UNDP Discussion Paper

Energy Access Projects and SDG benefits

Energy Access projects and assessment of their Contribution to the Sustainable Development Goals: SDG1, SDG3, SDG4 and SDG5

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UNDP Energy, Infrastructure, Transport and Technology

Bangkok Regional Hub, 2018

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Executive summary

Energy Access Projects and their contribution to the Sustainable Development Goals:

The United Nations Development Programme (UNDP) Strategic Plan 2018–2021 and its Strategy Note on Sustainable Energy emphasize the crucial role of energy access in helping countries to end extreme poverty, reduce inequalities and achieve the goals of the 2030 Agenda for Sustainable Development. UNDP's work on clean energy aligns with Sustainable Development Goal 7 (SDG7) on access to affordable and clean energy while it is acknowledged that energy is an 'intermediate' commodity: it powers appliances, equipment, and machinery as well as lighting and thermal applications. In relation to the Sustainable Development Goals in general, SDG 7 is primarily useful in that it helps to achieve other SDGs. In other words, the success of SDG 7 is a precondition for the success of many other SDGs. Especially the SDG7 goals related to energy access and clean cooking, have a direct impact on SDG1 No Poverty, SDG3 Good Health, SDG4 Quality Education and SDG5 Gender Equality.

UNDP is working on improving its assessment of the social and economic benefits of its energy-access projects and the contribution of these projects towards achieving other SDGs. In 2015, UNDP conducted analysis of the non-energy benefits of its sustainable energy projects as a scoping exercise for assessing impact (UNDP, 2015). The underlying report is a next step in developing a framework that can be used to assess the impact of the social and economic benefits for a specific subset of sustainable energy projects: access to electricity and clean-cooking projects.

The study reflected in this report aims to give UNDP staff and project managers tools and guidance on how to improve assessments of impacts associated with clean energy projects. Thus, the objectives of this study are:

- Develop a 'scoring' tool that can be used by Regional Technical Advisors, country offices and project managers, for an assessment of the relation between a clean energy project (focusing on SDG7) and the SDG1, SDG3, SDG4 and SDG5 goals.
- Provide an indication on the degree of social and economic benefits that can be observed for different types of energy access projects.
- Provide guidance for Regional Technical Advisors, country offices and project managers, on monitoring and data collection approaches to assess the social and economic benefits of their energy-access projects by doing ex-ante and ex-post analysis.

Access to electricity and clean-cooking solutions

UNDP defines energy access as "the need for electrical, thermal and mechanical energy for households, small and medium-sized businesses and communities, with an emphasis on clean energy for the poor". For the study reflected in this report, a distinction was made between (i) access to electricity and (ii) access to clean-cooking solutions.

This study focuses on the social and economic benefits related to the following SDGs:

- SDG 1—No Poverty: End poverty in all its forms everywhere
- SDG 3—Good health and well-being: Substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination
- SDG 4—Quality education: Ensure inclusive and quality education for all and promote lifelong learning
- SDG 5—Gender equality: Achieve gender equality and empower all women and girls

Levels of access to electricity

The World Bank recently developed a framework to categorize electricity-access projects. This framework distinguishes six tiers (levels) of access to electricity, with tier 0 representing the baseline situation with no access to electricity and tier 5 the most advanced level of access. The successive thresholds of supply (tiers) allow for increased use of end-use equipment (appliances) and hence access to energy services, which the following figure illustrates.

Figure S.1: Multi-tier matrix for Measuring Access to Household Electricity Supply (ESMAP, 2015)

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Capacity	No electricity	Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2000 W
Availability (hours/day)		Min 4		Min 8	Min 16	Min 23
Availability (hours/evening)		Min 1	Min 2	Min 3	Min 4	
Reliability					Max 14 disruptions per week	Max 3 disruptions per week of total duration < 2 hours
Quality					Voltage problems do not affect use of desired appliances	
Affordability				Cost of standard consumption package of 365 kWh/year < 5% of household income		
Legality					Legal payment of bill demonstrated	
Health and safety					Absence of accidents	

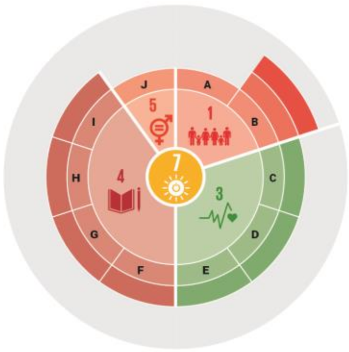
	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Energy services provided		Task lighting and phone charging	General lighting and phone charging and television and fan (if needed)	TIER 2 and medium-power appliances	TIER 3 and any high-power appliances	TIER 4 and any very high-power appliances
Possible appliances		- Radio - Task light - Charger	TIER 1 PLUS -Multi-point general lighting -Television -Computer -Fan	TIER 2 PLUS -Air cooler -Refrigerator -Food processor -Rice cooker	TIER 3 PLUS -Iron -Hair dryer -Toaster -Microwave	TIER 4 PLUS -Air conditioner -Water heater -Electric cooker

Social and economic benefits of electricity access

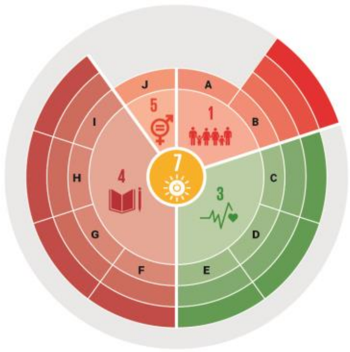
Ten social and economic metrics were drawn from reports in the reviewed academic and grey literature that positively correlate with the implementation of electricity-access projects and can be connected to the SDG1, SDG3, SDG4 and SDG5 goals. Findings from the literature indicate that the degree of social and economic benefits gradually increases when moving to higher tier levels for electricity access. In this study, this gradual increase was translated into a scale that moves from tier 0 (situation with no access to electricity and no benefits) to tier 5 (significant benefits to be anticipated from access to electricity). The following radar chart shows that, for example, when a project intervention provides access to lighting and phone charging (tier 1), moderate benefit generally can be expected from the expenditure on lighting while small benefit can be expected for health and education.

Figure S.2: Degree of expected benefits for SDG1, SDG3, SDG4 and SDG5 of five tiers of access to electricity-access, compared to tier 0 (no electricity access)

TIER 1: Task lighting and Phone Charging



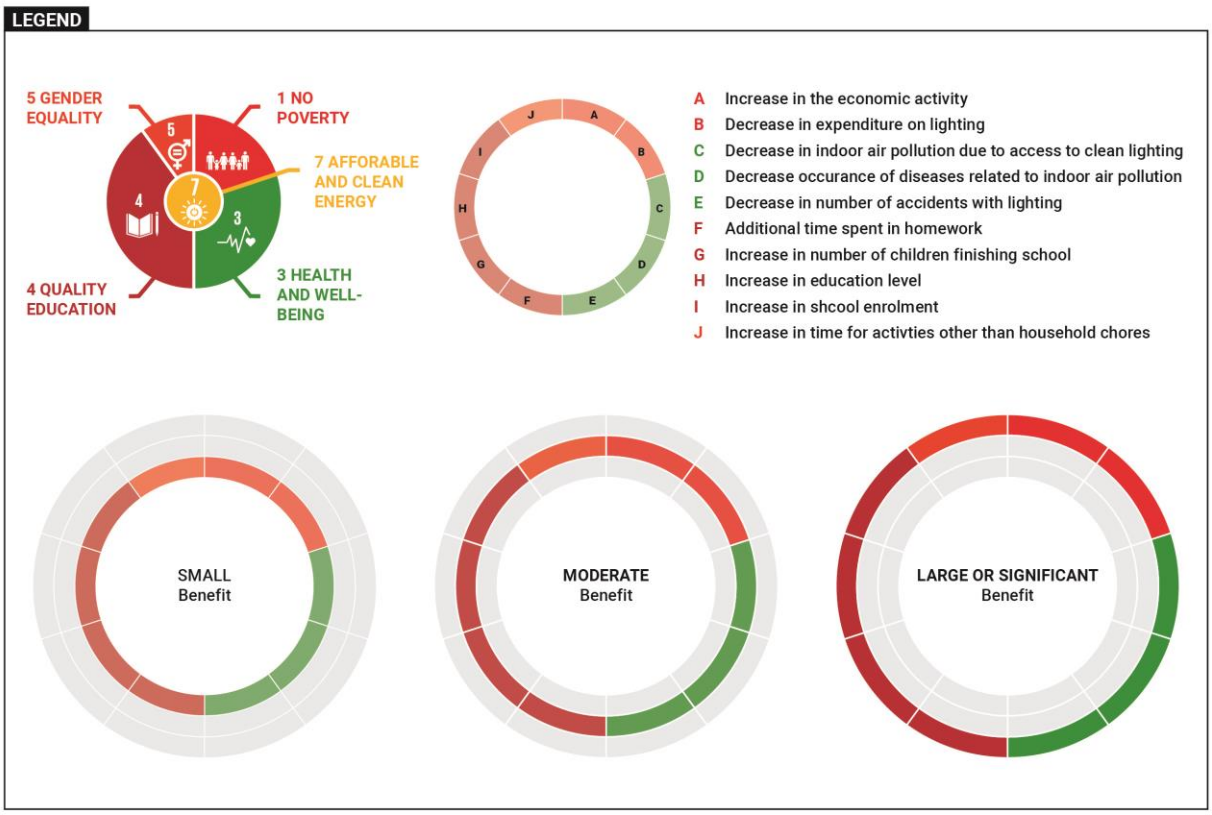
TIER 2: General lighting and Television and Fan



TIER 3: Tier 2 + Medium Power Appliances

TIER 4: Tier 3 + Any High-Power Appliances

TIER 5: Tier 4 + Any very High-Power Appliances



Levels of access to clean cooking

The Word Bank also developed a framework to categorize clean-cooking projects, which distinguishes six tiers of access to clean cooking. This framework was mirrored into a classification for cookstoves ranging from improved cooking solutions (tiers 1 and 2) to clean-cooking solutions (tiers 3—5).

