3 Governmental support policies for renewable energy

3.1 Introduction

For decades, national, state and local governments have led a sustained push to support renewable energy technologies through a wide mix of policy instruments aimed at development and commercialization. Laws and policies aim to increase the share of energy from renewable energy resources in electricity generation, transportation and other sectors of national and sub-national economies. These laws and policies include mandatory *targets* for renewable energy deployment, *feed-in tariffs* (FITs) with fixed, long-term guaranteed payments, tax incentives, and support for contracts offering certainty for purchase of the output of renewable energy facilities. Governments have also supported renewable energy with direct financial support, including loans, loan guarantees, grants, and research and development (R&D) programs.

Many programs have been extremely successful in securing market access for renewable generators and promoting technology improvements and the diffusion of new technologies. Global renewable energy deployment has increased greatly, costs have dropped and renewable energy industries have become more mature. There has been a robust discussion virtually since the inception of support programs about which policy or combination of policies provides the optimal support strategy overall or in a specific nation. This chapter briefly touches upon these debates.

Each nation will have different criteria and policy goals for adopting renewable energy support policies. Typical goals include:

(1) Promoting energy security and affordability: Governments aim to extend improved access to lower-cost energy to all residents, including lower-income residents. They often focus on investing in renewable energy that can be produced domestically and does

not require the nation to rely on imported fossil fuel resources. This reduces exposure to volatility of fossil fuel prices driven by world events.

(2) Addressing climate change and other environmental issues: Governments aim to reduce emissions of greenhouse gases (GHG) to meet national targets under international climate change agreements. The Paris climate change agreement of 2015 committed nations to limit the global average temperature rise to as close as possible to a maximum 2 °C by reducing GHG emissions more than 70 percent from 2015 levels by 2050. As noted in Chapter 1, this can only be achieved with accelerated deployment of renewables. Governments also aim to reduce emissions of conventional pollutants generated by the use of fossil fuels.

(3) Creating a level playing field with fossil fuel industries: Existing subsidies for fossil fuel extraction have skewed market dynamics, resulting in consumer energy prices that often fail to reflect the full environmental and social cost of those resources. Fossil fuel energy sources have been receiving subsidies for more than 100 years in the United States. A 2019 International Monetary Fund working paper estimated that subsidies for fossil fuels cost the world more than $5 trillion in 2017,[1] far more than government subsidies to renewable energy, which totaled $140 billion worldwide in 2016.[2]

(4) Capitalizing on the potential for economic growth and job creation: The expansion of renewable energy has been a driver of considerable economic growth. Some nations see potential for leadership in related manufacturing sectors and global exports of renewable energy technologies (such as China's dominance in solar panel manufacturing).

This chapter categorizes the different support policies and their implementation. Rather than describing any one form of support mechanism in depth, the chapter provides a brief description of each one and its features. This brevity is necessary for many reasons. At each

1 David Coady, Ian Parry, Nghia-Piotr Le and Baoping Shang, *Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates* 5 (Int'l Monetary Fund, Working Paper No. 19/89, 2019), https://perma.cc/M5J9-PHNZ.

2 Toshiyuki Shirai and Zakia Adam, *Fossil-Fuel Consumption Subsidies Are Down, but Not Out*, IEA: Comment. (Dec. 20, 2017), https://perma.cc/BJ6D-THGY.

level of government, policymakers tailor support strategies to nations' unique circumstances. As a result, an individual type of support can vary widely in its design.

The coverage is primarily limited to laws and policies that directly target renewable energy resources by aiming to encourage development of technologies and new projects. The chapter largely excludes from consideration other governmental programs which may be important to the success of renewables, but which have only indirect impacts on supporting their development. For the most part, this chapter focuses on incentives for increasing renewable electricity generation. Section 3.6 addresses policies in the transportation sector for production, sale and use of vehicles relying directly or indirectly on fuels derived from renewable resources. An example is programs to promote electric and other zero-emission vehicles, which can increase use of renewables and thereby lower emissions. Incentives for renewable resources in other economic sectors – such as buildings – are discussed briefly throughout the chapter.

Governmental support programs for renewable electricity generation can be grouped into several broad categories:

(1) Renewable energy quotas and targets, including national and sub-national percentage targets for renewable energy, and *renewable energy standards* (RESs) that typically require utilities to interconnect with renewable generators and purchase power from them, either as stand-alone measures or as complements to procurement schemes;
(2) Tariff-based incentives and guarantees, including FITs and premiums. These support projects through favorable payment rates that guarantee income that in turn covers costs and yields a return on invested capital. These payment rates can be uniform or differential across technologies;
(3) Direct procurement of renewable energy under government-established *tenders, auctions*, or other forms of public competitive bidding, by which investors compete to develop projects through bidding systems sponsored by government departments or agencies;
(4) Financial support to renewable energy developers in the form of grants, loans or tax incentives; and
(5) Conducting or funding R&D.

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There are substantial differences among these incentives. For example, the entity to which an incentive is directed can vary. A RES creates a requirement that applies to utilities and other electricity suppliers; by contrast, a R&D strategy impacts scientists and engineers in government and the private sector.

3.2 Renewable energy targets and quotas; renewable energy standards with tradable certificates

A popular type of support program, adopted by nearly all countries and many sub-national jurisdictions, is a renewable energy percentage quota or target. This section discusses two prominent forms of target: (1) a *renewable energy target* (RET), which is a national or sub-national target for renewable energy in final energy consumption, such as the European Union's target of meeting at least 32 percent of its final energy consumption from renewable sources by 2030; and (2) a RES which commonly requires a specified percentage of electricity sold by utilities or other suppliers to be derived from renewable resources, usually met in whole or in part through the use of tradable green certificates.

The core obligation under either policy is meeting a percentage target for renewable energy that applies to a national economy as a whole or to a specific sector, as in the case of an electricity sector RES. Target schemes are popular: 111 of the 152 Nationally Determined Contributions under the Paris Agreement (a core mechanism of the Agreement's implementation) formally submitted by 2018 included specific renewable energy targets.[3] Many targets are ambitious in requiring accelerated deployments to meet them, and have been successful in doing so. Some, although not a majority at present, call for an ultimate goal of 100 percent renewable energy.

At the outset, some distinctions among targets are important. Some are voluntary or otherwise aspirational, not mandatory. Yet even voluntary targets have been somewhat successful at stimulating renewable energy development. Many targets are national objectives developed and enforced by national regulators. Others are developed by sub-national jurisdictions, and may require actions on the part of other

3 Int'l Renew. Energy Agc'y, Climate Change and Renew. Energy, Nat'l Policies and the Roles of Communities, Cities, and Regions 18 (2019).

actors not subject to their authority. An example of this is the goals of numerous US cities that have pledged to satisfy all or a large part of their energy demand from renewable energy in the future.[4]

Targets can be set in laws specific to the renewable energy sector. A well-known example is the EU Renewable Energy Directive. That law, most recently updated in 2018, creates a legal framework for promotion of renewable energy throughout the European Union, currently calls for the European Union as a whole to meet at least 32 percent of its final energy consumption from renewable sources by 2030 and requires EU countries to draft national energy and climate plans specifying how they will meet individual national targets.[5] A target can be established in other types of documents, such as Brazil and Mexico's multi-year electricity expansion plans and *integrated resource plans* (see Chapter 5).

