changes

slowed growth in the Chinese battery market, with 520 MW and 855 MWh of new capacity added in 2019.<sup>135</sup> (→ See *Figure 56*.)

In Australia, 143 MWh of grid-scale battery capacity was installed, more than double the amount in 2018.<sup>136</sup> Australia added 233 MWh of new home batteries to reach 1 gigawatt-hour (GWh) of residential battery capacity.<sup>137</sup> In the Republic of Korea, battery installations fell 70% relative to 2018, mainly because a series of fires at battery installations triggered safety concerns.<sup>138</sup>

The European energy storage market (excluding pumped storage and TES) also contracted in 2019, with 1 GWh of new storage capacity added for a total of 3.7 GWh.<sup>139</sup> Despite around 5% growth in the behind-the-meter storage market (mostly residential), a decline in front-of-meter installations contributed to the overall market drop.<sup>140</sup>

**Renewables-plus-storage** has emerged as a major driver of battery market growth, and the direct coupling of batteries with VRE generators has become more widespread.<sup>141</sup> In the United States, utility-scale projects combining solar PV and storage were completed in Hawaii, Massachusetts, and Texas, and several other projects coupling solar PV or wind with batteries were under construction or planning.<sup>142</sup> VRE-plus-storage projects also were completed or in planning in Australia, China, the United Kingdom, and smaller or developing countries such as Mali, South Sudan and St. Kitts and Nevis.<sup>143</sup>

The United States is a leading market for stand-alone utility-scale batteries, many of which are being built to indirectly enable higher VRE shares or to directly provide power systems with services that increase flexibility and resilience.<sup>144</sup> In the state of New York, a 4.8 MW (16.4 MWh) battery was installed as part of a demand response programme, and facilities under development in Arizona and Texas planned to provide demand response and ancillary services.<sup>145</sup> Elsewhere in the world, a battery in South Australia entered operations to provide both frequency response and arbitrage services, and in Tonga a battery that aims to enable greater deployment of wind and solar power was expected to enter operations in mid-2020.<sup>146</sup>

Decentralised, behind-the-meter battery storage – including both stand-alone storage and VRE-plus-storage – showed strong growth in several markets. Germany was the leading European market for residential storage in 2019, with 369 MWh, and the number of US residential solar-plus-storage installations doubled between 2017 and 2019.<sup>147</sup> In the New England region of the United States, 20 MW of storage capacity – to be aggregated from around 5,000 residential systems – was approved for connection to the local grid, representing the first participation of residential solar-plus-storage in the US wholesale market.<sup>148</sup> Residential storage also grew strongly in South Australia, where the government's Home Battery Scheme secured 5,500 installations and orders by early 2020, equivalent to 62 MWh of storage capacity.<sup>149</sup>

i The terminology used to categorise energy storage by duration or discharge period varies widely in academia, industry and the media. The GSR considers "short-duration" storage to be energy storage for less than around 10 hours, and "long-duration" refers to periods of around 10 to 100 hours. "Long-term" or "seasonal" storage describes energy storage for periods in excess of 100 hours, typically for weeks, months and years. Pumped storage is a mature and widely commercialised form of long-term storage.

ii Energy storage installations are specified in terms of both rated power (measured in kilowatts (kW), MW or GW) and the energy capacity (kilowatt-hours (kWh), MWh or GWh). Where possible, information on energy storage installations is reported in terms of both the rated power and the energy capacity of the installation. In some cases, data are reported in terms of only power or energy due to a lack of available information. Energy storage data also are occasionally reported in terms of time (i.e., the number of hours at which a facility can operate at its rated power output, based on its energy storage capacity), notably in concentrating solar thermal power storage markets. In these cases, rated power and storage "hours" may be used to calculate energy capacity in kWh, MWh or GWh.

**Thermal energy storage** – mainly in the form of molten salts – has been commonly deployed alongside concentrating solar thermal power (CSP) to allow for greater generation flexibility. In 2019, 3.4 GWh of new TES was deployed at CSP facilities, increasing the global installed capacity nearly 20% to 21 GWh.<sup>150</sup> (→ See *CSP section in Market and Industry chapter*.) Other thermal storage media, including water, were in use or being developed for non-CSP applications. At least 45 cities across Africa, Asia, Europe, the Middle East and North America were using centralised water reservoirs to store hot or cold water in district heating and cooling systems.<sup>151</sup>

**Renewable hydrogen** is an emerging storage technology with long-duration and long-term applications, although virtually all hydrogen continued to be produced from fossil fuels in 2019. Renewable hydrogen is produced from water through a VRE-driven electrolysis<sup>i</sup> process, or alternatively from renewable feedstocks through gasification<sup>ii</sup>. Producing hydrogen using VRE with electrolyzers can enable significant power system flexibility when surplus VRE is utilised.<sup>152</sup> Renewable hydrogen also can unlock demand for VRE by acting as a substitute for non-renewable hydrogen, which is produced using natural gas and is widely used in global industry.<sup>153</sup>

As of early 2020, more than 70 MW of hydrogen electrolyser capacity was in operation globally, with a further 45 MW under

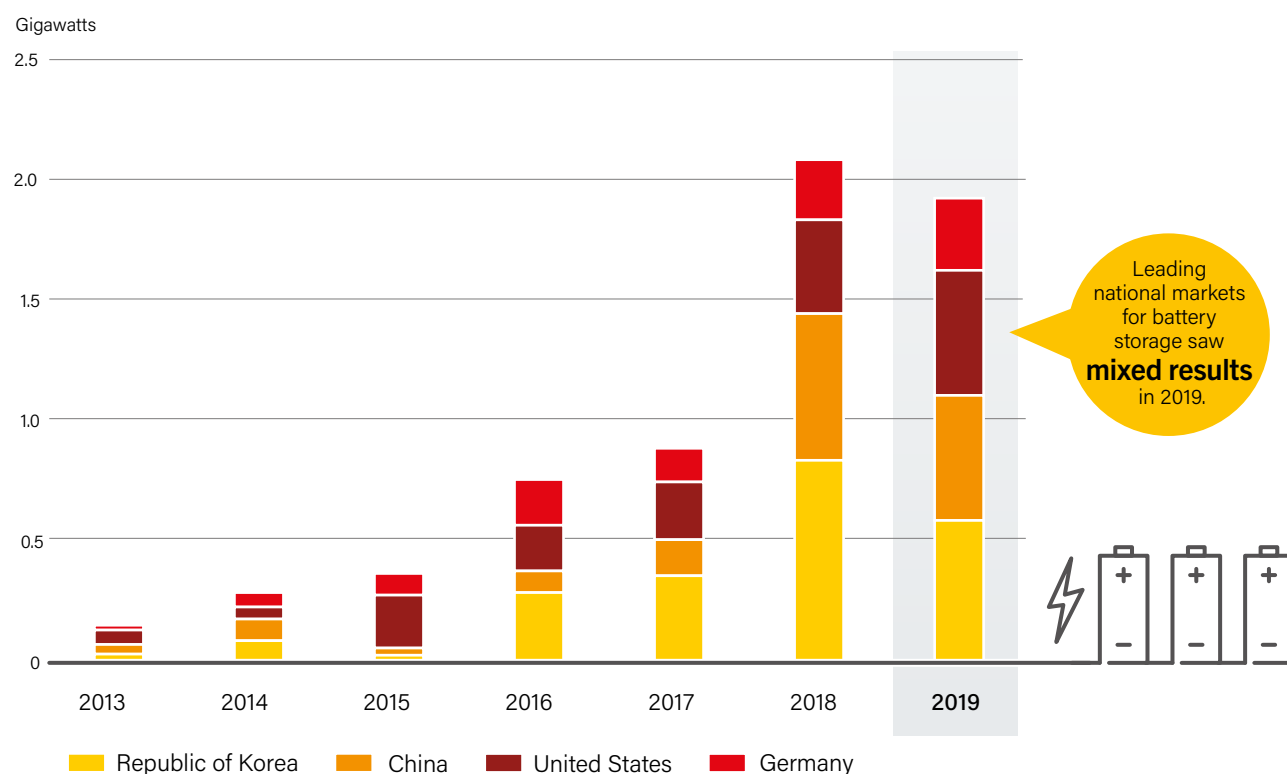
construction.<sup>154</sup> Efforts to scale up hydrogen production and demand received greater public support in 2019, although not always linked to renewable energy. Japan has driven support for the global hydrogen economy by promoting hydrogen-fuelled vehicles and initiatives aimed at greatly reducing hydrogen costs.<sup>155</sup> Australia's National Hydrogen Strategy targeted the creation of clusters of large-scale demand for hydrogen in ports, cities and rural locations.<sup>156</sup> Australia also planned to export renewable hydrogen to Asian markets, and a large-scale hydrogen production facility driven by 5 GW of wind and solar power capacity was slated to open in 2028.<sup>157</sup> The UK government backed a plan to deploy a GBP 12 billion (USD 16 billion) offshore wind farm in the North Sea with the aim of generating renewable hydrogen.<sup>158</sup>

Other long-duration or long-term storage technologies advanced in 2019. For example, a 2 MW (8 MWh) vanadium redox flow battery, originally launched in 2017, became the first battery of this type to be connected to a US wholesale power market (in California).<sup>159</sup> A long-term 1.75 MW (10 MWh) mechanical storage facility developed in Ontario, Canada by Hydrostor (Canada) was built to use (surplus) VRE to store energy in the form of compressed air.<sup>160</sup> The company was developing similar facilities elsewhere.<sup>161</sup>

i The electrolysis of renewable hydrogen makes use of an electrical current to split water molecules into hydrogen and oxygen.

ii The gasification process exposes feedstocks (for example biomass, fossil fuels, or municipal waste) to extremely high temperatures in order to split them into their component elements, including hydrogen, oxygen, and other metallic and nonmetallic byproducts.

**FIGURE 56.** Battery Storage Annual Additions, Selected Countries, 2013-2019



Note: Capacity shown for selected countries according to available data at the time of publication. Does not reflect global total.

Source: See endnote 135 for this chapter.

## Energy Storage Industry

The energy storage industry saw significant cost improvements, increased manufacturing capacity, large investments and ongoing R&D during 2019, with many of these activities focused on short-duration storage applications and battery technologies.

Notable cost improvements occurred for several storage technologies, particularly batteries. The average cost of a unit of lithium-ion battery capacity decreased 85% between 2010 and 2018.<sup>162</sup> Meanwhile, the levelised cost of electricity from lithium-ion batteries fell by half between early 2018 and early 2020.<sup>163</sup> In certain markets, lithium-ion battery storage coupled with VRE has become competitive with traditional, fossil fuel-based power in providing flexible, “dispatchable” power.<sup>164</sup> Declining lithium-ion costs are driving the increased competitiveness of EVs in relation to conventional fossil fuel-powered equivalents.<sup>165</sup> (→ See *Electric Vehicles* section in this chapter.)

The costs of low-carbon and renewable hydrogen produced via electrolysis fell 45% between 2015 and early 2020, but have remained high relative to non-renewable hydrogen.<sup>166</sup> By one estimate, the cost per kWh of renewable hydrogen produced with solar PV power was roughly two to four times that of petrol in the United States.<sup>167</sup> In Canada, a hydrogen producer began offering partially renewable hydrogen in early 2020 at a cost of USD 2.67 per kilogram (compared with USD 1.50 per kilogram for typical non-renewable hydrogen).<sup>168</sup>

The manufacturing capacity of certain types of storage has increased. For lithium-ion batteries, the global manufacturing capacity expanded from 14 GWh in 2010 to 316 GWh in early 2019, with more than 86% of this in China.<sup>169</sup> Large lithium-ion battery factories also were planned in Australia, India, South Africa and the United States.<sup>170</sup> As of mid-2019, the five largest lithium-ion manufacturers by capacity were LG Chem (Republic of Korea), CATL (China), BYD (China), Panasonic (Japan) and Tesla (United States).<sup>171</sup>

Global capacity for manufacturing renewable hydrogen was expected to grow strongly as of 2019, and in several countries large-scale electrolyzers were either opened, under construction or nearing construction. A 6 MW electrolyser powered by renewable electricity entered operations in Austria.<sup>172</sup> In Germany, a project was announced for what is expected to be the world's largest electrolyser when it opens in 2023 – a 100 MW electrolyser powered by wind and solar energy.<sup>173</sup> A 1.25 MW electrolyser started construction in Australia, and a 20 MW electrolyser in Canada aimed to start production in 2020.<sup>174</sup>

Energy storage, and particularly lithium-ion batteries, attracted significant investment in 2019. Venture capital firms contributed an estimated USD 1.7 billion to battery storage companies, with 80% of the total directed at lithium-ion technologies.<sup>175</sup> Several notable acquisitions occurred in the energy storage sector. For example, US-based private equity firm Energy Capital Partners acquired Convergent, a developer of the largest utility-scale battery projects in North America.<sup>176</sup>

Oil and gas companies made strategic investments in energy storage as a way to diversify their services. Shell (Netherlands) acquired 100% of the German battery storage firm Sonnen with the aim of offering cleaner energy solutions to customers, and

BP (United Kingdom) increased its stake in the solar PV and energy storage developer Lightsource.<sup>177</sup> In the areas of mining and battery raw material production, Wesfarmers (Australia) took a controlling stake in lithium mine developer Kidman Resources, which is involved in a lithium hydroxide project in western Australia that aims to supply the EV market.<sup>178</sup>

Among public investments in storage, the World Bank announced a partnership with 29 research and industry organisations aimed at advancing energy storage in developing countries.<sup>179</sup> In Tonga, the Asian Development Bank committed USD 44.6 million to a range of renewable-based systems and mini-grids, including battery systems.<sup>180</sup>

Significant investments in emerging storage technologies occurred, including in renewable hydrogen, mechanical or gravity-based energy storage, flow batteries, compressed air and cryogenic energy storage.<sup>181</sup> Amazon (United States) invested in Plug Power, a US company specialising in hydrogen fuel cells, and Cummins (United States) bought shares in Loop Energy (Canada), a provider of hydrogen fuel cell electric range extenders for commercial trucks.<sup>182</sup> Cummins also acquired the hydrogen and fuel cell technology company Hydrogenics (Canada) in 2019, the same year that Cummins made a commitment to be carbon neutral by 2050.<sup>183</sup>

In Sweden, the electric utility Vattenfall and the oil and fuel company Preem collaborated on designing a 20 GW renewable hydrogen facility that is expected to be Europe's largest water electrolysis facility – one of numerous “green hydrogen” initiatives that Vattenfall is involved in across the transport, power generation and industrial sectors.<sup>184</sup>

Among investments in long-term storage, SoftBank (Japan) invested USD 110 million in the mechanical storage company Energy Vault (Switzerland), and a consortium including the oil company Eni (Italy) invested USD 40 million in Form Energy (United States), a long-term chemical storage company.<sup>185</sup> Two long-term storage start-ups also received significant investments: ESS Inc. (United States), focused on iron-flow batteries, and Hydrostor (Canada), which is developing compressed-air storage.<sup>186</sup>

Wide-ranging R&D activities related to energy storage included a focus on improving battery efficiency, safety, reliability and cost.<sup>187</sup> The safety of lithium-ion battery storage facilities gained attention after a fire and explosion at a plant in the US state of Arizona and numerous fires in the Republic of Korea; research aimed at reducing these risks through the use of alternative electrolyte materials and other approaches.<sup>188</sup> Batteries also were investigated (alongside solar PV) for military applications, and the US Navy ordered two transportable solar-battery microgrids for test use.<sup>189</sup>

R&D in thermal energy storage included the testing of new storage media in Hamburg, Germany, where Siemens Gamesa (Spain) was piloting the use of crushed volcanic rock as the storage medium for VRE converted into heat using electrical resistance heating.<sup>190</sup> Novel applications of water- and ice-based thermal storage also advanced. In the US state of California, a distributed network of ice machines was being developed to produce ice during periods when electricity rates are low and to service air conditioning demand during high-rate periods.<sup>191</sup>





## GOVERNMENT SUPPORT FOR ENERGY EFFICIENCY, JORDAN



The Kingdom of Jordan's Renewable Energy & Energy Efficiency Fund (JREEEF) uses a bottom-up approach to make renewable energy more accessible to citizens. The Fund covers 30% of the costs of household solar PV systems and works with local banks to provide subsidised loans to cover the rest. Across Jordan, some 138 schools and 430 mosques and churches have benefited from JREEEF's support by installing solar water heaters and PV systems, improving insulation and lighting, and reducing their energy bills.