Figure S.3: Multi-tier Matrix for Measuring Access to Cooking Solutions (ESMAP, 2015)

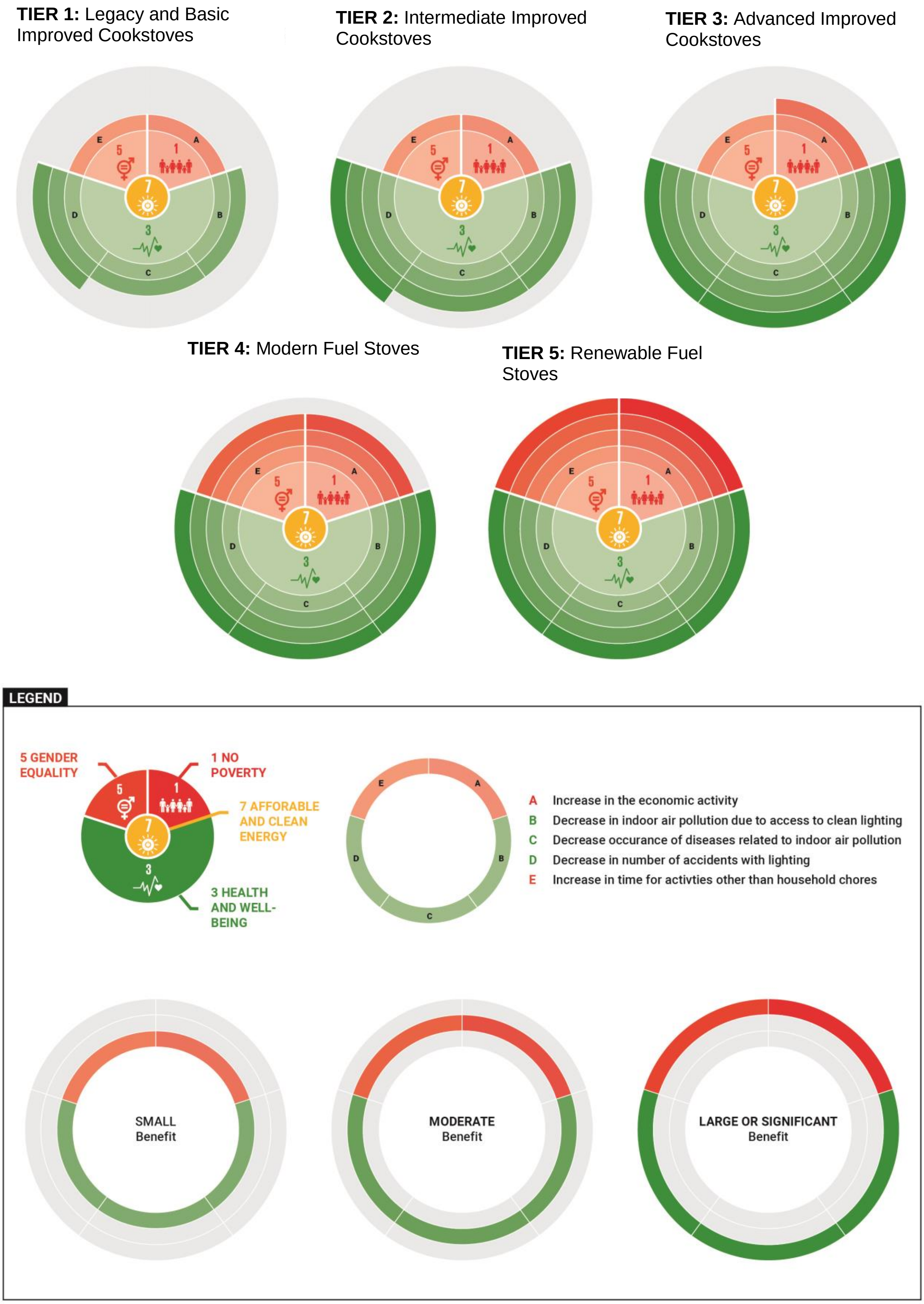
	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Availability of primary fuel	Availability inadequate				Available at least 80% of the year	Available all year
Quality of primary fuel: Variations in heat rate that affects ease of cooking	Low quality				High quality	
Affordability	Primary solution not affordable				Levelized cost < 5% of household income	
Convenience: Fuel acquisition & preparation time (hours/week)			< 7	< 3	< 1.5	< 0.5
Convenience: Stove preparation time (minutes/meal)			< 15	< 10	< 5	< 2
Health and safety	Self-made stove	Manufactured stove	Biogas/LPG/electricity/natural gas stoves			

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
		IMPROVED SOLUTIONS		**CLEAN-COOKING SOLUTIONS**		
Cookstove classification		**LEGACY & BASIC IMPROVED COOKSTOVE**	**INTERMEDIATE IMPROVED COOKSTOVE**	**ADVANCED IMPROVED COOKSTOVE**	**MODERN FUEL STOVES**	**RENEWABLE FUEL STOVES**
Key features		Small improvements in efficiency over tier 0	Rocket style designs with highly improved fuel efficiency and moderate gains in combustion efficiency; some with high-end materials	Fan jet or natural draft biomass gasifiers with very high fuel and combustion efficiencies; may equire pellet/briquette fuel	Rely on fossil fuels or electricity, have high fuel efficiency, and very low particulate emissions	Derive energy from renewable nonwood fuel energy sources; some are supplementary rather than primary cookstoves
Typical technologies /fuels		• Legacy biomass and coal chimney • Basic efficient charcoal • Basic efficient wood	• Portable rocket stoves • Fixed rocket chimney • Highly improved (low CO2) charcoal stoves	• Natural draft gasifier • Fan gasifier/ fan jet • TChar stoves	• LPG and DME • Electric and induction • Natural gas Kerosene	• Biogas • Ethanol • Methanol • Solar ovens • Retained heat cookers

Social and economic benefits of access to clean cooking

Five social and economic metrics were drawn from the review of the academic and grey literature that positively correlate with the implementation of projects providing access to clean-cooking solutions and can be connected to the SDG1, SDG3 and SDG5 goals. Findings from the literature show a gradual increase in the degree of social and economic benefits when moving to higher tier levels of access to clean cooking. The radar chart below shows that when, for example, a project intervention provides access to basic improved cookstoves (tier 1), moderate benefit can be expected in relation to the occurrence of accidents with cooking and small benefit can be expected from a decrease in indoor air pollutants and related diseases.

Figure S.4: Degree of expected benefits for SDG1, SDG3 and SDG5 of five tiers of access to clean-cooking, compared to tier 0 (traditional biomass cooking)



Monitoring social and economic benefits: From simple to advanced

The radar charts S.2 and S.4 enable a basic scoring on the social and economic benefits related to SDG1, SDG3, SDG4 and SDG5 that can be anticipated when the level of energy access (tier) for a project intervention is known. The charts can be useful for UNDP country offices when working on energy-access projects. In addition to this basic scoring, activities can be incorporated into the project plan to gather data ex-post and ex-ante project implementation to monitor relevant metrics. In this report, monitoring approaches for various metrics are classified from simple to advanced, as shown in Table S.1.

Table S.1: Overview of monitoring approaches, varying from simple to advanced

	Approaches
Simple	• *Basic scoring:* Apply basic scoring—four levels—based on observed social and economic benefits in the academic and grey literature for different levels of access to electricity and clean-cooking solutions.
	• *Rule of thumb:* Combining observed quantified impact factors (resulting from projects executed in divergent circumstances) reported in academic and grey literature with project data.
	• *Surveys:* Gathering data through surveys that can range from basic surveys, with a limited number of questions, to detailed surveys for scoring the baseline situation and project outcomes.
Advanced	• *Modelling:* Apply models to, for example, assess economic or health benefits.
	• *Measurements:* Apply measurements, for example, to determine level of indoor air pollution.

Start testing the scoring approach and collect feedback

If there is no budget reservation in the project for monitoring impact, then the basic scoring approach with radar charts as presented in this study can be the minimum level of indicating expected impact and can be useful in:

- Identifying the type and size of social and economic benefits associated with energy-access projects and
- Indicating the importance of monitoring to free up resources for activities that need to be incorporated in the project to gather data to monitor relevant metrics.

If the energy access project has limited resources available for monitoring the impact on SDG1, SDG3, SDG4 and/or SDG5, then the "Rule of Thumb" approach can help in getting an indication of impact by means of multiplying simple observations (e.g. number of households affected by the project, number of children affected by the project) with previously observed impact factors.

In case of time and resources available for more serious monitoring, conduct of surveys ex-ante and ex-post project intervention can give good indications of impact of the energy access project towards the goals of the SDG1, SDG3, SDG4 and/or SDG5. An example of possible content of a survey can be found in Annex A.

More advanced monitoring methods comprise of modelling exercises and measurements. In case energy access projects have a project component that is specifically aiming for certain impact, e.g. improved indoor climates, then it can be justified to use project budget for advanced monitoring by means of e.g. indoor air quality measurements, again ex-ante and ex-post project intervention.

Four recommendations for UNDP country offices emerged through this analysis:

- Promote the use of the basic scoring charts for energy-access projects **to identify type and size of social and economic benefits associated with energy-access projects** and the importance of monitoring impacts
- Promote the use of the basic scoring charts for energy-access projects to **explain the importance of realising full energy access up to Tier 5 level** since only then the full benefits for other SDGs will be realised.
- **Identify and apply an impact assessment monitoring approach as early as the inception phase** of a project to ensure that the social and economic benefits are properly monitored from the start of each project.
- Gather **feedback on the usefulness of impact assessment and different levels of monitoring (simple to advanced)** as well as problems encountered when gathering information on the social and economic indicators for energy-access projects to further develop mechanisms for assessing the social and economic benefits of completed energy-access projects.

1 Introduction

This chapter introduces the reason for this study, its objectives and approach.

1.1 UNDP work on sustainable energy

The United Nations Development Programme (UNDP) has more than 20 years of experience in sustainable energy. This experience substantiates the critical role of access to sustainable energy services across the different dimensions of sustainable development:

- The social dimension seeks to increase access to energy services, with focus on equity, building up resilience and addressing social inclusion.
- The economic dimension aims to increase economic growth by advancing the affordability and effectiveness of energy services, with focus on efficiency and productivity.
- The environmental dimension seeks to minimize greenhouse gas emissions and other negative environmental impacts while reducing disaster risks, with focus on sustainability.

The UNDP work on sustainable energy aligns with the seventh Sustainable Development Goal 7 (SDG7), on affordable and clean energy. This is elaborated in the UNDP Strategic Plan 2018–2021, which emphasizes the agency's role in helping countries end extreme poverty, reduce inequalities and achieve the goals of the 2030 Agenda for Sustainable Development. The Strategic Plan structures actions along six signature solutions. One of these solutions is 'closing the energy gap' by providing universal access to clean, affordable and sustainable energy (UNDP, 2017). This is further detailed in the UNDP Strategy Note on Sustainable Energy (UNDP, 2016).

1.2 Study objective: Improve the assessment of social and economic benefits of energy-access projects

UNDP's work on clean energy aligns with Sustainable Development Goal 7 (SDG7) on access to affordable and clean energy while it is acknowledged that energy is an 'intermediate' commodity: it powers appliances, equipment, and machinery as well as lighting and thermal applications. In relation to the Sustainable Development Goals in general, SDG 7 is primarily useful in that it helps to achieve other SDGs. In other words, the success of SDG 7 is a precondition for the success of many other SDGs. Especially the SDG7 goals related to energy access and clean cooking, have a direct impact on SDG1 No Poverty, SDG3 Good Health, SDG4 Quality Education and SDG5 Gender Equality.

UNDP is working on improving its assessment of the social and economic benefits of its energy-access projects and the contribution of these projects towards achieving other SDGs. In 2015, UNDP conducted analysis of the non-energy benefits of its sustainable energy projects as a scoping exercise for assessing impact (UNDP, 2015). The underlying report is a next step in developing a framework that can be used to assess the impact of the social and economic benefits for a specific subset of sustainable energy projects: access to electricity and clean-cooking projects.

UNDP monitors sustainable energy projects by reporting on indicators contained within each project document. Project objectives are monitored through annual progress reporting. Ideally, data gathered within the projects allow for tracking the direct and indirect benefits of energy projects across all dimensions. UNDP, however, lacks sufficient data to conduct a proper impact assessment of the social and economic benefits of its sustainable energy projects.

