Appendix A: Overview of the levelized cost of electricity method for renewable energy sources

The LCOE is the unique cost of an energy project, representing the present value of the costs over the lifetime of the project.

The LCOE is defined as the price of electricity "required for an energy project where revenues would equal costs, including a return on the capital invested equal to the discount rate".[58] An electricity price above this value would result in greater economic return on the investment, and an electricity price below the LCOE would result in a lower economic return.

The generic formulae to calculate the LCOE of RE technologies are as follows,[59] and the variables and parameters are listed in Table A.1:

Equation A.1

$$LCOE = \frac{\sum_{t=1}^{n} = \frac{I_t + M_t + F_t}{(1+\mathrm{d})^t}}{\sum_{t=1}^{n} = \frac{E_t}{(1+\mathrm{d})^t}}$$

Equation A.2

$$E_t = P_t \times 8760 \times CF_t$$

TABLE **A.1**

Input parameters and description for calculation of the project levelized cost of electricity

Input parameter	Description	Unit
LCOE	The average lifetime levelized cost of electricity generation	USD/kWh
I_t	Investment expenditures in year *t*	USD
M_t	Operational and maintenance costs in year *t*	USD
F_t	Fuel costs in year *t*	USD
E_t	Electricity generation in year *t*	kWh
d	Discount rate (or weighted average cost of capital)	%
n	Economic lifetime of the system	Years
P_t	Power generation capacity of the system	kW
CF_t	Capacity factor in year *t*	Dimensionless

[58] IRENA (2018b).

[59] IRENA (2018b).

Given the capital-intensive nature of most RE technologies and the fact that fuel costs are low (zero for many RE technologies), the WACC, also referred to as the discount rate *d*, used to evaluate the RE project has a critical impact on the LCOE.[60] For more information on the WACC, see Appendix B.

The LCOE of RE technologies varies by RE technology, country and project size. It is determined taking into account the RE resource at a project site, capital and operating costs, and the performance/efficiency of the RE technology. When a policy has a wide geographical coverage with different physical conditions for RE generation (e.g. wind power), it is recommended that LCOEs are calculated specifically for each region or location.

IRENA provides input values for LCOE (USD/kWh), total investment costs (USD/kW) and capacity factors for different RE technologies across different regions.[61]

[60] IRENA (2018b).

[61] IRENA (2018b, 2019a).

Appendix B: Overview of the weighted average cost of capital for renewable energy sources

Financing is an important part of the electricity generation cost. Project finance generally comes in three different forms: equity, private debt financing and public debt financing. In the calculations, these are captured in the WACC. The WACC is the rate a company is expected to pay, on average, to compensate all its investors. Section 7.4.1 explains the use of the WACC in financial feasibility calculations.

To calculate a WACC, we refer to the UNFCCC methodological tool on investment analysis developed for CDM projects.[62] WACCs are calculated using equation B.1. Table B.1 provides the input parameters and assumptions to calculate the WACC. The UNFCCC tool also provides default values for the cost of equity (r_e).

Equation B.1

$$WACC = r_e \times W_e + r_d \times W_d \times (1 - T_c)$$

TABLE **B.1**

Assumptions in the calculation of the weighted average cost of capital

Input parameter	Description	Unit
r_e	Cost of equity (expected return on equity)	Dimensionless
W_e	Percentage of financing that is equity	Dimensionless
r_d	Cost of debt	Dimensionless
W_d	Percentage of financing that is debt	Dimensionless
T_c	Corporate tax rate	Dimensionless

[62] UNFCCC (2018b).

For policy impact assessments, users may want to quantify a more generalized WACC that is broadly applicable to a range of RE projects that are expected to be installed under a policy. In such cases, users may use the WACCs developed by IRENA for region-level calculations of the LCOE[63] presented in Table B.2.

TABLE B.2

Economic lifetime and weighted average cost of capital used for levelized cost of electricity calculations

	Economic life (years)	Weighted average cost of capital, real	
		OECD and China	Rest of the world
Wind power	25	**7.5%**	**10%**
Solar PV	25		
CSP	25		
Hydropower	30		
Biomass for power	20		
Geothermal	25		

Source: IRENA (2018b).
Abbreviations: OECD, Organisation for Economic Co-operation and Development

[63] IRENA (2018b).

Appendix C: Example renewable energy policies

This appendix provides examples of RE policies from a number of countries, and case studies of RE policies from the literature. This information can be used to support the benchmarking exercise users can undertake after calculating RE addition.