A renewable energy target typically has three core elements: a nation, region, state or other sub-national jurisdiction subject to the target; a percentage target and the unit of energy consumption or other baseline to which it applies; and a date by which the target must be met. Examples of national targets include China's target of 35 percent renewable electricity consumption by 2030[6] and Morocco's National Energy Strategy that calls for generating 42 percent of its electricity production from renewables by 2020, and 52 percent by 2030.[7] A target may be specific to a particular sector of a nation's economy. For example, Australia's Renewable Energy Target calls for 33,000 *gigawatt-hours* (GWh) in utility-scale generation from renewable energy in 2020, or about 23.5 percent of Australia's total electricity generation.[8] A separate Renewable Energy Scheme, achieved through a form of tradable certificate, applies to smaller-scale distributed generation facilities.

4 *See* Sabrina Vivian, Kanchan Swaroop, Matt Haugen, Samantha VanDyke and Sydney Troost, Inst. for Local Self-Reliance (ILSR), Investigating City Commitments to 100% Renewable Energy: Local Transitions and Energy Democracy (2020), https://perma.cc/F2PV-YTA2.

5 *2030 Climate & Energy Framework*, European Comm'n, https://perma.cc/4LFM-EBRB.

6 *China Sets New Renewables Target of 35 Percent by 2030*, Renew. Energy World (Sept. 26, 2018), https://perma.cc/6BDH-53EC.

7 *Renewable Energy*, Royaume du Maroc, https://perma.cc/3CUG-MRHM.

8 *Renewable Energy Target Scheme*, Dep't of Industry, Sci., Energy, and Resources, Aus. Gov't, https://www.industry.gov.au/funding-and-incentives/renewable-energy-target-scheme (last visited Mar. 24, 2021).

Renewable energy targets are not self-executing. Instead, compliance requires further activity by regulated entities. There are as many different schemes for compliance as there are targets, so generalization is difficult. However, there are some common features. Typically, a target will differentiate among entities subject to it, setting individual sub-targets. These sub-targets can account for disparities in maturation of renewable energy industries and nations' different economic conditions, and provide unique paths for each nation to meet its respective obligations. For example, the EU-wide target sets individual national renewable targets for Member States and specifies that each nation can choose the type of renewable energy policy it uses to implement its target.

Regulators' action plans typically outline commitments to growth and deployment of renewable energy in the sectors of the economy covered by the targets. An action plan may be explicitly required by the law establishing the target, as in the case of the EU Renewable Energy Directive, which requires that a national energy and climate plan include specific measures designed to achieve that nation's target. An action plan will usually specify the combination of renewable energy technologies the nation or sub-national jurisdiction expects to be in place by the target year. It will also usually discuss policy measures in place or expected to be implemented to achieve the target. Compliance can come through specific mechanisms described in the remainder of this section (such as tradable green certificates) and other sections in this chapter (such as FITs, discussed in section 3.3, and other pricing and procurement mechanisms). One point worth noting in the European Union is that these support measures can sometimes be challenged as impermissible restrictions on cross-border trade, as discussed in section 8.5.

A target may be revised upward if a political and social consensus supports revision, or as other circumstances warrant. For example, the EU Renewable Energy Directive's current 32 percent target was increased from the 2009 Directive's 20 percent target. Yet even if compliance is achieved, a target is not always increased. Australia's target was met early (in 2019) and to date has not been changed, due to political opposition from a more conservative national government, among other reasons. Recall, too, the discussion in Chapter 2 about which resources count as renewable. This may spur controversy about whether the target actually achieves environmental benchmarks such as reductions in GHG emissions. For example, the EU 32 percent target is often criticized for relying in large part on biomass for electricity generation.

The RES is a governmental target that is specific to the electricity sector. This section uses "renewable energy standard," though the RES is known variously as a renewable portfolio standard, clean energy standard or alternative energy standard. This requirement applies to utilities or other suppliers of electricity to end users (known collectively as *load-serving entities* in the United States), which this section will refer to as "electricity suppliers" for convenience. The RES typically aims to accelerate deployments, reduce electricity generation from fossil fuels and prompt the growth of renewable energy suppliers and their access to electricity marketplaces.

A RES creates a requirement that a specific percentage of the electricity delivered originates from renewable energy resources. In the United States, 29 states, Washington, DC, and three territories have adopted RESs;[9] eight more states and one territory have voluntary renewable energy goals. These standards vary widely on several design elements, including:

(1) The specific percentage target: At present, this ranges up to 100 percent, the higher figure being adopted in states including New York and California.[10] The percentage targets for RESs are often revised upward, as for example, ten US states have done since 2018.
(2) The entities included in the standards: Notably, utilities subject to less comprehensive state utility regulation, such as municipalities and electric cooperatives (see Chapter 5), are often either excluded or subject to different percentage targets.
(3) The resources eligible to meet requirements and other implementation criteria, as discussed below.

Over 20 US states have some form of additional incentive within their RES. States have various set-asides (requirements to use a specific technology) and multipliers (premiums for use of specific technologies)

9 *See Database for State Incentives for Renewables & Efficiency*, NC Clean Energy Tech. Ctr., https://perma.cc/XP5M-MV9F.

10 *See* Heather Payne, *Pulling in Both Directions: How States are Moving Towards Decarbonization While Continuing to Support Fossil Fuels*, 45 Colum. J. Envtl. L. 285, 296 (2020), https://perma.cc/9R37-CEML.

within their RESs. Maryland, for example, has a RES of 50 percent by 2030, 14.5 percent of which must come from solar energy.[11] States may also differentiate among renewable energy resources by classifying them into different levels or tiers, depending on their perceived environmental impacts and other factors. These incentives have often been challenged in courts as inconsistent with the US federal Constitution's *dormant Commerce Clause* (see Chapter 8), but challengers have lost most of these lawsuits.

While design criteria differ, electricity suppliers can typically comply with a RES in one of three ways: (1) generating renewable electricity from power plants they own; (2) purchasing renewable electricity from other generators, obtaining the renewable attributes of that generation in the transactions; or (3) purchasing tradable certificates (typically known in the United States as *renewable energy certificates* (RECs)). The tradable certificate is a contractual means of guaranteeing that a buyer has purchased renewable electricity. Electric grids cannot differentiate the power flowing on them: electrons are electrons. Thus, suppliers that purchase power in a marketplace in which numerous producers sell their output, such as a wholesale electricity market, cannot identify the precise source of the electricity they have purchased. A tradable certificate such as a REC addresses this problem by separating the physical flow of electricity from its environmental benefits.

Ordinarily, a REC is created for each mWh of electricity generated from a qualifying renewable energy source. This REC can be accounted for and traded separately from the electricity. In theory and in practice, it gives flexibility by allowing trade between producers of electricity from renewable resources and suppliers that need to purchase RECs to satisfy their obligations under a RES. These certificates are also an additional source of revenue for renewable electricity generators, which has spurred the deployment of new facilities in many states in the United States.