The study reflected in this report is a next step to develop a framework that can be used by UNDP country office staff and project managers to improve the impact assessment of social and economic benefits for a subset of sustainable energy projects: access to electricity and clean-cooking projects. Hence, the study's objectives centred on:

- Developing a 'scoring' tool that can be used for assessment of potential impact of energy access projects towards SDG1, SDG3, SDG4 and SDG5 by UNDP country offices (and project managers);
- Providing an indication on the degree of social and economic benefits that can be observed for different types ("Tiers") of energy-access projects; and
- Providing guidance for country offices (and project managers) on more advanced methods of impact assessment and data collection approaches to assess social and economic benefits for energy-access projects.

1.3 Report structure

This report is structured as follows.

- Chapter 2 provides an introduction to the field of energy access, the relationship with social and economic development goals and applied definitions for energy-access projects.
- Chapter 3 describes social and economic benefits of access to electricity projects and provides a score on the degree of social and economic benefits for different levels of access to electricity.
- Chapter 4 describes the social and economic benefits of access to clean-cooking projects and provides a score on the degree of social and economic benefits for different levels of access to clean cooking.
- Chapter 5 provides an overview on possible monitoring approaches that can be applied to assess the social and economic benefits of UNDP energy-access projects.
- Chapter 6 presents case studies for which the scoring approach developed in this study was applied to two UNDP energy-access projects.
- Chapter 7 presents the conclusions and recommendations from this analysis

2 Defining energy access

This chapter defines households' access to energy. It starts with providing an overview of the links between energy-access projects and socioeconomic development goals. It then details the impact pathway for energy-access projects, before discussing commonly used definitions and categorizations for energy-access projects.

2.1 Context: Sustainable Development Goals

Figure 1 Sustainable Development Goals

The United Nations member States agreed in 2014 on an agenda to eradicate poverty everywhere and to provide a better life for all people over the next 15 years: The 2030 Agenda for Sustainable Development. This agenda comprises 17 goals and 169 underlying targets (Figure 1).

The 2030 Agenda constitutes a network in which the goals are linked through targets that, in turn, refer to multiple goals. SDG 7 aims at realizing access to affordable and clean energy and is, directly or indirectly, linked to several other SDGs. These links were comprehensively analysed by the Institute for Global Environmental Strategies (2017) and Le Blanc (2015). The results of those studies along with UNDP priorities led to this analysis focusing on the social and economic benefit assessment of energy-access projects towards the following SDGs and targets (United Nations, 2018):

- SDG 1—No poverty: End poverty in all its forms everywhere
- SDG 3—Good health and well-being: Substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination
- SDG 4—Quality education: Ensure inclusive and quality education for all and promote lifelong learning
- SDG 5—Gender equality: Achieve gender equality and empower all women and girls and enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women

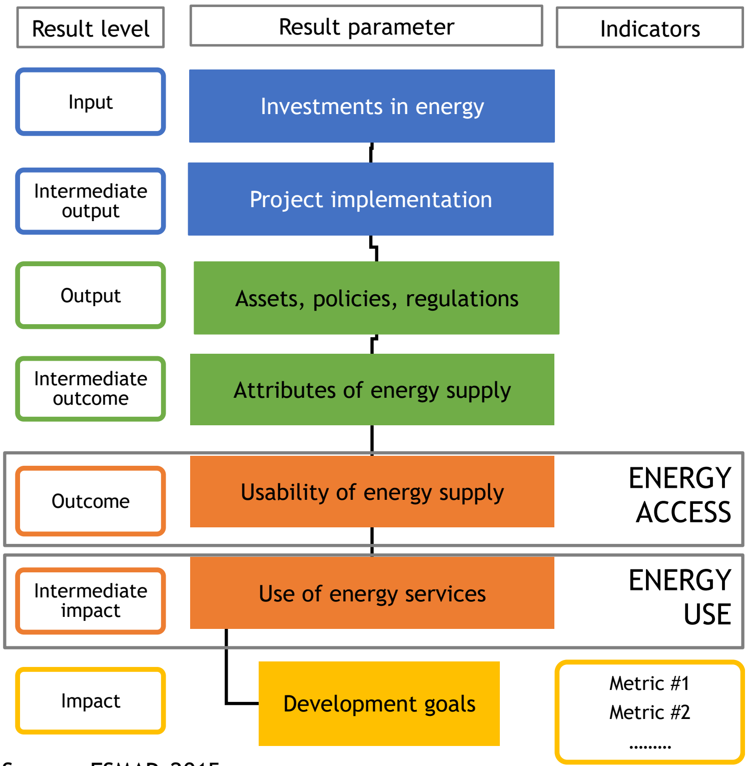
2.2 Context: UNDP signature solution 5: Close the energy gap

The UNDP Strategic Plan for 2018–2021 includes the vision to support countries achieving the 2030 Agenda. This plan structures UNDP activities along six signature solutions. Signature solution 5 to 'close the energy gap' aims at achieving access to clean and affordable energy and focuses on increasing energy access, promoting renewable energy and enhancing energy efficiency. This should be done in a manner that is inclusive and responsive to the needs of different sections of a population. Access to sustainable energy is considered an enabler of sustainable development, particularly in the areas of nutrition, transport, education, economic opportunity and reducing the impacts of indoor and outdoor air pollution (UNDP, 2017). The desired benefits are detailed in the UNDP Strategy Note on Sustainable Energy (UNDP, 2016).

2.3 Energy results chain: Impact pathway of energy-access projects

Figure 2 depicts the impact pathway for energy-access projects developed by the World Bank, referred to as the 'energy results chain' (ESMAP, 2015). The energy results chain represents how investments in energy-access projects potentially can lead to social and economic benefits (impact). The model assumes that investments in energy-access projects (input) lead to project implementation (intermediate output) and the delivery of assets or policy reforms (outputs). In turn, this improves one or more attributes of energy supply (intermediate outcome), such as greater availability, improved quality or increased affordability of energy. Collectively, these attributes increase the usability of the energy supply, thus improving energy access (outcome) and, eventually, the actual use of energy services (intermediate impact).

Figure 2 Energy results chain



Source: ESMAP, 2015.

This process can subsequently contribute to the achievement of developmental goals (impact). Each step in the energy result chain can be translated into an indicator to measure progress towards reaching targeted results.

Higher up on the results chain, however, it becomes harder to link investments in energy to the outcomes. This indicates that when the effects of an intervention are sought at higher levels in the results chain, which was the objective for this study, attribution of benefits becomes more difficult. This is important to keep in mind when reviewing and analysing reported social and economic benefits of energy-access projects: can the observed benefits be attributed to a single intervention (in the UNDP case, investment in the energy system) or should other causes be considered as well?

2.4 Applied definitions for energy access

No single internationally accepted definition of energy access exists. The International Energy Agency defines it as "a household having reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average" (IEA, 2017).

UNDP includes businesses and communities in its understanding of energy access, which is thus characterized as "the need for electrical, thermal and mechanical energy for households, small and medium-sized businesses and communities, with an emphasis on clean energy for the poor" (UNDP, 2016).

Within its Energy Sector Management Assistance Programme (ESMAP), the World Bank also applies a broader scope than the International Energy Agency: "Access to energy is the ability to avail energy that is adequate, available when needed, reliable, of good quality, affordable, legal, convenient, healthy and safe, for all required energy services across household, productive and community uses" (ESMAP, 2015).

The study reflected in this report assessed the social and economic benefits deriving from energy access for households, businesses and communities. This wider perspective was chosen because UNDP energy access projects support a diverse range of activities and technologies targeted at different end users. This study also accounted for differences in the type and extent of social and economic benefits with increasing levels of energy access.

3 Access to electricity

This chapter starts with clarifying the framework developed by the Word Bank to categorize electricity-access projects. This framework distinguishes six tiers of access to electricity, with tier 0 representing the baseline situation with no access to electricity and tier 5 the most advanced level.

Furthermore, the chapter presents an overview of the social and economic benefits of access to electricity projects reported in the reviewed academic and grey literature, resulting in a list of 10 social and economic metrics covering poverty alleviation, health, education and gender equality. Findings from the literature show a gradual increase in the degree of social and economic benefits when moving to higher tiers of electricity access. This is visualized in radar charts to show the degree of social and economic benefits for different levels of electricity-access projects, as compared to tier 0.

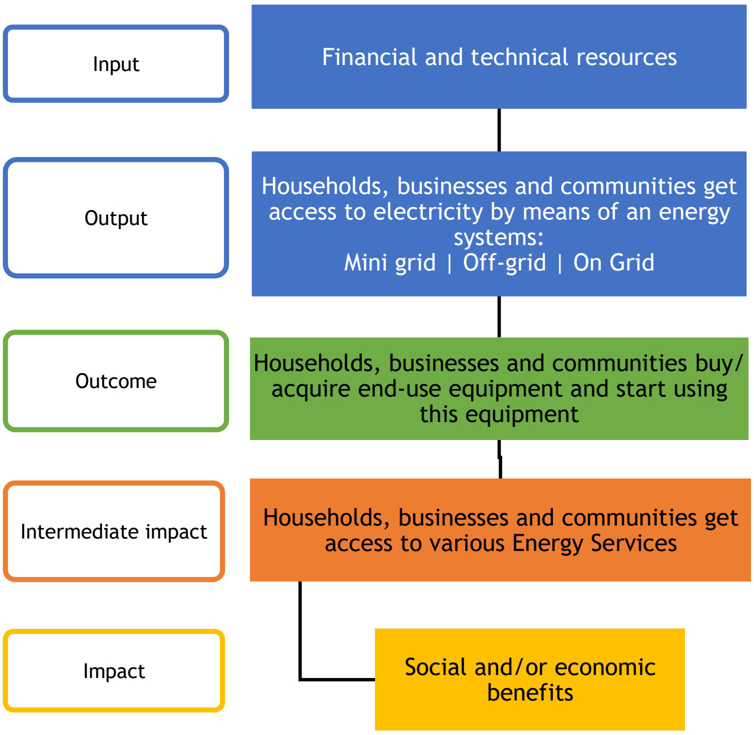
3.1 Energy result chain for electricity-access projects

Figure 3 illustrates the energy results chain (impact pathway) for interventions aimed at providing access to electricity. The inputs are the financial and technical resources that are used to stimulate [1] actual investment in energy supply systems (including transmission and distribution equipment for a grids) and provide households, businesses and communities with access to electricity (output).

The output enables households, businesses and communities to use end-use equipment (appliances) that they either bought or acquired outside or through the project (outcome).

By using these appliances, households get access to energy services (intermediate impact) that deliver social and economic benefits in the end (impact).

Figure 3 Energy results chain for electricity-access projects



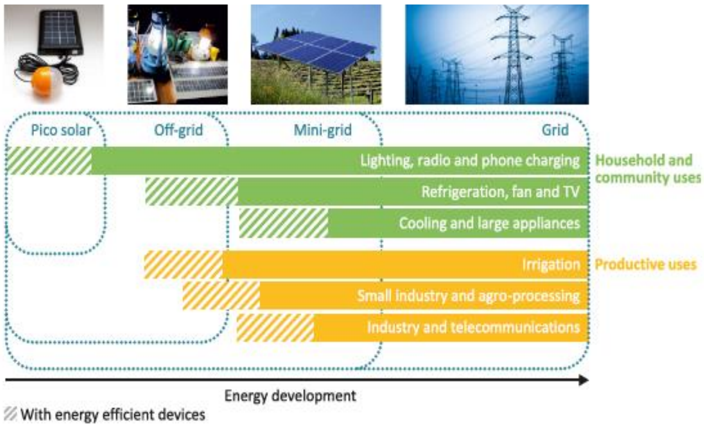
Source: Based on ESMAP, 2015.