# 07 ENERGY EFFICIENCY AND RENEWABLES

## KEY FACTS

- Global primary energy intensity continued to fall in recent years, enabled in part by increased renewable electricity production.
- Global final energy demand has risen, despite improvements in energy intensity that have facilitated larger renewable energy shares.
- The increase in final energy demand has been driven largely by rapid economic growth and improved energy access in developing and emerging economies and a global shift towards energy-intensive transport.

**I**nternational efforts to meet energy demand in a safe and reliable manner generally acknowledge the complementary nature of renewable energy deployment and energy efficiency measures.<sup>1</sup> Both renewables and efficiency can contribute significant benefits including lower energy costs on a national, corporate or household level, increased grid reliability, reduced environmental and climate impacts, improved air quality and public health, and increased jobs and economic growth.<sup>2</sup> The United Nations' Sustainable Development Goal 7<sup>i</sup> (SDG 7) recognises that combining renewables and efficiency provides an integrated means towards achieving sustainable energy access for all.<sup>3</sup>

Energy production and use account for more than two-thirds of global greenhouse gas emissions.<sup>4</sup> Taken together, renewable energy deployment and energy efficiency measures can potentially achieve most of the carbon reductions required to keep global temperature rise below 1.5 degrees Celsius.<sup>5</sup> Moreover, renewables and efficiency maximise their emissions mitigation potential when pursued together.<sup>6</sup>

Coalitions of governments, corporations, institutions and non-governmental organisations have boosted global energy efficiency efforts, recognising the potential to greatly reduce greenhouse gas emissions.<sup>7</sup> As of the end of 2019, 131 parties

<sup>i</sup> In 2015, the United Nations General Assembly adopted a set of 17 goals as part of a new global agenda on sustainable development. SDG 7 aims to ensure access to affordable, reliable, sustainable and modern energy for all – including targets to “increase substantially the share of renewable energy in the global energy mix” and to “double the global rate of improvement in energy efficiency” by 2030. See endnote 3 for this chapter.

to the Paris Agreement mentioned renewable energy in their Nationally Determined Contributions (NDCs) to reduce emissions, while 112 parties mentioned energy efficiency, and 94 mentioned both.<sup>8</sup> Energy efficiency was a main contributor to stabilising global greenhouse gas emissions in 2019, along with renewables.<sup>9</sup> (→ See Box 1.)

Energy intensity, which represents primary energy supply per unit of economic output<sup>i</sup>, plays an important role in evaluating developments in energy efficiency (for example, it is a key indicator for tracking efficiency improvements under SDG 7). Energy intensity is complemented by carbon intensity, which measures the amount of carbon dioxide emitted per

i See Glossary for expanded definition and for details on why energy intensity is used as a proxy for energy efficiency. Energy intensity is an imperfect indicator for energy efficiency, as it reflects not only changes in relative energy efficiency but also structural changes in economic activity (such as a shift from heavy industry towards services and commerce). (→ See Box 2.)

## BOX 1. Energy Efficiency and the Deployment of Renewables: Working Together with Limited Resources

Energy efficiency and renewables generally complement each other in an integrated approach to achieve common global goals. In some cases, however, trade-offs can occur between the two, due mainly to competing costs. Given that financial resources are inherently limited in most economies and for most actors, the relative prices for energy efficiency and renewable energy have the capacity to reduce the incentive to implement one or the other. This is not necessarily a negative phenomenon, as both efficiency and renewables serve largely the same objective.

The costs of generating electricity from renewable energy technologies continued to decline in 2019, with solar photovoltaic (PV), hydropower, onshore wind power, bioenergy and geothermal projects becoming increasingly competitive with fossil energy generation. (→ See Sidebar 5.) In some locations, however, renewable electricity prices for end-consumers remain higher than conventional electricity prices<sup>i</sup>.

Meanwhile, plenty of no- or low-cost energy conservation and efficiency measures exist that can be implemented at a wide scale, such as turning off appliances that are not in use or activating “sleep” settings, switching to low-energy lighting and installing insulation films for windows. The public

and private sectors are increasingly recognising how such “low-hanging fruit” can yield major energy cost savings.

Ultimately, the optimal combination of efficiency and renewables is both location- and sector-specific. Additionally, implementing efficiency measures facilitates the deployment of renewable energy either concurrently or subsequently. Integrated strategies for efficiency and renewables thus can be the most effective approach for maximising the potential of both. For example, in the Seychelles an Energy Efficiency and Renewable Energy Programme in place since 2017 aims to encourage residents to buy energy-efficient appliances and renewable energy, and Morocco’s Jiha Tinou programme seeks to stimulate renewables and efficiency initiatives in cities and regions. (→ See Policy Landscape chapter for additional developments in 2019.)

i Some of this price discrepancy can be attributed to ongoing adjustments to variable electricity supplies in power markets and to the diverse business models of energy utilities and infrastructure operators. Conventional electricity prices are those from fossil fuel and nuclear power plants.

Source: See endnote 9 for this chapter.





unit of final energy consumed<sup>i,10</sup>. In general, interactions between the deployment of renewable energy technologies and improvements in energy efficiency are complementary, as efficiency reduces the overall primary energy needed, while the use of renewables minimises both the primary energy needed as well as the carbon intensity.<sup>11</sup> (→ See Box 2.)

Factors behind these reductions in primary energy demand and carbon emissions include:

■ **Interactions between renewables and primary energy efficiency.** Primary energy demand includes all of the energy contained in all the energy sources required to meet the final energy consumption of end-users, taking into account losses from transforming primary energy (such as oil, coal or natural gas) into secondary energy (such as electricity or oil distillates). Because the use of some sources of renewable power – particularly hydropower, solar PV and wind power technologies – reduces the overall transformation losses in generation, the

uptake of renewables lessens the amount of primary energy needed to meet final energy needs, thus improving primary energy intensity.<sup>12</sup> Increasing the share of electricity generation from renewables also helps to reduce overall carbon intensity.

■ **Interactions between renewables and final energy efficiency.** Energy efficiency measures are necessary for increasing the overall share of renewables in final energy consumption. By lowering final energy consumption, energy efficiency allows the same level of renewable energy uptake to meet a larger share of energy consumption, and also reduces the capital investment required to supply the demand through on-site and/or off-site renewables. This is particularly pertinent in light of rising energy use in developing and emerging economies, and in light of barriers that limit the speed of renewables deployment (such as land scarcity, potential opposition by local communities, etc.).<sup>13</sup> (→ See Feature chapter.)

i Energy intensity and carbon intensity are complementary because, taken together, they indicate the primary energy required per unit of GDP and the carbon dioxide emissions produced through the transformation and use of this energy.

## BOX 2. Energy Optimisation: Efficiency, Conservation and Structural Changes

The term energy efficiency is often used as a proxy term for energy savings. Yet improvements in efficiency alone do not necessarily lead to energy savings. Energy reduction or optimisation is simultaneously influenced by:

- energy efficiency improvements through technology and design;
- energy conservation measures, which are related to the behaviours and habits of energy end-users; and
- structural changes, or changes in the composition of sectors or within a sector (for example, a switch to less energy-intensive or more service-oriented industries), which can be achieved through policies, investments and planning processes.

Both energy efficiency improvements and the integration of behavioural measures are necessary within energy optimisation strategies, whereas structural changes generally are kept outside of the scope.

Energy efficiency measures without behavioural awareness can lead to a “rebound effect”, whereby the energy reductions generated by nominal efficiency improvements are either lower than expected or even negative. For example, in response to improved insulation in buildings, residents may opt to maintain warmer homes rather than to reduce their energy consumption – resulting in a direct rebound effect – or they may spend the cost savings on other goods and services that also require energy to provide (an indirect rebound effect).

Often, the benefits of efficiency are not “lost” but rather are redirected; thus, it is important to distinguish two types of impact of the rebound effect:

- The reduction in energy expenditure due to energy efficiency leads to wasteful energy use with no appreciable increase in utility to the consumer. This could include, for example, leaving the lights on in a vacant room because lighting is cheap.
- The reduction in energy expenditure due to energy efficiency leads to the opportunity to increase the consumer’s utility, by using some or all of the energy that is otherwise saved for new or improved energy services. This could include, for example, increasing space heating to a range of comfort from a previously unhealthy state, or efficient lighting allowing for more study time during non-daylight hours.



Source: See endnote 11 for this chapter.

In addition, specific efficiency measures in end-use sectors, such as energy-efficient building codes, can be enablers for both energy efficiency and renewable energy. These efficiency measures often are coupled with measures to supply the remaining energy demand either directly with renewables (for example, bioenergy, solar thermal and geothermal heat) or indirectly with renewables-based electricity.<sup>14</sup> The electrification of end-use sectors, such as heating, cooling and transport, is one pathway to achieving a double benefit: electrified systems can be more energy efficient than their fossil fuel-based counterparts, and electricity demand can be sourced more readily from a wide variety of renewables.<sup>15</sup> (→ See *Systems Integration* chapter.)

Renewables and energy efficiency maximise their emissions mitigation potential when pursued together.

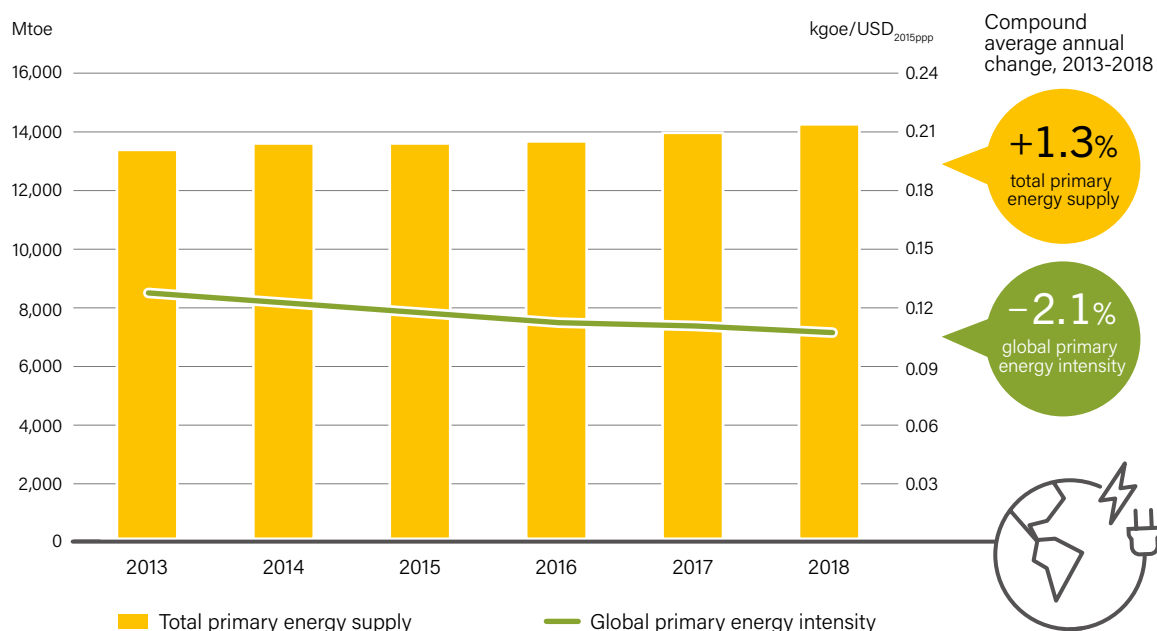
## RENEWABLES AND PRIMARY ENERGY EFFICIENCY

The world's total primary energy demand increased 2.3% in 2018, the largest increase since 2010, driven by global economic growth.<sup>16</sup> However, improvements in primary energy intensity helped limit the growth in demand to some extent. Global primary energy intensity decreased more than 10% during the five-year period between 2013 and 2018, at an average annual rate of 2.1%.<sup>17</sup> (→ See *Figure 57*.) On a year-to-year basis, the improvement in energy intensity has slowed more recently, falling from 3.0% in 2015 to 1.2% in 2018.<sup>18</sup>

If the total primary energy demand had moved in tandem with global economic growth<sup>i</sup> – with no reduction in energy intensity – during 2013-2018, and considering that primary energy demand grew 6.5% over this period (average annual growth of 1.3%), total primary energy demand would have risen 19.2% over the five-year span (or 3.6% per year).<sup>19</sup> In the context of a growing global economy, improvements in energy intensity thus are key to curbing global growth in energy demand.

i This does not take into account unknown feedback from higher energy intensity on economic growth. In other words, global economic growth might not have been as large over the observed period if not for the benefit of more efficient use of energy in economic activity.

FIGURE 57. Global Primary Energy Intensity and Total Primary Energy Supply, 2013-2018



Note: Dollars are at constant purchasing power parities.  
Mtoe = megatonnes of oil equivalent;  
kgoe = kilograms of oil equivalent.

Source: Enerdata. See endnote 17 for this chapter.