TABLE **C.1**

Example feed-in tariff policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
Algeria (Nganga, Wohlert and Woods, 2013) FiT introduced in 2004 (Meyer-Renschhausen, 2013); 2014 for PV (PwC and Eversheds, 2016)	• All RE technologies eligible • Tariff differentiation with tariff premiums ranging between 80% and 300% • Government-owned single buyer with guaranteed purchase up to the annual production quota • FiTs are offered over a project's lifetime	• **Market barrier:** Significant subsidies available for conventional energy sources that reduce the price for all consumers • **Regulatory and policy uncertainty barrier:** Regulatory obstacles • **Financial barrier:** Lack of available capital (BETTER, 2013) • **Institutional and administrative barrier:** Regulatory and bureaucratic uncertainty and inefficiency (BETTER, 2013) • **Policy design challenge:** Insufficient level and variability of tariffs	• No single project has become operational, as of February 2013
Tanzania (Nganga, Wohlert and Woods, 2013) FiT introduced in 2009 (Weischer, 2012)	• Eligible projects must be at least 100 kW and export no more than 10 MW • No differentiation based on technology, size, fuel type or application, but depending on whether the SPP is grid connected or mini-grid • Payment duration of 15 years • 100% of energy purchased by utility and independent power producers	• **Financial barrier:** Solvency of state-owned utility (TANESCO) • **Infrastructure barrier:** Underdeveloped grid and problems with grid stability • **Financial barrier:** Low-interest financing as key challenge for SPP developers (with interest rates of 12–15% and payback periods of only 7–10 years, as of February 2013) • **Regulatory and policy uncertainty barrier:** Complicated regulatory requirements coordinated by several agencies (Weischer, 2012) • **Lack of awareness and skilled personnel:** Lack of experience in RE projects. Lack of confidence among stakeholders due to inexperience • **Public acceptance and environmental barrier:** Conflicts over land ownership and water rights (Weischer, 2012)	• 24.4 MW of newly developed capacity as of February 2013 • Additional 60 projects of a combined 130 MW in the pipeline as of February 2013

TABLE **C.1**, continued

Example feed-in tariff policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
Thailand (Beerepoot et al., 2013; ADB, 2015) Feed-in premium introduced in 2007, revised in 2009. Solar FiT introduced in 2013 (Tongsopit, 2014)	• Technologies eligible are biomass, biogas, municipal solid waste, wind, mini- and micro-hydropower, and solar; however, purchase of solar energy through the premium programme has been suspended • Feed-in premium rates for RE are differentiated by technology capacity, location, use as diesel replacement and installed capacity • 100% of energy purchased by Thai power utilities (EGAT, PEA and MEA) • Projects are eligible for support for 7–10 years • FiT programme for solar (Tongsopit, 2014))	• **Regulatory and policy uncertainty barriers:** Weak regulation and lack of transparency (Tongsopit and Greacen, 2012; Pacudan, 2014). Conflicting laws (Chaianong and Pharino, 2015). Uncertainty over future policy (Tongsopit, 2014). • **Techno-economic barriers:** Technical barriers, including severe energy shortages (Chaianong and Pharino, 2015) • **Public acceptance and environmental barrier:** Lack of public discourse (Tongsopit and Greacen, 2012) • **Lack of awareness and skilled personnel:** Limited number of skilled workforce in various technologies (Sawangphol and Pharino, 2011). Lack of domestic production of PV and wind (Chaianong and Pharino, 2015) • **Market barriers:** High capital investment, especially for PV (break-even point of 7–9 years). Fluctuation of fossil fuel price (Sawangphol and Pharino, 2011). • **Institutional and administrative barriers:** Lack of coordination among implementing bodies (Pacudan, 2014). Complex permitting process (Tongsopit, 2014) • **Policy design challenge:** Planning barriers (Tongsopit and Greacen, 2012) • **Market barrier:** Absence of consumer demand (Tongsopit and Greacen, 2012)	• 215.66 MW of installed capacity for rooftop solar PV as of 2012 (Chaianong and Pharino, 2015)

