

Next level sustainable energy provision in line with people's needs

**A proposal for extending the Multi-Tier Framework for
monitoring the SDG7**



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| Authors | Dr. Inga Boie, Dr. Jan Steinbach, Catrice Christ, Natalia Ashley Belbin, Oliver Lösch, Alexandra Denishchenkova, Jose Ordonez |
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EXECUTIVE SUMMARY

The Sustainable Development Goals and the productive use of electricity

In 2016, the United Nations (UN) adopted 17 sustainable development goals (SDGs) within the framework of the UN Agenda 2030 (UN 2015). Of the 17 SDGs, the SDG7 aims to ensure universal access to affordable, reliable, sustainable and modern energy for the entire world population and to increase the global share of renewable energy and the level of energy efficiency. Enhanced access to electricity for productive uses especially is also expected to catalyse an increase in welfare and economic development across all sectors and company sizes, as it constitutes a key element for job creation and increased added value (BMZ 2018).

In this context, productive use of electricity can be defined as the utilisation of electricity for activities which generate a monetary value or contribute to an enhanced productivity or increased welfare of the affected population (Kapadia 2014, Brüderle and Bodenheimer 2011). This may involve a broad range of activities such as water pumping in agriculture, water purification, processing of agricultural products, preservation or refrigeration of goods, manufacturing of durable products or provision of various types of services. Therefore, productive uses go beyond the consumption of electricity for private household applications. However, a clear separation between productive uses and household use of electricity is difficult, especially if small family-run businesses or activities in the informal sector are concerned. Thus, there is a fuzzy transition between electricity use in households and by commercial businesses or service providers in developing and emerging countries and both, centralized and decentralized electricity supply solutions are relevant.

Economic growth and climate and energy strategies

Along with economic growth, developing and emerging economies face the formation and expansion of commercial activities and energy-intensive industrial sectors, which may lead to significant increases in greenhouse gas emissions. Economic development, the creation of jobs and the increase of welfare for the population have a high political priority, especially in developing and emerging countries. However, economic growth and increased purchasing power, the expansion of infrastructures and the emergence and extension of commercial and industrial uses of electricity are generally related to an increased energy demand. This inevitably leads to growing greenhouse gas emissions if no strategies for developing a clean and sustainable energy supply are implemented at the same time.

Especially the industrial sectors of developing countries show a remarkable growth rate, e.g. a compounded average annual growth rate of 6.1 % in non-OECD countries compared to 1.1 % in OECD countries in the timeframe 2000-2017. Further, non-OECD countries have a substantially higher energy intensity, i.e. energy consumption per unit of value added, in comparison to OECD countries. This again becomes particularly apparent when looking at the industrial sector: with 0.2 koe/\$, non-OECD countries use almost twice as much energy as OECD countries, with 0.08 koe/\$^a.

These figures highlight the significant impact that the growing productive use of electricity in developing and emerging economies can have on global CO₂ emissions and emphasise the need for an integrated framework for monitoring and managing the access to sustainable electricity sources in these countries.

The present monitoring framework for SDG7

The progress towards reaching the SDG7 is currently monitored based on a Multi-Tier Framework (MTF) for assessing the electricity access conditions on the national level. Although separate matrices exist for the assessment of energy access for households, public and productive uses, so far, the focus of the MTF has been mainly on the electricity needs of private households, for example, for the provision of lighting, clean cooking solutions or basic communication services such as mobile phone charging.

Regarding the definition of the metrics for the tiers for assessing electricity access, the MTF for productive applications is based on the same assumptions concerning

connection power and daily available capacity as defined for households (see table below). For the five tiers describing the levels of energy supply for productive applications, the MTF further assumes that tiers 3-5 successively meet the requirements of commercial activities and that in tier 5, electricity access does not cause significant issues for productive activities (Bhatia et al. 2015).