Purchases and sales of RECs typically take place in organized markets. In the United States and other nations, REC markets have two distinct forms. In REC compliance markets, electricity suppliers issue and purchase RECs for the purpose of meeting the RES. An electricity supplier subject to a RES can obtain RECs for some or all of the required

11 S.B. 516, 439th. Gen. Assemb., Reg. Sess. § F(b)(25)(I) (Md. 2019).

percentage of its generation, depending on its needs. Markets sometimes differentiate among RECs of particular vintages (for example, "2020 RECs"), allowing electricity suppliers to tailor their purchases to meet their needs in specific current or future years. In voluntary REC markets, RECs are bought and sold without the mandate of a RES. In the United States, purchases of RECs account for nearly half of all voluntary green power purchases, typically by large companies aiming to meet corporate renewable energy goals.[12] Chapter 7 discusses this and other measures to allow individual consumers or large companies to voluntarily purchase renewable electricity, such as *utility green pricing options.*

In the United States, administration of REC compliance markets and tracking of RECs is often performed by *independent system operators* or *regional transmission organizations*. Known as ISOs/RTOs, they administer transmission grids and oversee electricity wholesale markets in roughly two-thirds of the nation under the regulation of the Federal Energy Regulatory Commission (FERC). These ISOs/RTOs use computer tracking systems to track the generation and retirement of compliance RECs. See Chapter 4 for a fuller discussion of regional grid operators and their impact on renewable energy deployments.

In the absence of a national statutory or regulatory climate mandate, the RES is considered one of the United States' most successful climate policies, having effectively promoted market access for renewable electricity generators and deployment of new power plants. A controversial study from 2019[13] claims to the contrary: that RESs tend to make electricity more expensive at relatively little increase percentage-wise in renewable energy deployment, and that a carbon pricing scheme would be more effective. See Chapter 9 for a discussion of this issue. This study was based on a comprehensive data set, but it has been criticized for its methodology.

Tradable green certificates are prevalent around the world. Australia's Renewable Energy Target for utility-scale generation is backed by

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12 *See* Eric O'Shaughnessy and Jenny Heeter, Nat'l Renew. Energy Lab., Status and Trends in the U.S. Voluntary Green Power Market (2017 Data) (2018), https://perma.cc/7XJR-THBF.

13 Michael Greenstone and Ishan Nath, *Do Renewable Portfolio Standards Deliver?* 1 (Energy Policy Inst. at the Univ. of Chi., Working Paper No. 2019-67, 2019), https://perma.cc/42RY-TZZG.

Large-scale Generation Certificates (LGCs). A central government registry (not grid operators as in the United States) tabulates LGCs, each representing 1 mWh of eligible renewable electricity produced by an accredited power plant. Electricity retailers purchase LGCs in a secondary market and match their accounts annually with the nation's Clean Energy Regulator to demonstrate their compliance. As in the United States, the revenue earned by renewable electricity generators on the sale of LGCs is an additional revenue stream.

In the European Union, national RET schemes in Belgium, Italy, Poland, Romania, Sweden and the United Kingdom rely on tradable green certificates. In addition, the European Union maintains a Union-wide system designed to ensure transparency in information based on the *guarantee of origin*, which verifies to an electricity customer that electricity has been produced from a specified renewable energy source. The main objective of this system is to provide disclosure and transparency in Europe's electricity market. The 2009 EU Renewable Energy Directive required Member States to implement guarantee of origin certificate systems. Guarantees of origin provide a means for consumers to choose renewable energy production and send a market signal about their preference. As the 2018 Renewable Energy Directive provides, "Guarantees of origin . . . have the sole function of showing to a final customer that a given share or quantity of energy was produced from renewable sources."[14]

By one estimate, about 35 percent of renewable electricity production in EU countries plus Switzerland and Norway was verified with guarantees of origin in 2015.[15] Guarantees of origin can be traded bilaterally between individual parties without a centralized market. They have increasingly been *bundled* (included as part of the transaction together with the electricity) with power purchase agreements between power consumers and producers (see section 6.3) to promote project financing.

14 Directive 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the Promotion of the Use of Energy from Renewable Sources (Recast), 2018 O.J. (L 328) 82, 90, https://perma.cc/U4YS-W2Q9.

15 Daan Hulshof, Catrinus Jepma and Machiel Mulder, *Performance of Markets for European Renewable Energy Certificates*, 128 Energy Pol'y 697, 697 (2019), https://perma.cc/5YNW-HCHX.

3.3 Feed-in tariffs and feed-in premiums

FITs and *feed-in premiums* (FIPs) work differently from RESs. Rather than impose an obligation on electricity suppliers, they offer direct payments to electricity generators under constant benchmark prices. FITs are currently the most widely adopted form of incentive for renewable electricity generation, with 111 countries and states or provinces having adopted some form of FIT or FIP policy as of 2018.[16] Section 4.2 discusses a related but different payment scheme: the compensation regime for renewable electricity under the US Public Utility Regulatory Policies Act of 1978 (PURPA). Unlike a FIT, the PURPA structure bases the payment to the renewable energy generator on the utility's *avoided cost*, not on the generator's costs.

FITs have been successful in stimulating rapid and large-scale development of renewable energy in countries such as Germany, Denmark and Spain. As FITs have become more widely implemented, there have been substantial debates about the relative merits of a FIT compared to a quota or RES with tradable green certificates. There has also been a backlash and claims that FITs have resulted in overstimulation of the renewable energy market and higher electricity rates for some customers, with paring back of some programs as a result.

The central design feature of a FIT or FIP is providing a guaranteed price for renewable electricity produced and fed into the electric grid by eligible generators, including homeowners, power plant developers, and others. A FIP is different from a FIT in that it provides the producer with a guaranteed premium over the electricity market price. The government sets the premium and the mechanism for its determination, but total revenue fluctuates according to changes in the market price of electricity.

A FIT policy has three main elements:

(1) Guaranteed access to the electric grid: The generator is guaranteed *interconnection* with the electric grid, and the utility or other grid operator is required to accept delivery of the electricity. A nation may require utilities, load-serving entities or transmission system operators to purchase the entire

16 *See* REN21, RENEWABLES 2019: GLOBAL STATUS REPORT (2019) 208 tbl. R11, https://perma.cc/6VFG-FKJY.

output from eligible generators, creating secure demand for the electricity they generate from qualifying resources.

(2) Fixed prices for purchase of electricity: Eligible generators are paid for the electricity they supply to the grid. The price can be calculated in different ways. The security of a direct payment to renewable energy generators is meant to create a secure market, support a reasonable profit for project investors and make it easier to secure project financing.

(3) Long-term guaranteed payments: Payments are guaranteed for a time period usually correlated to the expected life of the specific renewable energy project, often 15–25 years or more. FITs thereby reduce financial risk for the lifetime of the payments. This also makes project financing more likely, as it creates certainty for a potential investor in the project about the project's revenue stream, allowing for more precise calculations of the expected rate of return. See Chapter 6 for further discussion of this issue.

European FITs have had considerable success in prompting renewable energy deployments. The German FIT policy has been frequently identified as one of the most successful, and is often cited as a model for FIT development in other nations.[17] Introduced in the German Renewable Energy Sources Act of 2000, and a core building block of the country's "Energiewende" energy transition, the German FIT caused explosive growth in electricity generated from solar and wind. Over 1.7 million solar projects have been installed, and at peak levels solar power can provide over 40 percent of Germany's power. As a result, renewables' share of electricity production in Germany increased from less than 4 percent in 1990 to 38 percent in 2018.[18] Similarly, Spain's FIT was an instrumental element in a doubling in the national share of renewable electricity to 42 percent in 2020.[19]

FITs have not been widely adopted in the United States. By 2018, only six US states – California, Washington, Vermont, Oregon, Rhode Island and Hawaii – had experience with them. The state of Hawaii

17 Joern Hoppmann, Joern Huenteler and Bastien Girod, *Compulsive Policy-Making: The Evolution of the German Feed-In Tariff System for Solar Photovoltaic Power*, 43 Res. Pol'y 1422, 1437 (2014), https://perma.cc/RCB2-6H66.