TABLE **C.1,** continued

Example feed-in tariff policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
United Kingdom (UK Department of Energy and Climate Change, 2015) FiT introduced in 2010	• Technologies eligible are solar PV, onshore wind, hydropower, anaerobic digestion and micro combined heat and power (micro CHP) • Tariff differentiation with higher tariffs for less mature technologies and small-scale installations • Tariffs were set to give rates of return of 5–8%	• **Regulatory and policy uncertainty barrier:** Policy risk and uncertainty result from changing policies, including financial support policies (Renewable Energy Association, 2015). These changes include large digressions in the FiT and impending solar FiT review (European Forum for Renewable Energy Sources, 2015) • **Lack of awareness and skilled personnel:** Insufficient skilled workers for installation of microgeneration technologies (Tallat-Kelpšaitė and Aaskov, 2015) • **Institutional and administrative barrier:** The objectives of Ofgem (UK's independent national energy regulator) are not aligned with national and European RE and green economic objectives (Tallat-Kelpšaitė and Aaskov, 2015) • **Policy design challenge:** Problems with FiT cost control mechanism for small-scale anaerobic digestion exist • **Policy design challenge:** The financial support for FiT technologies is unbalanced. While there is adequate support for PV, other technologies do not receive enough support to encourage similar investments (Tallat-Kelpšaitė and Aaskov, 2015)	• 3,567.40 MW of installed RE capacity over period of operation (April 2010 to March 2015), with total of 682,511 installations • PV accounts for 83.46% of all installed capacity, and wind accounts for 11.47% of all installed capacity
Uruguay (IRENA, 2015e) ***Only FiT policy for biomass in 2010 covered in this overview;*** however, note hybrid FiT/net metering policy for microgeneration in 2010, and hybrid policy of FiT and auction for PV in 2013 (Glemarec, Rickerson and Waissbein, 2012)	• Only eligible technology is biomass • Production capacity up to 20 MW (Government of Uruguay, 2010) • Payment duration of up to 20 years	• **Institutional and administrative barriers:** Significant barriers in licensing process for wind (Glemarec, Rickerson and Waissbein, 2012). Lack of experience in issuing permits for micro hydro (Terra and Schenzer, 2014). Absence of a regulated tariff for cogeneration as of 2012 (Garmendia, 2012)	• While the initial proposals received under the FiT totalled 354 MW of capacity, as of late 2014 only 0.6 MW was installed, with 43 MW in the pipeline (IRENA, 2015e)

Abbreviations: FiT, feed-in tariff; SPP, solar power plant

TABLE **C.2**

Example auctions and tender policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
Brazil (IRENA, 2013, 2015d) Laws adopted in 2004	• Auctions for wind, solar, small-scale hydro, large-scale hydro and conventional power sources • Projects contracted in auction required to start delivery after 3–5 years • PPAs are typically secured for 30 years for hydro, and 20 years for wind and biomass • 100% of the energy is bought in competitive bids with guaranteed revenue for power producers • Several prerequisites for bidders to participate in bidding process • Bidders have to deposit several guarantees including a bid bond of 1% of project's investment cost and a project completion bond of 5% of project's investment cost • Additional reserve energy auctions	• **Institutional and administrative barrier:** Difficulty in financing and problems getting environmental permits approved • **Infrastructure barrier:** Problems accessing the grid that lead to delays (Tiedemann, 2015) • **Policy design challenge:** The hybrid system of auctioning may allow the "winner's phenomenon", where bidders underbid to win the auction and ultimately undergo economic losses (Ferroukhi et al., 2015) • **Policy design challenge:** The auctioning process may last too long (Ferroukhi et al., 2015)	• Total of 62 GW has been contracted through 25 auctions for new capacity, including 9 GW of RE-based electricity generation auctions between 2005 and 2013 • 443 new generation projects for all technologies, including conventional power, with 60% renewables (40% large-scale hydro and 20% other RE)
China (IRENA, 2013) Auctions between 2003 and 2007 (IRENA, 2013)	• Auctions for wind (onshore and offshore), solar PV and CSP • Selection in one stage based on price (following the "lowest price wins" criterion) or weighted score from price and local content • Duration of tariff is 25 years for onshore wind and 30 years for offshore wind (including 4-year construction period) • No specific compliance rules nor clear penalties for non-compliance	• **Market barrier:** Information errors during the first and second bidding rounds that presented risks for bidders (Steinhilber, 2016) • **Lack of awareness and skilled personnel:** Lack of experience by bidders (Steinhilber, 2016). Lack of sufficiently stringent procedures to qualify bidders (Azuela et al., 2014) • **Regulatory and policy uncertainty barriers:** Conflicting policies and absence of penalties (Steinhilber, 2016). Lack of clear compliance rules such as ex-post change of location and Investment uncertainty (Held et al., 2014). • **Institutional and administrative barrier:** Lack of coordination between the auction organizer and the State Oceanic Administration (responsible for management of sea areas) (Azuela et al., 2014)	• Total of 8.64 GW of capacity contracted between 2003 and 2011 (7.3 GW of onshore wind; 10 MW of solar PV; 280 MW of CSP; 1.0 GW of offshore wind) (IRENA, 2013)