In 2017, the world's total primary energy supply was 584 exajoules (EJ).<sup>20</sup> Each year, more than 23% of the primary energy supply is dissipated through various transformation processes (such as conventional electricity generation).<sup>21</sup> The fossil fuel energy industry itself consumes another 6% of the total primary energy supply through its net demand for energy, including for operating oil refineries and mining and extracting fossil fuels.<sup>22</sup> Less than 2% of the total primary energy supply goes to "non-productive" losses, which occur mainly during the transmission and distribution of electricity.<sup>23</sup>

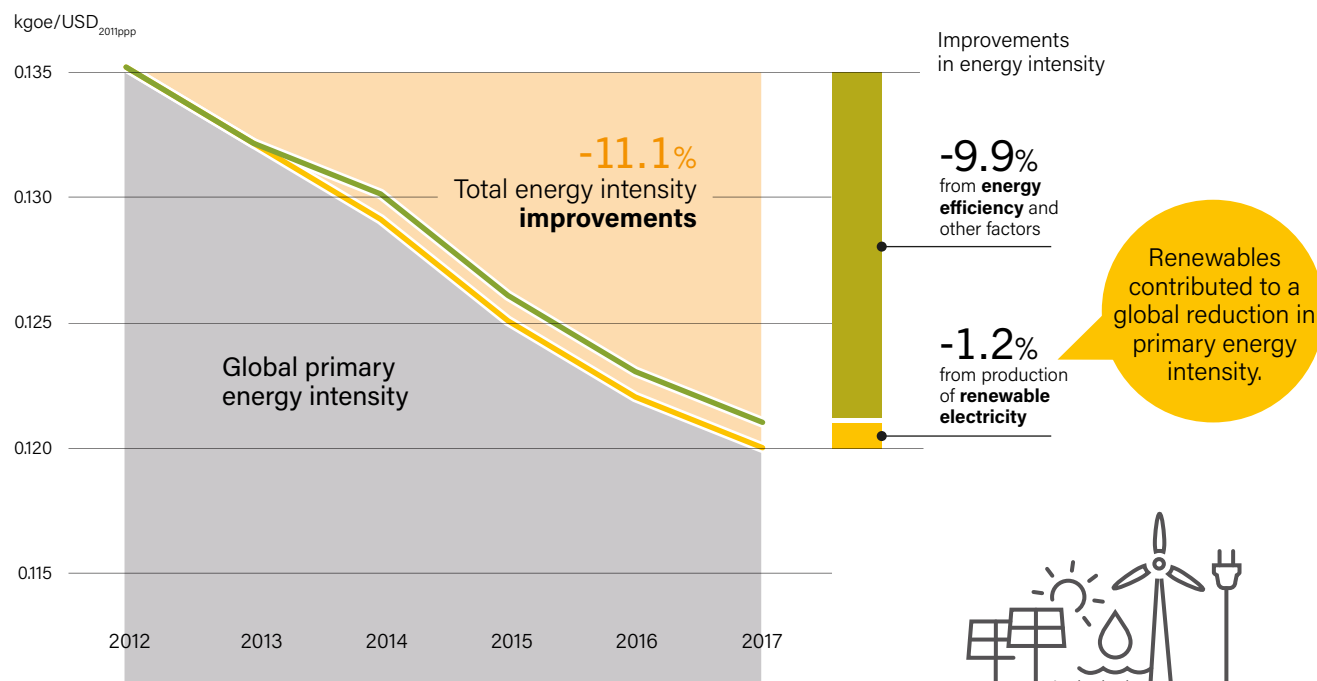
Looking specifically at thermal power plants (combustion only; biomass-, coal-, natural gas- and oil-fired power plants), more than half of the primary energy input is lost during the transformation process.<sup>24</sup> Non-thermal renewable energy technologies (such as wind power and solar PV) also have a low conversion efficiency, but in these cases the energy loss is irrelevant, because any potential energy not harnessed by these technologies is never part of the primary energy supply, unlike with fossil fuels that are extracted for electricity generation and for the production of refined fuels.<sup>25</sup> As a consequence,

non-thermal renewables have a higher primary energy efficiency. Additionally, the dissipated energy in fossil fuel power plants (unlike "lost" solar and wind energy) manifests itself in increased emissions of greenhouse gases and other pollutants.

Based on these factors, improving primary energy efficiency (and thus reducing greenhouse gas emissions) in the power sector can be achieved in one of two ways: either by improving the efficiency of thermal power plants (through greater thermal conversion efficiency and through direct use of residual heat, or co-generation), or by reducing transformation losses through a shift to non-thermal renewable energy technologies.

Between 2012 and 2017, the increase in renewable electricity production reduced global primary energy intensity an estimated 1.2%.<sup>26</sup> Meanwhile, general improvements reduced global primary energy intensity an estimated 9.9%, with energy efficiency playing a role alongside fuel switching and regional shifts in energy demand, among other factors.<sup>27</sup> (→ See Figure 58.)

**FIGURE 58.** Estimated Impact of Increased Renewable Electricity Production on Global Primary Energy Intensity, 2012-2017



Note: The figure estimates the additional primary energy input that would have been required in the absence of the renewable electricity uptake since 2012, all else being equal. The estimation accounts for the difference in transformation losses between conventional and renewable electricity generation but does not account for potential feedback loops on the energy demand itself due to energy prices, structural changes in economic activity or similar effects. The figure is not intended to provide results of a comprehensive energy model. For further explanation of the methodology, see endnote 27 for this chapter.

Dollars are at constant purchasing power parities.  
kgoe = kilograms of oil equivalent.

Source: See endnote 27 for this chapter.

# RENEWABLES AND FINAL ENERGY CONSUMPTION

Total final energy consumption (TFEC) – that is, what remains of the total primary energy demand following all of the losses that occurred during the processes of transformation, energy sector use, transmission and distribution – amounted to 370 EJ in 2017.<sup>28</sup>

Like primary energy intensity, global final energy intensity improved during the 2012-2017 period, although by a higher margin of 13%.<sup>29</sup> Because of this higher improvement in final energy intensity, which reduces overall energy demand, the same renewable energy sources can supply a larger share of the world's final energy needs.<sup>30</sup>

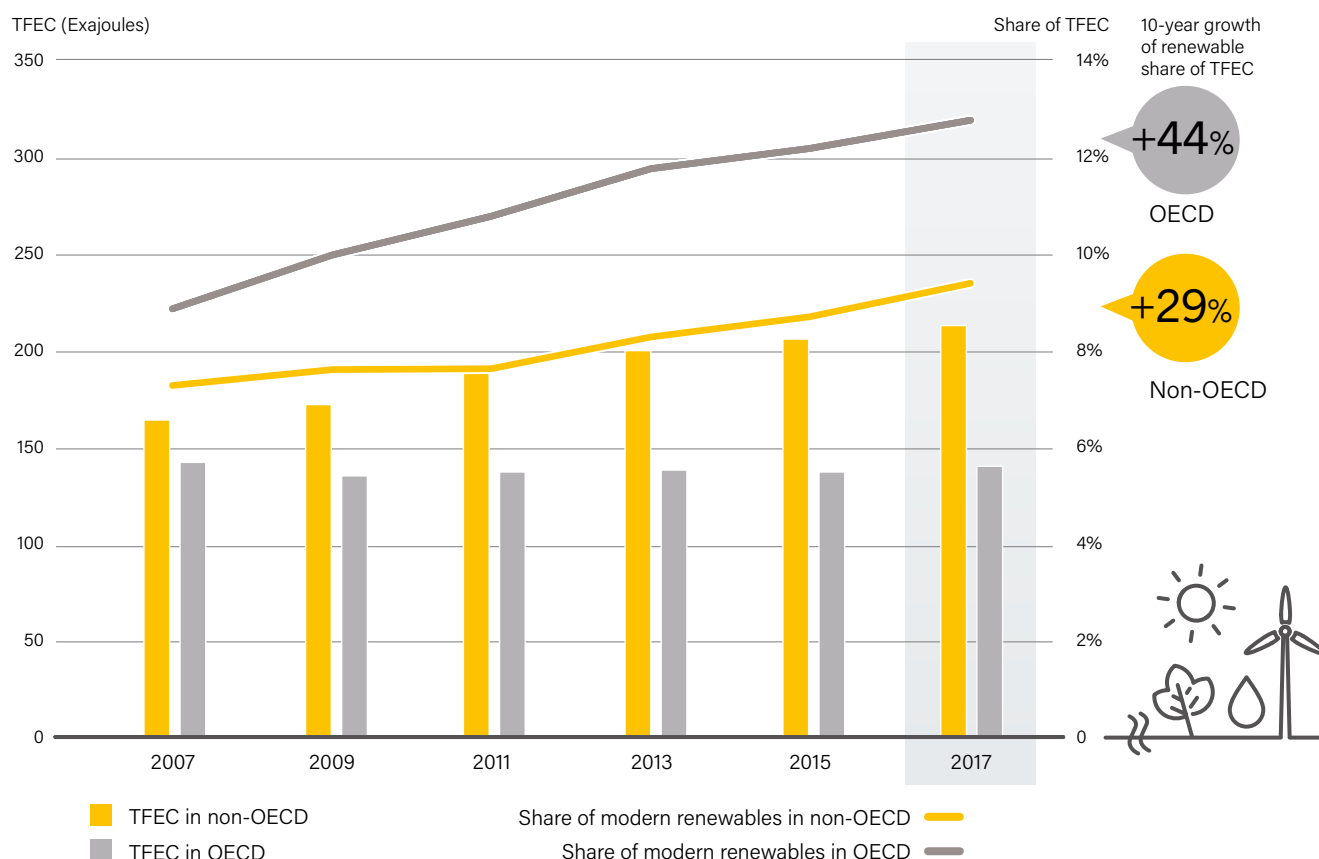
Between 2007 and 2017, global TFEC increased 1.4% annually, while the share of TFEC met by modern renewables grew at an average annual rate of 3.0%.<sup>31</sup> Differences are evident between the member countries of the Organisation for Economic Co-operation and Development (OECD) and the countries outside of it.<sup>32</sup> (→ See Figure 59.)

■ In **OECD countries**, contrary to the global trend, TFEC decreased 1.8% between 2007 and 2017, due in part to a 14% improvement in final energy intensity during this period.<sup>33</sup> This decrease facilitated larger growth in the share of consumption met by renewables: while consumption of renewable energy increased around 42% between 2007 and 2017, the share of modern renewables in TFEC increased 44% during the period.<sup>34</sup>

■ **Non-OECD countries** experienced a large rise in energy demand (TFEC increased 30%) between 2007 and 2017, driven by rapid economic growth and improved energy access, but limited to an extent by a 20% improvement in final energy intensity.<sup>35</sup> This growth tempered the increase in the share of consumption met by renewable energy. While the absolute amount of renewable energy in TFEC grew at a higher rate than in OECD countries (68%) during the period, the share of renewables in TFEC increased to a lesser extent (29%).<sup>36</sup>

i The member states of the OECD (37 countries, as of end-2019) account for the majority of the world's gross domestic product (GDP) and are among the countries with the highest GDP per capita as well as rank near the top of the Human Development Index. They typically are classified as countries with developed economies. Non-OECD countries are normally classified as countries with developing or emerging economies, some of which have seen rapid rises in GDP per capita in recent decades.

**FIGURE 59.** Total Final Energy Consumption and Share of Modern Renewables in OECD and non-OECD Countries, 2007-2017



Note: TFEC = total final energy consumption.

Source: Based on IEA. See endnote 32 for this chapter.



## BUILDINGS

The buildings sector accounted for around 33% of global TFEC in 2018.<sup>37</sup> Residential buildings consumed nearly three-quarters of this energy, and the rest was used in commercial and public buildings.<sup>38</sup> In 2017, electricity end-uses (for example, lighting and appliances) accounted for less than 25% of building energy demand, with various fuels (natural gas, biomass, fuel oil, coal, etc.) serving most of the remaining (mostly thermal) demand.<sup>39</sup> Although the overall share of renewable energy used to meet building energy demand remained low (13.6%), renewables were the fastest growing energy source in the sector.<sup>40</sup> (→ See *Global Overview chapter*.)

Despite the development of more-efficient appliances and improvements in building structure and construction, the energy demand of buildings rose 38% globally between 2000 and 2017.<sup>41</sup> In OECD countries, TFEC in the buildings sector *decreased* 2.6% between 2005 and 2017, whereas in non-OECD countries it *increased* 26% during this period.<sup>42</sup> Various factors explain these differences, shaping the trends in energy consumption.<sup>43</sup> As a consequence, issues related to the share of renewables in the sector, and how to increase it, can differ.

In **OECD countries**, the energy intensity of buildings – measured as the final energy use per unit of floor area – fell 1.3% annually between 2000 and 2018, leading to a decrease in final energy consumption.<sup>44</sup> Although energy use for cooling per OECD household has increased in recent years, this has been offset by a decrease in the average energy intensities of space heating and lighting.<sup>45</sup> Since 2010, heating and lighting have seen the highest efficiency improvements among household energy uses in OECD countries, with average annual energy intensity improvements per dwelling of 1.4% for heating and 1.7% for lighting.<sup>46</sup>

Electricity is the predominant energy carrier used in OECD countries, accounting for 37% of the energy consumption of residential buildings.<sup>47</sup> The overall improvement in the energy intensity of buildings in these countries reflects declines in the average electricity use per electrified household in Europe (down 9% since 2010), North America (down 5%) and the Pacific (down 14%).<sup>48</sup>

Interest in energy-efficient buildings is increasing, mainly in developed countries where the implementation and updating of energy codes, certification policies and energy performance requirements for construction and renovation at the national level are influencing energy use in the sector.<sup>49</sup> Numerous building standards emphasise a high commitment to energy efficiency, ensuring that the energy performance of buildings is as efficient as possible, and often interlinking efficiency with on-site and/or off-site renewable generation (mostly through solar PV) to cover residents' remaining energy use.<sup>50</sup> However, policy approaches to energy efficiency and renewables in the buildings sector range widely in their level of commitment. (→ See *Policy Landscape chapter*.)

Despite advances  
in energy efficiency,  
**global energy  
demand** in buildings  
has continued to rise.

The market penetration of energy-efficient buildings<sup>i</sup> is difficult to estimate due to varying definitions and a lack of monitoring.<sup>51</sup> However, a clear upward trend can be seen in the United States and Canada, where the number of zero energy housing units either in the design phase, under

construction or completed increased 59% between 2017 and 2018, from 13,960 units to 22,146 units.<sup>52</sup> This still represents only a tiny share of the reported 1.47 million new construction starts in 2017 in the two countries.<sup>53</sup> In the European Union, the ZEBRA2020 project monitors the market uptake of “nearly zero-energy buildings” across 17 Member States and shows the wide variance in deployment across the region.<sup>54</sup>

**Countries outside of the OECD** have the highest growth in building energy demand, but in many instances mandatory building energy standards and policies either are not in place or cover a small portion of building energy use.<sup>55</sup> The average annual electricity consumption in non-OECD countries, at around 2,100 kilowatt-hours (kWh) per household, remains below the global average (some 3,500 kWh per household) and is less than one-third that of the OECD countries.<sup>56</sup> However, average electricity consumption increased in non-OECD countries between 2010 and 2018, mainly in Asia (up 37%) and Africa (15%) but also in Latin America (4%).<sup>57</sup>

The growth in electricity consumption in non-OECD countries can be explained mainly by rising wealth and increased access to energy in these countries. Many poor and lower-middle income residents have gained access to modern energy services for the first time: between 2015 and 2017, an estimated 153 million people gained electricity access worldwide.<sup>58</sup> (→ See *Distributed Renewables chapter*.) Consumers also are opting for larger homes, increasing the building floor area and appliance ownership per household, which ultimately expands energy use.<sup>59</sup> This shift, coupled with a lack of access to efficient systems and appliances due primarily to a lack of economic resources, has led to the overall rise in energy demand – despite the introduction of minimum energy performance standards in many countries.<sup>60</sup>

This challenge is particularly apparent in the cooling sector. While many lower- to middle-income people in developing countries are now able to purchase cooling systems, their preference for the most affordable (upfront) solution leads to greater inefficiency and impacts the rise in energy use and associated greenhouse gas emissions.<sup>61</sup> Efforts to implement regulations in the sector include the COOL\_ME project to scale up “sustainable cooling” in the Middle East (funded through Germany's International Climate Initiative) and China's Green and High-Efficiency Cooling Action

i Such buildings are characterised by the efficient use of energy (and sometimes of water and other resources, as in “green buildings”); they can include generation from renewables to fulfil their current energy consumption (e.g., “zero energy”, “zero emission” or “energy neutral” buildings), to meet their future energy consumption (e.g., “zero energy ready” buildings) or even to produce more energy than they consume (e.g., “energy positive” buildings). See Glossary for definitions.

Plan, released in 2019.<sup>62</sup> Ultimately, rising energy demand from increased access is related to improving quality of life, but it poses threats of long-term lock-in to fossil fuel use if the access is provided by renewables coupled with energy efficiency.