18 *Germany 2020*: *Energy Policy Review*, IEA: Country Report (Feb. 2020), https://perma.cc/9Q93-VRU2.

19 *See* Sladaja Djunisic, *Renewables Share in Spain Reaches 42.8% in Feb.*, Renewables Now (Mar. 19, 2020), https://perma.cc/4X8H-VNAS.

established a FIT in 2009, but that program is now closed to new entrants. A notable example of a US FIT is the Renewable Market Adjusting Tariff (Re-MAT) program established in California in 2012. The state's utility regulator, the California Public Utilities Commission, established this FIT program for small renewable producers (having an individual facility capacity of less than 3 MW), with a total statewide cap of just under 500 MW on participation by the state's three large investor-owned utilities. The pricing formula differentiated among three types of resources (*base load*, peaking as-available and non-peaking as-available) and based payments on market prices that were subject to upwards or downward adjustments every 2 months. In 2019, a US federal appeals court held that the federal PURPA (see section 4.2) preempted Re-MAT,[20] because it capped the amount of energy utilities must purchase from renewable energy facilities and used a market-based price rather than the avoided cost price that PURPA requires. Following that decision, the Re-MAT program is now under revision.

A FIT's design criteria are typically set by policymakers or regulators and can differ widely, depending on governmental objectives. FIT programs may include some technologies and exclude others. Generally speaking, most FITs include solar PV and some other renewable energy technologies such as wind, hydropower and other. Broader coverage allows more technologies to be developed and provides investors in different types of projects more secure returns on their investments. As an example, the German FIT originally included onshore and offshore wind, biomass, hydropower, geothermal and solar PV. The Hawaiian FIT included solar PV, onshore wind, concentrating solar power (CSP) and inline hydropower. Other nations, such as Denmark, have supported both wind and solar. The list of included resources may parallel those eligible under a jurisdiction's RES. For example, California's Re-MAT program applied to all technologies eligible for the state's renewable portfolio standard.

Other ways in which programs differ involve the rate offered to the renewable generator, the calculation of the rate and the group of generators to which it applies. A popular approach bases FIT payments on the levelized cost of electricity or other measure of the cost of a benchmark facility that qualifies for the FIT, plus a targeted return. A different approach calculates the price with reference to the value the

20 Winding Creek Solar LLC v. Peterman, 932 F.3d 861, 866 (9th Cir. 2019).

renewable energy system provides to the electric grid. Like a *value of solar tariff* (see section 5.4), this calculation can incorporate valuation of such factors as compensation for environmental externalities and costs avoided in construction of new power plants and other infrastructure. Some FIT systems base payments on a simple, fixed-price incentive that does not follow either of the above approaches. FIT rates are sometimes differentiated by project size and by technology. The US state of Hawaii set different rates for solar PV, wind, hydropower and CSP facilities, and further differentiated the rates across a range of system sizes. Rates can also be related to the program caps, often decreasing as the overall expected amount of deployed capacity approaches.

An example of the complexity in rate design is the United Kingdom's Contract for Differences FIT scheme, introduced in the 2013 Energy Act.[21] Contract for Difference FITs subsidize eligible generators for the shortfall between the market price of electricity and a pre-defined strike price based on the cost of a particular technology. Successful developers of renewable projects enter into contracts with the government-owned Low Carbon Contracts Company (LCCC). Payments are at a flat rate for electricity production over a 15-year period, at the difference between the strike price and the "reference price" (a measure of the average market price for electricity).

To stimulate investment, FIT programs often set payment rates above the prevailing price of electricity. It has been widely noted that these premium rates have spurred additional installations, as in Germany and Spain. Similarly, in the US state of Florida, the municipal utility in the city of Gainesville established a FIT in 2009 at 32 cents per kWh for electricity generated from solar PV and fed into the utility's grid. Total installed capacity soared from about 300 kW in 2008 to approximately 20.5 MW by 2014.[22] Regulators may revise rates upward to stimulate additional development, or, conversely, may reduce rates when development has been sufficient or when impacts on electric customers are perceived to be excessive. An example of the latter is Japan, which implemented a FIT in 2012 with particularly high solar PV tariff rates (more than 40 yen/kWh in some cases). In 2018, however, in a

21 Energy Act, 2013, c.32 (Eng.).

22 Alavaro Queiroz, Fazil T. Najafi and Pegeen Hanrahan, *Implementation and Results of Solar Feed-In-Tariff in Gainesville, Florida,* Abstract, 143 J. of Energy Engr'g 6005 (2017), https://perma.cc/7MC6-GSYK.

move aimed to reduce burdens on ratepayers, its industry ministry announced cuts to the rates of more than half to take effect between 2022 and 2027 for utility-scale and residential projects.[23]

Program sizes also differ among FITs. Programs can cap maximum project sizes for individual projects and maximum annual capacity, cumulative capacity or both for the entire program. In its original design, the German FIT program specified a maximum size of 5 MW for roof-mounted solar PV and 100 kW for other facilities. Similarly, Hawaii's FIT had maximum system sizes ranging from 2.7 MW to 5 MW, depending on the island. The California Re-MAT program was capped overall at just under 500 MW, with specific sub-caps for the state's three largest utilities. In 2000, the German program had a cap of 350 MW for the maximum cumulative installed capacity of solar PV. Over the next decade, the cap was increased, then finally removed as experience demonstrated to policymakers that a more aggressive approach was warranted.

FIT programs are not without controversy. Generous contract terms and high payment rates can have negative impacts on other electric customers. In some cases, above-market FIT payment levels can lead to more investment in the renewable energy sector than originally intended if the policy is not adjusted to account for changing circumstances. In Spain, high tariff rates led to a rush of development that overwhelmed regulators and prompted a significant rate reduction a year after the program's start. In 2013, Spain suspended the FIT altogether and replaced it with a new compensation system. Similarly, China announced a substantial cut in FIT rates in 2018, and capped the capacity of solar PV projects eligible for the FIT.[24] This led to a 17 percent drop in solar installation in China from 2018 to 2019.[25] An American example of a reversal in FIT policy is the Gainesville, Florida solar program, which is now suspended, with some city officials terming it a burden on the city's ratepayers.[26]

23 *See* Marian Willuhn, *Japan's METI Cuts C&I FIT by 22%*, PV Mag. (Mar. 27, 2019), https://perma.cc/R2UZ-CRAE.

24 *See* Emma Foehringer Merchant, *China's Bombshell Solar Policy Shift Could Cut Expected Capacity by 20 Gigawatts*, Greentechmedia (June 6, 2018), https://perma.cc/F4N8-3MP7.

25 David Feldman and Robert Margolis, Nat'l Renew. Energy Lab., Q4 2019/Q1 2020 Solar Industry Update 6 (2020), https://perma.cc/A6H5-89KN.

26 Jim Konish, *Solar Feed-In Tariff is Huge Burden on GRU Ratepayers*, The Gainesville Sun (Mar. 6, 2019), https://perma.cc/7X3Y-8EZ8.

