Eleventh meeting of the Technology Executive Committee

AHH, Bonn, Germany
7–11 September 2015

Background note

Draft TEC Brief on distributed renewable electricity generation

I. Background

1. The Technology Executive Committee (TEC) held at its 10th meeting a thematic dialogue on the development and transfer of technology for distributed renewable energy generation and integration.[1] Based on the outcomes of the dialogue, and in accordance with its updated rolling workplan for 2014–2015, the TEC agreed to prepare a TEC Brief by turning the background paper presented at the thematic dialogue into a brief, and taking into account relevant elements and outcomes of the thematic dialogue and inputs from relevant international/regional organizations.

II. Scope of the note

2. This background note provides, in its annex, the final draft TEC Brief on distributed renewable electricity generation prepared by the TEC task force on mitigation.

III. Possible action by the Technology Executive Committee

3. The TEC will be invited to finalize the TEC Brief on distributed renewable electricity generation.

[1] http://unfccc.int/ttclear/templates/render_cms_page?s=TEC_TD5

Annex

TEC Brief:
Facilitating technology deployment
in distributed renewable electricity generation

Why this TEC Brief? *{front page}*

Distributed small-scale electricity generation from renewable energy has emerged as a technically and financially viable alternative to electricity produced from fossil fuels. Distributed renewable generation offers significant promise as a route for decarbonization of the electricity sector, and can provide environmentally sound technologies as a means to achieve the objective of holding the increase of global average temperature below 2° C. It also enables increased energy access by providing rural electrification and satisfying demand growth.

The rise of distributed renewable generation is also changing a century-old paradigm of centrally located facilities producing electricity and sending this to the consumer over a transmission and distribution network.

Intended for policymakers and related stakeholders, this TEC Brief provides an overview of distributed renewable technologies and offers policy options that can facilitate their deployment and absorption.

Highlights *{In a box, top of second page}*

- Distributed renewables can contribute significantly to mitigation action and reduce greenhouse gas (GHG) emissions by generating near zero-carbon electricity.
- It can deliver electricity services in areas that cannot be supplied by centralized grids in addition to providing co-benefits to all communities, such as enhanced energy security, reduced local air pollution and reduced dependence on imported fossil fuels.
- For distributed renewables to reach widespread use, the following actions and measures are, generally, needed:
    - Build in-country capacity in the form of human and institutional capabilities in order to fully enable countries to receive and absorb as well as to adapt and develop nationally distributed renewable technologies;
    - Develop and implement transparent, effective policy and regulatory frameworks specific to distributed renewables, including quality control of PV systems and for power management systems and measures to ensure security of investments;
    - Stimulate robust private-sector involvement and investment through appropriate incentives, and facilitate implementation of effective and proven business models;
    - Enhance demand side monitoring and conservation technologies to reduce excessive demand peaks during operation;
    - Make best use of international cooperation and support institutions, including the Climate Technology Centre and Network (CTCN) and its more than 120 national designated entities (NDEs), in order to put in place the needed enabling environments to further deploy distributed renewable technologies;
    - Ensure active participation of, and effective collaboration between all stakeholders involved in generation and provision of distributed renewable electricity.
- Distributed renewable systems have been successfully deployed in a number of environments, as discussed below, demonstrating the real potential of such technologies.

Distributed electricity generation: Concepts and definitions

Most electricity worldwide is produced at large power plants (1-megawatt [MW] to 1,000-MW) and delivered to electricity users through a transmission and distribution system. This is called a “centralized” electricity system.

There is, however, another approach: the use of smaller power systems, with a capacity of up to 1 MW, located at or near electricity users,[1] known as a "decentralized" or "distributed" electricity generation.

Distributed electricity generation has advantages relative to the traditional, centralized electricity generation, yet the centralized model has some advantages as well (see table A). For example, in rural areas without electricity service, distributed electricity generation in off-grid or mini-grid systems (see below) may be the only practical option, as the costs of extending the centralized grid may be prohibitive. In areas where the centralized grid is already installed, adding distributed electricity generation increases diversity of supply and can improve system resilience and enhance energy security.