[1] UNDP energy-access projects cover a range of inputs, from capacity building on the national (government) and community levels to distributing appliances and co-investing in energy production technologies.

3.2 Levels of access to electricity

'Access to electricity' used to be defined in a binary approach as whether a household had electricity to use. This characterization, however, does not account for different levels of access to electricity provided to end users. Electricity, after all, is only useful if the desired energy services become available. Energy services require different levels of electricity supply in terms of quantity, time of day, supply duration, quality and affordability. Energy systems range from the most basic pico solar system, to off-grid and local mini grids to the most advanced system, with access to an integrated electricity grid. Figure 4 illustrates how investments in different energy systems result in incremental levels of access to electricity and the possibility for end users to utilize more advanced end-use technologies with increasing access levels.

Figure 4 Electricity access and illustrative technology options



Source: IEA, 2017.

The World Bank (ESMAP, 2015) recently developed a comprehensive framework to measure the levels of access to electricity provided to end users, where successive thresholds of supply allow for increased use of end-use equipment (appliances). This framework defines six levels for electricity access: Tier 0 represents the baseline situation with no access to electricity and, consequently, no access to energy services.

Subsequently, tier 1 represents the most basic level, tier 2 a more advanced level and, ultimately, tier 5 is the most advanced level. This framework tries to account for the multidimensional nature of access to energy and includes seven attributes.

A score can be determined for each of the seven attributes to produce an energy-access diagnostic for a given geographical area. If deemed useful, a simple *energy-access index* can be calculated by weighing the tiers (ESMAP, 2015). Figure 5 provides an overview of the seven attributes and the way they are scored for each tier within the framework developed by the World Bank:

1. *Capacity* refers to the ability of the system to deliver a quantity of electricity to operate different appliances (peak capacity).
2. *Duration/availability* refers to the amount of time during which electricity is available (including daily and evening supply).
3. *Reliability* is defined in terms of frequency and duration of unscheduled outages. For example, an electricity system is scored as tier 4 with a maximum of 14 outages per week and is scored as tier 5 with a maximum of three disruptions per week, with aggregate disruption duration of less than two hours per week.
4. *Quality* is defined in terms of voltage. An electricity system scores tier 4 or 5 if voltage problems do not prevent the use of desired appliances.
5. *Affordability* refers to whether households can pay for the electricity they need. Affordable levels are defined as consumption of 365 kWh per year that costs less than 5 percent of the household income.
6. *Legality* is inferred by bill payment. An energy system scores tier 4 or 5 if it can be demonstrated that the bill is paid to the utility, a prepaid card seller or authorized representative. This attribute is included because illegal connections pose a significant safety risk and affect the financial sustainability of the utility. However, the user may utilize various electricity services from an illegal connection.

7. *Health and safety* is measured by the safety of the electricity system. Electricity systems are scored tier 4 or 5 in the absence of past accidents and without the perception of high risk in the future.

The boundaries between the various tiers are not always as clear-cut as presented in Figure 5. They could follow a more gradual path.

Figure 5 Multi-tier matrix for measuring access to household electricity supply

<table>
<tr><th></th><th>TIER 0</th><th>TIER 1</th><th>TIER 2</th><th>TIER 3</th><th>TIER 4</th><th>TIER 5</th></tr>
<tr><td>Capacity</td><td>No electricity</td><td>Min 3 W</td><td>Min 50 W</td><td>Min 200 W</td><td>Min 800 W</td><td>Min 2000 W</td></tr>
<tr><td>Availability (hours/day)</td><td></td><td colspan="2">Min 4</td><td>Min 8</td><td>Min 16</td><td>Min 23</td></tr>
<tr><td>Availability (hours/evening)</td><td></td><td>Min 1</td><td>Min 2</td><td>Min 3</td><td colspan="2">Min 4</td></tr>
<tr><td>Reliability</td><td colspan="4"></td><td>Max 14 disruptions per week</td><td>Max 3 disruptions per week of total duration < 2 hours</td></tr>
<tr><td>Quality</td><td colspan="4"></td><td colspan="2">Voltage problems do not affect use of desired appliances</td></tr>
<tr><td>Affordability</td><td colspan="3"></td><td colspan="3">Cost of standard consumption package of 365 kWh/year < 5% of household income</td></tr>
<tr><td>Legality</td><td colspan="4"></td><td colspan="2">Legal payment of bill demonstrated</td></tr>
<tr><td>Health and safety</td><td colspan="4"></td><td colspan="2">Absence of accidents</td></tr>
</table>

Source: ESMAP, 2015.

In addition to scoring energy systems by the seven attributes, the matrix is also used to derive an overall score for the energy systems in a geographical region, which becomes the energy- access index. This index evaluates both the extent of access (how many households have access) and the intensity of that access (the level of access that each household has). For example, the Council on Energy, Environment and Water (2015) produced a comprehensive illustration of the use of the framework and determining indices for access to electricity and clean cooking for various regions in India.

3.3 Levels of access to electricity services

A gradual improvement of access to electricity (a higher tier) implies enhanced opportunities to electricity services because households and/or businesses can utilize a larger and more diverse set of appliances. The World Bank developed this into a second matrix mirroring the supply matrix, which measures the access to household electricity services (Figure 6). Higher levels of energy services offer the possibility for end-users to use more and higher-powered appliances.

Figure 6 Multi-tier matrix for measuring access to household electricity services

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Energy services provided		Task lighting and phone charging	General lighting and phone charging and television and fan (if needed)	TIER 2 and medium-power appliances	TIER 3 and any high-power appliances	TIER 4 and any very high-power appliances
Possible appliances		- Radio - Task light - Charger	TIER 1 PLUS -Multi-point general lighting -Television -Computer -Fan	TIER 2 PLUS -Air cooler -Refrigerator -Food processor -Rice cooker	TIER 3 PLUS -Iron -Hair dryer -Toaster -Microwave	TIER 4 PLUS -Air conditioner -Water heater -Electric cooker

Source: ESMAP, 2015; SE4All, 2017.

It is possible for a household to obtain different tier ratings across the range of access to electricity supply and access to electricity services—reflecting either availability of appliances despite poor supply or inability to afford appliances despite adequate supply (ESMAP, 2015).

3.4 Social and economic benefits

This section summarizes the results of this study's review of academic and grey literature on reported (i) evidence of social and economic benefits from access to electricity projects, (ii) metrics to measure these benefits and (iii) available data. The benefits are categorized along the line of the SDGs to which these benefits potentially contribute. Each section starts with a description on the anticipated impact pathway.

SDG 1—No poverty: Changes in household expenditure

Anticipated impact pathway:

Access to electricity influences household expenditure because the costs for traditional fuels are replaced by the expenditure on electricity and related services.

Evidence from literature:

Determining the impact on household expenditure is not a straightforward exercise, according to report by the Dutch Policy and Operations Evaluation Department (IOB, 2013), for the following reasons:

- Energy sources could be subsidized.
- The nominal price paid for energy is not equal to the net price (the price per unit energy effectively used). The poorer households often use the most expensive fuels in terms of the price per unit of useful energy, and the poorer households tend to use less efficient devices.
- Expenditure does not only rely on the price of the fuel but includes also the amortized capital costs of the equipment and the appliances needed for each energy source.

Comparing 'before' and 'after' a project is even more complex in the case of electricity, because electricity also provides the opportunity to use new services (IOB, 2013).

Different metrics are applied in comparing the applications of traditional fuel sources versus improved sources. These metrics include expenditure per kilowatt-hour (kWh), expenditure per lumen (lm) or the absolute expenditure in amount of cash spent on energy.

The impact on household expenditure from gaining access to electric lighting is significant. A study in Ghana, for example, found a positive correlation between ownership of photovoltaic solar home systems and a decrease in expenditure for kerosene, candles and dry-cell batteries: 21 percent of the households accomplished savings of approximately 10 percent for lighting only. Studies in eastern Zambia came to comparable findings (IOB, 2013).

SDG 1—No poverty: Economic growth and increase in household income

Anticipated impact pathway:

Access to electricity provides the opportunity to develop other economic activities. For instance, more efficient electric machinery and equipment can be used for manufacturing and for raising productivity, economic growth and household income. This is only feasible, however, beyond tier level 2, because a certain minimum level of access to electricity is required to enable productive uses of electricity, such as the generation of additional income.

Evidence from literature:

The impact of electrification on economic activities has not been clearly established, however:

- An evaluation of 23 local development projects in 14 countries (covering Asia, Africa and Latin America) revealed that only in a small number of projects was electricity applied for productive use. Even though 12 projects identified possible productive uses of energy, the number of people who used the energy to start business activities was small (Terrapon-Pfaff and others, 2014). Most evaluated projects in this study would categorize as tier 1 to 2 in the framework presented in this report, in which case, productive use is expected to be limited because no use can be made of medium- and high-power appliances (see Figure 6).
- A study in Benin found that the installation of an electricity grid spurred new businesses, but, at the same time, led to a decline of profits for existing businesses (crowding-out effect). On average, an 8 percent increase in rural per capita income over a five-year period was observed (Peters, Vance and Harsdorff, 2011).
- Khandker and others (2009) reported an increase in total income attributable to electrification by as much as 30 percent in Viet Nam, which sustained for as long as eight years, after which the benefits levelled off.
- World Bank data from 1998 to 2003 for Ghana showed a positive impact of electrification on home-based businesses. In this period, the number of home businesses grew significantly more in communities that became electrified—more than in those communities without electricity and more than those that were already electrified in 1988 (IEG, 2008).
- A study in 10 African countries found that, immediately after electrification in the region, the number of newly established enterprises increased substantially. But many of those initiatives were discontinued soon afterwards (Arnold, Matto and Narciso, 2006).

SDG 3—Good health and well-being: Reduction of indoor air pollution and related diseases

Anticipated impact pathway:

Access to electricity leads to a reduction of exposure to indoor air pollution because households no longer need to rely on kerosene and paraffin-fuelled lamps for lighting (typically the tier 0 baseline situation) (see the next chapter for details on clean cooking). This reduction in indoor air pollution also leads to a reduction in related diseases.

Evidence from literature:

Indoor air pollution from the combustion of kerosene is related to catarrh and headache, with one reported situation of harmful mental development of children (measured by exposure to carbon monoxide and particulate matter ($PM_{2.5}$)). This conclusion is based on four studies covering the period 2003–2014 (IOB, 2013). In the short term, the health benefits of replacing fuel-based lighting by electric lighting is only minor because households initially continue to use traditional lamps—complementary to electric lighting. A study in Ghana, for example, revealed that solar photovoltaic lighting reduced the proportion of household members affected by indoor smoke from kerosene lanterns by 50 percent, while the proportion of household members with blackened nostrils decreased by almost 30 percent (in this group, however, kerosene was still used in addition to electric lighting) (IOB, 2013).