Meanwhile, the deployment of renewables and efficiency has played a major role in electrifying rural areas of developing countries, where on average 77% of the population has access to electricity.<sup>63</sup> The deployment of off-grid solar systems such as solar lighting and solar home systems has emerged as an important driver of rural energy access.<sup>64</sup> Between 2011 and 2016, the global number of people connected to off-grid renewables grew by a factor of six, to nearly 133 million, with countries in Africa and Asia accounting for most of the growth.<sup>65</sup> (→ See *Distributed Renewables chapter*.) In this context, the interaction between efficiency and renewables is evident, as energy-efficient appliances enable a wider spectrum of electricity services to be delivered by small-scale renewable energy systems that offer both reduced capacity and lower costs. (→ See *Box 1 in Distributed Renewables chapter*.)

## INDUSTRY

The industrial sector accounts for nearly 35% of global TFEC, excluding non-energy uses of fossil fuels. Despite a 19% improvement in global industrial energy intensity between 2010 and 2017 (a 3% yearly decrease in intensity on average), industrial energy use has gradually increased, at an annual average rate of 0.9% during the period.<sup>66</sup>

As in the residential sector, key contributors to improved energy intensity in industry are:

- **Deployment of more-efficient technologies** and operational improvements, leading to gains in overall efficiency. This is due mainly to more-efficient heavy industrial production in emerging economies such as China and India, with a consequent greater decrease in energy intensity in the region.<sup>67</sup> More recently, however, the impact of annual efficiency gains in the industry and services sector has fallen, from around 4% savings in final energy demand in 2015 to just under 2% savings in 2018, a return to the trend of previous years (2012-2014).<sup>68</sup>
- **Structural factors**, notably the shift, primarily in developed countries, away from energy-intensive industry and towards less energy-intensive sectors of the economy (particularly services) as well as higher value-added<sup>i</sup> economic activities (such as automotive manufacturing, food and beverages, and textiles). However, this effect has slowed globally since 2013 as energy-intensive manufacturing has shown renewed growth.<sup>69</sup> As of 2017, renewable energy, including renewable electricity, supplied more than 14% of industrial energy demand.<sup>70</sup> This share grew only slightly between 2007 and 2017, despite increases in the use of renewables in the sector over the period.<sup>71</sup> (→ See *Global Overview chapter*.)

Electrification of industry can potentially play a role in increasing the share of renewables in TFEC. For example, during the 2007-2017 period the share of electricity in industrial TFEC grew from 25% to 27%.<sup>72</sup>



As in the buildings sector, electrification of industry generally results in gains in final energy efficiency, thereby reducing overall energy demand, and it facilitates the uptake of renewables indirectly to the extent that the electricity comes from renewable sources.<sup>73</sup>

## TRANSPORT

Energy use in the transport sector grew 20% between 2007 and 2017 – at an average annual rate of 1.8% – and accounted for 32% of TFEC in 2017.<sup>74</sup> Most of the increase in energy use reflects the growing size and number of vehicles on the world's roads (and the accompanying passenger-kilometres travelled) as well as, to a lesser extent, rising air transport.<sup>75</sup> As of 2016, road transport continued to account for the bulk of energy demand for transport (at 75%), followed by aviation (11%), marine transport (9.6%) and rail (1.8%).<sup>76</sup> (→ See *Global Overview chapter*.)

In developed countries, passenger road transport data reveal a shift towards the use of light-duty vehicles and continued growth in sales of sport utility vehicles (SUVs).<sup>77</sup> Between 2010 and 2018, the average passenger-kilometres travelled per person for buses decreased 9%, whereas for light-duty vehicles it increased 15%.<sup>78</sup> However, major differences exist between countries: bus use has increased in Australia, France and Portugal (up 11%, 25% and 33% respectively) but has decreased in Belgium, the United Kingdom and the United States (down 17%, 20% and 33% respectively).<sup>79</sup> Considering that the average energy intensity per passenger-kilometre of a bus, at 0.89 megajoules (MJ), is about half that of a light-duty vehicle (1.71 MJ), this has led to increased energy demand from road transport.<sup>80</sup> Furthermore, fuel economy standards for light-duty vehicles exist in only 37 countries, and just 5 countries have fuel economy policies for trucks. (→ See *Policy Landscape chapter*.)

The shift towards more energy-intensive transport modes is not specific to developed countries and can be observed globally. Coupled with behavioural factors and consumer preferences,

i Higher value-added sectors generate a larger margin between the final price of a good or service and the cost of the energy inputs used to produce it.

## Electric vehicles

show a complementarity between energy efficiency and renewable energy.

such as lower vehicle occupancy and a demand for larger cars and SUVs, this can counteract any improved efficiency of motor vehicles.<sup>81</sup>

The transport sector has the lowest penetration rate of renewable energy among end-use sectors, with renewables supply-

ing only a small share of final energy (3.3%), mostly in the form of biofuels and the remaining share from renewable electricity.<sup>82</sup> Overall, both renewable and non-renewable electricity supply only around 1.1% of the TFEC of transport, mostly in road transport (15%) and rail (around 70%).<sup>83</sup>

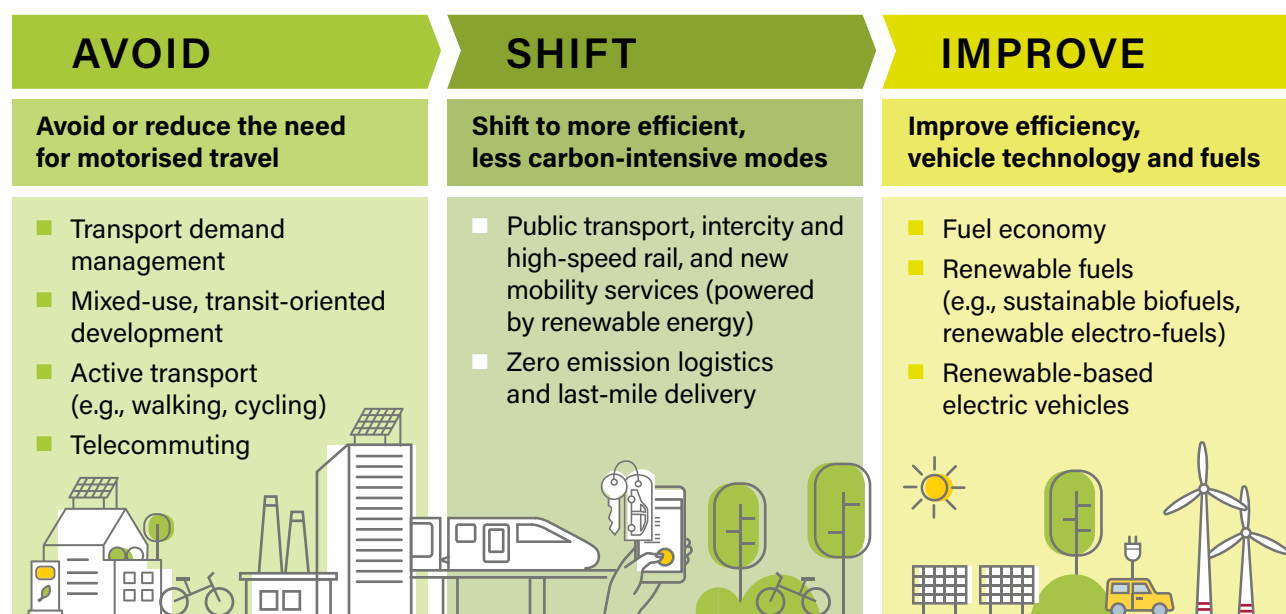
In addition to efforts to incorporate more renewables in the transport sector (through both renewable fuels and electricity from renewable sources), renewable energy can benefit from wider initiatives to decrease energy demand in the sector, as this could help boost the renewable share. Ways to reduce energy demand include avoiding the need for motorised transport, transitioning to more-efficient transport modes such as (renewable based) public transport and rail and efforts to improve vehicle technology and fuels, such as through higher fuel efficiencies and emission standards.<sup>84</sup> (→ See *Global Overview chapter*.)

These actions, commonly referred to together as Avoid-Shift-Improve, seek to address broader policy maker concerns in the transport sector, such as environmental and health impacts (e.g., congestion, pollution, road safety) and transport security.<sup>85</sup> (→ See *Figure 60*.)

**Electric vehicles** (EVs) for passenger and freight use highlight an area where a complementarity between energy efficiency and renewable energy can clearly be seen. EVs have a higher technical efficiency than vehicles with internal combustion engines (higher kilometres travelled per unit of energy) and can be supplied easily with renewable energy, both as distributed generation with renewables rises and as electricity systems gradually integrate higher renewable energy shares.<sup>86</sup> (→ See *Systems Integration chapter*.) Although policy maker attention to EVs has increased in recent years, policies and targets for EVs rarely include a direct link to renewable electricity; meanwhile, the number of countries with biofuel blend mandates has levelled off in recent years (standing at 70 countries since 2017).<sup>87</sup>

The worldwide EV market has grown dramatically in recent years, with the global stock of passenger EVs surpassing 7 million in 2019.<sup>88</sup> Nevertheless, the rise in renewable energy use related to EV deployment remains a slow process, due to the need to both shift the vehicle fleet and to install charging stations that are either directly linked to renewable electricity or planned in parallel with shares of renewables in electricity generation.<sup>89</sup>

FIGURE 60. Avoid-Shift-Improve Framework in the Transport Sector



Note: Transport demand management refers to encouraging travelers to avoid trips or shift to more resource-efficient options to limit vehicle traffic. Mixed-use development refers to having more than one use or purpose within a building or development area, ranging from housing on upper floors of a building and office or commercial space on the ground floor, to comprehensive developments with multiple buildings having separate but compatible uses. Transit-oriented development refers to mixed urban development around or near a transit station to reduce the need for motorised trips.

Source: See endnote 85 for this chapter.





## CO-OPERATIVE RENEWABLE ENERGY CAMPAIGNS, MAURITIUS



In Mauritius, a coalition of groups formed the People's Cooperative Renewable Energy Society in 2013 and launched a Power Shift Campaign to accelerate the transition to renewables. The campaign challenges the privately owned, non-renewable sector by providing co-operative solar energy alternatives that unemployed farmers can use to power greenhouses and improve local food production. The campaign's actions led to the cancellation of plans for a new coal plant, and have improved government transparency by pushing for the creation of a national commission to review Mauritius' energy policies.



# 08

## FEATURE: PUBLIC SUPPORT FOR RENEWABLES

### KEY FACTS

- The extent to which renewables gain public support and are able to attract adequate private or public investment is key to their further uptake.
- Although individuals and some groups have expressed concerns about specific renewable energy projects, opinion polls indicate strong public support for the growth of renewables.
- Governments have sought to improve public participation, strengthen regulatory control and share economic benefits with host communities to further build citizen support for renewable energy projects.

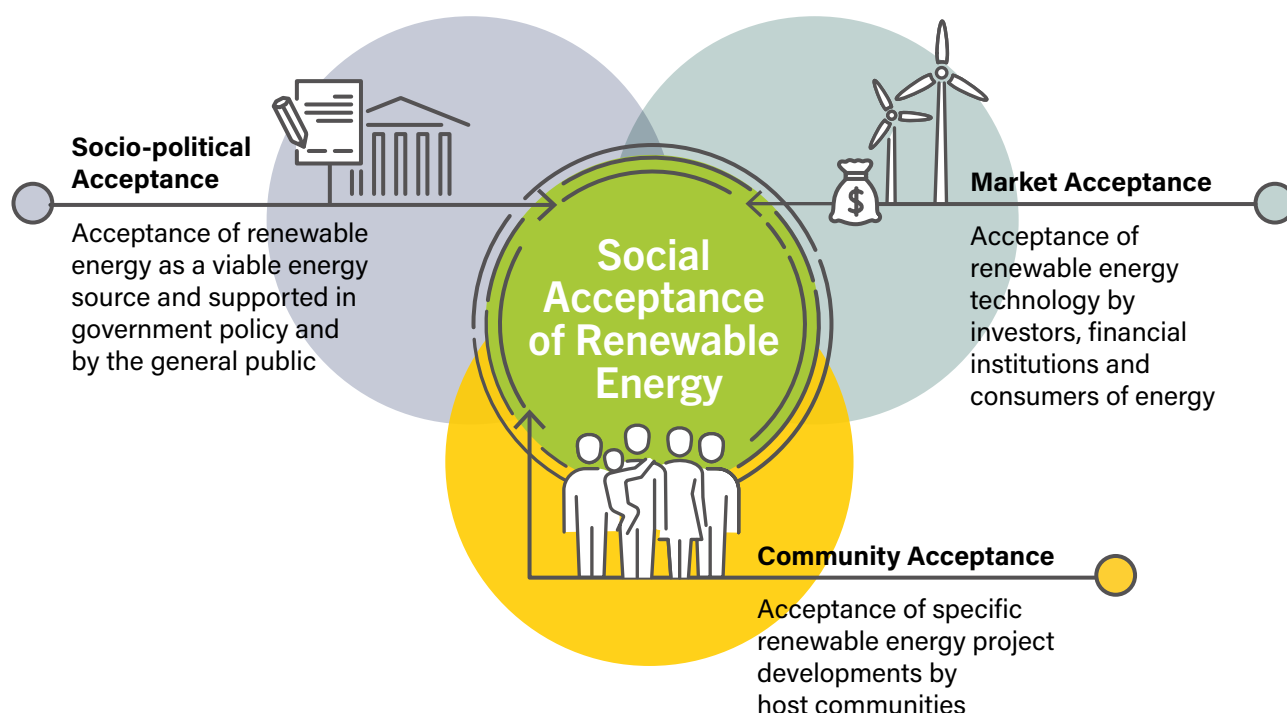
**A** complex array of technological, economic, environmental and social factors can affect the extent and pace of renewable energy deployment. However, also critical is how these technologies are perceived by society. In 2019, global climate strikes and opinion polls revealed rising public demand for a shift away from fossil fuels; at the same time, opposition from local communities limited the implementation of renewable energy projects in some regions. The extent to which renewables gain public support<sup>i</sup> and are able to attract adequate private or public investment is a key factor in increasing their deployment. Consideration of the range of reactions related to the public response to renewables can help build support for these technologies and ultimately encourage broader inclusion and participation.

Although the views of local communities are an important factor in the uptake of renewables, they are only one part of a broader condition of social acceptance of renewables that also includes market and socio-political dimensions.<sup>1</sup> (→ See Figure 61.) Each of these three dimensions can influence the overall acceptability of renewable energy, and each has the potential to stimulate a virtuous or detrimental cycle of support or opposition. Rather than looking at public support for renewables solely through the lens of concepts such as “NIMBYism”<sup>ii</sup> (→ See Box 1), a more holistic approach includes community engagement, financial measures, political leadership and market confidence.<sup>2</sup>

i For the purposes of this chapter, “public” is defined, in most cases, as all citizens/residents and does not include specific private or state energy interests or non-governmental organisations; the public often is distinguished from those most directly affected by energy projects, which are referred to here as “host communities”.

ii NIMBY (“Not In My Backyard”) and NIMBYism refer to the behaviour of a person or group of people that objects to a development project (such as a renewable energy plant) being built near to where they live.

**FIGURE 61.** Dimensions of Social Acceptance of Renewable Energy



Source: See endnote 1 for this chapter.