However, considering the connection power and daily capacities defined for the tiers, it becomes evident that the present monitoring of the attainment of SDG7 mainly places emphasis on the fulfilment of the basic needs for the use of private household applications and does not allow for a systematic and comparable assessment of electricity access conditions for private and productive uses.

Excerpt from Multi-Tier matrix for electricity supply for productive applications

| | Tier 0 | Tier 1 | Tier 2 | Tier 3 | Tier 4 | Tier 5 |
|--|--------|-----------|-----------|--------------------------------------|---|--|
| Power | | ≥ 3 W | ≥ 50 W | ≥ 200 W | ≥ 800 W | ≥ 2 kW |
| Daily capacity | | ≥ 12 Wh | ≥ 200 Wh | ≥ 1.0 kWh | ≥ 3.4 kWh | ≥ 8.2 kWh |
| Availability of electricity (daily) | | Min 2 hrs | Min 4 hrs | Half of the working Hours (min 50 %) | Most of working hours (min 75 %) | Almost all working hours (min 95 %) |
| Reliability | | | | | Reliability issues with moderate impact | No reliability issues or little (or no) impact |
| Quality | | | | | Quality issues with moderate impact | No quality issues or little (or no) impact |

Source: Bhatia et al. (2015)

Goal of this study

Considering the above, it is the goal of this study to review the present methodology for monitoring the SDG7 targets and to develop an approach for monitoring access to electricity which also considers the significant role of productive uses of electricity in developing and emerging economies. By adding to a better understanding of the electricity access needs of a broader range of user types (including households as well as commercial and

industrial applications), the results further aim to support the implementation of sustainable energy strategies, i.e. the development of energy supply solutions which are needs-oriented and at the same time sustainable. Thus, the developed framework can be used as a tool for energy planning to safeguard that, as a basis for economic development, the requirements of various types of productive users of electricity can be met while at the same time being consistent with climate change strategies.

Review of the present MTF framework

Tier 1 covers merely very basic energy services for simple lighting applications with a strongly limited availability during the day. Even for household applications it is questionable whether the parameters defined for this tier actually represent a significant step towards enhanced energy access. A productive use of electricity in this tier cannot be assumed.

Tier 2 intends to cover the needs for electric lighting, air circulation and basic communication needs such as television and phone charging in private households. However, although a peak capacity as low as 50 W would be sufficient for charging a mobile phone, it would not suffice to provide enough electricity for powering a television or for using lighting and communication applications in parallel. Also, productive uses of electricity are likely not possible based on this definition. Therefore, in order to represent a more substantial step towards enhanced electricity access and towards the simultaneous provision of a minimum of adequate lighting and basic communication services for a significant timeframe, the definition of the parameters for this tier should be raised at least to an available minimum capacity of 100 W for 4 hours daily.

Tier 3 would allow for the simultaneous use of lighting and communication appliances as well as, for example, ventilators or other small household applications. However, for the use of electric hotplates or other fundamental domestic appliances, such as electric cooling units, this capacity and daily availability would still not be sufficient. It is also questionable whether an availability of 200 W (or 1 kWh daily) for 50 % of the working hours would be sufficient to allow for any significant productive activity.

Tier 4 is characterised by a connection capacity which would be enough to allow for the provision of lighting and communication services as well as the parallel use of several household appliances such as ventilators, but it still does not suffice to power, for example, a small electric hotplate with an

average connected load of about 2.5 kW. Regarding the productive use of electricity, tier 4 assumes that for 75 % of the working hours electricity supply is available and that reliability issues only cause a moderate impact. However, with a connection power of only 800 W, only the requirements of basic applications at a small scale (such as e.g. a food blender, a rice cooker, simple tools or a sewing machine) could be covered.

Tier 5 would allow a household to use various types of domestic applications in addition to lighting and communication services but a use of basic applications with a higher connection load such as electric stoves would still not be possible.