DALYs

Health benefits are in some cases expressed in averted disability adjusted life years, or DALYs. One DALY can be thought of as one lost year of 'healthy' life. The sum of these DALYs across the population, or the burden of disease, can be envisioned as a measurement of the gap between current health status and an ideal health situation in which the entire population lives to an advanced age, free of disease and disability. DALYs for a disease or health condition are calculated as the sum of the years of life lost due to premature mortality in the population and the years lost due to disability for people living with the health condition or its consequences. See www.who.int/healthinfo/global_burden_disease/metrics_daly/en/.

SDG 3—Good health and well-being: Reduction of accidents

Anticipated impact pathway:

Legal access to electricity leads to a reduction in occurrence of accidents, along two pathways.

1. Due to access to electricity, households no longer need to use fuel-based lighting (tier 0). This leads to a reduction in occurrence of accidental fires (accelerated by spilled fuel, broken glass from lamps and use of candles) that result in burns or death.
2. Due to legal access to electricity, illegal and secondary connections to the electricity grid will diminish. This results in a decrease of occurrence of electrocution caused by poor wiring and absence of safety devices.

Evidence from literature:

An analysis of the impact of rural electrification projects in Mali, South Africa and Uganda in 2012 found a significant reduction in accidents due to the use of candles and paraffin (FRES, 2013).

Several publications have reported on the number of victims of electrocution (see ESMAP, 2015), but no evaluations were made of the impacts of energy-access projects on the number of electrocution victims. The study in Mali, South Africa and Uganda revealed that the number of energy-related accidents (burns and electrocution) was slightly larger for respondents who had access to electricity (at 7 percent) than for households who do not have access to electricity (at 2 percent). This was somewhat unexpected and was attributed to the occasional tampering by clients with the solar installations by using converters or equipment not suited to solar home systems or mini grids (FRES, 2013).

SDG 3—Good health and well-being: Improved access to health services

Anticipated impact pathway:

Access to electricity improves access to health services and health care quality. This ultimately advances life expectancy.

Evidence from literature:

Improved access to health care materializes through several channels.

1. Access to mobile phones can be important, in theory, for getting help in medical emergencies, although no studies were found in which this benefit was quantified.
2. Access to electricity (beyond tier 3) provides the possibility to make use of a refrigerator to store vaccines (maintain the cold chain). In theory, electrification may shorten the cold chain, or make

it more efficient, resulting in higher immunization rates.[2] The immunization rate in areas with clinics with access to electricity beyond tier 3, however, hardly differs from areas with clinics with lower access to electricity levels. This was shown by studies in Bangladesh, Egypt, Ghana, Kenya, Nicaragua and Rwanda (IEG, 2008).
3. Research in 2003, although limited, revealed that communities in Bangladesh attracted more qualified health workers in areas with access to electricity and that health services with electricity had longer opening hours (IEG, 2008).
4. Access to mobile phones enables health applications and access to other communication services, such as television and computers facilitating public health education and information.

No single measurement is available to monitor either access to or quality of health care services. As with access to energy, access to health care comprises a broad set of attributes,[3] and it goes beyond the scope of this study to assess this in the context of access to electricity.

SDG 4—Quality education: Enhanced schooling

Anticipated impact pathway:

Access to electricity provides the possibility to improve the levels of illumination that enable children to spend additional time on homework after dark and providing the opportunity for more children to finish school.

Evidence from literature:

The number of lighting hours is not the single determinant for additional time spent by children studying at home (IOB, 2013). The quality of lighting and the brightness (measured in lumen) have an equally important role. The priority for electricity use for households with solar home systems shifts over time towards the use of appliances, mainly television, displacing electricity utilized for lighting. Over time, though, both school enrolment and years of completed schooling improve with increasing available electricity at home (World Bank, 2017):

- In Bangladesh and Viet Nam and because of access to lighting, school enrolment for boys went up by 11 percent and for girls by 4 percent.
- In the Philippines, children in electrified households acquired almost two years of additional education.
- Grid connectivity in the Lao People's Democratic Republic increased study time in the evening by 30 minutes for boys and 19 minutes for girls and grade completion of secondary schooling was raised by 3.6 percent points for men and 3.4 percent points for women.

SDG 5—Gender equality: Time-savings and improved time management and female employment

Anticipated impact pathway:

Access to electricity frees up time for households because less time is needed to purchase kerosene, paraffin and candles. This increases the efficiency of household chores. In addition, the access to lighting provides the opportunity to shift domestic tasks (usually for women) to the evening, providing room for other economic, social and educational activities, including time for radio and TV entertainment.

Evidence from literature:

[2] Many vaccines are sensitive to both heat and cold and need to be stored between 2° and 8° Celsius. In almost all countries, health authorities organize a system that keeps vaccines at that temperature between manufacturing and vaccination (the cold chain).
[3] See www.who.int/bulletin/volumes/95/6/17-195099/en/.

The actual time-savings resulting from not having to purchase kerosene, paraffin, candles or batteries for lighting are not known. Because these fuels are usually available from local retailers, the time-savings are probably small (IOB, 2013).

Electrification impacts the time management of households. For example, lighting provides between one and three hours of additional time for other activities (IOB, 2013). Projects in South Africa, Bangladesh and Guatemala, for example, showed an increase of 9 percent of employment of women after electrification. In contrast, employment in these projects for men did not change (Köhlin and others, 2011).

SDG 5—Gender equality: Increase in (perceived) safety

Anticipated impact pathway:

Access to electricity provides the opportunity to provide more and better-quality illumination (outside light) and to have immediate access to communication (charged batteries) resulting in an increase in (perceived) safety.

Evidence from literature:

In African countries, studies on perceived safety present a mixed picture. In some cases, perceived safety went up after electrification, whereas in other situations it went down (FRES, 2013). A study conducted in 2012 in Senegal surveyed people on the impact of lighting and compared those in the project with people who had no lighting at night. They did not find a measurable difference in sense of security, when, for example, comparing the number of robberies and attacks by snakes and scorpions. In interviews, however, people declared that lighting did affect their perceived feeling of security. No differences were found in the frequency of leaving the house after nightfall between people with and without lighting (IOB, 2013).

SDG 5—Gender equality: Impact on social change

Anticipated impact pathway:

Access to electricity provides people with the opportunity to use different means of communication (television, Internet), which can lead to changes in attitudes and behaviours.

Evidence from literature:

- A positive relationship was found between watching television and fertility by the World Bank in a study covering nine countries (Bangladesh, Ghana, Indonesia, Morocco, Nepal, Nicaragua, Peru, Philippines and Senegal (IEG, 2008) and by another study in India (Jensen and Oster, 2009). This was largely attributed to better knowledge about contraceptives and health in general.
- A positive relationship emerged between watching television and a decrease in the acceptance of domestic violence and a decline in the preference for having sons instead of daughters in India (Jensen and Oster, 2009).

3.5 Summary of social and economic benefits

Table 1 summarizes the results of this study's assessment on the social and economic benefits reported in academic and grey literature due to electricity-access projects. The 10 social and economic metrics were drawn from the reviewed literature. These are metrics for which a positive correlation was found with the implementation of electricity-access projects. The metrics that were evaluated in this chapter for which no evidence was found of a positive relationship were omitted from the matrix.

The matrix in table 1 provides a basic scoring based on the relationship between level of access to energy and the social and/or economic benefits. The following scoring level was applied:

(0) No benefit is to be expected for this social or economic metric.
(1) Degree of social and economic benefit is small, compared with tier 0.
(2) Degree of social and economic benefit is moderate, compared with tier 0.
(3) Degree of social and economic benefit is large or significant, compared with tier 0.

The matrix shows a gradual increase in the degree of social and/or economic benefits when moving to higher tiers for electricity access. Most of the reviewed literature focused on accessing impacts up to tier 2 or 3; it is assumed that benefits fully materialize when moving towards the higher tier levels.

The results presented in Table 1 are visualized in a radar chart (Figure 7), showing the degree of social and economic benefits for different levels of electricity access projects, compared with tier 0. These radar charts can be useful for UNDP country office staff and project managers of energy-access projects because they provide, at a glance, what social and economic benefits could be anticipated based on the level (or "tier") of energy access for their project intervention. Based on the results of this basic scoring, activities can be incorporated into the project plan to gather data to monitor the relevant metrics.

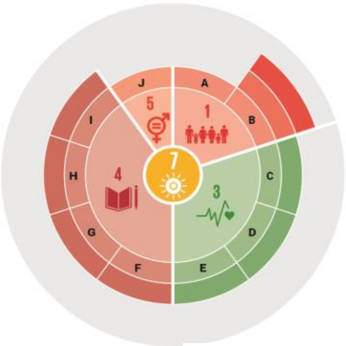
Table 1 Degree of social and/or economic benefits of electricity-access projects, when compared with tier 0

(0) No benefit
(1) *Small* benefit, compared with tier 0
(2) *Moderate* benefit, compared with tier 0
(3) *Large or significant* benefit, compared with tier 0

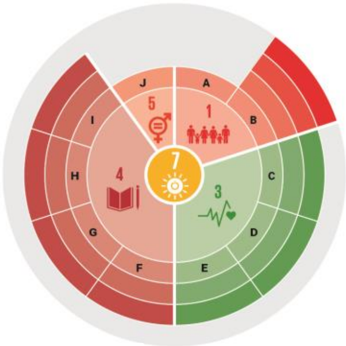
			TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
			Task lighting and phone charging	General lighting and television and fan	TIER 2 and any medium-power appliances	TIER 3 and any high-power appliances	TIER 4 and any very high-power appliances
#SDG	**Metric**	**Indicator**	**Indication of the degree of the benefits, compared with TIER 0**				
No poverty (SDG1)	Increase in economic activity	• Household income • Employment, male and female • No. of new firms/year	0	0	1	2	3
	Decrease in expenditure on lighting	• Expenditure on lighting	2	3	3	3	3
Good health & well-being (SDG 3)	Decrease in indoor air pollution due to access to clean lighting	• Carbon monoxide concentration • $PM_{2.5}$ concentration	1	2	3	3	3
	Decrease in occurrence of diseases related to indoor air pollution due to access to clean lighting	• Occurrence of respiratory disease symptoms • Occurrence of eye infections • Averted DALYs	1	2	3	3	3
	Decrease in number of accidents with lighting	• Occurrence of burn accidents • Occurrence of electrocution accidents	1	2	2	3	3
Quality education (SDG 4)	Additional time spent on homework	• Hours/day	1	2	2	3	3
	Increase in number of children finishing school	• No. of children finishing school/year	1	2	2	3	3
	Increase in education level	• Years at school	1	2	2	3	3
	Increase in school enrolment	• No. of children enrolling in school/year	1	2	2	3	3
Gender equality (SDG 5)	Increase in time for activities other than household chores	• Additional hours/day available for other activities	0	0	1	2	3

Figure 7 Degree of expected benefits for SDG1, SDG3, SDG4 and SDG5 of five tiers of access to electricity-access, compared to tier 0 (no electricity access)

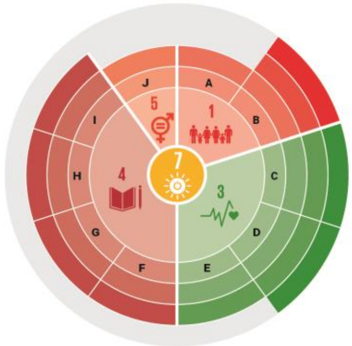
TIER 1: Task lighting and Phone Charging