There has also been substantial debate about the merits of FITs compared to RESs backed by RECs.[27] The debate tends to treat the policy instruments as mutually exclusive, although that is sometimes not the case, as California's FIT policy was specifically intended to promote compliance with the state's RES. On the one hand, proponents of mandates claim they promote renewable electricity generation in a least-cost fashion by obliging electricity suppliers to procure supply at market prices. But FITs allow any renewable generator to receive support, not just those producing at utility scale. By setting a contract price up front, and guaranteeing producers a market for their output, FITs offer a certainty for investors that mandates cannot. Yet, as outlined above, FITs can be rather blunt policy instruments. No matter how they are designed, they may distort the market for electricity as a country's renewables sector matures.

Criticisms of FITs have led European nations such as Germany and Asian nations such as India and China to turn to market-based auctions and other alternatives to FIT policies. The most recent revisions to Germany's Renewable Energy Act effectively abandon the FIT scheme in favor of a competitive auction process in which renewable generators compete in a market-based auction for supplying their electricity. The next section discusses auctions and other procurement-based schemes.

3.4 Procurement mechanisms (auctions, requests for proposals, tendering schemes)

While many national governments continue to use FIT systems and quotas, others now support renewables through competitive bidding programs. Forty-one countries used some form of renewable energy bidding as of 2019.[28] In Latin America, auctions have taken place in 12 countries, including Argentina, Brazil, Chile and Guatemala. EU Member States are increasingly using competitive bidding to procure renewable electricity capacity.

The terms "auction" and "tender" are often used interchangeably to describe these schemes. However, this section differentiates between

27 *See, e.g.*, Lincoln L. Davies and Kirsten Allen, *Feed-In Tariffs in Turmoil*, 116 W. Va. L. Rev. 937 (2014).

28 REN21, Renewables 2020: Global Status Report 72 (2020), https://perma.cc/S2DU-BRAZ.

the two terms, using "tender" and "tendering scheme" for the criteria established by the government for participation, and the act of submitting applications. Similarly, in the United States, the term "request for proposals" (RFP) is used to refer to the process of submitting applications for governmental support for renewable energy. "Auction" refers to a specific bidding-based means of selecting generators to supply electricity. Not all tendering schemes rely on auction mechanisms, as described below.

The main features of tendering or RFP schemes are:

(1) Governmental authorities organize the programs, prepare the tender documents and establish bidding criteria and requirements. They publish the tenders, receive bids from applicants, evaluate the bids and select the winning bids. Winning bidders are typically chosen to undertake the projects.
(2) Tenders seek to procure a specific amount of installed capacity or electricity production. In 2019 in the United States, New York state selected two entities to build a total of 1,700 MW of offshore wind capacity through a competitive solicitation process.[29] This highlights one advantage of a tendering scheme over other support mechanisms: the government can design the scheme to secure an exact amount of capacity on precise terms. As a result, tendering schemes are thought to be effective in preventing both under- and overdevelopment of renewable electricity production capacity.
(3) Tender solicitation documents impose requirements for potential bidders. There are numerous variables involved, including the core requirement of bidding to provide a specific amount of capacity at a price per unit.

Some other common variables in tender design include the following:

Procurement may be for one specific technology, such as wind or solar PV. The tender may be technology-neutral, providing for procurement of capacity through competition among several qualifying renewable energy technologies. Or it may target a group of technologies with a multi-technology procurement process. Specificity about technologies is often done for a wide variety of reasons. As the EU Renewable Energy Directive states, "While Member States develop their support

29 *See 2018 Solicitation*, N.Y. St. Energy Res. and Dev. Auth., https://perma.cc/65VV-ZK4H.

schemes, they may limit tendering procedures to specific technologies where this is needed to avoid sub-optimal results with regard to network constraints and grid stability, system integration costs, the need to achieve diversification of the energy mix, and the long-term potential of technologies."[30]

Bidders are increasingly submitting a combination of resources in their bids. This may demonstrate potential to smooth out the inherent variability of one renewable resource by combining it with another resource or with storage. In the US state of New York, several winning bidders in the state's 2018 solicitation committed to develop renewable energy capacity combined with energy storage.[31] Similarly, in 2018, India held hybrid auctions for projects combining solar and wind capacity, awarding 840 MW of capacity at the equivalent of $38/MWh.[32] The tendering scheme announced in Italy in 2019 provided an extra incentive for renewable energy projects linked to electric vehicle (EV) charging.

Tenders also typically often include criteria relating to the developers' capabilities. Developers may be required to submit proof of their financial abilities to undertake the projects, and deposit guarantees to ensure projects' successful completion. Governmental authorities commonly administer pre-qualification processes to determine which project developers are authorized to bid. Tenders may also be designed to meet specific national objectives, such as promotion of domestic industries. In India, for example, a recent tender for solar PV required bids to include at least 50 percent locally manufactured components (see Chapter 8 for the intersection between this policy and international trade rules).

Assuming the tender results in multiple competitive bids, the governmental authority evaluates the bids on the basis of the price and other criteria specified in the tender document. The bidder(s) chosen as winners execute power purchasing agreements or other commitments with the governmental authorities. Thus, the tendering scheme has an

30 Directive 2018/2001, *supra* note 14, at 106.

31 *See 2018 Solicitation*, *supra* note 29.

32 World Bank, Investment in Renewable Energy Companies 65 (2019), https://perma.cc/HFM4-T9A2; Nat'l Wind-Solar Hybrid Pol'y No. 238/78/2017-Wind, Wind Energy Div., Ministry of New & Renew. Energy (May 14, 2018) (India).

obvious risk. It is not competitive if bidders offer less total capacity or electricity production than the quantity sought.

The evaluation process need not be run as an auction. This is particularly true and even likely if the tendering scheme includes criteria other than price, as in the case of New York state's offshore wind procurement. However, governmental authorities commonly use auctions in their procurement systems. In traditional auctions, bidders compete with prices increasing until a winning price is determined. Renewable energy auctions are typically reverse auctions, in which bids are submitted and then winning bidders are selected. One form of reverse auction is the sealed bid auction. Bidders submit information without knowing each other's bids. The auctioneer aggregates offer quantities and prices into a supply curve. It then sets a *clearing price* (price where supply and demand meet); participants submitting bids at or below that amount are successful and receive that price for their output. Bids above the clearing price are disregarded. Another form of auction is an iterative or descending clock auction, in which the administrator begins the auction at a specific price point. Bidders reveal the quantities which they wish to offer at the stated price, with the auctioneer dropping the price until supply meets demand, forming the clearing price. Brazil has used a hybrid process in which the first phase operates as a descending clock auction, and the second phase operates as a sealed bid auction.

The principal claimed advantage of tendering schemes is that they procure precise target levels of investment in renewable energy capacity at the lowest cost. By stimulating competition among different participants, locations and technologies, the governmental authority can control the process precisely in a cost-effective manner. There are other benefits. Specificity about tender terms can give stable revenue guarantees to project developers, particularly if the government uses long-term contracts. Some auction schemes yield payments at a premium to market prices. For example, the scheme announced in Italy in 2019 provided winning bidders a premium tariff on top of the market price of electricity. Like the FIT, this can promote confidence among potential investors in renewable energy projects. Because the governmental authority spells out the procurement terms, there is greater transparency between the government and project developers. In many nations, renewable energy industries are still in their infancy. As a result, developers often have an information disadvantage and would benefit from the information provided in a tender document.