Table A. Comparison of centralized and distributed electricity generation

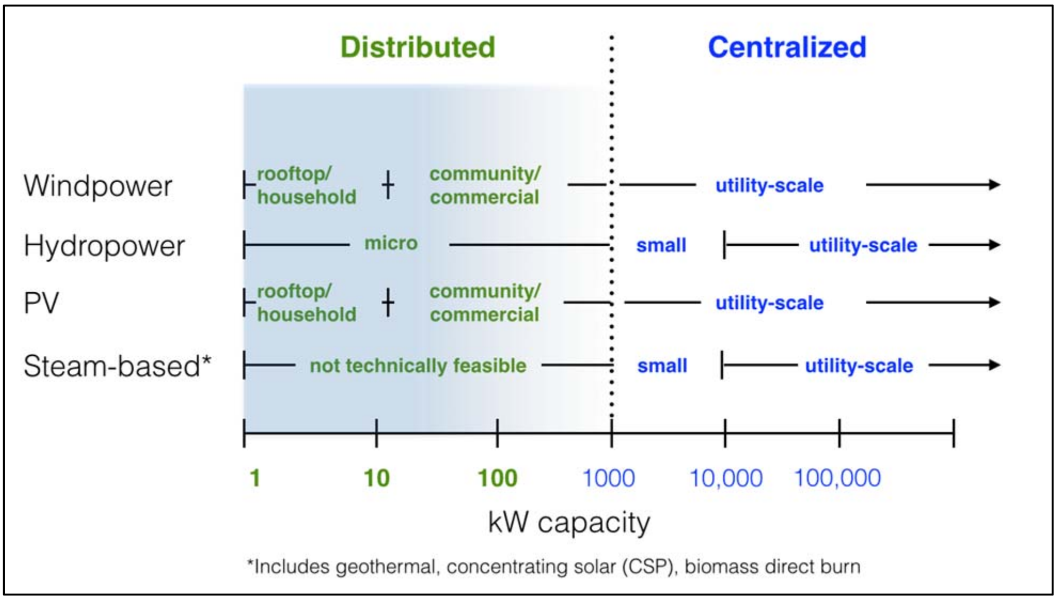
Model		Advantages
Centralized	**Generation**	- Wide range of mature technologies for generation - Lower per-kW costs for generation
	System	- Higher load diversity->flatter demand profile - Well-developed industry
Distributed	**Generation**	- Allows for direct and local private investment - Increases diversity of supply, greater system resilience and enhanced energy security
	System	- Applicable to small/remote communities and urban areas - Reduced transmission and distribution losses

In terms of definition, a common – but by no means universal – use of the term "distributed" is to refer to electricity-generating technology with a rated capacity of 1 MW or less. The technologies themselves are typically described or defined with a range of terms, including "commercial", "micro," and "household" (see Figure A).

For "distributed systems", there is a range of other terms often encountered in relation to such technologies:

- **Off-grid.** This typically refers to a single structure that provides its own electricity and is not connected to any other electricity users.
- **Nano-, micro-, and mini-grids.** These are electricity grids that typically serve anywhere from one to thousands of electricity users. In general, *nano* refers to grids serving one to tens of users, *micro* tens to hundreds, and *mini* hundreds to thousands. These smaller grids can be connected to larger, centralized grids.

Figure A: What counts as distributed renewables?



[1] To put this in context, a typical residence in a developed country needs about 1 kW, but much smaller systems, down to 10 W, are also very common, such as for lighting.

Distributed renewable electricity generating technologies

There are several renewable technologies that can provide electricity at a distributed level. Table B outlines the most common ones.

Table B: Comparison of common distributed renewable technologies

Technology	Typical Capital Cost (USD/kW)*	Resource or Fuel Needs	Operations and Maintenance Needs	Variability of Output –Diurnal**
Distributed PV system	2 to 5	Sunlight	Low	High
Micro hydropower	3.4 to 10+	Consistent water flows	Medium	Low
Small wind turbine	7	Wind > 3 meters per second	Medium	***

* For sources, see Komor and Molnar 2015. These costs do not include storage.

** Other time scales may be of interest as well, notably annual and 'climatic' (longer-term). For these time scales, variability may vary by location. For example, PV output will vary considerably over the course of a year for installations at greater latitudes, but much less so for installations near the Equator.

*** Depends on specific location. Some regions show large day/night variability in the wind resource, others much less so.

Distributed renewable technologies have their own specific characteristics, which have to be taken into account to ensure appropriate deployment. These characteristics include: modular, high-up front costs but low marginal costs, and resource dependent production profiles.

Technology needs assessments conducted by developing countries in the last years prioritized many renewable technologies, with solar PV being the most prioritized for the energy industries subsector.[2] Out of these, more than 20% of the total number of prioritized technologies for electricity generation was small-scale technologies (home application or not grid-connected).