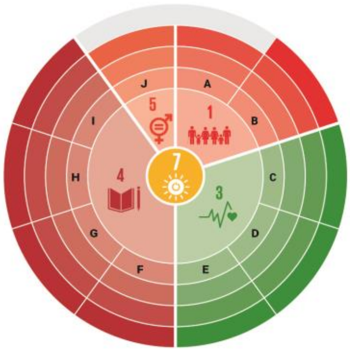
TIER 2: General lighting and Television and Fan



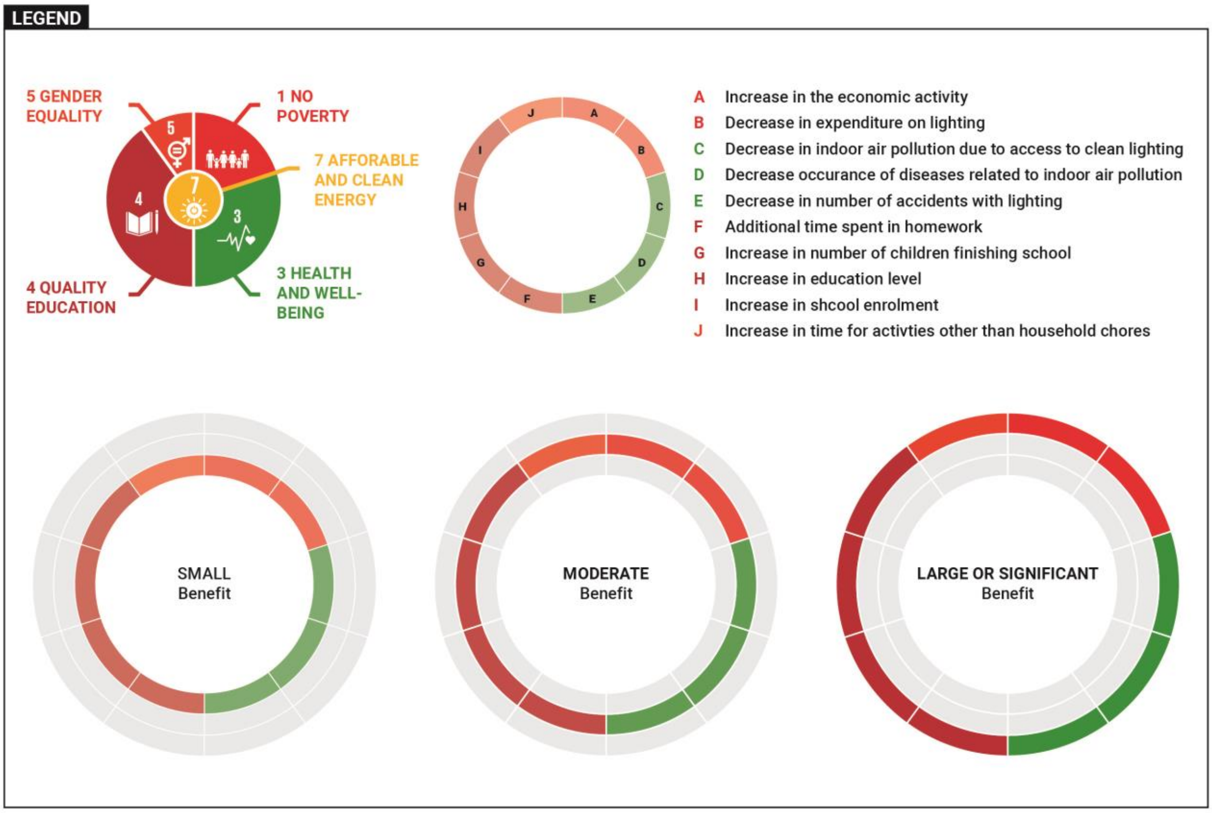
TIER 3: Tier 2 + Medium Power Appliances



TIER 4: Tier 3 + Any High-Power Appliances



TIER 5: Tier 4 + Any very High-Power Appliances



4 Access to clean cooking

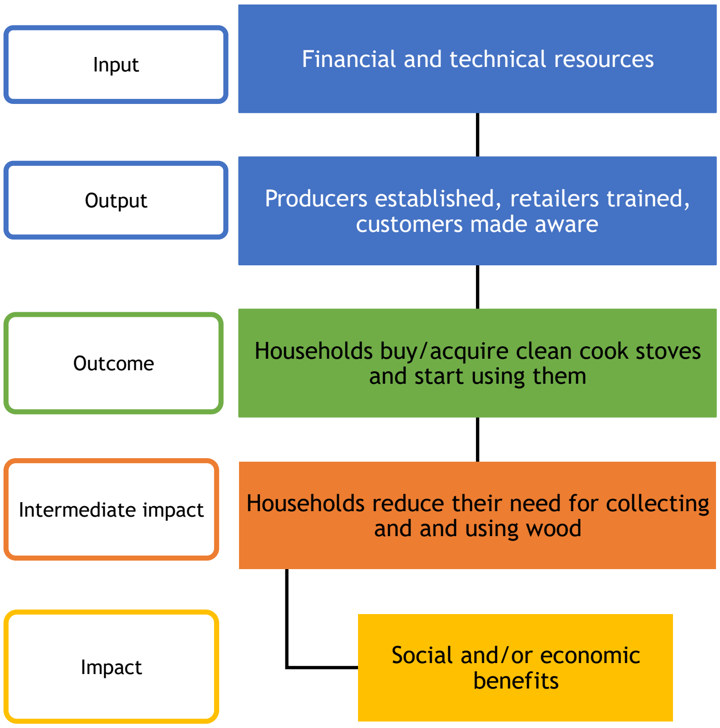
This chapter starts with clarifying the framework developed by the Word Bank to categorize clean-cooking projects. This framework distinguishes six tiers of access to clean cooking, which is mirrored into a classification for cookstoves, ranging from improved cooking solutions (tiers 1 and 2) to clean-cooking solutions (tiers 3 and up). An overview is provided of the social and economic benefits of access to clean-cooking projects reported in the academic and grey literature, which led to a list of five social and economic metrics covering poverty alleviation, health and gender equality. Findings from the literature review show a gradual increase in the degree of social and economic benefits when moving to higher tier levels for access to clean cooking. This is visualized in a radar chart that reflects the degree of social and economic benefits for the different levels of access to clean-cooking projects, as compared to tier 0.

4.1 Energy results chain

The International Energy Agency defines 'access to clean cooking' as a household primarily relying on cooking facilities, which are used without harm to the health of those in the household and which are more environmentally sustainable and energy efficient than biomass cookstoves and the three-stone fires used in developing countries (IEA, 2017).

Figure 8 depicts the energy results chain (impact pathway) for interventions aimed at providing access to clean cooking. Inputs include financial and technical resources that are employed to ensure that clean-cooking systems are available and can be used in a proper way (output). The output enables households to acquire clean cookstoves and to start using them (outcome). By using the cookstoves, households reduce their wood consumption (intermediate impact), which ultimately generates social and/or economic benefits (impact).

Figure 8 Energy results chain for access to clean-cooking and space-heating projects



Source: Based on ESMAP, 2015.

4.2 Levels of access to clean cooking

Most households who do not have access to clean cooking (baseline) rely on the traditional use of solid biomass, unprocessed coal, kerosene and/or liquid oil. These households use a traditional (or basic) cookstove, a simple open fire built on the ground with three stones to support a pot or a basic ceramic, clay or metal stove.

The World Bank developed a framework that is broadly applied to measure access to clean-cooking solutions. As with access for electricity, this framework defines six levels for access to clean-cooking solutions. Tier 0 represents the baseline situation with no access to clean cooking, evolving to tier 5 and the most advanced level of access. The framework tries to account for the multidimensional nature of access to energy and includes six attributes. A score can be determined for each of the six attributes to produce a clean cooking diagnostic for a given area.

Figure 9 provides an overview of the six attributes and the way they are scored for the different tiers within the framework developed by the World Bank:

1. *Availability of the primary fuel* is included as an attribute because this can be an issue regardless of the technology; if not available, it often requires the use of a secondary fuel.
2. *Quality of the primary fuel* refers to caloric value, moisture and combustion characteristics, or voltage (for electricity), which, if inadequate, may impact the performance of the cooking solution.
3. *Affordability* refers to the multifaceted interaction between the quantities of energy consumed, its price per unit and the ability of the user to pay.
4. *Convenience* refers to the overall time and effort involved in the process of securing and processing energy for cooking, including the time and effort involved in obtaining the fuel and preparing the fuel and stove.
5. *Health*[4] refers to the level of indoor air and overall pollution and its adverse impacts on women's and children's health.
6. *Safety* refers to possible injury during use and is determined based on an evaluation of the cookstove design in terms of equipment stability, sharp edges, exposed hot surfaces and fuel containment.

Figure 9 Multi-tier matrix for measuring access to clean-cooking solutions

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Availability of primary fuel	Availability inadequate				Available at least 80% of the year	Available all year
Quality of primary fuel: Variations in heat rate that affects ease of cooking	Low quality				High quality	
Affordability	Primary solution not affordable				Levelized cost < 5% of household income	
Convenience: Fuel acquisition & preparation time (hours/week)			< 7	< 3	< 1.5	< 0.5
Convenience: Stove preparation time (minutes/meal)			< 15	< 10	< 5	< 2
Health and safety	Self-made stove	Manufactured stove	Biogas/LPG/electricity/natural gas stoves			

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Indoor air quality						
Overall pollution						
Efficiency						
Safety						

Test results

Source: ESMAP, 2015.

In addition to scoring energy systems on the six attributes, the matrix is also used to establish an overall score for access to clean cooking in a geographical region, thus providing a *clean-cooking index*. The

[4] If cookstoves are tested, the tier for health and safety can be based on measurements for indoor air pollution, overall pollution, efficiency and safety, according to the International Workshop Agreement guidelines developed by the Global Alliance for Clean Cookstoves (http://cleancookstoves.org/technology-and-fuels/standards/iwa-tiers-of-performance.html)

approach is identical to arriving at the index to access for electricity, presented in the previous chapter (ESMAP, 2015).

4.3 Classification of cookstoves

The matrix for access to clean cooking can be mirrored into a classification for cookstoves. Figure 10 provides an overview of this classification, including key characteristics for the various classes and typical examples of applied technologies. The classification covers:

- *Traditional (or basic) cookstoves* (tier 0). These are typically very cheap or no-cost devices. This can include simple open fires built on the ground with three stones to support a pot or a basic ceramic, clay or metal stove. The stoves are characterized by very low efficiency and high particulate matter. They burn solid biomass, including fuelwood, agricultural waste or charcoal.
- *Intermediate improved cookstoves* are typically described as stoves with higher efficiency or generating a lower level of pollution than traditional stoves, through improvements, including a chimney or closed combustion chamber.
- *Advanced improved cookstoves* include technical improvements that further increase combustion efficiency and lower pollutant emissions. These can include highly performing micro-gasifiers and improved cookstove versions with a forced draft, which have a blower injecting air into the fire to improve the stove's performance.
- *Modern and renewable fuel and stoves* use liquids or gas, including LPG, biogas, electricity or natural gas. Efficiency is high, and air pollution is very low or even zero.