Well-designed auction schemes allow bidders to tailor their bids to their individual cost structures.

Some critics believe that auction schemes have disadvantages. With some nations increasingly using auctions to transition away from FITs, some believe competitive bidding will drive financial support for renewable energy downward and result in fewer deployments. Some observe that tendering schemes are complex and primarily benefit large entities that can understand the process and afford the administrative and transaction costs associated with bidding. This is different from FITs, which can be designed to enable broad-based participation with fewer transaction costs. And the International Renewable Energy Agency (IRENA) has observed that unless auction schemes are held regularly, there may be a "stop-and-go pattern of deployment" that may hamper a nation's path of developing its renewable energy industries and electricity generation capacity.[33]

Despite the criticisms, renewable energy auctions are increasingly popular. According to the International Energy Agency (IEA), competitive bidding processes will be held for more than half of all new capacity procured during the 5-year period from 2018 to 2023.[34] One notable example of a nation that has transitioned from FITs to competitive bidding is China. In 2018, the National Energy Administration announced that auction schemes, not FITs, would be used for onshore wind and solar PV procurement after 2020.[35] Competitive bidding mechanisms are expected to be responsible for almost half of utility-scale capacity deployment during this time period.

3.5 Governmental support for renewable energy: grants, loans and loan guarantees, research and development

This section discusses the role of direct *public investment* (or "public financing") programs administered by national governments and their

33 Int'l Renew. Energy Agc'y, Renewable Energy Auctions in Developing Countries 13 (2013), https://perma.cc/DJP4-3MTY.

34 *See id.*

35 *See Notice of the National Development and Reform Commission and the National Energy Administration on Actively Promoting the Work Related to Unsubsidy*, Nat'l Energy Admin. (Jan. 10, 2019), https://perma.cc/WGB3-673K.

agencies in supporting renewable energy projects and R&D. Almost 100 countries have public investment policies. Public investment also includes support by the European Union and by *development finance institutions* (DFIs). These are specialized banks, such as the African Development Bank, that support private sector development in developing countries. According to the IRENA, DFIs account for as much as three-fourths of all public investment.[36] Investments in Western Europe and the Latin America-Caribbean region attracted more than half of public investment in 2013–15.

Public investment supports a wide range of projects. Financial assistance forms include *grant programs* (which provide funds directly to recipients with no expectation of repayment), *loan programs* (which provide funds conditioned on repayment, including *concessional loans* with generous terms such as below-market interest rates and grace periods in which repayments are not required), loan guarantees and funding of R&D programs. This definition excludes the following: (1) governmental expenditures for FITs, targets and other policy support measures discussed in the earlier sections of this chapter, which can support individual firms but do not involve direct investment; (2) private sector investment in renewable energy, discussed in Chapter 6; (3) direct investment by private foundations and other nonprofit entities; and (4) governmental subsidies under tax code provisions, also discussed in Chapter 6.

Low-cost or free capital through a governmental investment can be indispensable to renewable energy projects and industries. Public investment can help discover and develop new technologies, make incremental improvements and cost reductions in existing ones, and accelerate deployment and improve performance of facilities that are ready for deployment. Grants and concessional finance are less common than other forms of financial assistance. According to the IRENA, grants made up only 0.5 percent of public investment in renewable energy annually between 2013 and 2016, and low-cost debt and concessional finance accounted for only 4 percent.[37]

Public investment is readily justified for renewable energy R&D, as it often yields benefits greater than its costs. For many reasons, the

36 Int'l Renew. Energy Agc'y, Global Landscape of Renewable Energy Finance 2018 13 (2018), https://perma.cc/GH8F-5Q45.

37 *Id.* at 25.

private sector supports energy R&D at an inefficiently low level. Basic research to advance the knowledge base and activities to develop and commercialize new products are lengthy processes. And individual firms may not be able to capture the benefits that result from the research, as it may take years after the start of R&D before technology may be sold commercially. In general, funding aimed at basic research yields considerable benefits over the long term, as robust, sustained programs can make headway in addressing fundamental challenges to demonstrating and deploying new technologies. Support for applied research (developing practical applications of new scientific findings through such means as demonstration projects) is also often critical. R&D with a medium and long-term perspective often supports long-term improvements in renewable energy technologies and enables breakthroughs that could allow them to succeed in the marketplace.

By one estimate, total global government renewable energy R&D was $5.5 billion in 2018.[38] In Europe, the Horizon 2020 program supported over €5.2 billion in funding for multinational collaboration projects and individual researchers from 2014 to 2020. In the United States, funding for renewable energy R&D is largely the responsibility of the Department of Energy (DOE). The energy crises of the 1970s prompted the US federal government to act broadly on a number of energy issues, some of which are discussed in other chapters (such as the purchase obligation for renewable energy, discussed in section 4.2). At that time, the federal government expanded its existing energy R&D programs to include renewable energy. Since then, funding for renewable energy R&D has totaled over $27 billion in 2016 dollars, with just over $9 billion funded between 2009 and 2018.[39]

The United States established a new R&D funding agency in 2007, Advanced Research Projects Agency-Energy (ARPA-E).[40] ARPA-E was modeled after the Defense Advanced Research Projects Agency, a highly renowned government R&D agency that (among other successes) played a key role developing technologies that undergird the Internet. ARPA-E funds high-risk, high-payoff research for renewable

38 Frankfurt Sch. FS-UNEP Collaborating Ctr. for Climate & Sustainable Energy Fin., Global Trends in Renewable Energy Investment 2019 30 (2019), https://perma.cc/F3LF-KUXD.

39 Corrie E. Clark, Cong. Research Serv., Renewable Energy R&D Funding History: A Comparison with Funding for Nuclear Energy, Fossil Energy, Energy Efficiency, and Electric Systems R&D 4 tbl 1 (June 18, 2018), https://perma.cc/6A9M-JV6A.

40 ARPA-E, https://perma.cc/FN9X-8K7B.

energy technologies, focusing on research projects that are too early to attract private sector funding but that have the potential to rapidly advance and achieve commercialization. Other nations have similar agencies, such as the Australian Renewable Energy Agency. However, in the United States and Australia, R&D funding has sometimes been targeted for deep cuts by governments hostile to renewable energy development. For example, the US Trump Administration slashed funding for renewable R&D by over 70 percent. This can seriously hamper the sustained commitment needed to bring new technologies from the lab bench to commercialization.

An example of a DFI's renewable energy program is the African Development Bank's Sustainable Energy Fund for Africa. This program aims to support small- and medium-scale renewable energy projects in developing countries in North Africa and Sub-Saharan Africa. It provides financing for project design and preparation to bring projects to a stage where either the bank or other entities can invest in them. This includes investment capital for projects and technical assistance for capacity building, with a particular focus on less well-established technologies and off-grid installations. The program is supported with financial commitments by Denmark, the United States and Norway.

Loan guarantees have supported renewable energy technologies, particularly those too risky to secure other types of financing. The United States created an energy loan guarantee program in the Energy Policy Act of 2005, establishing an agency in the DOE called the Loan Programs Office (LPO). As part of the American Recovery and Reinvestment Act of 2009, the US stimulus law after the worldwide recession in 2008, the LPO expanded the amounts it expended on loan guarantees. Eventually, the LPO loaned $34.2 billion to a variety of businesses. The agency had a high-profile failure in 2011, when the solar panel company Solyndra defaulted on a $535 million loan. This attracted considerable public criticism, with many calling for the LPO to be abolished. Still, the total rate of default was only about 2 percent, comparable to that of many private lenders for other types of projects.[41]

41 *See* Energy Futures Init., Leveraging the DOE Loan Program: Using $39 Billion in Existing Authority to Help Modernize the Nation's Energy Infrastructure 3 (Mar. 2018), https://perma.cc/9KQA-XNEB.