Many of the factors that shape the rate and nature of renewable energy uptake depend on local, regional and national contexts. They also include issues such as the availability of renewable resources (such as solar and wind energy), environmental constraints (such as settlement patterns or protected landscapes), political conditions, planning and environmental governance, and procurement and financial arrangements.<sup>3</sup> Likewise, the extent and features of public support vary depending on demographics, socio-economic characteristics and the local/national context, which can be influenced by a complex set of issues.<sup>4</sup>



## FACTORS BEHIND PUBLIC SUPPORT FOR RENEWABLES

### LANDSCAPE OF REACTIONS TOWARDS RENEWABLE ENERGY

Although individuals may express concerns about specific renewable energy projects, the public generally has shown support for renewables based on the multiple benefits that these technologies provide.<sup>5</sup> For example, people may recognise that renewable energy brings health improvements (through reduced pollution), greater energy reliability and resilience, increased energy security, climate change mitigation and the alleviation of energy poverty.<sup>6</sup> In specific locations, residents may appreciate the job creation and other economic opportunities that come from renewables, which are necessary for an inclusive and just energy transition.<sup>7</sup> (→ See Sidebar 2.)

In the past few years, opinion polls have consistently indicated strong public support for the expansion of renewables. In a 2019 survey in the European Union (EU-28), 90% of respondents agreed that the region should encourage greater investment in renewable energy, and participants showed widespread support for all renewable technologies.<sup>8</sup> A poll in Indonesia, Pakistan, the Philippines, South Africa, Turkey and Vietnam identified a strong preference (61-89%) for “clean energy”, with solar power receiving the highest positive responses.<sup>9</sup> Strong preferences for renewables also are visible in Australia, Canada, France, Switzerland and the United States.<sup>10</sup> Meanwhile, in a 2017 survey of more than 26,000 people across 13 countries in Asia Pacific,

### BOX 1. Social Acceptance and NIMBYism

Often, local disputes about proposed development projects, including new renewable energy infrastructure, are associated with the concept of NIMBY, or “Not In My Backyard”. The term is used to imply that individuals opposing a development are acting out of self-interest – in other words, while they may recognise the benefits of the infrastructure (implied by societal support for technologies, climate response, etc.), they do not want projects sited close to their residences because of perceived impacts and costs to themselves.

Many studies, however, assert that the NIMBY label is unhelpful, pejorative and a myth. The concept is criticised for failing to explore the actual motivations of individuals opposing a development, the strong influence of wider institutional arrangements for regulating such developments and the value of competing concepts such as attachment to place. The term NIMBY also is “weaponised”, as it implies that any objection to a proposed project is due to the irrational and selfish attitude of host communities, rather than to issues related to project design or the decision-making process. Thus, use of the term allows developers and regulators to displace responsibility for community acceptance.

In some cases, the use of “NIMBY” can increase conflict over proposed developments, as the host community often deeply resents the implication that a dispute over a project is because of them. This outcome can reduce the conditions for effective dialogue and community engagement, which have been shown to offer more effective responses to such situations.

Source: See endnote 2 for this chapter.



Europe and North America, 82% of respondents – independent of age, education and political ideology – believed that it was important to create a world “fully powered” by renewable energy.<sup>11</sup>

Despite this support, many individual renewable energy projects – including wind, solar, bioenergy, geothermal and hydropower plants – still face opposition from local host communities. This creates an apparent “**social gap**” between strong overall support for renewables and the disapproval with specific proposed projects expressed at a local level.<sup>12</sup> Although the social gap varies depending on the context, project scale and type of technology being deployed, policy makers are faced with the challenge of developing an appropriate response to this gap. To better understand the nature of public support for (or opposition to) renewable energy projects at the local, national and global levels, the public’s reaction has to be considered within the wider context of public engagement with energy and related issues, including climate action.<sup>13</sup>

Public engagement with renewables reflects a broad continuum – from collective mass movements to individual action – and it can either align or conflict with wider energy objectives. The landscape of social responses to renewables illustrates a wide range of aspirations and motivations, including concerns about technologies, projects or processes; visions for the future; and/or inertia and resistance to change. Reactions can range from apathy to “strongly against” or “strongly in favour”, and can occur at scales from a societal level (for example, global climate action) to a local level (relating to individual projects).

At a **societal level**, global climate strikes and litigation often are aligned with implicit support for renewable energy. During 2019, millions of people participated in international strikes and protests in more than 4,500 locations across 150 countries, demanding political action on climate change.<sup>14</sup> In addition, more than 1,300 climate lawsuits were filed around the world between 1990 and 2019 to oppose the ongoing reliance on fossil fuels, representing civil society efforts to hold companies and governments accountable for supporting activities that exacerbate the climate challenge.<sup>15</sup> Most of these disputes – which arose not just in the United States (where they have been most common) but increasingly in Asia, Europe and Latin America – target national governments, but some also target private companies for their contribution to climate change.<sup>16</sup>

At the same time, public reactions at a societal level can hinder the development of renewables, particularly when perceptions of unfairness or a lack of transparency lead people to oppose these technologies. In France and Iran, protests emerged in late 2018 and 2019, respectively, against government energy policies that disproportionately impacted lower-income households and adversely affected living standards.<sup>17</sup> Fuel taxation efforts in France, for example, may have stimulated negative public perception of environmentally driven policies and projects, a response that manifested in the so-called yellow vest protests.<sup>18</sup> In Canada, the implementation of carbon taxes (which generally lead to net economic benefits) also triggered ideological opposition, resulting in the election of provincial governments that rejected renewable energy policies and projects.<sup>19</sup>

Industry actions can lead to opposition to renewables as well, for example if companies lack transparency or engage in real or perceived violations of human rights, labour rights, (indigenous) land rights and others.<sup>20</sup>

The neglect of socially responsible and ethical practices in renewable energy manufacturing and project development could result in broad societal opposition to the industry, diminishing the prospects of renewables in certain regions as well as globally.<sup>21</sup>

At the **local level**, movements for energy sufficiency and conservation<sup>i</sup> have spread around the world since the early 2000s, as both community energy projects and the number of prosumers<sup>ii</sup> continue to grow. In Australia, Europe, and North America, and increasingly in Asia and Latin America, communities have established “transition towns” aimed at boosting energy self-sufficiency (often through renewables) to counter the effects of climate change and economic instability.<sup>22</sup>

Although community energy initiatives have existed since the mid-19th century, it was not until the late 1970s that these efforts became more associated with modern renewables, beginning in Denmark. (→ See *Feature chapter in GSR 2016*.) On the Danish island of Samsø, for example, community financial participation has played a major role in the development of renewable energy sources.<sup>23</sup>

At the same time, host communities may be sceptical of, or oppose, certain forms of infrastructure development (transport, commercial and even residential) because of the perceived

Opinion polls have consistently indicated **strong public support** for the expansion of renewables.



impacts on the character of a neighbourhood or landscape.<sup>24</sup> Renewable energy projects in particular may trigger concerns because of their proposed locations – for example, wind projects sited on relatively untouched landscapes, or the presence of multiple dispersed renewable energy projects within a host community (as opposed to a single large, thermal (e.g., fossil fuel) power station that is typically out of sight).

The term “NIMBYism” has been used to depict opposition by individuals or grassroots organisations to local renewable energy projects; however, this type of dissent commonly reflects ineffective consent-building and project development processes, rather than any ideological objection by locals.<sup>25</sup> Still, such opposition has taken root against many different types of renewable energy projects, including geothermal, wind, solar, hydropower and production of biofuels.<sup>26</sup> Over the last decade, there has been a growing recognition that effectively engaging local communities around renewable energy projects is critical for gaining sufficient public support, and necessary for larger objectives of decarbonising the energy supply.

## INFLUENCING FACTORS AND THE ROLE OF STAKEHOLDERS

A wide range of complex and inter-related **factors** can influence the public's perception of local or regional renewable energy projects, often based on different perceptions of justice.<sup>27</sup> These could be generalised as follows:

- *Concerns about health and environmental impacts.* Potential impacts include the noise or shadow flicker from wind energy projects, emissions from bioenergy or geothermal plants, the disruption of landscapes, land acquisitions and impacts on biodiversity. To respond to concerns about environmental justice, some of these impacts can be ameliorated through effective project design, planning regulations and other environmental safeguards.
- *Perceptions of the distribution of economic costs and benefits.* Some local communities have expressed concerns that renewable energy project developers are securing economic gain at the expense of local amenities, farming or fishing assets, or residential property values. Responses to these concerns have included the creation of community benefit funds, local procurement and employment policies, and encouraging community investment in a project to create a sense of distributive justice.
- *Perceived fairness of the consenting process.* Some communities have argued that decision making for renewable energy projects has not been transparent or that public engagement has not been appropriate. In such cases, more effective community engagement, information giving and openness can help to create a better atmosphere of trust and generate a sense of procedural justice.

i See Energy Efficiency chapter and Glossary.

ii A prosumer, in the context of the energy sector, is an individual or entity that both generates and consumes energy. Many different categories of prosumers exist, including residential, commercial and industrial scale, but the most common is homeowners who install solar PV on their rooftops. See Systems Integration chapter and Glossary.



These factors are managed and perceived differently by the range of key **stakeholders** in the energy system. Among the stakeholders that have crucial roles in the social acceptance of renewable energy are national governments, cities and municipal regulatory bodies, developers, energy trade bodies and host communities.

- *National governments* are responsible for meeting overall energy goals, including renewable energy targets. They are central to fostering socio-political and market acceptance of renewables by being primarily responsible for setting strategic policy directions, aligning energy policy with other objectives, and deploying financial instruments to support renewable energy and enabling technology uptake. National governments also frame the standards and regulatory arrangements around renewable energy projects, which play a critical role in community acceptance. In some countries, state or provincial governments can have a similar supporting role.
- *Municipalities and other regulatory bodies* often are responsible for local consenting permits (such as planning permissions) and planning policy, and for ensuring that the environmental and socio-economic impacts of projects are minimised. In some cases, these bodies have the capacity to develop economic instruments, which some have used to bring energy under local democratic control.<sup>28</sup>
- *Developers* have the ability to propose high-quality projects at appropriate sites and to act with transparency and integrity towards host communities.
- *Energy trade bodies* have a critical role in ensuring effective standards across the renewable energy sector, issuing guidance and protocol, and sharing best practices.
- *Host communities* can be given the capacity to participate appropriately in consenting and engagement processes. Through such engagement, they can articulate their concerns about projects in their communities and better ensure that their perspectives and needs are taken into account.



## LEVERS TO BUILD PUBLIC SUPPORT AND ENCOURAGE ACTION

As governments have become aware of the impacts that community concerns can have on renewable energy development, they have sought to pursue more effective responses. These include improving public participation, strengthening regulatory control (such as through more detailed planning policy) and making efforts to better share the economic benefits with host communities (for example, through benefit funds, local share offers and community-run energy projects).

Around the world, a wide range of initiatives seek to advance citizen support for renewables, including awareness campaigns, policy and regulatory measures, and new approaches to participation, control and ownership<sup>i</sup>.

### AWARENESS CAMPAIGNS

Campaigns to **raise awareness about renewable energy technologies** are important measures to build citizen support and have been employed widely in recent years, often at the national level. Such campaigns typically aim not just to increase awareness, but also to **encourage changes in energy use** and "climate-friendly" behaviour. For example, a national energy transition awareness project in Mauritius aims to increase the presence of women in the renewable energy sector, and the Netherlands' Save Energy Now! campaign encourages residents to increase energy efficiency at home and to install rooftop solar PV and other domestic renewables.<sup>29</sup> Some campaigns target a global audience: for example, the Global Bioenergy Partnership aims to both facilitate the development of bioenergy and raise awareness of the technology worldwide.<sup>30</sup>

Governments also can raise awareness of the benefits of renewables and energy efficiency by making **declarations on the "climate emergency"** or "climate crisis". Such declarations have become more frequent in recent years and often are combined with efforts to reduce reliance on fossil fuels. In November 2019, the EU declared a climate emergency and emphasised the need to reduce greenhouse gas emissions and phase out fossil fuel subsidies in the region by 2050.<sup>31</sup> As of April 2020, at least 1,490 jurisdictions in 29 countries worldwide, covering a total population of 822 million, had issued climate emergency declarations.<sup>32</sup>

In addition, many non-governmental organisations have initiated campaigns to raise awareness about climate change, stressing the urgent need for a renewable energy transition. Numerous student-led groups and other campaigns have called on corporations, governments and others to divest from fossil fuels.<sup>33</sup> In late 2019, Greenpeace Australia launched REenergise, one of its biggest campaigns yet, to address carbon dioxide emissions in Australia and to urge the country's largest energy-consuming companies to switch to 100% renewable electricity use.<sup>34</sup>

<sup>i</sup> This chapter provides examples of only a small selection of initiatives; a more extensive list can be found in the GSR 2020 data pack at [www.ren21.net/GSR](http://www.ren21.net/GSR).

## POLICIES IMPACTING PUBLIC ENGAGEMENT WITH RENEWABLES

A range of public bodies have adopted policies and other regulatory measures that enable civic and market actors to engage in the development and procurement of renewable energy. These include efforts designed to encourage energy efficiency, new forms of energy ownership and "green consumerism"<sup>i</sup> to help achieve national, state and local climate and energy targets, based on complex market incentives and measures to encourage grassroots development of renewables.

**Feed-in tariff (FIT) schemes** have been conducive to renewable energy development not only at a large scale but also at the community and residential levels.<sup>35</sup> Such efforts have involved households, small and medium-sized businesses, energy co-operatives and municipalities, with benefits for energy democracy, citizen participation and social acceptance of renewables.<sup>36</sup> Since the early 2010s, however, interest has shifted away from FITs and towards competitive tendering schemes such as auctions, as a way to improve cost effectiveness and increase control over renewable capacity levels, although FITs remain in place in 87 countries.<sup>37</sup> (→ See *Policy Landscape chapter*.) The introduction of auctions has tended to favour large-scale developers and to disadvantage citizen-driven initiatives seeking to participate in ongoing decarbonisation efforts.<sup>38</sup>

Both Ireland and Germany have put in place measures to encourage **community ownership** of renewable energy as a means to retain stakeholder diversity, wider public engagement and citizen support.<sup>39</sup> Similarly, governments can enable the growth of renewable energy **prosumers** through grid integration, peer-to-peer models and prosumer community groups.<sup>40</sup> Consumers also can be encouraged to purchase renewable energy as part of more conventional **electricity contracts**: "green power programmes" are now offered in Australia, Canada, Denmark, Finland, France, Germany, the Netherlands, Slovenia, Sweden and the United

States, among others, and "green electricity" certification schemes are offered by many companies, such as Blue Energy (Slovenia), Eesti Energi (Estonia), EKOenergy (Finland), Green-e (United States) and Nanoenergies (Czech Republic).<sup>41</sup>

By necessity, a transition towards more renewable energy means phasing out high-carbon industries that rely on fossil fuels, including coal mining and oil and gas extraction. However, this shift may impact regional economies and communities that depend heavily on such industries, resulting in opposition to initiatives and projects – such as renewable energy developments – that displace these sectors. **Ensuring a "just" energy transition** is central to the wider objectives of a sustainable economy.<sup>42</sup> The EU's Green Deal, for example, includes a Just Transition Fund aimed at guaranteeing a fair allocation of impacts and equitable distribution of benefits of its climate plans; similar efforts have emerged in Spain, Ireland and among US philanthropic institutions.<sup>43</sup>

In some countries, it has become common for developers to establish some form of **benefits package for local communities**, whether through a fund for local community projects, education bursaries or discounts on electricity bills. The United Kingdom's Coastal Communities Funds give a percentage of state royalties from offshore wind energy to adjacent coastal areas.<sup>44</sup> These "passive" forms of financial participation are becoming increasingly formalised and institutionalised.<sup>45</sup> For example, Scotland has a searchable register of community benefits packages associated with wind power projects, with the aim of increasing fairness and transparency, and in 2009 Denmark introduced a compulsory option-to-purchase share scheme that requires developers of wind energy projects to offer a proportion of investment in the project to the local community.<sup>46</sup>



Awareness campaigns, supporting policies, and new forms of participation, control and ownership further **build citizen support** for renewables.