Figure 10 Multi-tier matrix for classifying cookstoves

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
		IMPROVED SOLUTIONS		CLEAN-COOKING SOLUTIONS		
Cookstove classification		LEGACY & BASIC IMPROVED COOKSTOVE	INTERMEDIATE IMPROVED COOKSTOVE	ADVANCED IMPROVED COOKSTOVE	MODERN FUEL STOVES	RENEWABLE FUEL STOVES
Key features		Small improvements in efficiency over tier 0	Rocket style designs with highly improved fuel efficiency and moderate gains in combustion efficiency; some with high-end materials	Fan jet or natural draft biomass gasifiers with very high fuel and combustion efficiencies; may equire pellet/briquette fuel	Rely on fossil fuels or electricity, have high fuel efficiency, and very low particulate emissions	Derive energy from renewable nonwood fuel energy sources; some are supplementary rather than primary cookstoves
Typical technologies /fuels		• Legacy biomass and coal chimney • Basic efficient charcoal • Basic efficient wood	• Portable rocket stoves • Fixed rocket chimney • Highly improved (low CO2) charcoal stoves	• Natural draft gasifier • Fan gasifier/ fan jet • TChar stoves	• LPG and DME • Electric and induction • Natural gas Kerosene	• Biogas • Ethanol • Methanol • Solar ovens • Retained heat cookers

Source: ESMAP, 2015b; Vanellio, 2016.

4.4 Social and economic benefits

This section summarizes the results of the review of academic and grey literature on the reported (i) evidence of social and economic benefits from access to clean-cooking projects, (ii) metrics to measure these benefits and (iii) available data. The benefits are categorized along the line of the SDGs, to which these benefits potentially contribute. Each section starts with a description on the anticipated impact pathway.

SDG 1—No poverty: Household expenditure

Anticipated impact pathway:

Access to clean cooking impacts a household's expenditure because the expense for traditional fuel comes to an end and is replaced by spending on improved cooking equipment and fuel.

Evidence from literature:

Determining the impact on expenditure is not a straightforward task. Studies are sometimes hard to compare due to the different methodologies that were applied[5] (IOB, 2013). Cost savings on fuel due to the introduction of an improved cookstove in a range of global studies varied from zero to approximately €34 per household per year.[6] No or limited savings were reported in those studies because (i) often no monetary value was attached to time for wood collected and a reduction of the time spent on wood gathering has no impact on expenditure and (ii) time savings resulted in households cooking more or over a longer time period (rebound effect).

A study conducted in Mongolia in 2014 reported a 47 percent reduction in fuel costs for households with improved stoves (Social Impact, 2014). The decrease in household expenditure on fuelwood, charcoal or kerosene can amount up to 40 percent due to improved-cookstove projects (Terrapon-Pfaff and others, 2014, based on a review of 23 projects in 14 countries in Africa, Latin America and Asia).

The replacement of open-fire cooking by improved wood stoves may produce little savings in absolute terms. Nevertheless, taking into consideration the low-income levels of households participating in the projects, the reduction of expenditure is more important in relative terms.

SDG 1—No poverty: Economic growth and increase in household income

Anticipated impact pathway:

Access to clean cooking and electricity provides households with the possibilities to embark on other economic activities as a result of time saved for fuel collection and thus leading to an increase in household income.

Evidence from literature:

Freed-up time is not always spent on income-generating activities that lead to an increase in household income (see the discussion in chapter 3 on gender equality). Most studies in the literature review looked at economic benefits of electrification without mentioning the specific energy service.

SDG 3—Good health and well-being: Reduction of indoor air pollution and related diseases

Anticipated impact pathway:

Access to clean cooking contributes to a reduction of indoor air pollution because households no longer need to rely on the use of traditional fuels (solid biomass, unprocessed coal, kerosene and liquid oil) and traditional or basic cooking techniques. This reduction in indoor air pollution generates a decline in related diseases.

Evidence from literature:

The Dutch Policy and Operations Evaluation Department reviewed a broad range of studies, which evaluated the impact of improved cookstoves on indoor air pollution (IOB, 2013). The impact was typically expressed in terms of concentration of carbon monoxide as well as in particulate matter. The decline in the concentration of carbon monoxide ranged from 30 percent to 88 percent and from 25

[5] Some researchers add a monetary value to the time investment for wood gathering (the opportunity cost of labour), others included the time costs or transaction costs for acquiring fuels or referred to cash expenditure only.

[6] See table 10 in IOB, 2013 for the complete list of studies.

percent to 73 percent for $PM_{2.5}$.[7] More recent studies concluded that cookstoves distributed through development projects have not radically reduced emissions of $PM_{2.5}$ (Rosenthal and others, 2017).

Indoor air pollution emanating from the use of traditional stoves is linked to respiratory disease symptoms (acute lower respiratory infections (pneumonia) and chronic obstructive pulmonary disease), eye infections and stunted growth of children. Studies that evaluated the health impacts of improved cookstoves found (IOB, 2013):

- A substantial reduction in 2011 in Guatemala in the risk for respiratory symptoms with children and women and a reported reduction of sore eyes during cooking: a reduction of respiratory symptoms, at 48.6 percent among women and 63.3 percent among children.
- Women in Mexico in 2009 reported a significantly lower risk of respiratory symptoms, eye discomfort, headache and back pain.
- A reduction of 8 percent in self-reported respiratory symptoms and 10 percent in eye problems in Senegal in 2011.

Most reviewed studies indicated positive health impacts, with only a minority of studies that did not find any positive effect on health indicators due to use of improved cookstoves (IOB, 2013).

Available evidence suggests that health benefits most likely materialize when clean-cooking programmes focus on clean fuels, such as LPG, electricity, biogas or ethanol (Rosenthal and others, 2017).

SDG 3—Good health and well-being: Reduction of accidents

Anticipated impact pathway:

Access to clean cooking leads to a reduction in the number of accidents because households can dispense with the use of open fires, which thus leads to a decrease in burns and unintended fires.

Evidence from literature:

In Africa, for example, 2–14 percent of surveyed households were involved in energy-related accidents. Between 30 percent and 50 percent of those accidents related to the use of firewood. Electrification was expected to decrease the number of accidents due to inflammable material (firewood, candles, diesel). The possibility of short-circuits, however, presents a new risk if households are not sufficiently educated on the risks of tampering with new electric installations (FRES, 2013, based on three studies in Africa).

SDG 5—Gender equality: Time savings, time management and female employment

Anticipated impact pathway:

Access to clean cooking frees up time for other (economic) activities and raises (female) employment. Within the household, women are often responsible for cooking and fuelwood collection. Freeing up their time provides scope to increase women's involvement in income-generating activities. Time becomes available along two pathways:

1. A reduction in fuelwood consumption and, consequently, time-savings for fuelwood collection or buying at the market.
2. A reduction in cooking times.

Evidence from literature:

Research found that the time-savings for fuelwood collection after adopting an improved cookstove (reported in the reviewed literature) was as high as 36 percent[8] (IOB, 2013, based on several studies).

[7] See table 13 in IOB, 2013 for an overview of reductions and the absolute level in the various studies.

[8] The Independent Evaluation Group (2008) reported daily time spent on wood collection for six countries, ranging from 3.5 hours to 0.3 hours per day.

However, some studies show no time-savings, even though there were significant reductions in fuelwood use. An explanation given for this discrepancy is that time spent to collect fuelwood remains the same but that quantities collected per trip reduced. As modern and renewable cookstoves do not (or hardly) require collection of fuel, these do lead to significant time saving.

- How much time is saved on cooking depends on the type of improved stove and the base line. Studies reviewed by IOB (2013) in Kenya, Madagascar and Senegal found cooking time reductions ranging from 15 minutes up to 69 minutes per day. However, various other studies reported no savings or even increase in cooking time.

In the reviewed studies, women spent the time they had saved in the following ways.

- A study in Nepal in 2009 in which biogas digesters were introduced to improve cooking conditions, 28 percent of the women involved said they spent saved time on income-generating activities (without specifying what these activities entailed). Approximately a third said they spent this time on social and community activities (Katuwal and Bohara, 2009).
- A study in Madagascar showed that a majority of the women involved used the saved time for other chores, like doing more laundry, and about a third of the women spent it in their business (usually a shop or farming) (Practical Action, 2011).

However, analysis of national household survey data in Malawi found no increase in income-generating activities of women (Wodon and Beegle, 2006).

4.5 Summary of social and economic benefits

Table 2 summarizes the results of this study's assessment of reported social and economic benefits from access to clean-cooking projects. The table includes five social and economic metrics that emerged from the review of the academic and grey literature. These are metrics for which a positive relationship was found with access to clean-cooking projects. The metrics that were evaluated in this chapter but for which no evidence was found on a positive relationship with clean-cooking projects were omitted from the matrix.

The matrix in table 2 provides a basic scoring based on the relationship between levels of access to clean cooking and the social and/or economic benefits. The following scoring level was applied:

(0) No benefit is to be expected for this social or economic metric.
(1) Degree of social and economic benefit is small, compared with tier 0.
(2) Degree of social and economic benefit is moderate, compared with tier 0.
(3) Degree of social and economic benefit is large or significant, compared with tier 0.

The matrix shows a gradual increase in the degree of social and economic benefits when moving to higher tiers in term of access to clean-cooking projects. Most of the reviewed literature focused on accessing impacts up to tiers 2 or 3, and it was assumed that benefits fully materialize when moving towards the higher tier levels.

The results in Table 2 are visualized in a radar chart (Figure 11) to show the degree of social and economic benefits for different levels of clean-cooking projects. These radar charts can be useful for UNDP country office staff and project managers of clean-cooking projects because they provide, at a glance, what social and economic benefits could be anticipated based on the level (or "tier") of clean cooking for their project intervention. Based on the results of this basic scoring, activities can be incorporated into the project plan to gather data to monitor the relevant metrics.