A major constraint for some distributed renewable systems, such as wind turbines and PV, is the variability of output. When they supply a modest fraction of total electricity, their variability can be managed by various techniques such as ramping of dispatchable renewable generation (like hydropower or biomass plants) and demand management. However, for distributed systems without dispatchable generation, storage is needed, posing economic and technical challenges.

Demand side management is also an important aspect in renewable electricity systems. Estimation methodologies to set energy efficiency criteria can help reduce excessive demand peaks during operation. Technologies, such as smart grids, can also increase grid efficiency.

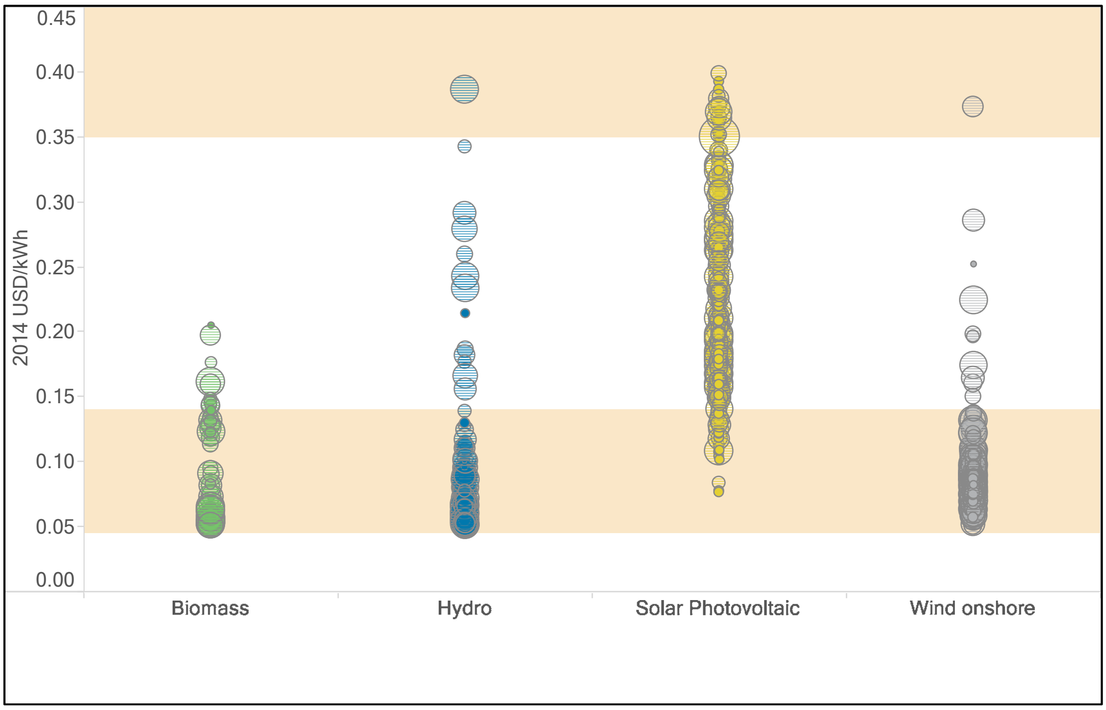
In terms of costs, those of PV have dropped significantly recently – halving between 2010 and 2014 alone (IRENA, January 2015; IEA, 2014) – bringing focus on this technology and increasing its cost-competitiveness. As its prices fall, PV may eventually reach socket parity (cost-competitive with retail electricity) and even grid parity (cost-competitive with wholesale electricity).[3] As solar PV module prices continue to decline, also reducing total installed costs, the number of markets where solar PV is competitive will continue to grow.

Figure B shows that in some instances, distributed generation can be very competitive, even with wholesale electricity generation costs. However, the smaller projects can't achieve these levels of competiveness and small-scale solar PV with storage can have delivered electricity costs as high as USD 0.65/kWh. However, in remote areas this can still be a cheaper and more reliable solution than diesel-fired generation (IRENA, January 2015).

[2] See the "Third synthesis report on technology needs identified by Parties not included in Annex I to the Convention" (FCCC/SBSTA/2013/INF.7).

[3] In some areas in some countries, PV is already cost-competitive.

Figure B: Cost data on renewable and non-renewable electricity generation



***Notes**: The beige upper and beige lower ranges illustrate the cost of: distributed diesel-fired electricity generation, and utility-scale fossil fuel-fired electricity generation, respectively.*
Biomass power generation projects will be mostly cogeneration, and solar PV data excludes projects with battery storage.