<sup>i</sup> Green consumerism refers to the willingness of consumers to purchase goods that have been produced in a manner that protects the natural environment, such as from renewable energy.

## PUBLIC PARTICIPATION, CONTROL AND OWNERSHIP

The distributed nature of many new renewable energy projects has shifted the scale and geography of energy generation, creating new opportunities for more dispersed patterns of ownership and control of energy production.<sup>47</sup> This has given rise to the concept of **energy democracy**, which covers different aspects of renewable energy – from “good governance” and public consultation in policy making (such as Citizen Assemblies or civil society movements for decarbonisation, for example the Mauritian Power Shift Plan) to more widespread civil society ownership and control of energy infrastructure.<sup>48</sup>

Greater democratic engagement in energy systems increases social acceptance and can lead to more equitable socio-economic outcomes.<sup>49</sup> The movement for energy democracy has many disparate and contested goals and instruments.<sup>50</sup> In developing countries, for example, narratives remain focused on issues such as energy justice or energy sovereignty.<sup>51</sup>

The opportunities for community participation in renewable energy have been expressed in many different ways. For example, efforts to ensure stakeholder engagement throughout the life cycle of a renewable energy project are considered best practice as part of environmental impact assessments (EIAs) or environmental and social impact assessments (ESIAs). Examples of **extended participation processes** include the Stakeholder Engagement Plans for the Baikonur Solar Power plant in Kazakhstan and the Sebzor Hydropower Plant Project in Tajikistan.<sup>52</sup> In many jurisdictions, stakeholder engagement is mandatory: Ireland’s proposed Renewable Electricity Support Scheme includes provisions on how communities should be consulted during project development, and in Victoria, Australia proof of community engagement is required as part of the 2017 renewable energy auction scheme.<sup>53</sup>

Although the private sector plays a strong role in driving renewable energy projects in many parts of the world, public bodies, particularly municipalities, have assumed more direct involvement in energy projects. In some cases, public ownership is considered an instrument for energy democratisation, because of the accountability that elected officials have towards citizens and their mandate to protect the public interest. Between 2005 and 2019, some 374 processes to re-municipalise energy generation and supply were undertaken across 19 countries.<sup>54</sup>

**Re-municipalisation**<sup>ii</sup> often is a result of grassroots activity and engagement.<sup>55</sup> Communities also have become more directly engaged in the ownership of energy. **Community ownership** implies a high level of control and allows local residents to maximise economic benefits. Locally owned energy co-operatives involve various technologies and have burgeoned across diverse geographies, from the El Cuá community hydropower project in Nicaragua to the Aran Islands Energy Co-operative in Ireland.<sup>56</sup>














Some models of ownership have wider definitions of community. In Japan, more than 200 open shareholder models, which are not restricted to a specific geographic area, provide over 70 megawatts of renewable power.<sup>57</sup> In Costa Rica, four regional co-operatives distribute and transmit electricity to rural areas that were not being serviced by the state or private companies, covering a geographical area representing 9% of the national territory.<sup>58</sup>



i EIAs/ESIAs are usually required under legislation before consent is granted for construction and are sometimes a condition attached to receipt of project finance from financial institutions; however, the quality of engagement and consultation varies widely in practice.

ii Re-municipalisation refers to efforts by citizens or cities to reverse the privatisation of local services such as water provision, waste collection and management services, and energy generation and distribution through local or municipally owned utility companies. See REN21’s *Renewables in Cities 2019 Global Status Report* at [www.ren21.net/cities](http://www.ren21.net/cities).

■ TABLE R1. Global Renewable Electricity Capacity, Heat Demand and Biofuel Production, 2019

Power Capacity (GW)	Change in 2019	Existing at End-2019
 Bio-power	8.3	139
 Geothermal power	0.7	13.9
 Hydropower	15.6	1,150
 Ocean power	~0	0.5
 Solar PV <sup>a</sup>	115	627
 Concentrating solar thermal power (CSP)	0.6	6.2
 Wind power	60	651
Heat Demand (EJ)	Change in 2019	Consumption in 2019
 Modern bio-heat	0.2	14.1
 Geothermal direct use <sup>b</sup>	<0.1	0.4
 Solar hot water <sup>c</sup>	~0	1.4
Transport Fuel Production (billion litres per year)	Change in 2019	Production in 2019
 Ethanol	3	114
 Biodiesel (FAME)	1.4	47
 Biodiesel (HVO)	0.5	6.5

<sup>a</sup> Solar PV data are provided in direct current (DC).

<sup>b</sup> Data do not include heat pumps.

<sup>c</sup> Data do not include air, PV-thermal or concentrating collectors.

Note: Annual capacity additions are net. Values are rounded to the nearest full number, with the exceptions of numbers <15, which are rounded to the first decimal point, and transport fuels; where totals do not add up, the difference is due to rounding. Rounding is to account for uncertainties and inconsistencies in available data. Capacity amounts of <50 MW (including pilot projects) and heat consumption <0.01 EJ are designated by “~0”. FAME = fatty acid methyl esters; HVO = hydrotreated vegetable oil. For more precise data, see Reference Tables R13-R19, Market and Industry chapter and related endnotes.

Source: See endnote 1 for this section.



■ TABLE R2. Renewable Power Capacity, World and Top Regions/Countries<sup>a</sup>, 2019

Technology	World Total	BRICS <sup>b</sup>	EU-28	China	United States	India	Germany	Japan	United Kingdom
	GW			GW					
 Bio-power	139	48	44	22.5	16.0	10.8	8.9	4.3	7.9
 Geothermal power	13.9	0.1	0.9	~0	2.5	0	~0	0.6	0
 Hydropower	1,150	530	131	326	80	45	5.6	22	1.9
 Ocean power	0.5	0	0.2	0	0	0	0	0	~0
 Solar PV <sup>c</sup>	627	256	132	205	76	43	49	63	13.4
 Concentrating solar thermal power (CSP)	6.2	1.1	2.3	0.4	1.7	0.2	0	0	0
 Wind power	651	292	192	236	106	38	61	3.9	24
<b>Total renewable power capacity (including hydropower)</b>	<b>2,588</b>	<b>1,127</b>	<b>502</b>	<b>790</b>	<b>282</b>	<b>137</b>	<b>124</b>	<b>94</b>	<b>47</b>
<b>Total renewable power capacity (not including hydropower)</b>	<b>1,438</b>	<b>597</b>	<b>371</b>	<b>464</b>	<b>202</b>	<b>92</b>	<b>119</b>	<b>72</b>	<b>45</b>
<b>Per capita capacity (kilowatts per inhabitant, not including hydropower)</b>	<b>0.2</b>	<b>0.2</b>	<b>0.7</b>	<b>0.3</b>	<b>0.6</b>	<b>0.1</b>	<b>1.4</b>	<b>0.6</b>	<b>0.7</b>

<sup>a</sup> Table shows the top six countries by total renewable power capacity not including hydropower; if hydropower were included, countries and rankings would differ (the top six would be China, the United States, Brazil, India, Germany and Canada).

<sup>b</sup> The five BRICS countries are Brazil, the Russian Federation, India, China and South Africa.

<sup>c</sup> Solar PV data are in direct current (DC). See Solar PV section in Market and Industry chapter and Methodological Notes for more information.

Note: Global total reflects additional countries not shown. Numbers are based on the best data available at the time of production. To account for uncertainties and inconsistencies in available data, numbers are rounded to the nearest 1 GW, with the exception of the following: capacity totals below 20 GW and per capita totals are rounded to the nearest decimal point. Where totals do not add up, the difference is due to rounding. Capacity amounts of <50 MW (including pilot projects) are designated by "~0". For more precise capacity data, see Global Overview and Market and Industry chapters and related endnotes. Numbers should not be compared with prior versions of this table to obtain year-by-year increases, as some adjustments are due to improved or adjusted data rather than to actual capacity changes. Hydropower totals, and therefore the total world renewable capacity (and totals for some countries), reflect an effort to omit pure pumped storage capacity. For more information on hydropower and pumped storage, see Methodological Notes.

Source: See endnote 2 for this section.

■ TABLE R3. Renewable Energy Shares of Primary and Final Energy, Targets as of End-2019 and Status in 2018

Note: Text in **bold** indicates new/revised in 2019, and text in *italics* indicates mandates adopted at the state/provincial level.

Country	Primary Energy		Final Energy	
	Target	Status in 2018 <sup>a</sup>	Target	Status in 2018 <sup>a</sup>
EU-28		13.3%	→ 20% by 2020 → 32% by 2030	18.9%
Afghanistan			→ 10% <sup>b</sup>	8.8%
Albania	→ 18% by 2020	34.4%	→ 38% by 2020	34.9%
Angola	→ 7.5% by 2025			4.4%
Armenia	→ 21% by 2020 → 26% by 2025	12.4%		6.4%
Austria <sup>c</sup>		30.1%	→ 45% by 2020	33.4%
Bangladesh		24.8%	→ 10% by 2020 <sup>d</sup>	0.2%
Belarus		5.5%	→ 32% by 2020	6.8%
Belgium	→ 9.7% by 2020	6.7%	→ 13% by 2020	9.4%
<i>Wallonia</i>			→ 20% by 2020	
Benin		59.6%	→ 25% by 2025 <sup>d</sup>	8.8%
Bosnia and Herzegovina		24.9%	→ 40% by 2020	8.9%
Brazil		40.3%	→ 45% by 2030 → 81% by 2029	43.3%
Brunei Darussalam			→ 10% by 2035	0.1%
Bulgaria <sup>c</sup>		10.7%	→ 16% by 2020 → 27% by 2030	20.5%
Burundi			→ 2.1% by 2020	2.6%
Canada		17.4% (2016)		17.4% (2016)
China <sup>e</sup>	→ 15% by 2020 → 20% by 2030	8.4%		7.8%
Chile			→ 20% by 2024 <sup>d</sup>	21%
Côte d'Ivoire	→ 15% by 2020 → 20% by 2030	3%		7.6%
Croatia		23.3%	→ 20% by 2020 → <b>36.4% by 2030</b>	28%
Cuba				19.3%
Cyprus		7.3%	→ 13% by 2020	13.9%
Czech Republic <sup>c</sup>		10.5%	→ 13.5% by 2020	15.1%
Denmark		30%	→ 35% by 2020 → 100% by 2050	36.1%
Djibouti	→ 17% by 2035			
Egypt	→ 14% by 2020	3.8%	→ 25% by 2020	4%
Estonia		17.6%	→ 25% by 2020	30%
Fiji			→ 23% by 2030	30.1%
Finland		31.2%	→ 38% by 2020 → 40% by 2025 <sup>c</sup>	41.2%
France		9.6%	→ 23% by 2020 → 33% by 2030	16.6%
Gabon		76.7%	→ 80% by 2020	60.1%
Germany <sup>c</sup>		13.8%	→ 18% by 2020 → 30% by 2030 → 45% by 2030 → <b>65% by 2030</b>	16.5%
Ghana		42.5%	→ Increase 10% by 2030 (base year 2010)	13.5%

■ TABLE R3. Renewable Energy Shares of Primary and Final Energy, Targets as of End-2019 and Status in 2018 (continued)

Note: Text in **bold** indicates new/revised in 2019, and text in italics indicates mandates adopted at the state/provincial level.

Country	Primary Energy		Final Energy	
	Target	Status in 2018 <sup>a</sup>	Target	Status in 2018 <sup>a</sup>
Greece <sup>c</sup>		12.1%	→ 20% by 2020 → <b>35% by 2030</b>	18%
Grenada	→ 20% by 2020			0.7%
Guatemala		63%		
Guinea			→ 30% by 2030	2.4%
Guinea-Bissau				7.8%
Guyana			→ 20% by 2025	20.8%
Hungary <sup>c</sup>		11.5%	→ 14.65% by 2020	12.5%
Iceland		89.5%	→ 64% by 2020	77%
India			→ 40% by 2030	9.9%
Indonesia	→ 23% by 2025 → 31% by 2050	13%		6.2%
Ireland		7.9%	→ 16% by 2020	11.1%
Israel		2.4%	→ 13% by 2025 → 17% by 2030	3.7%
Italy		17.4%	→ 17% by 2020	17.8%
Jamaica		18.6%	→ 20% by 2030	7.5%
Jordan	→ 10% by 2020	16%	→ 15% by 2025	2.8%
Korea, Republic of	→ 6.1% by 2020 → 11% by 2030	1.7%		2.7%
Kosovo <sup>f</sup>			→ 25% by 2020	24.9%
Lao PDR		80%	→ 30% by 2025 <sup>d</sup>	23.4%
Latvia		39.1%	→ 40% by 2020	40.3%
Lebanon			→ 12% by 2020 → 15% by 2030	1.6%
Liberia	→ 30% by 2030	5%	→ 10% by 2030	73.8%
Libya	→ 10% by 2020			
Lithuania	→ 20% by 2025	19.6%	→ <b>45% by 2030</b>	24.4%
Luxembourg		5.6%	→ 11% by 2020	9.1%
Macedonia, North		15.7%	→ 28% by 2020	18.1%
Madagascar			→ 54% by 2020 <sup>d</sup>	38.6%
Malawi	→ 7% by 2020			47.3%
Mali	→ 15% by 2020			4.3%
Malta		3.2%	→ 10% by 2020	8%
Mauritania	→ 20% by 2020			1.1%
Moldova	→ 20% by 2020	10.3%	→ 17% by 2020	14.3%
Mongolia	→ 20-25% by 2020	3.2%		1.4%
Montenegro		30.6%	→ 33% by 2020	38.8%
Nepal	→ 10% by 2030 <sup>d</sup>	84.1%		6.4%
Netherlands <sup>c</sup>		4.9%	→ 14% by 2020	7.4%
Niger	→ 10% by 2020 <sup>d</sup>	74.7%		
Norway		49.2%	→ 67.5% by 2020	72.8%
Palau	→ 20% by 2020			
Palestine, State of	→ 20% by 2020		→ 25% by 2020	4.4%
Panama	→ 30% by 2050	21.1%		16.4%
Philippines		30%		

■ TABLE R3. Renewable Energy Shares of Primary and Final Energy, Targets as of End-2019 and Status in 2018 (continued)

Note: Text in **bold** indicates new/revised in 2019, and text in *italics* indicates mandates adopted at the state/provincial level.