Productive uses of electricity, for example in a small family-run workshop or a retail shop, would be possible, based on this definition. With 95 % availability and no significant quality issues, economic activities would not be severely affected. However, the assumed connection power and daily capacity would only suffice to cover small to medium scale commercial businesses but would not allow for larger-scale commercial or even industrial activities. The emergence and evolution of such productive activities in developing and emerging economies, however, is a key element for the creation of jobs and a sustained increase in value added.

Recommendations for an extended monitoring framework for SDG7

Against the background of the above, this study suggests revising and extending the current MTF in order to:

- ✓ Reflect significant steps towards an enhanced electricity access for households and small-scale family businesses;
- ✓ Take account of the important role that the productive use of electricity plays at all stages of value chains (ranging from family businesses or agricultural applications to the provision of professional services or large-scale industrial production) for climate

change abatement and sustainable energy strategies;

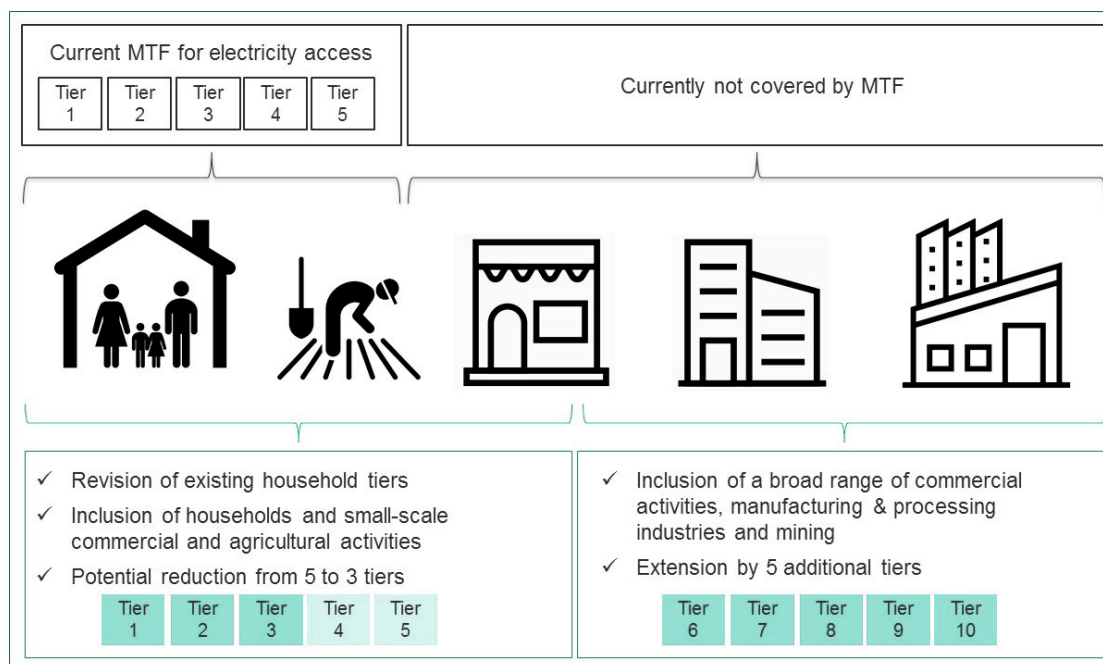
- ✓ Develop an integrated and seamless framework for monitoring and managing the access to sustainable electricity sources which considers the fuzzy transition between the needs of households and commercial or industrial applications;

- ✓ Allow for a closer link between climate change policies and strategies for economic development and sustainable energy supply to safeguard that the electricity requirements on all tiers can be met with needs-oriented but environment-friendly energy solutions. Here, especially the application of decentralized renewable energy solutions plays a major role.

This implies the following recommendations:

- Revising the current MTF tiers for the household sector in order to represent essential development steps from basic household applications and requirements for clean (electric) cooking and cooling applications to small-sized commercial activities.
- Adding 5 additional tiers for productive uses covering electricity access requirements of a broad range of business activities along value chains - ranging from processing of agricultural products to highly sensitive and energy-intensive production processes.