***Source:** Irena Renewable Cost Database.*

Perspectives of Stakeholders and Barriers

The specific characteristics of distributed renewable generation are requiring a wider range of stakeholders – from electric utilities to financiers to regulators to end-users – to pro-actively engage in the production and provision of electricity. It is therefore critical to understand and respond to stakeholders' perspectives on and concerns with these technologies (see table C).

Table C: Stakeholders and their perspectives/concerns

Stakeholder	Perspectives / Concerns
Electric utility	Technical: - Grid integration and reliability - Power quality - Energy demand peaks Operational/financial: - Potential loss of revenue - Loss of control over generation assets - Outdated perceptions of technology cost and performance
Financial and investment community	- Policy uncertainty and political risk - Expected financial return - Business risks (e.g., technical performance, regulatory change) - High first cost - Competition from subsidized fossil fuels - Consumer acceptance
Government	- Grid access rules - Equity and distributional impacts - How to allocate costs and benefits
Consumers	- Price of electricity - Reliability of systems and electric service - Up-front investment requirements - Lack of information/awareness related to technologies - Consumption habits

In addition to the diversity of stakeholders' perspectives and concerns, which can be barriers to deployment of distributed renewable technologies, there are overarching barriers that also stifle their greater deployment, covering technical, financial, capacity and policy aspects.

Policymakers have a critical role in guiding the process of technology deployment by addressing the associated stakeholders' concerns and barriers and facilitating opportunities offered by distributed renewable generation.

The Technology Mechanism, with its two components – the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN) – can play a key role in supporting policy-makers by providing recommendations and direct technical assistance to develop effective policies.

Best practices and lessons learned from case studies can provide good model for deployment of distributed renewable generation around the world (see Box 1).

Box 1
Case study: "Energising Development" in Indonesia

An innovative initiative in Indonesia that supports access to electricity in rural areas, using distributed renewable electricity technologies, illustrates the opportunities and challenges of such systems. "Energising Development" (EnDev) Indonesia has supported the installation of over 500 minigrids, providing electricity to over 225,000 people. Two technologies are used: micro-hydro systems of 5-200 kW capacity, and PV with 15-150 kW capacity. Throughout the initiative's implementation, the following key challenges to rural electrification using distributed renewables have been identified:

- Institutional aspects, notably a lack of coordination across governmental programs, and issues on ownership of land and the facility;
- Management aspects, notably ensuring sufficient in-village operational and management skills, and setting tariffs that meet all stakeholders' needs;
- Post-installation issues, notably ensuring sufficient technical knowledge and funds for continued operation and maintenance of the facility.

To address these challenges, EnDev Indonesia offers several solutions, such as "mini-grid service package," which comprises technical support, village participation schemes, and feedback mechanisms. EnDev Indonesia is also monitoring and maintaining the sites' information, including data visualization with a consolidated map. Throughout the years of support activities in Indonesia, it is observed that the availability of the technology is not the main issue, but rather its applicability to local conditions (Suryani, 2015).

Benefits of distributed renewables

In addition to providing electricity, distributed renewables bring very important benefits. By replacing fossil-fueled electricity, distributed renewable generation can reduce GHG emissions, thus contributing significantly to mitigation action.

Placeholder for further information on mitigation potential to be added[4] INTERNAL NOTE

In addition to mitigation benefits, distributed renewables can provide very important co-benefits to local communities, which are often more relevant to the needs and interests of users and policy-makers in developing countries. These include enhanced energy security, reduced local air pollution and reduced dependence on imported fuels.

Policy Options

The growing body of on-the-ground experience with distributed renewable technologies, the identified barriers to their deployment and the diversity of stakeholders with their perspectives and concerns point to a number of policy options that can facilitate greater deployment and absorption of these technologies. Such policy options can be subdivided into three broad categories:

1) Build in-country capabilities;

[4] INTERNAL NOTE OF THE TASK FORCE: Further information will be provided by IRENA on mitigation potential, for consideration at TEC 11.

2) Develop and implement sound policy and regulatory frameworks for technology deployment;
3) Stimulate robust private-sector involvement and investment.

1. Build in-country capabilities

Traditionally, knowledge about the production and management of power systems was located in national utilities, whilst technology development and transfer was supported by large international engineering and specialized consultancy firms. With a larger range of stakeholders involved in distributed renewable generation, it is critical to build both short-term and long-term in-country human and institutional capabilities, for both the public and private sectors, including local communities.