Loans to individuals from private banks are discussed in section 6.5. In addition, national and sub-national governments have created government sponsored loan funding incentives for renewable energy systems. Sub-national jurisdictions, such as states in the United States, have established revolving loan programs to fund individual system deployments. For example, the US state of Colorado offers the RENU Loan program. The state partnered with a credit union that offers loan financing for renewable energy systems and other types of projects. Other sub-national jurisdictions have created authority for utility *on-bill financing*, in which the utility pays for the system, and the customer repays it on the monthly utility bill. Depending on how they are set up, these programs involve either financing, in which the utility funds the systems, or repayment, in which the funding comes from non-utility sources (for example, governmental agency loan programs or banks), with the utility being a conduit for repayment.

On-bill financing has a number of advantages. For the consumer, a primary advantage is that the same bill includes repayment and electricity savings. The customer's payment history with the utility can be used as a means of evaluating whether the customer will repay, with the potential threat of disconnection if they do not. This is different from loans for system purchases (see section 6.5), which require guarantees of a customer's creditworthiness. This also allows for a streamlined billing process, if utilities are willing to change their systems to accommodate it.

A final type of government sponsored loan in the United States, *Property Assessed Clean Energy financing* (PACE) programs, gives incentives to property owners to install renewable energy systems. Owners repay funding over time through an assessment on their property tax bills. As of 2020, 37 US states and the District of Columbia had enacted PACE legislation, with programs available in 22 states.[42] However, only three states – California, Florida and Missouri – offer PACE loans for private residences.

In summary, there are many forms of public investment in renewable energy. However, most renewable energy investment comes from private sources. By the IRENA's estimate, less than 10 percent of total renewable energy finance comes from public sources.

42 *PACE Programs,* PACENation (2019), https://perma.cc/KHL2-Q7NG.

3.6 Incentives for renewable energy in the transportation sector

This section covers measures most directly tied to renewable energy usage in the transportation sector. This section addresses the wide variety of measures aimed at reducing fossil fuel consumption in transportation by using renewable resources. For the most part, the measures covered here focus on ground transportation, which includes the use of cars, trucks and other vehicles for intra- and inter-urban trips. The considerable potential for use of renewable fuels in air and maritime transport is not addressed here.

Some governmental incentives aim at transitioning the vehicle fleet from *internal combustion* vehicles that run on fuels derived from fossil fuels, such as gasoline, to other types of vehicles powered directly or indirectly by renewable resources. These include EVs and other vehicles that do not emit pollutants (collectively known as *zero-emission vehicles* (ZEVs)). EVs are battery-electric vehicles that run solely on electricity (BEVs), and plug-in hybrid vehicles that can run on both electricity from their batteries and on gasoline. They are increasingly popular in many nations, as in China, the Netherlands and Norway, where the majority of new cars sold are EVs.[43] Other ZEVs run on alternative fuels, such as biofuels.

The incentives discussed here take three basic forms: (1) direct regulation aimed at increasing the share of alternative powertrains for vehicles, such as EVs or plug-in hybrid vehicles; (2) renewable fuel regulations and mandates; and (3) tax policies aimed at changing the transportation vehicle mix. A typical example of direct regulation is a mandate that auto manufacturers meet a minimum share of EVs or ZEVs in their total vehicle sales. It is claimed that this is the most direct and strongest incentive to vehicle manufacturers for developing, offering and marketing ZEVs. Countries including China, France, Germany, India and the United Kingdom, and sub-national jurisdictions such as the US state of California, have targets for EV sales. China's New Energy Vehicle mandate requires that EVs make up 12 percent of new car sales by 2019,[44] and China is considering a much

43 David Nikel, *Electric Cars: Why Little Norway Leads the World in EV Usage*, Forbes (June 18, 2019), https://perma.cc/SHW6-N4G8.

44 *New Energy Vehicle (NEV) Mandate Policy*, IEA: Policies Database, https://perma.cc/JCZ3-J9W8.

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higher percentage mandate for the years 2025 or 2035.[45] California's ZEV program, which other US states have adopted, sets targets for sales of EVs, plug-in hybrid vehicles and hydrogen-powered fuel cell vehicles. The Californian and Chinese programs contain incentives for automakers to exceed their percentage targets, allowing them to sell credits to other companies.

Another form of direct regulation is controls of vehicle GHG emissions to promote increased market share and deployment of EVs and ZEVs. Europe's Regulation (EU) 2019/631 set stronger CO_2 emission performance standards for new passenger cars and for new light commercial vehicles (vans) in the European Union after 2020.[46] Similarly, in the United States, two federal agencies agreed on standards for automakers to build new vehicles with improved fuel economy and GHG emissions performance by the year 2025 under the federal Clean Air Act of 1963 as amended and the Corporate Average Fuel Economy program. These standards were the result of unprecedented negotiation among automakers, governmental agencies and the US state of California. While the Trump Administration subsequently issued a rule to roll back the standards, that effort was challenged in the federal courts.

National governments have established regulatory programs to expand EV charging infrastructure. China's 2015 Guidance on Accelerating the Construction of Electric Vehicle Charging Infrastructure called for "charging infrastructure sufficient for 5 million EVs by 2020, all new residential construction to be equipped for EV charging, 10% of parking spaces in large public buildings to be available for EV charging and at least one public charging station for every 2,000 EVs."[47] Other policies and guidance followed. A wide variety of sub-national jurisdictions in China offer subsidies for residential and commercial installation of charging equipment.

45 *China Targets 35 Million Vehicle Sales by 2025, NEVs to Make Up One-Fifth*, Reuters (Apr. 24, 2017), https://perma.cc/86VJ-KM7B.

46 Commission Regulation 2019/631 of the European Parliament and of the Council of 17 April 2019, Setting CO_2 Emission Performance Standards for New Passenger Cars and for New Light Commercial Vehicles, and Repealing Regulations (EC) No 443/2009 and (EU) No 510/2011 (Recast), 2019 O.J. (L 111), 13, https://perma.cc/K8RA-AZNZ.

47 Anders Hove and David Sandalow, Columbia | SIPA: Ctr. on Glob. Energy Pol'y, Electric Vehicle Charging in China and the U.S. 13–14 (Feb. 2019), https://perma.cc/NK34-WHD4.

In the United States, federal policies aim at development of charging infrastructure, though not on the scale of China's effort. An example is the plan announced in 2016 by the US Federal Highway Administration to expand the number of charging stations in the nation by establishing 48 new "charging corridors" on about 25,000 miles of major highways in 35 states.[48] The plan contemplated that EV charging stations would eventually be available about every 50 miles along these routes. Twenty-eight states committed to accelerate the deployment of charging infrastructure on these corridors, together with utilities, vehicle manufacturers and others. In Europe, the 2014 Alternative Fuels Infrastructure (AFI) Directive aimed to promote the growth of EV and alternative fuel vehicle infrastructure.[49] It required Member States to create National Policy Frameworks leading to installation of public charging infrastructure by 2030. Canada's federal government launched a Zero-Emission Vehicle Infrastructure Program in 2019, with rebates to businesses and governments for new EV charging stations.