Overview over the proposed revision of the current MTF



Source: Own depiction IREES / Fraunhofer ISI

Instead of applying different MTF matrices for households and productive uses, the proposed framework represents an integrated scale covering the electricity access requirements of households, various commercial or manufacturing activities and industrial processes. On the one hand, the scale is extended to consider requirements

of manufacturing and processing industries, on the other hand the smaller development steps of the current scale might be adjusted with a potential reduction from 5 to 3 tiers.

Thus, the approach generates a tool to evaluate electricity access not only against the background of the current economic structures as present in many developing






and emerging countries, i.e. a strong focus on agricultural production and extraction of raw materials, but also from a forward-looking, development perspective. The steps defined for the revised framework represent the fuzzy transition between household electricity demand and commercial activities and allow for an assessment of electricity supply conditions as required to increase the local manufacturing share in the value-chain of products based on the productive use of electricity.

The newly developed tiers for productive uses are categorised based on a systematic analysis of a broad range of business activities and production processes. For this purpose, the European classification of economic activities, NACE, is used as it ensures transparency and comparability on a European as well as on a global level. For the analysis, the focus is laid on manufacturing and industrial production processes (including mining) to include a wide range of possible economic activities along the value chain.

For each category of productive activities, the following characteristics are described: Share of electricity consumption in total energy demand and specific energy demand in relation to turnover (as indicators for the capacity requirements and energy-intensity of the activities) and the main critical processes affected by potential power outages (as an indicator for the sensitivity of the processes to power cuts and voltage fluctuations and the potential economic impact that a power outage might have on the respective business).

On this basis, the electricity access requirements of each economic activity are evaluated as specified for the MTF, namely referring to the availability, reliability, quality and affordability of the electricity supply. The results are further clustered in order to derive groups of productive activities with similar requirements regarding electricity access. Thereby five tiers for electricity access for productive uses can be derived (see box below).

Classification of productive uses of electricity for the definition of tiers

| | |
|---|---|
|  | Tier 6: Mechanical manufacturing technologies with low electrical control requirements and a low automation level, such as e.g. crop and animal production, production of wearing apparel, leather, tobacco products or furniture. |
|  | Tier 7: Mass production of consumer goods without utilisation of sensitive production technologies, such as e.g. food products, beverages, textiles, wood and wood products, print media or other manufacturing. |
|  | Tier 8: Mass production of investment goods and durable products with a relevant degree of automation and electric control systems, such as e.g. paper and paper products, metal products, electrical equipment and machinery, motor vehicles and transport equipment. |
|  | Tier 9: Manufacturing of high technology or highly sensitive products with a high degree of automation, such as e.g. production of basic pharmaceutical products or computers, electronic and optical products. |
|  | Tier 10: Mining and chemical processing of raw material with a very high energy demand, such as e.g. processing of coal, metal ores, natural gas, coke and petroleum products, chemicals, rubber and plastic products, non-metallic and metallic products. |

A more detailed description of the five tiers for productive uses of electricity, including the specification of the respective NACE codes, is provided in the table below.

Even though the industry structure and the standard of production processes in developing and emerging countries obviously vary from those in developed countries, the approach is still suitable to obtain a reliable indication of the capacity requirements of a broad range of productive activities. Many economic activities, such as higher-level processing and manufacturing processes, are not yet established in developing and emerging economies as these countries still largely rely on the export of raw materials or unprocessed agricultural products. However, in order to allow for a forward-looking and development-oriented approach, the assessment of electricity access requirements should not be limited to the status quo of economic activities in developing countries but should also consider the requirements of potential future industries and orientation at world market standards.