Effective capacity-building should enable countries to fully deploy distributed renewable technologies either for technologies imported from other countries, or technologies adapted to local conditions or developed nationally, for example solar PV, wind and mini-hydro technologies. Such action may also help countries develop and strengthen their national systems of innovation, critical tool to enhance climate action.[5]

For the public sector, key needs include the knowledge and skills to:

- Collect high-quality data and undertake appropriate studies (e.g. economic and resource evaluation) to support policy and regulatory decisions;
- Develop and enforce fair and appropriate policies, regulations and standards (including quality guarantees);
- Facilitate demonstration and pilot projects.

Local and small businesses would benefit from an enhanced understanding of both technical and economic issues related to distributed renewables. A compelling business case for distributed renewables is needed, which requires business and financial skills, in order to illustrate that these systems can be achieved at costs similar to those of traditional systems, while providing co-benefits to the community.

Local communities are critical stakeholders as well, and need improved energy literacy and awareness, organizational and entrepreneurial skills, and technical skills to operate and maintain distributed renewable systems in a sustainable manner.

Reassess import duties and taxes[6] INTERNAL NOTE

Distributed renewable power generation has higher up-front capital costs, but low marginal costs. Consequently, import taxes and duties on distributed renewable technologies raise the costs of these technologies and thereby delay their implementation. Governments may want to reconsider these taxes and duties, and determine whether their potential benefits (presumably support and protection of domestic manufacturing) outweigh the costs of delayed implementation. An alternative path to limit importation of low-cost technology is to consider other aspects of the supply chain, such as ensuring the maximum value from the low or zero marginal costs of power production, system installation and maintenance, the creation of local businesses and domestic industry growth supported by distributed renewable power generation.

Benefit from international cooperation

The deployment of distributed renewable generation is new for both developed and developing countries. Many agencies and support organizations worldwide have considerable expertise in distributed renewables. These organizations, such as the CTCN, can assist in deploying and transferring technology, particularly on “soft technologies”[7], for example through:

- Training programs and other capacity-building support;
- Enhanced sharing of technology data and analysis tools;
- Programs to assist in research and development as well as in adapting technologies to local needs;
- Support for local technology certification and testing;
- Methodologies or sample of business cases;
- Advice on preparing projects seeking financial support;

[5] More information may be found in the *TEC Brief on Strengthening national systems of innovation to enhance action on climate change* (October 2015).
[6] INTERNAL NOTE OF THE TASK FORCE: This paragraph is still under consideration by the task force, and will be addressed at TEC 11.
[7] Critical to sustainable technology development and transfer, “soft technologies” usually refer to activities in the field of capacity building, behavioral change, building information networks, training and research.

- Technical assistance on development of necessary policy framework for successful, sustained deployment of distributed renewable systems.

2. Develop and implement sound policy and regulatory framework for technology deployment

Distributed renewables deployment has been driven by policies to reduce GHG emissions, improve rural electrification, and stimulate economic development. However, the particular modular and production characteristics of these technologies will require new specific policies for the management of the power system, and to stimulate private sector involvement, as current regulatory models were designed for traditional, centralized generation. Such policies need to include quality control for power system management and measures to ensure security of investments.

New policies will not only need careful design and thoughtful implementation, but also on-going monitoring, evaluation, and fine-tuning. As such, policy development should be thought of as an ongoing process rather than a one-off event. Policies must also be designed in a way that matches the technical reality of the grid to ensure effective integration of distributed renewable, yet also promotes technical innovation.

As observed in case studies, policy development and implementation require effective coordination across government ministries, institutions and agencies.

Value co-benefits

Distributed renewables can bring very important co-benefits to communities. Policies to further distributed renewables should recognize these benefits in their analyses of cost-effectiveness, and build coalitions of stakeholders who value such benefits.

Rethink public and private roles in electricity supply

In many countries, electricity supply is historically a public function. However, the continued development of distributed renewables means that opportunities for direct private-sector investment in electricity supply will expand. This is of great potential benefit, as it brings a new source of capital for investment. Changes may be needed in the energy industry structure, as current regulatory models were designed for traditional, centralized generation. New institutional mechanisms may be needed to allow for both public and private participation in electricity generation.

Work with electric utilities to facilitate deployment

Electric utilities are and will remain key stakeholders even though their traditional business models are threatened by the deployment of distributed renewables. Governments should consider how electric utilities could be encouraged to facilitate the deployment of distributed renewables. Such engagement should address how to deal with integration of variable renewables, including the provision of different services (different from baseload and peaking plants as in the traditional model), as well as innovation. Electric utilities will need to tackle the following technical issues:
- Electricity loads, customer and community needs, and the effects of distributed variable generation on the grid;
- Roles for technologies that can support distributed renewable technologies, including smart grid and demand response;
- Roles for technology standardization and practitioner licensing.