TABLE **C.2,** continued

Example auctions and tender policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
Morocco (IRENA, 2013) Tendering of hydro projects since 1960, legislation revised in 2010. Wind projects tendered since 1998 (Ecofys, 2013)	• Technology-specific auctions for wind (onshore), hydro and solar CSP in designated locations and for maximum capacity installed • Selection process with pre-qualification phase (experience, financial, technical capacity) and evaluation phase (technical specifications, financial aspects, industrial integration) • Duration of tariff is 20 years for wind and 25 years for solar • Penalties for delay and underperformance determined in PPA, guarantee paid at signature of PPA and termination of PPA as last resort	• **Institutional and administrative barriers:** Complex tendering system that involve five international financing institutions with different sets of procurement rules and processes (Ecofys, 2013). The tendering process is long, and implementation of the requirements is still unclear (Ecofys, 2013). • **Regulatory and policy uncertainty barrier:** Details for contracting projects are not transparent to the public (Ecofys, 2013) • **Infrastructure barrier:** Issues with integrating renewable power into the transmission grid system • **Overcoming potential barrier:** Stable political and regulatory environment, and Morocco's experience with independent power producers are essential in attracting investors • **Overcoming potential barrier:** Establishment of governing agency for solar energy (MASEN) was instrumental in the successful management of CSP solar auction • **Overcoming potential barrier:** Adoption of the public–private partnership model was crucial in de-risking the large-scale projects	• Total of 310 MW of RE capacity contracted between 2011 and 2012 (150 MW of wind; 160 MW of solar) • In March 2016, Morocco tendered a total of 850 MW of wind energy capacity to be installed on five wind farms (El Yaakoubi, 2016)
Peru (IRENA, 2013) Start of auctioning scheme in 2009 (IRENA, 2015a)	• Technology-specific auctions targeting solar, biomass and waste, wind, small hydro and geothermal • Selection in one round without a pre-qualification phase based on price and quota of energy (with ceiling price) • Duration of tariff 20 years (in the form of a PPA) • Performance bonds deposited by the power producers to secure completion of projects • Compliance with volume of energy generation contracted is ensured by penalizing shortages	• **Market barrier:** Gas-powered plants have preference over hydro plants through tax incentives (IRENA, 2012b). • **Institutional and administrative barriers:** Environmental impact assessment for hydro can be a hurdle (IRENA, 2012b). Problems with environmental permits and agreement with local people exist. The low level of technical barriers to participate in the auctions increases the risk of delays and non-execution (Ecofys, 2013) • **Lack of awareness and skilled personnel:** Feasibility studies, technical knowledge and a comprehensive legal framework are missing for geothermal (IRENA, 2012b)	• Total of 639 MW of RE capacity contracted between 2009 and 2011 across 36 projects (142 MW wind, 80 MW solar; 23 MW biomass, 4 MW biomass and 180 MW small hydro) • 236 MW of capacity operated as of December 2012 (GIZ, 2015)

TABLE **C.2,** continued

Example auctions and tender policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
Peru, continued	• Almost no administrative barriers due to high bidding guarantees and low pre-qualification requirements (GIZ, 2015)	• **Regulatory and policy uncertainty barrier:** Access to finance for RE projects is unregulated (Ecofys, 2013)	• Cumulative capacity for solar 184.5 MW as of July 2016 (SolarPower Europe, 2016)
South Africa (IRENA, 2013) The RE Independent Power Producer Procurement, REIPPP, was introduced in August 2011, last round in 2014 and planned auctions for 2016	• Technology-specific volume targeted across five auctions • Selection process with first phase (bidders have to meet minimum criteria related to legal, financial, technical and environmental requirements) and second phase (price 70%, economic development including local content 30%) • Duration of tariff is 20 years • Contracts terminated for bidders who fail to meet their commitment under the PPA • Current technologies considered within the PPA programme are onshore wind, CSP, solar PV, small hydro, biomass, biogas, landfill gas and co-generation from agricultural waste of by-products (del Río, 2015)	• **Institutional and administrative barriers:** Auction process complex and not automated. External transaction advisers are needed (Eberhard, Kolker and Leigland, 2014). Administrative hurdles (IRENA, 2013) • **Lack of awareness and skilled personnel:** Little provision of local capacity building and knowledge transfer (IRENA, 2013) • **Financial barrier:** High transaction costs for both the government and bidders (Eberhard, Kolker and Leigland, 2014) • **Financial barrier:** Eskom is the grid operator and single buyer, which makes power producers vulnerable to its responses (Ecofys, 2013) • **Policy design challenge:** As of August 2012, there were no successful bids for biomass, biogas or landfill gas technologies, possibly because of low price ceilings (IRENA, 2013) • **Policy design challenge:** Short timespans between auctions may negatively affect competition (del Río, 2015)	• Total of 2.46 GW of RE capacity contracted between 2011 and 2013 of 5.93 GW auctioned over the same period (1.2 GW of onshore wind, 200 MW of CSP, 1.05 GW of solar PV, 14.3 MW of small hydro) • Cumulative capacity of solar 1,048 MW as of July 2016 (SolarPower Europe, 2016) • By end of June 2015, 1,860 MW of procured capacity had already started operations (960 MW solar PV, 790 MW onshore wind, 100 MW CSP, 10 MW hydro) (del Río, 2015)