In contrast to the MTF framework for household electricity access, the results indicate more qualitative assessments of the electricity supply requirements for each tier. This is due to the fact that business operations and company sizes within each group of activities can be highly heterogeneous. This distinguishes the commercial and industrial sector from the household sector where defining standard sizes and typical applications is more straightforward, while, for example, the electricity demand of a commercial business is almost freely scalable depending on the size of the company. A more detailed analysis of the commercial and industrial sector would require a further differentiation on the level of subgroups or even a bottom-up assessment on the company level. However, although such an approach could capture the individual characteristics of a particular country or region, it would not suffice to derive a universally applicable assessment

framework for electricity access requirements. Therefore, the applied top-down method, based on the analysis of the energy intensity and process technologies of the most relevant industrial sectors, is a valid approach for deriving a holistic MTF for productive uses in the industry and service sector since the classification comprises all potential business activities.

Outlook and possible further analysis activities

Based on the results of this study a range of further activities could be pursued to verify and refine the results.

It would be particularly beneficial to make further use of the results of the still ongoing World Bank enterprise survey in order to verify and possibly refine the proposed definition of the extended MTF matrix for productive uses. This would permit to compare the systematic top-down approach applied in this study against the country-level bottom-up assessment of the World Bank survey to ensure that the definitions actually capture the requirements of the local industries and businesses.

Another focal point of further activities should be the development of methodologies and frameworks for the collection of data for country level assessments of the suggested tiers. Here, it would be particularly important to coordinate and align efforts with national climate change mitigation strategies as well as with plans for economic development and industry expansion. In this context it is particularly crucial to ensure that the institutions concerned work together in order to avoid adverse effects and to maximise policy efficiency.

Also, in order to ensure the practicability when using the proposed framework for the targeted selection and prioritisation of actual energy supply or infrastructure projects, it would be helpful to develop a more detailed definition and design of suitable technical solutions to meet the respective access requirements for the proposed tiers.

Proposal for the extension of the Multi-Tier Framework for productive uses

| Tier | Definition | Tier 6 | Tier 7 | Tier 8 | Tier 9 | Tier 10 |
|------------|--|--|---|--|--|---|
| | | Mechanical manufacturing technologies with low electrical control requirements/ low automation level, agriculture | Mass production of consumer goods without sensitive production technologies | Mass production of investment and durable products and a relevant degree of automation and electric control systems | Manufacturing of high technology or highly sensitive products with a high degree of automation | Mining and chemical processing of raw materials |
| | | Industry sectors <i>NACE Code</i> | 1, 12, 14, 15, 31, 33 | 10, 11, 13, 16, 18, 32 | 17, 22, 25, 27, 28, 29, 30 | 21, 26 |
| Indicators | Capacity requirements | Low | Low - medium | Medium - high | Low | Low - high |
| | Availability | All working hours (100 %) | All working hours (100 %) | All working hours (100 %) | All working hours (100 %) | All working hours (100 %) |
| | Reliability <i>Intolerance to power cuts</i> | <ul style="list-style-type: none">▪ Power cuts during working hours acceptable▪ No harmful impacts on machinery, processes and products | <ul style="list-style-type: none">▪ Short power cuts during working hours acceptable▪ Harmful impacts on products possible (temperature sensitive process such as food production) | <ul style="list-style-type: none">▪ Power cuts during working hours critical as significant damage to products is possible | <ul style="list-style-type: none">▪ No power cuts acceptable▪ Significant impacts on products | <ul style="list-style-type: none">▪ No power cuts acceptable▪ Significant impacts on machinery, processes and products |
| | Quality <i>Intolerance to voltage fluctuations</i> | Low: voltage fluctuations do not significantly affect production processes | Low: voltage fluctuations do not significantly affect production processes | High: undue voltage fluctuations affect production technologies | High: undue voltage fluctuations affect production technologies | High: undue voltage fluctuations affect production technologies |
| | Affordability <i>Economic impacts of power cuts</i> | Low | Low - medium | Medium | High | High |

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^a Calculations based on global energy and CO₂ data (ENERDATA 2018). Calculation of energy intensity refers to kilogram of oil equivalent (koe) per 2015 US\$

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