Country	Primary Energy		Final Energy	
	Target	Status in 2018 <sup>a</sup>	Target	Status in 2018 <sup>a</sup>
Poland	→ 12% by 2020	8.5%	→ 15% by 2020	11.3%
Portugal		26.8%	→ 31% by 2020 → 47% by 2030	30.3%
Qatar			→ 25% by 2030	
Romania		18.7%	→ 24% by 2020	23.9%
Rwanda				8.2%
Samoa	→ 20% by 2030			4.8%
Serbia		13.1%	→ 27% by 2020	20.3%
Slovak Republic		9.7%	→ 14% by 2020	11.9%
Slovenia		16.8%	→ 25% by 2020	21.1%
Spain <sup>c</sup>		14.6%	→ 20% by 2020	17.4%
Sudan	→ 20% by 2020			24.7%
Sweden <sup>c</sup>			→ 49% by 2020	54.6%
Tajikistan		37%	→ 50% by 2020	44.6%
Tanzania	→ 24% by 2020	22.3%		19.8%
Thailand		19.2%	→ 25% by 2021 → 40% by 2035	14.4%
Togo		78.9%	→ 4% <sup>b</sup>	12.7%
Tonga				0.8%
Tunisia		78.9%		1.3%
Ukraine	→ 18% by 2030	3%	→ 11% by 2020 → 25% by 2035	1.9%
United Arab Emirates			→ 44% by 2050	
United Kingdom		8.2%	→ 15% by 2020	11%
Vanuatu			→ 65% by 2020	11%
Vietnam	→ 5% by 2020 → 8% by 2025 → 11% by 2050	0.28%		13.3%

<sup>a</sup> Status data are for 2018 unless otherwise noted.

<sup>b</sup> No date given.

<sup>c</sup> Final energy targets by 2020 for all EU-28 countries are set under EU Directive 2009/28/EC. The governments of Austria, the Czech Republic, Germany, Greece, Hungary, Spain and Sweden have set higher targets, which are shown in this table. The government of the Netherlands has reduced its more ambitious target to the level set in the EU Directive.

<sup>d</sup> Targets may exclude large-scale hydropower and/or traditional biomass. Large-scale hydropower generally is defined as more than 10 MW of installed capacity, but the definition may vary by country.

<sup>e</sup> The Chinese target is for share of "non-fossil" energy. All targets include nuclear power.

<sup>f</sup> Kosovo is not a member of the United Nations.

Note: Traditional biomass has been removed from share of final energy. Actual percentages are rounded to the nearest whole decimal for numbers over 10% except where associated targets are expressed differently. Historical targets have been added as they are identified by REN21. A number of nations have already exceeded their renewable energy targets. In many of these cases, targets serve as a floor setting the minimum share of renewable energy for the country. Some countries shown have other types of targets (→ See Reference Tables R4-R8). Some targets shown may be non-binding.

Source: See the REN21 GSR 2020 data pack online at [www.ren21.net/GSR](http://www.ren21.net/GSR).



■ TABLE R4. Renewable Heating and Cooling, Targets as of End-2019 and Status in 2017

Note: Text in **bold** indicates new/revised in 2019.

Country	Target	Status in 2017 <sup>a</sup>
<b>EU-28</b>	<b>1.3% annual increase in the share of renewable heat through 2030</b>	19.5%
Albania		24.9%
Austria	33% by 2020	32%
Belgium	11.9% by 2020	8.1%
Bhutan	Solar thermal: 3 MW equivalent by 2025	
Bulgaria	24% by 2020	30%
China	Solar thermal: 800 million m <sup>2</sup> by 2020	462.9 million m <sup>2</sup> (2016)
Croatia	19.6% by 2020	36.6%
Cyprus	23.5% by 2020	24.5%
Czech Republic	14.1% by 2020	19.7%
Denmark	39.8% by 2020	46.5%
	100% by 2050	
Estonia	38% by 2020	51.6%
Finland	47% by 2020	54.8%
	<b>10% of heating for construction machines and fitted motors from bio-based light fuel oil starting in 2021</b>	
France	38% by 2030	21.4%
Germany	14% by 2020	13.7%
Greece	20% by 2020	26.6%
	<b>30% by 2030 (60% domestic hot water from solar thermal systems)</b>	
Hungary	18.9% by 2020	19.6%
India	Solar water heating: 14 GW <sub>th</sub> (20 million m <sup>2</sup> ) by 2022	6.7 GW <sub>th</sub> (2016)
Ireland	15% by 2020	6.8%
Italy	171% by 2020	20%
	Bioenergy: 5,670 ktoe by 2020	6,320 ktoe
	Geothermal: 300 ktoe by 2020	207 ktoe (2016)
	Solar water and space heating: 1,586 ktoe by 2020	231.3 ktoe (2016)
Jordan	Solar water heating: 30% of households by 2020	882 MW <sub>th</sub> of solar thermal (2015)
Kenya	Solar water heating: 60% of annual demand for buildings that use more than 100 litres of hot water per day (voluntary/no date)	
Kosovo <sup>b</sup>	45.6% by 2020	50.5%
Latvia	53.4% by 2020	54.6%
Lebanon	15% renewables in gross final consumption in power and heating by 2030	
Libya	Solar water heating: 80 MW <sub>th</sub> by 2015; 250 MW <sub>th</sub> by 2020	
Lithuania	90% of district heating and cooling by 2030	46.5%
	80% of household-based heating and cooling by 2030	
Luxembourg	8.5% of gross final heating and cooling use by 2020	8.1%
Macedonia, North	11% by 2020	36.4%
Malawi	Solar water heating: produce 2,000 solar water heaters; increase total installed to 20,000 by 2030	
Malaysia	B10 in industrial sector by 2020 <sup>c</sup>	

■ **TABLE R4. Renewable Heating and Cooling, Targets as of End-2019 and Status in 2017 (continued)**

Note: Text in **bold** indicates new/revised in 2019.

Country	Target	Status in 2017 <sup>a</sup>
Malta	6.2% by 2020	19.8%
Mexico	Solar water heating: 18.2 million m <sup>2</sup> of collectors by 2027	3.4 million m <sup>2</sup>
Moldova	27% by 2020	
Montenegro	38.2% by 2020	67.5%
Morocco	Solar water heating: 1.2 GW <sub>th</sub> (1.7 million m <sup>2</sup> ) by 2020	316 MW <sub>th</sub> (2015)
Mozambique	Solar water and space heating: 100,000 rural systems (no date)	1 MW <sub>th</sub> of solar thermal (2015)
Netherlands	8.7% by 2020	5.9%
Poland	17% by 2020; emission standards for heating appliances in single-family homes banning use of coal and wood in 11 of 16 regions, 2022-2027	14.5%
Portugal	34% by 2020	41%
	38% by 2030	
	69-72% by 2050	
Romania	22% by 2020	26.6%
Serbia	30% by 2020	24.4%
Sierra Leone	Solar water heating: 2% in hotels, guest houses and restaurants by 2020, and 5% by 2030; 1% in the residential sector by 2030	
Slovak Republic	14.6% by 2020	9.8%
Slovenia	30.8% by 2020	33.2%
Spain	17.3% by 2020	17.5%
Sweden	62.1% by 2020	69%
Thailand	Bioenergy: 8,200 ktoe by 2022	6,573 ktoe
	Biogas: 1,000 ktoe by 2022	495 ktoe
	Organic municipal solid waste <sup>d</sup> : 35 ktoe by 2022	88 ktoe
	Solar water heating: 100 ktoe and 300,000 systems in operation by 2022	11.3 ktoe (2016)
Ukraine	12.4% by 2020	
United Kingdom	12% by 2020	7.5%
Uruguay	50% solar thermal water heating in certain types of non-residential buildings/refurbishments after 2014	

<sup>a</sup> Status data are for 2017 unless otherwise noted. Status and targets are for overall share of renewable heat unless otherwise noted.

<sup>b</sup> Kosovo is not a member of the United Nations.

<sup>c</sup> The Malaysia target is mandated for industry in general, not specifically for heating.

<sup>d</sup> It is not always possible to determine whether municipal solid waste (MSW) data include non-organic waste (plastics, metal, etc.) or only the organic biomass share.

Note: Targets and status refer to share of renewable heating and cooling in total energy supply unless otherwise noted. Historical targets have been added as they are identified by REN21. A number of countries have already exceeded their renewable energy targets. In many of these cases, targets serve as a floor setting the minimum share of renewable heat. Because calculation of heating and cooling shares is not standardised across countries, the table presents a variety of targets for the purpose of general comparison.

Source: See the REN21 GSR 2020 data pack online at [www.ren21.net/GSR](http://www.ren21.net/GSR).

■ TABLE R5. Renewable Transport, Targets as of End-2019 and Status in 2017

Note: Text in **bold** indicates new/revised in 2019 and text in *italics* indicates policies adopted at the state/provincial level.

Country	Target	Status in 2017 <sup>a</sup>	Country	Target	Status in 2017 <sup>a</sup>
<b>EU-28</b>	→ 10% of transport final energy demand by 2020 → 14% minimum share of renewable fuels for transport energy by 2030 (7% cap on share from conventional food and feed-based biofuels)	8.3%	Luxembourg	→ 10% by 2020	6.4%
Albania	→ 10% by 2020	13.4%	Macedonia, North	→ 2% by 2020	0.1%
Austria	→ 11.4% by 2020	9.7%	Malta	→ 10.7% by 2020	6.8%
Belgium	→ 10% by 2020	6.6%	Moldova	→ 20% by 2020	
<i>Wallonia</i>	→ 10.14% by 2020		Montenegro	→ 10.2% by 2020	1%
Bulgaria	→ 11% by 2020	7.2%	Netherlands	→ 10% by 2020	5.9%
Croatia	→ 10% by 2020	1.2%	Norway	→ 20% by 2020	19.7%
Cyprus	→ 10% by 2020	2.6%	Poland	→ 20% by 2020	4.2%
Czech Republic	→ 10.8% by 2020	6.6%	Portugal	→ 10% by 2020	7.9%
Denmark	→ 10% by 2020 → 100% by 2050	6.8%		→ 13% by 2025	
Estonia	→ 10% by 2020	0.4%		→ 20% by 2030 <sup>b</sup>	
Finland	→ 40% by 2030	18.8%	Qatar	→ 10% by 2020	
France	→ 15% by 2020	9.1%	Romania	→ 10% by 2020	6.6%
Germany	→ 10% by 2020	7%	Serbia	→ 10% by 2020	1.2%
Greece	→ 10.1% by 2020	14%	Slovak Republic	→ 10% by 2020	7%
Hungary	→ 10% by 2020	6.8%	Slovenia	→ 10.5% by 2020	2.7%
Iceland	→ 10% by 2020	7.2%	Spain	→ 10% by 2020	5.9%
India	→ 20% by 2030		Sri Lanka	→ 20% biofuels by 2020	
Ireland	→ 10% by 2020	7.4%	Sweden	→ Vehicle fleet independent from fossil fuels by 2030	38.6%
Italy	→ 10.1% (2,899 ktoe) by 2020	6.5%	Thailand	→ 9 million litres per day ethanol consumption by 2022	
Latvia	→ 10% by 2020	2.5%		→ 6 million litres per day bio-diesel consumption by 2022	
Liberia	→ 5% palm oil blends in transport fuel by 2030			→ 25 million litres per day advanced biofuel production by 2022	
Lithuania	→ 10% by 2020 → 15% by 2030	3.6%	Ukraine	→ 10% by 2020	
			United Kingdom	→ 10.3% by 2020	5.1%
			Vietnam	→ 5% of transport petroleum energy demand replaced by 2025	

<sup>a</sup> Status data are for 2017 unless otherwise noted.

<sup>b</sup> Excluding aviation and shipping

Note: Targets refer to share of renewable transport in total energy supply unless otherwise noted. Historical targets have been added as they are identified by REN21. A number of countries have already exceeded their renewable energy targets. In many of these cases, targets serve as a floor setting the minimum share of renewable energy for the country.

Source: See the REN21 GSR 2020 data pack online at [www.ren21.net/GSR](http://www.ren21.net/GSR).

■ TABLE R6. Renewable Share of Electricity Generation, Targets as of End-2019 and Status in 2018

Note: Text in **bold** indicates new/revised in 2019, brackets '[ ]' indicate previous targets where new targets were enacted, and text in *italics* indicates policies adopted at the state/provincial level.

Country	Target	Status in 2018 <sup>a</sup>	Country	Target	Status in 2018 <sup>a</sup>
EU-28	→ 57% by 2030	32.1%	<i>Nova Scotia</i>	→ 40% by 2020	
Afghanistan <sup>b</sup>	→ 100% by 2050	86.1%	<i>Saskatchewan</i>	→ 50% by 2030	
Algeria	→ 27% by 2030 → 22 GW by 2030	2% of installed capacity (2012)	Cabo Verde	→ 100% by 2025	25%
Antigua and Barbuda	→ 10% by 2020 → 15% by 2030		Chile	→ 70% by 2030	22.8% (2019)
Argentina	→ 12% by 2019 → 16% by 2021 → 18% by 2023 → 20% by 2025	2%	China	→ 35% by 2030	26.7%
Armenia	→ 40% by 2025	12%	<i>Hainan Province</i>	→ 80% by 2030 <sup>e</sup>	23% (2019)
Aruba	→ 100% by 2020		Chinese Taipei	→ 9% by 2020 → 20% by 2025	4.5%
Australia	→ 23% by 2020	19%	Colombia <sup>b</sup>	→ 70% by 2030 → 100% by 2050	
<i>Tasmania</i>		90% (2017)	Comoros <sup>b</sup>	→ 43% by 2030 → 100% by 2050	
<i>Australian Capital Territory</i>	→ 100% by 2025		Congo, Democratic Republic of the <sup>b</sup>	→ 100% by 2050	
<i>Northern Territory</i>	→ 50% by 2030		Congo, Republic of	→ 85% by 2025	
<i>Queensland</i>	→ 50% by 2030		Costa Rica	→ 100% by 2030	99.62% (2019)
<i>Victoria</i>	→ 25% by 2020 → 40% by 2025 → 50% by 2030		Côte d'Ivoire	→ 42% by 2020	
Austria	→ 70.6% by 2020	77%	Croatia	→ 39% by 2020	71%
Azerbaijan	→ 20% by 2020		Cuba	→ 24% by 2030	4%
Bahamas, The	→ 15% by 2020 → 30% by 2030		Cyprus	→ 16% by 2020	8%
Bahrain	→ 5% by 2025 → 700 MW by 2030 → 10% by 2035		Czech Republic	→ 14.3% by 2020	13.7% (2018)
Bangladesh <sup>b</sup>	→ 10% by 2020 → 100% by 2050		Denmark <sup>f</sup>	→ 50% by 2020 → 100% by 2050	76%
Barbados <sup>b</sup>	→ 65% by 2030 → 100% by 2050		Djibouti	→ 100% by 2020	
Belgium	→ 21% by 2020	20% (2018)	Dominica	→ 100% (no date)	
Belize	→ 85% by 2030	91%	Dominican Republic <sup>b</sup>	→ 25% by 2025 → 70% by 2030 → 100% by 2050	12%
Benin	→ 50% by 2025 (off-grid and rural)		Egypt	→ 20% by 2022 → 37-42% by 2035	
Bhutan <sup>b</sup>	→ 100% by 2050		Eritrea	→ [50% (no date)] → 70% by 2030	
Bolivia	→ 79% by 2030		Estonia	→ 17.6% by 2020	14%
Brazil <sup>c</sup>	→ 87% by 2026	83.3%	Ethiopia <sup>b</sup>	→ 100% by 2050	
Brunei Darussalam	→ 10% by 2035		Fiji	→ 100% by 2030	
Bulgaria	→ 16.7% by 2020	17%	Finland	→ 33% by 2020	44%
Burkina Faso <sup>b</sup>	→ 50% by 2025 → 100% by 2050		France	→ 40% by 2030	20%
Cambodia	→ 100% by 2025 [100% by 2035] [50% by 2020]		Gabon	→ 70% by 2020 → 80% by 2025	
Cameroon	→ 25% by 2035		Gambia <sup>b</sup>	→ 35% by 2020 → 100% by 2050	
Canada	→ no national target	65.19% <sup>d</sup>	Germany	→ 40-45% by 2025 → 55-60% by 2030 → 80% by 2050	38%
<i>Alberta</i>	→ 30% by 2030		Ghana <sup>b</sup>	→ 10% by 2020 → 100% by 2050	
<i>British Columbia</i>	→ 93% (no date)		Greece	→ 34.3% by 2020 → 63.54% by 2030	32%
<i>New Brunswick</i>	→ 40% by 2020		Grenada <sup>b</sup>	→ 100% by 2050	
			Guatemala <sup>b</sup>	→ 80% by 2030 → 100% by 2050	59%



■ TABLE R6. Renewable Share of Electricity Generation, Targets as of End-2019 and Status in 2018 (continued)

Note: Text in **bold** indicates new/revised in 2019, brackets '[']' indicate previous targets where new targets were enacted, and text in *italics* indicates policies adopted at the state/provincial level.