Abbreviations: CSP, concentrated solar power; PPA, power purchase agreement

TABLE **C.3**

Example tax incentive policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
Argentina (IRENA, 2015c) Law 25.019 Art. 3 enacted September 1998 for solar and wind (Government of Argentina, 1998); Law 26.190 Art. 9 enacted December 2006 (Government of Argentina, 2006), including decree 562/2009 (including wind, solar, geothermal, tidal, hydraulic, biomass, landfill gas, purification gas and biogas); Law 27.191 Arts 3 & 4 enacted October 2015 (amendment to law 26.190) (Government of Argentina, 2015) Law 26.334 01/2008 for biofuels	• Available technologies are wind, solar, geothermal, tidal, small hydro, biomass, landfill gas, purification gas and biogas (Climatescope, 2015a) At national level: • **Accelerated income tax depreciation** • **VAT rebate:** 15-year VAT deferral from capital investments in wind and solar equipment (from enactment of Law 25.019) At provincial/local level (KPMG, 2012; IRENA, 2015c): • **Real estate tax exemption** • **Stamp tax exemption** • **Turnover tax exemption/ deferral** • **Tax stability**	• **Market barriers:** Subsidies for consumption of fossil fuels. Tax breaks for companies investing in oil and gas. Tax incentives to promote exploration (Pickard, 2015) • **Institutional and administrative barrier:** Public investment in fossil fuel power stations (Pickard, 2015) • **Market barrier:** Availability of substantial amounts of natural gas and hydropower makes other sources uncompetitive (UNEP, 2011) • **Financial barrier:** Lack of support from financial institutions	• No ex-post impact study available
Colombia Law 1715 (Government of Colombia, 2014) and its decree 2143 (Government of Colombia, 2015) published November 2015 and effective February 2016 Law 1716 (2014) Art. 11 to 14	Four explicit fiscal incentives described in Laws 1716 and 1715 (decree 2143): • 50% tax break on investment over 5 years • VAT exemption for equipment and machinery (local or foreign) associated with the project • Accelerated depreciation of assets • Exemption from import duty • Tax exemptions for biofuels: some biofuel plants are labelled tax-free zones (IRENA, 2015b)	• **Market barriers:** Subsidies for fossil fuels, although reduced over time, are still present (UPME, 2015b). Oligopolies for conventional energy production (UPME, 2015a). Slightly higher investment costs for renewable technology than for conventional • **Techno-economic barrier:** Lack of technical requirements to connect and operate wind parks and small solar PV projects (UPME, 2015a) • **Infrastructure barrier:** Lack of transmission lines in areas with the greatest potential for wind energy generation	• No ex-post impact study available

TABLE **C.3**, continued

Example tax incentive policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
Colombia, continued		• **Public acceptance and environmental barrier:** Competition with historical heritage interests in the area • **Lack of awareness and skilled personnel:** Insufficient skilled workers, and lack of training and education	
Indonesia Implemented by Government Regulation No. 1/2007 (amended by GR No. 62/2008 and GR No. 52/2011), Ministry of Finance Regulation No. 21/2010 and Regulation No. 130/2011 (Damuri and Atje, 2012; PwC, 2013)	• **Import duty and VAT exemption:** Import duty exemption on machinery and capital for development of power plants. Exemption from VAT on importation of taxable goods • **Income tax reduction:** Reduction and various facilities for income tax on energy development projects, including net income reduction, accelerated depreciation, dividends reduced for foreign investors and compensation for losses • **Accelerated depreciation and amortization:** This allows investments to be depreciated within 2–10 years, depending on type of asset. This incentive would reduce the income tax paid by investors and is expected to encourage expansion of investment (Government Regulation No. 1/2007) • **Income tax reduction for foreign investors:** Allows them to pay a rate of only 10% on dividends they receive • Income tax holidays/ reductions under "Pioneer Industries Facility": **corporate income tax (CIT) exemption** for 5–10 years, 50% reduction of CIT for 2 years after end of exemption period	• **Market barriers:** The tariff for electricity set by the government is lower than the costs of production (indirect subsidy on conventional energy production). Unequal tax burdens between conventional and renewable energy sources (WWF, 2014) • **Institutional and administrative barriers:** Multilayer government approval procedures (IEA, 2015b). Difficult licensing acquisition • **Regulatory and policy uncertainty barrier:** Unclear regulations	• No company in the RE sector has qualified as a pioneer to receive additional tax exemptions (tax holidays of 5–10 years) as of April 2015 (Ministry of Finance Indonesia, 2015) • No further ex-post impact study found