3. Stimulate robust private-sector involvement and investment

Greater private-sector involvement will not only be allowed in distributed renewables but crucial to widespread deployment. While the policy options outlined above will contribute to stimulating the private-sector interest, the specific measures below may help further attract private-sector investment.

Balance financial innovation and regulation

Financial innovation from the private sector is needed to support installation of distributed renewable systems in some areas. Examples include leases for rooftop PV systems, aggregation and securitization of debt, and community-owned systems.[8] With this innovation comes some amount of risk and the need for appropriate regulation. Governments may want to address the challenging topic of how to balance their support of innovation with their responsibility to provide appropriate regulation, attempting to strike equilibrium between risk and reward for private-sector investors and financiers.[9]

Reduce financial risk

Robust private-sector investment and activity is critical to full deployment of distributed renewables. There must be some means to minimize financial risks while providing the appropriate rewards to attract the private sector. Experience to date has suggested that the perceived risks may be higher than investors consider optimal. In addition to sound policy and regulatory frameworks, governments may take additional steps as well, notably through providing more certainty around revenues, especially in the first stage of deployment. Examples include feed-in-tariffs, industry-funded insurance pools and standardized contracts and contractual processes.[10] Measures to facilitate the implementation of effective and innovative business models can also stimulate private sector interest.

Rethink fossil fuel subsidies

Historically, some governments have subsidized diesel for electricity generation in order to provide electricity to those who do not have it or are unable to pay for it. Governments may now want to reexamine these diesel subsidies, which distort the business case for distributed renewables, and consider other technological routes that can provide electricity at a lower economic and environmental cost. Such analyses should also consider the benefits of limiting import dependence and reducing exposure to fuel price variability, while allowing for public funds to be allocated to other societal needs and services, such as healthcare, education and security.

Other possible actions by the Technology Executive Committee[11] INTERNAL NOTE

In addition to providing policy recommendations, as presented above, the TEC can undertake other actions to facilitate deployment of distributed renewable technologies:

- Provide advice to and assist the Financial Mechanism, for example on technology needs of developing countries related to renewable energy, and on enabling environments to put in place;
- Share best practices and lessons learnt and provide recommendations to the technical examination of opportunities with high mitigation potential in the period 2015–2020 (in reference to decision 1/CP.20) to support countries in the identification and implementation of policy options, practices and technologies;
- Others?

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International Energy Agency (IEA), *Medium-term renewable energy market report 2014 – Market analysis and forecasts to 2020.*

International Renewable Energy Agency (IRENA), *IOREC 2014: Accelerating Off-Grid Renewable Energy, Key Findings and Recommendations,* January 2015a.

International Renewable Energy Agency (IRENA), *Renewable Power Generation Costs for 2014*, January 2015b.

[8] For example, in 2014 a large US-based rooftop solar system company issued USD 70 million in asset-backed securities, and used those funds to support new PV installations.
[9] An example is a requirement for an electric utility (or other energy provider) to procure a minimum amount of distributed generation as part of their overall electricity mix. This sets a guaranteed minimum market size for distributed generation, but still provides for price competition among distributed generation providers.
[10] More information may be found in the *TEC Brief on climate technology financing* (October 2015).
[11] INTERNAL NOTE OF THE TASK FORCE: This paragraph is still under consideration by the task force, and will be addressed at TEC 11.

Komor, P. and T. Molnar, *Background Paper on Distributed Renewable Energy Generation and Integration*, prepared for the Technology Executive Committee, United Nations Framework Convention on Climate Change, 20 February 2015. Available at: <http://unfccc.int/ttclear/templates/render_cms_page?s=TEC_TD5>.

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Contact Details

The Technology Executive Committee may be contacted through the United Nations Climate Change Secretariat (UNFCCC):
Platz der Vereinten Nationen 1, 53113 Bonn, Germany
E-mail: tec@unfccc.int
Website: www.unfccc.int/ttclear/tec

About the Technology Executive Committee

The Technology Executive Committee (TEC) is the policy component of the Technology Mechanism, which was established by the Conference of the Parties in 2010 to facilitate the implementation of enhanced action on climate technology development and transfer. Along with the other component of the Technology Mechanism, the Climate Technology Centre and Network, the TEC is mandated to facilitate the effective implementation of the Technology Mechanism.