Country	Target	Status in 2018 <sup>a</sup>	Country	Target	Status in 2018 <sup>a</sup>
Guyana	→ 90% (no date)		Malaysia	→ 9% by 2020 → 20% by 2030	2%
Haiti <sup>b</sup>	→ 70% by 2030 → 100% by 2050		Maldives <sup>b</sup>	→ 100% by 2050	
Honduras <sup>b</sup>	→ 60% by 2022 → 70% by 2030 → 80% by 2038 → 100% by 2050	60% (2017)	Mali <sup>h</sup>	→ 25% by 2033	
Hungary	→ 10.9% by 2020		Malta	→ 3.8% by 2020	16%
Iceland	→ 100% by 2020		Marshall Islands <sup>b</sup>	→ 20% by 2020 → 100% by 2050	
India <sup>a</sup>	→ 10% by 2022	9.2%	Mauritania	→ 60% by 2020	
Indonesia	→ 23% by 2020 → 26% by 2025	12% (2017)	Mauritius	→ 35% by 2025	22% (2019)
Iraq	→ 10% by 2020		Mexico	→ 30% by 2021 → 35% by 2024 → 38% by 2030 → 40% by 2035 → 50% by 2050	11.5% (2013)
Ireland	→ 42.5% by 2020 → 70% by 2030	29%	Micronesia, Federated States of	→ 10% in urban centres and 50% in rural areas by 2020	
Israel	→ 10% by 2020 → 17% by 2030	2%	Moldova	→ 10% by 2020	
Italy	→ 26% by 2020	39%	Mongolia <sup>b</sup>	→ 20% by 2020 → 30% by 2030 → 100% by 2050	
Jamaica	→ 50% by 2030		Montenegro	→ 51.4% by 2020	
Japan	→ 24% by 2030	17.84%	Morocco	→ 42% by 2020 → 52% by 2030 → 11 GW by 2030 → 100% by 2050	
Jordan	→ 20% by 2020 → 1.8 GW by 2020 → 30% by 2030		Namibia	→ 70% by 2030	
Kazakhstan	→ 3% by 2020 → 50% by 2030	2.3%	Nepal <sup>b</sup>	→ 100% by 2050	100%
Kenya <sup>b</sup>	→ 100% by 2050		Netherlands	→ 37% by 2020	15%
Kiribati <sup>b</sup>	→ 3% by 2020 → 100% by 2050		New Zealand	→ 90% by 2025	83.21%
Korea, Republic of	→ 6% by 2019 → 7% by 2020 → 20% by 2030 → 35% by 2040	6% (2017)	<i>Cook Islands</i>	→ 100% by 2020	
Kuwait	→ 15% by 2030 4.5 GW by 2030		<i>Niue</i>	→ 100% by 2020	
Latvia	→ 60% by 2020	50%	<i>Tokelau</i>	→ 100% (no date)	
Lebanon <sup>b</sup>	→ 12% by 2020 → 30% by 2030 → 100% by 2050		Nicaragua	→ 90% by 2027	50%
Lesotho	→ 35% by 2020 (off-grid and rural)		Niger <sup>b</sup>	→ 100% by 2050	
Liberia	→ 30% by 2021		Nigeria <sup>i</sup>	→ 10% by 2020	
Libya	→ 7% by 2020 → 10% by 2025 → 22% by 2030		Norway		99% (2016)
Lithuania	→ 45% by 2030 → 100% by 2050	83%	Oman	→ 10% by 2020 → 2.6 GW by 2025	
Luxembourg	→ 11.8% by 2020	58%	Palau <sup>b</sup>	→ 100% by 2050	
Macedonia, North	→ 24.7% by 2020	24.8%	Palestine, State of <sup>b</sup>	→ 10% by 2020 → 100% by 2050	
Madagascar <sup>b</sup>	→ 85% by 2030 → 100% by 2050		Papua New Guinea	→ 100% by 2030	
Malawi <sup>b</sup>	→ 100% by 2050		Paraguay	→ 60% increase 2014-2030	
			Peru	→ 70% by 2030	59.44% (2017)
			Philippines <sup>b</sup>	→ 40% by 2020 → 100% by 2050	24.56% (2017)
			Poland	→ 19.3% by 2020	14%
			Portugal	→ 59.6% by 2020 → 80% by 2030 → 100% by 2050	52.2%

■ TABLE R6. Renewable Share of Electricity Generation, Targets as of End-2019 and Status in 2018 (continued)

Note: Text in **bold** indicates new/revised in 2019, brackets '[ ]' indicate previous targets where new targets were enacted, and text in *italics* indicates policies adopted at the state/provincial level.

Country	Target	Status in 2018 <sup>a</sup>	Country	Target	Status in 2018 <sup>a</sup>
Qatar	→ 2% by 2020 → 20% by 2030		Trinidad and Tobago	→ 5% of peak demand (or 60 MW) by 2020	
Romania	→ 43% by 2020	41%	Tunisia <sup>b</sup>	→ 30% by 2030 → 4.7 GW by 2030 → 100% by 2050	
Russian Federation <sup>i</sup>	→ 20% by 2024 (including large hydro)	18%	Turkey	→ 65% by 2023	64%
<i>Altai Republic</i>	→ 80% by 2020		Tuvalu	→ 100% by 2020	
Rwanda <sup>b</sup>	→ 100% by 2050		Ukraine	→ 11% by 2020 → 20% by 2030 → 25% by 2035	5.68%
Samoa	→ 100% by 2030		United Arab Emirates	→ 44% by 2050	0.59% (2017)
São Tomé and Príncipe	→ 47% (no date)		<i>Abu Dhabi</i>	→ 7% by 2020	
Saudi Arabia	→ 9.6 GW by 2023 → 30% by 2030		<i>Dubai</i>	→ 25% by 2030	
Senegal <sup>b</sup>	→ 100% by 2050		United Kingdom	→ no national target	34%
Serbia	→ 37% by 2020	28.7%	<i>Scotland</i>	→ 100% by 2020	
Seychelles	→ 5% by 2020 → 15% by 2030		<i>Wales</i>	→ 70% by 2030	
Sierra Leone	→ 33% by 2020 → 36% by 2030		United States <sup>i</sup>	→ no national target	18.2% (2019)
Singapore	→ 8% (no date)		<i>Arizona</i>	→ 15% by 2025	
Slovak Republic	→ 24% by 2020	23%	<i>California</i>	→ 33% by 2020 → 60% by 2030	
Slovenia	→ 39.3% by 2020	32%	<i>Colorado</i>	→ 30% by 2020 <sup>m</sup>	
Solomon Islands	→ 100% by 2030		<i>Connecticut</i>	→ 27% by 2020 → 40% by 2030	
South Africa	→ 9% by 2030	3.11%	<i>Delaware</i>	→ 25% by 2026	
South Sudan <sup>b</sup>	→ 100% by 2050		<i>Hawaii</i>	→ 25% by 2020 → 40% by 2030 → 100% by 2045	
Spain	→ 39% by 2020 → 70% by 2030 → 100% by 2050	38%	<i>Illinois</i>	→ 25% by 2026	
Sri Lanka <sup>b</sup>	→ 20% by 2020 → 100% by 2050		<i>Maine</i>	→ 100% by 2050	
St. Lucia <sup>b</sup>	→ 35% by 2020 → 100% by 2050		<i>Maryland</i>	→ 25% by 2020 → 50% by 2030	
St. Vincent and the Grenadines	→ 60% by 2020		<i>Massachusetts</i>	→ 40% by 2030 → 100% by 2090	
Sudan <sup>b</sup>	→ 11% by 2031 → 100% by 2050		<i>Michigan</i>	→ 15% by 2021	
Sweden	→ 100% by 2040	55%	<i>Minnesota</i>	→ 31.5% by 2020 <i>Xcel Energy (utility)</i> [25% by 2025 (other utilities)] → 26.5% by 2025 (IOUs) <sup>i</sup>	
Syria	→ 4.3% by 2030		<i>Missouri</i>	→ 15% by 2021 <sup>i</sup>	
Tajikistan	→ 10% (no date)		<i>Nevada</i>	→ 25% by 2025	23% (2015)
Tanzania <sup>b</sup>	→ 100% by 2050		<i>New Hampshire</i>	→ 24.8% by 2025	
Thailand <sup>k</sup>	→ 20% by 2036		<i>New Jersey</i>	→ 20.38% by 2020 → 4.1% solar by 2027 → 50% by 2030	
Timor-Leste <sup>b</sup>	→ 50% by 2020 → 100% by 2050				
Togo	→ 15% by 2020				
Tonga	→ 50% by 2020				

■ TABLE R6. Renewable Share of Electricity Generation, Targets as of End-2019 and Status in 2018 (continued)

Note: Text in **bold** indicates new/revised in 2019, brackets '[']' indicate previous targets where new targets were enacted, and text in *italics* indicates policies adopted at the state/provincial level.

Country	Target	Status in 2018 <sup>a</sup>	Country	Target	Status in 2018 <sup>a</sup>
<i>New Mexico<sup>n</sup></i>	→ 50% by 2030 → 80% by 2040		<i>Vermont</i>	→ Increasing by 4% every three years until reaching 75% by 2032	
<i>New York</i>	→ 70% by 2030		<i>Washington, DC</i>	→ 15% by 2020 → 100% by 2032	
<i>North Carolina</i>	→ 12.5% by 2021		<i>Washington State</i>	→ 100% by 2045	
<i>Ohio</i>	→ 12.5% by 2026		<i>District of Columbia</i>	→ 100% by 2032	
<i>Oregon</i>	→ 50% by 2040 [25% by 2025 (utilities with 3% or more of state's load); 10% by 2025 (utilities with 1.5-3% of state's load); 5% by 2025 (utilities with less than 1.5% of state's load)]		<i>Puerto Rico</i>	→ 20% by 2035 → 100% by 2050	
<i>Pennsylvania</i>	→ 18% by 2021		<i>U.S. Virgin Islands</i>	→ 30% by 2025	
<i>Rhode Island</i>	→ 38.5% by 2035		<b>Uzbekistan</b>	→ 19.7% by 2025	12.6%
			<b>Vanuatu</b>	→ 65% by 2020 → 100% by 2030	
			<b>Vietnam<sup>b</sup></b>	→ 7% by 2020 → 10% by 2030 → 100% by 2050	
			<b>Yemen<sup>b</sup></b>	→ 15% by 2025 → 100% by 2050	

<sup>a</sup>Status data are for 2018 unless otherwise noted.

<sup>b</sup>100% by 2050 target established by the Climate Vulnerable Forum.

<sup>c</sup>Brazil's target excludes all hydropower.

<sup>d</sup>Canada's share excludes all hydropower.

<sup>e</sup>Hainan's share of 80% is from both renewables and nuclear energy.

<sup>f</sup>In March 2012, Denmark set a target of 50% electricity consumption supplied by wind power by 2020.

<sup>g</sup>India does not classify hydropower installations larger than 25 MW as renewable energy sources, so hydropower >25 MW is excluded from national targets. De facto sub-national targets have been set through existing RPS policies.

<sup>h</sup>Mali's target excludes large-scale hydropower.

<sup>i</sup>Nigeria's target excludes hydropower plants >30 MW.

<sup>j</sup>The Russian Federation's targets exclude hydropower plants >25 MW.

<sup>k</sup>Thailand does not classify hydropower installations larger than 6 MW as renewable energy sources, so hydropower >6 MW is excluded from national shares and targets.

<sup>l</sup>The United States does not have a national renewable electricity target. De facto state-level targets have been set through RPS policies.

<sup>m</sup>RPS mandate for Investor-owned utilities (IOUs), which operate under private control rather than government or co-operative operation.

<sup>n</sup>RPS mandate for co-operative utilities.

Note: Unless otherwise noted, all targets and corresponding shares represent all renewables, including hydropower. A number of state/provincial and local jurisdictions have additional targets not listed here. Historical targets have been added as they are identified by REN21. Only bolded targets are new/revised in 2019. A number of nations have already exceeded their renewable energy targets. In many of these cases, targets serve as a floor setting the minimum share of renewable electricity for the country. Some countries shown have other types of targets (→ See Tables R3-R8). See Policy Landscape chapter for more information about sub-national targets. Existing shares are indicative and may need adjusting if more accurate national statistics are published. Sources for reported data often do not specify the accounting method used; therefore, shares of electricity are likely to include a mixture of different accounting methods and thus are not directly comparable or consistent across countries. Where shares sourced from EUROSTAT differed from those provided to REN21 by country contributors, the former was given preference.

Source: See the REN21 GSR 2020 data pack online at [www.ren21.net/GSR](http://www.ren21.net/GSR).

■ TABLE R7. Renewable Power, Targets for Technology-Specific Share of Electricity Generation as of End-2019

Note: Text in **bold** indicates new/revised in 2019, and text in *italics* indicates mandates adopted at the state/provincial level.

Country	Technology	Target
Denmark	Wind power	50% by 2020
Eritrea	Wind power	50% (no date)
Egypt	Wind power	12% by 2020
Germany	Solar power	<b>17% by 2030</b>
Guinea	Solar power	6% by 2025
	Wind power	2% by 2025
Haiti	Bio-power	5.6% by 2030
	Hydropower	24.5% by 2030
	Solar power	7.55% by 2030
	Wind power	9.4% by 2030
India <sup>a</sup>		
<i>Bihar</i>	<i>Solar power</i>	<i>1.75% by 2018-19; 2% by 2019-20; 2.5% by 2020-21; 3% by 2021-22</i>
<i>Himachal Pradesh</i>	<i>Solar power</i>	<i>0.75% by 2018-19; 1% by 2019-20; 2% by 2020-21; 3% by 2021-22</i>
<i>Kerala</i>	<i>Solar power</i>	<i>0.25% by 2021-22</i>
Japan	Bio-power	3.7-4.6% by 2030
	Geothermal power	1% to 1.1% by 2030
	Hydropower	8.8-9.2% by 2030
	Solar PV	7% by 2030
	Wind power	1.7% by 2030
United Kingdom	Wind power (offshore)	33% by 2030

<sup>a</sup> India has established state-specific solar power purchase obligations.

Source: See the REN21 GSR 2020 data pack online at [www.ren21.net/GSR](http://www.ren21.net/GSR).