In the United States, Western European nations and Scandinavian nations, private sector providers such as Tesla, Allego and Fastned are building charging networks. Charging stations may eventually provide other services that promote renewable energy. Using vehicle-to-grid technology, vehicle batteries can serve as a source of electric power for the grid. Plugging multiple cars into a charging station at once might allow EVs to provide electricity back to the grid at times, and EVs could be compensated for their role in providing ancillary services (see section 4.2).

Turning to policies for renewable fuels, two common strategies are tax incentives for biofuels, and blending mandates that require a specific percentage of motor fuels to come from biofuels. Eight Latin American nations have biofuel blending mandates. A well-known example of a blending mandate is the US Renewable Fuel Standard (RFS), established as an amendment to the federal Clean Air Act. The RFS requires that US transportation fuels contain a minimum volume of biofuel, with a minimum of 36 billion gallons of ethanol to be blended into

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48 *Alternative Fuel Corridors*, U.S. Dep't. of Transp., Fed. Hgwy. Admin., https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/ (last visited Mar. 24, 2021).

49 Directive 2014/94/EU, of the European Parliament and of the Council of 22 October 2014 on the Deployment of Alternative Fuels Infrastructure, 2014 O.J. (L 307), 1, https://perma.cc/KC37-K4Z7.

the US fuel supply each year by 2022. California's Low Carbon Fuel Standard (LCFS) also regulates fuels, using a carbon intensity standard. Both the RFS and the LCFS are enforced using tradable compliance credits.

Critics of these mandates claim that biofuels are unsustainable because they require large tracts of agricultural land for feedstock production. Similarly, critics of the EU AFI Directive believe that the alternative fuels included within its coverage – particularly biofuels (including palm oil), and even natural gas and liquefied petroleum gas – do not reduce emissions sufficiently, and that more attention should be given to zero-emission alternatives. Critics of California's LCFS have also tried twice, unsuccessfully, to stop it in federal courts on constitutional grounds. See section 8.4 for a discussion of this issue.

Tax policies for the purchase of EVs and other alternative-fueled vehicles have been effective at stimulating consumers to buy them. In Germany, purchasers of EVs and fuel cell vehicles may receive as much as €5,000 per vehicle, up to a vehicle purchase price of €65,000.[50] The United States has a tax credit for $2,500 to $7,500 per new EV purchased, which varies by the size of the vehicle and its battery capacity.[51] The credit phases out once a manufacturer has sold 200,000 vehicles. In addition, a number of US states offer state tax credits. In 2020, South Korea offered national subsidies of 8 million won (about $6,600 equivalent) for the purchase of each EV.[52] China offers similar subsidies, although the levels are decreasing. Studies have shown that these incentives prompt increased EV purchases. Other tax policies for ZEVs are financial incentives in vehicle registration taxes and value added tax reductions. At present, 22 EU Member States currently apply some form of registration tax to the purchase or registration of vehicles that is based on CO_2 emissions.[53] The Czech Republic exempts BEVs and fuel cell vehicles emitting 50g CO_2/km or less from registration

50 *Increased EV Subsidies Go into Effect in Germany*, Electrive.com (Feb. 18, 2020), https://perma.cc/52V7-RLMQ.

51 *Federal Tax Credits for New All-Electric and Plug-In Hybrid Vehicles*, FuelEconomy.Gov, https://perma.cc/N5X9-5UVU.

52 *S. Korea to Overhaul Subsidy Scheme for EVs*, Yonhap News Agc'y (Aug. 9, 2020), https://perma.cc/6AVW-L2NM.

53 *See* Arno Schroten, principal author, European Comm'n, Transport Taxes and Charges in Europe: An Overview Study of Economic Internalisation Measures Applied in Europe 36–38 (Mar. 2019), https://perma.cc/VV8X-2SMQ.

charges altogether. Austria features a value added tax (VAT) deduction and exemption from tax for ZEVs.

Programs aimed at promoting EVs do not by themselves increase renewable energy usage in transportation. Without increased support for renewable electricity, a national EV mandate may simply increase electricity demand and even prompt higher fossil fuel usage. Similarly, a mandate for increased biofuel usage does not necessarily prompt an increase in sustainable fuel production (see section 2.6), unless it is properly structured to do so.

Numerous other forms of regulating transportation may reduce fossil fuel consumption and increase renewable energy's share. These regulatory strategies include tolls, parking regulations and the like. There is considerable potential for substitution of transportation trips currently accomplished by trucks and private cars by other modes of transportation such as electric trains for freight and passengers, or electric bicycles for intra-urban trips. Most inter-urban land transport in the United States, for example, is done by private cars and trucks. Substituting other modes that rely on electricity for some of all of these trips might increase renewable energy use in transportation. A bicycle sharing program, for example, can be an effective means of providing sustainable transportation, and if it were to incorporate e-bikes it might prompt use of renewable energy.

The billions of dollars being invested in research and testing of autonomous vehicles might someday feature a convergence of electricity generated from renewable resources with artificial intelligence. EVs may someday be used as autonomous vehicles due to reduced costs of operation and maintenance. These vehicles could operate more continuously than today's vehicles because they would not sit idle for hours at a time. And if the electricity used to power the EVs was generated from renewable resources, there would be considerable benefits. But it would require many changes in the transportation and electricity sectors for autonomous vehicles to reduce fossil fuel usage.

In summary, a wide variety of actors is involved in greening the transportation sector, including national, state and local governments, and industries that produce vehicles (such as automobile manufacturers) and the components that go into them. Other industries support vehicle operation (such as operators of EV charging stations and fuel filling stations), and produce energy sources for use in vehicles (oil companies and biofuel producers). In the case of electricity, the entire infrastructure for electricity generation and delivery involves multiple entities, including utility companies, grid operators and generators. Also, transportation users, such as individuals, and operators of fleets, such as private companies and governmental agencies, are involved in setting policies.

Substituting renewable fuels and electricity for fossil fuels in vehicles is therefore challenging. Vehicle design and infrastructure buildout is complex. In many nations, there is a lack of political and public support for vehicle fuel transitions. Each form of energy that could serve as an alternative to a fossil fuel (such as electricity and biofuels) has a different maturity level and poses unique barriers to widespread usage. As an example, consider a national goal to enable transport users to fuel or charge their vehicles with alternative fuels within reasonable distances and times. For EVs, this might require a significant increase in the number of available charging points and attention to their technical characteristics, such as the time required for a full charge. In many nations, the infrastructure to recharge EVs at scale is just beginning to be developed and technologies for fast recharging are not standardized. Hydrogen filling stations for fuel cell vehicles might allow for faster refueling, but there are relatively few of these at present in nations such as the United States, and many more would be needed for a national network.

A well-designed initiative for transitioning the vehicle fleet to higher penetration of renewable fuels and renewable electricity must feature an integrated approach. It would simultaneously target the vehicle fleet, the infrastructure, the behavior of end users, and the energy producers. Moreover, it would need to differentiate among the multiple potential pathways for renewable energy usage in transportation and recognize the potential for changed economic and technology environments over time. For the most part, however, nations have not embarked on such integrated approaches. Instead, the policies discussed in this section tend to target individual aspects of the challenge.