TABLE **C.3,** continued

Example tax incentive policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
Panama For all renewables: Law 45 (2004) Arts 9 and 10. For wind installations: Law 44 (2011) Art. 22. For wind installations: Law 37 (2013) Art. 20 and its reform (2016) (Government of Panama, 2013, 2016)	• Available technologies are solar, wind, hydro, small hydro and geothermal • Incentives for the construction, operation and maintenance are valid for up to 20 years for solar and 10 years for other renewable energies For projects up to 0.5 MW (Climatescope, 2015b): • **Import tax exemptions** • **VAT exemptions** • **Income tax credit** equivalent to up to 100% of direct investment for 10 years For projects up to 10 MW (Climatescope, 2015b): • Exemption from **import, transmission** and **distribution taxes** • **Income tax credit** equivalent to up to 50% of direct investment For projects up to 20 MW: • Exemption from transmission taxes (on the first 10 MW for 10 years)	• **Infrastructure barrier:** Lack of transmission lines in areas with the greatest potential for wind energy generation • **Financial barrier:** Absence of adequate funding opportunities and financing products for RE • **Market barrier:** Price structure that disadvantages renewables • **Lack of awareness and skilled personnel:** Insufficient skilled workers, and lack of training and education • **Public acceptance and environmental barrier:** Competition with protected status in some potential areas	• No ex-post impact study available

TABLE **C.3**, continued

Example tax incentive policies

Country	Main design characteristics	Main barriers and challenges	Achieved impact
United States (California) 26 USC § 25D and § 48 established in 2005 (for solar), extended in 2008 and in 2015 (California Energy Commission, 2015) 26 USC § 45 established in 1992 and subsequently amended numerous times (NC Clean Energy Technology Center, 2016b) 26 USC § 136 (1992) Cal Rev & Tax Code § 73 (2012) (NC Clean Energy Technology Center, 2016a)	• **Federal ITC:** 30% for solar, fuel cells and small wind; 10% for geothermal, microturbines, and combined heat and power • **Federal renewable electricity PTC:** Available technologies are geothermal, wind, biomass, hydroelectric, municipal solid waste, landfill gas, tidal, wave, ocean thermal • **Non-taxable energy conservation subsidies:** Applicable to residential solar thermal and PV systems • **Section 73 of the California Revenue and Taxation code:** Property tax exclusion of certain solar energy systems installed between January 1999 and December 2016	• **Institutional and administrative barrier:** State incentive programmes can have complex eligibility requirements (California Energy Commission, 2015) • **Regulatory and policy uncertainty barriers:** Financial incentive legislation for RE has been volatile. Typically, extensions for tax credits are only given for 1–3 years; barriers in environmental permitting due to strict requirements for large-scale RE technologies (U.S. EPA, 2016) • **Infrastructure barrier:** Constraints in existing transmission infrastructure (California Energy Commission, 2011).	• Residential and commercial solar ITC has helped annual solar installation grow by more than 1,600% since 2006 – a compound annual growth rate of 76% (SEIA, 2016) • In years following PTC expiration, wind installations drop by about 80% (Spengler, 2011)

Abbreviations: ITC, investment tax credit; PTC, production tax credit; VAT, value-added tax; USC, United States Code

TABLE **C.4**

Case studies of renewable energy policies in the literature

Study	Author, year	Case study countries	Type of policy	Link
Renewable Energy Auctions in Developing Countries	IRENA, 2013	Brazil, China, Morocco, Peru, South Africa	In-depth description of country case studies, including design characteristics and achieved auction outcomes for all case studies	www.irena.org/DocumentDownloads/Publications/IRENA_Renewable_energy_auctions_in_developing_countries.pdf A continuation of this study is available at: https://irena.org/publications/2019/Jun/Renewable-energy-auctions-Status-and-trends-beyond-price
Renewable Energy in Latin America 2015: an Overview of Policies	IRENA, 2015b	20 countries in Central and South America	Overview of all implemented policies in the fields of national policy, fiscal incentives and grid access, especially Table 1 (plus IRENA in-depth country profiles); no/limited information on achieved outputs linked to specific policies	www.irena.org/DocumentDownloads/Publications/IRENA_RE_Latin_America_Policies_2015.pdf
Powering Africa through Feed-in Tariffs	Heinrich Böll Stiftung and World Future Council, 2013	13 countries in Africa ("pioneers" and "late movers")	Country profiles for each country with design characteristics and (short) impact assessment	https://ke.boell.org/sites/default/files/2013-03-powering-africa_through-feed-in-tariffs.pdf
Evaluation of feed-in tariff-schemes in African countries	Meyer-Renschhausen, 2013	4 countries in Africa	Overview of FiT design choices; no information on achieved outputs/impacts	www.erc.uct.ac.za/sites/default/files/image_tool/images/119/jesa/24-1jesa-meyer.pdf
Performance and Impact of the Feed-in Tariff Scheme: Review of Evidence	UK Department of Energy and Climate Change, 2015	Country case study for the UK	In-depth description of FiT policy and impact/output assessment	www.gov.uk/government/uploads/system/uploads/attachment_data/file/456181/FIT_Evidence_Review.pdf
Comparison of Feed-in Tariffs and Tenders to Remunerate Solar Power Generation	Grau, 2014	Country case studies for Germany and France	Overview of FiT and tender policies in both countries	www.diw.de/documents/publikationen/73/diw_01.c.437464.de/dp1363.pdf
Ontario's Feed-in Tariff Program: Two-Year Review Report	Ontario Ministry of Energy, 2012	Case study for Ontario (province in Canada)	Overview of FiT design and impact plus policy recommendation	www.chfour.ca/uploads/1/4/1/9/14199462/fit-review-report-en.pdf
A Policymaker's Guide to Feed-in Tariff Policy Design	NREL, 2010	Information overview for 5 countries	Information on FiT tariff payment levels for Germany, Spain, Ontario, Switzerland, Minnesota (USA)	www.nrel.gov/docs/fy10osti/44849.pdf

Abbreviation: FiT, feed-in tariff

Appendix D: Overview of the Clean Development Mechanism combined margin approach

The combined margin approach used in the CDM has gained wide technical and political acceptance over the years. The combined margin is calculated in the CDM Tool to Calculate Emission Factor for an Electricity System using the following formula:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times W_{OM,y} + EF_{grid,BM,y} \times W_{BM,y}$$

where

$EF_{grid,CM,y}$	=	combined margin emission factor for a defined time frame *y* (tCO_2e/MWh)
$EF_{grid,OM,y}$	=	operating margin emission factor for a defined time frame *y* (tCO_2e/MWh)
$EF_{grid,BM,y}$	=	build margin emission factor for a defined time frame *y* (tCO_2e/MWh)
$W_{OM,y}$	=	weighting of operating margin emission factor (%)
$W_{BM,y}$	=	weighting of build margin emission factor (%)

The main steps of the CDM tool are summarized as follows:

Step 1: Determine the operating margin ($EF_{grid,OM,y}$). Operating margin provides the GHG impact due to displacement of power generated from existing grid-connected power plants by the introduction of new capacity. The CDM tool provides four calculation approaches for estimating the operating margin, outlined in Table D.1. The appropriate approach should be selected based on the composition of the generation mix, particularly the extent of use of low-cost/must-run plants in the grid.[64]

TABLE **D.1**

Overview of options for calculating operating margin

Input parameter	Description
Simple operating margin	The emission factor is calculated as the power generation weighted average of all power units supplying to the grid, except for low-cost/must-run plants.
Simple adjusted operating margin	If low-cost/must-run power plants generate a significant share of electricity (>50%) and daily load (average load > average lowest recorded hourly load over a year), these must be included in the simple operating margin calculation. In such cases, first the generation-weighted average emissions rate is estimated separately for power plants that fall in the low-cost/must-run category and for the rest. Next, these two are weighted based on the number of hours when low-cost/must-run power units are on the margin in a year.
Average operating margin	The average operating margin emission factor is a simple average of all power plants that contribute to the grid, including low-cost/must-run plants.
Dispatch data analysis operating margin	The operating margin is calculated using the electricity displaced hourly by the project and the emission factor of the grid power units that are at the top of the dispatch order in that hour (whose power is replaced by the project).

Source: UNFCCC (2015).

[64] Low-cost/must-run resources are power plants with low marginal generation costs, or power plants that are dispatched independently of the daily or seasonal load of the grid (e.g. hydro, geothermal, wind, low-cost biomass, nuclear, solar generation) (UNFCCC, 2015).

Step 2: Calculate the build margin ($EF_{grid,BM,y}$). Build margin refers to the GHG impacts of future capacity expansion. The CDM recommends using historical data from the most recently built power plants as a proxy for determining the make-up of future power units in the energy system.

$$EF_{grid,BM,y} = \frac{\sum m \; EG_{m,y} \times EF_{EL,m,y}}{\sum m \; EG_{m,y}}$$

where

$EF_{grid,BM,y}$	=	build margin emission factor (tCO_2e/MWh)
$EG_{m,y}$	=	electricity generated and delivered to the grid in a defined time frame y (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor for power plants m in a defined time frame y (tCO_2e/MWh)
m	=	all power plants serving the grid in defined time frame y except low-cost/must-run power units
y	=	defined time frame (most recent historical year for which electricity data are available)

Step 3: Determine combined margin emission factor. The combined margin is calculated as a weighted average of the operating margin and build margin:

- The sum of the weighting factors for operating margin ($W_{OM,y}$) and build margin ($W_{BM,y}$) must be equal to 1.
- They must reflect the age of currently operational plants and expected future capacity additions.
- Common default values used in the CDM, are as follows
  - » wind and solar – operating margin, 0.75; build margin, 0.25
  - » other RE technologies – operating margin, 0.5; build margin, 0.5.

Selecting alternative weights for operating and build margin

The CDM tool provides for some adjustments to the default weighting of operating and build margin. Users should consider the technology focus of the policy, the national electricity generation mix and load characteristics when determining whether the weightings should be adjusted. The CDM tool provides further guidance on adjusting weights.

Appendix E: Stakeholder participation during the assessment process

This appendix provides an overview of the ways that stakeholder participation can enhance the process of assessment of GHG impacts of renewable energy policies. Table E.1 provides a summary of the steps in the assessment process where stakeholder participation is recommended and why it is important, explaining where relevant guidance can be found in the ICAT *Stakeholder Participation Guide*.

TABLE **E.1**

Steps where stakeholder participation is recommended in the impact assessment

Chapter/step in this document	Why stakeholder participation is important at this step	Relevant chapters in *Stakeholder Participation Guide*
Chapter 2 – Objectives of assessing the GHG impacts of RE policies	Ensure that the objectives of the assessment respond to the needs and interests of stakeholders	Chapter 5 – Identifying and understanding stakeholders
Chapter 4 – Using the methodology Section 4.2.5 – Planning stakeholder participation	Build understanding, participation and support for the policy or action among stakeholders Ensure conformity with national and international laws and norms, as well as donor requirements related to stakeholder participation Identify and plan how to engage stakeholder groups who may be affected, or may influence the policy or action Coordinate participation at multiple steps of this assessment with participation in other stages of the policy design and implementation cycle, and other assessments	Chapter 4 – Planning effective stakeholder participation Chapter 5 – Identifying and understanding stakeholders Chapter 6 – Establishing multi-stakeholder bodies Chapter 9 – Establishing grievance redress mechanisms
Chapter 6 – Identifying impacts: how RE policies reduce GHG emissions	Enhance completeness of the list of GHG impacts with stakeholder insights Improve and validate causal chain with stakeholder insights on cause–effect relationships between the policy, behaviour change and expected impacts	Chapter 5 – Identifying and understanding stakeholders Chapter 8 – Designing and conducting consultations
Chapter 7 – Estimating RE addition of the policy ex-ante	Improve identification of barriers and evaluation of their severity with stakeholder insights	Chapter 8 – Designing and conducting consultations
Chapter 10 – Monitoring performance over time	Ensure that monitoring frequency addresses the needs of decision makers and other stakeholders	Chapter 8 – Designing and conducting consultations
Chapter 11 – Reporting	Raise awareness of benefits and other impacts to build support for the policy or action Inform decision makers and other stakeholders about impacts to facilitate adaptive management Increase accountability and transparency, and thereby credibility and acceptance of the assessment	Chapter 7 – Providing information to stakeholders

Appendix F: Selecting the scope of the methodology

The scope of this methodology was selected using a set of criteria developed with the Technical Working Group:

- role of the subsector in countries' NDCs
- GHG emissions reduction potential
- extent to which policies for the subsector exist in countries and are being implemented to directly promote renewable electricity generation
- current and future emissions levels/share of subsector emissions
- potential lock-in/transformation
- gaps in available guidance
- investment needs under a 1.5–2°C temperature goal.