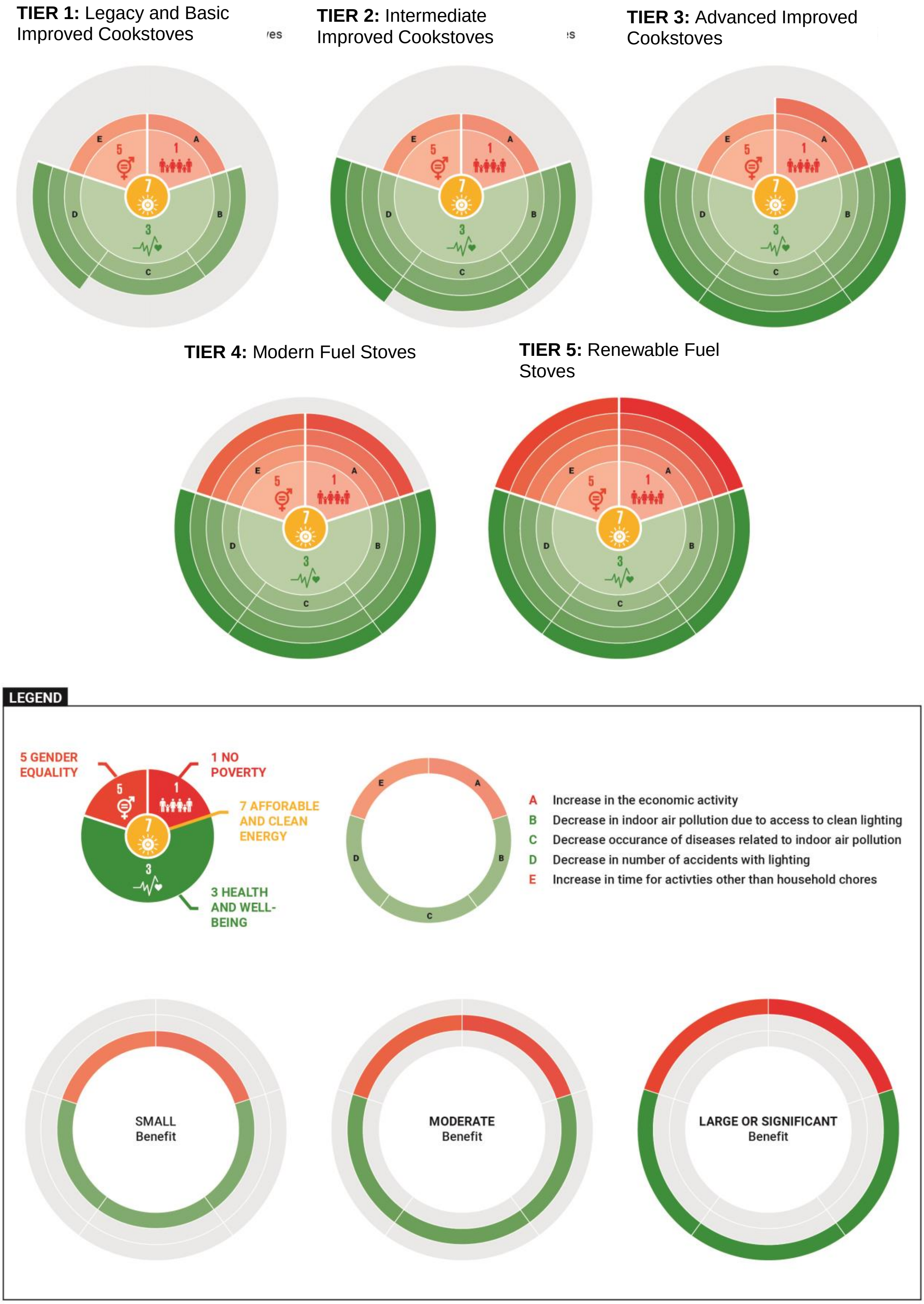
Table 2 Degree of social and economic benefits from access to clean-cooking projects, when compared with tier 0

(0) No benefit
(1) *Small* benefit, compared with tier 0
(2) *Moderate* benefit, compared with tier 0
(3) *Large and significant* benefit, compared with tier 0

#SDG	Metric	Indicator	TIER 1 Legacy and basic improved cookstoves	TIER 2 Intermediate improved cookstoves	TIER 3 Advanced improved cookstoves	TIER 4 Modern fuel stoves	TIER 5 Renewable fuel stoves
			Indication of degree of benefit, compared to TIER 0				
No poverty (SDG1)	Increase in economic activity	• Female employment rate • Increase in household income	0	0	1	2	3
Good health & well-being (SDG 3)	Decrease in indoor air pollution due to access to clean cooking	• Carbon monoxide concentration • $PM_{2.5}$ concentration	1	2	3	3	3
	Decrease in occurrence of diseases related to indoor air pollution due to access to clean cooking	• Occurrence of respiratory disease symptoms • Occurrence of eye infections • Averted DALYs	1	2	3	3	3
	Decrease in number of accidents with cooking	• Occurrence of accidents	2	3	3	3	3
Gender equality (SDG 5)	Increase in time for activities other than household chores	• Decrease in time for fuel collection	0	0	0	2	3

§

Figure 11 *Degree of expected benefits for SDG1, SDG3 and SDG5 of five tiers of access to clean-cooking, compared to tier 0 (traditional biomass cooking)*



5 Monitoring the social and economic benefits of energy-access projects

This chapter provides an overview of the available approaches to monitor the social and economic benefits - beyond the basic approach of the radar charts presented in Chapters 3 and 4 — by distinguishing between simple and advanced methods that can be applied within the UNDP energy-access projects.

5.1 Introduction

This chapter explores how the monitoring of social and economic benefits can be integrated into the regular monitoring cycle of UNDP energy-access projects. The analysis presented in chapters 3 and 4 allows for the most basic level of information on the relationship between energy access and socio-economic benefits. Any impact measurement beyond this basic level requires some form of data gathering through measurements to assess the real effects. Monitoring approaches range from ***simple*** (efforts for data gathering and analysis are limited) to ***advanced*** (methods require collecting detailed data on the project level and/or the use of advanced modelling) (see Table 13).

Table 3 Overview of monitoring approaches, moving from simple to advanced

	Approaches
↑ Simple	*Basic scoring:* Apply basic scoring of expected impact with "radar charts" presented in this study —at four levels—based on observed social and economic benefits highlighted in the academic and grey literature for different levels of access to electricity and clean-cooking solutions.
	Rule of thumb: Apply a rule of thumb is a straightforward approach in which observed impact factors reported in academic or grey literature are combined with basic data gathering on the project level or making use of publicly available statistics. This entails working with average impacts resulting from projects executed in divergent circumstances. In this approach, however, calculations are surrounded by large uncertainties.
	*Surveys:** Surveys are widely used to collect data on social and economic impacts. These can range from basic surveys, with a limited number of questions, to detailed surveys for scoring the baseline situation and project outcomes.
	Modelling: Modelling can, for example, be applied to assess economic or health impacts. Models include simplified or generalized benefit pathways derived from huge amounts of data. Combined with specific local or regional data, these models can be used to calculate economic or health impacts. Modelling is not a straightforward exercise because it requires running complex models and either collecting detailed data or making plausible assumptions.
Advanced ↓	*Measurements:* Measurements are the most detailed and most precise way to determine socioeconomic benefits. Measurements, however, can be costly because they require a well-prepared monitoring protocol, installation of measuring equipment and longer-term measurements to attain reliable results.

Note: *) In the ideal case, surveys are carried out twice: before (ex-ante) and after the project intervention (ex-post). Another option is to carry out a survey after project invention among the participants and compare these results with data gathered from a group of non-participants. The last option is more challenging because observed differences can be the result of other factors than the project intervention. In case the project includes a large number of households, a random sample of households should be used. This sampling needs to be carefully designed to ensure that the sample is representative for the whole group of project participants.

5.2 Monitoring approaches suitable for each impact category

Table 4 provides an overview of the approaches that can be applied to monitor the social and economic benefits per impact category (see chapters 3 and 4), with further explanation in the sections that follow the table.

Table 4 Overview of approaches to monitoring the social and economic benefits for UNDP energy-access projects

#SDG	Project category	Metric	Indicator	Monitoring approach: Simple	Monitoring approach: Advanced
No poverty (SGG 1)	Access to electricity	Decrease in expenditure on lighting	Expenditure on lighting (% of household income)	• Measure the number of households and number of household members who got access to clean cookstoves and/or lighting equipment. Use a rule of thumb derived from the academic or grey literature on decrease in expenditure, increase in income and employment rate combined with project data on number of households and household members involved in the project who got access to clean cookstoves and/or lighting equipment.	• Conduct a detailed survey to collect data on household income, expenditure and involvement of household members in economic activities, among a representative group of households participating in the project.
	Access to clean cooking	Increase in economic activity	Household income Employment, male/female (%)		
	Access to electricity		No. of new firms/year		• Conduct a detailed survey among firms that got access to electricity via the project, among a representative group of firms participating in the project.
Good health & well-being (SDG 3)	Access to electricity	Decrease in indoor air pollution owing to access to clean lighting	Carbon monoxide concentration (mg/m^3) $PM_{2.5}$ concentration (μg/m^3)	• Measure the number of clean cookstoves and/or electric lighting equipment distributed. Use a rule of thumb derived from the academic or grey literature on decrease of indoor air pollution combined with project data on supplied or distributed number of clean cookstoves and/or lighting equipment. • Compare available emission levels of cookstoves combined with project data on applied cooking fuel and technologies in the baseline, the number and type of cookstoves supplied or distributed in the project per household.	• Modelling: Combine publicly available performance data with project data on kitchen volumes, air exchange rates, ambient air pollutions levels (fraction of emissions entering a room) in indoor air pollution models. • Measurements: Measure indoor pollution in kitchens among a representative group of households participating in the project.
	Access to clean cooking	Decrease in indoor air pollution owing to access to clean cooking			
	Access to electricity	Decrease in occurrence of diseases related to indoor air pollution	Occurrence of respiratory disease symptoms (% of people affected) Occurrence eye infections (% of people affected)	• Measure the number of households and involved members per household who received access to electricity. Use a rule of thumb derived from the academic or grey literature on decrease in occurrence of disease combined with project data on the number of households and involved members per household.	• Conduct a detailed (standardized) survey on the occurrence of respiratory diseases and eye infections among a representative group of households participating in the project.
	Access to clean cooking		Burden of diseases (DALYs)		• Modelling: Apply integrated exposure response models, which require input data from indoor air pollution models.

#SDG	Project category	Metric	Indicator	Monitoring approach: Simple	Monitoring approach: Advanced
	Access to electricity; Access to clean cooking	Decrease in number of accidents	Occurrence of burn accidents (% of people affected) Occurrence of electrocution accidents (% of people affected)	• Measure the number of households and involved members per household who received access to electricity or clean cooking. Use rule of thumb derived from academic or grey literature on the decrease in accidents, combined with project data on the number of households and involved members per household.	• Conduct a detailed survey on the occurrence of accidents among a representative group of households participating in the project.
Quality education (SDG 4)	Access to electricity	Additional time spent on homework	Hours/day spent on homework	• Rule of thumb derived from academic or grey literature on additional time spent on homework, combined with project data on the number of school-going children per household involved in the project.	• Conduct a detailed survey on the number of school-going children and time spent on homework among a representative group of households participating in the project. • Conduct a detailed survey among a representative group of households participating in the project in which they keep detailed time records for a period of time, such as a full week.
		Increase in number of children finishing school	No. of children finishing school/year	• Rule of thumb derived from academic or grey literature on enhancement in schooling, combined with project data on the number of school-going children per household involved in the project.	• Conduct a detailed survey among a representative group of households participating in the project on the number of children who enrolled and finished school and the number of years they spent in school.
		Increase in education levels	Years at school		
		Increase in school enrolment	No. of children enrolling in school/year		
Gender equality (SDG 5)	Access to electricity; Access to clean cooking	Increase in time for activities other than household chores	Additional time available for other activities (hours/day) Decrease in time for fuel collection (hours/day)	• Rule of thumb derived from academic or grey literature on additional time spent on other activities, combined with project data on the number of households and involved members per household.	• Conduct a detailed survey on time spent on various household chores among a representative group of households participating in the project. • Conduct a detailed survey among a representative group of households participating in the project in which they keep detailed time records, for a full week, for example.

5.3 Impact monitoring methods: No poverty (SDG 1)

Metrics: Decrease in expenditure on lighting and increase in economic activity

Simple monitoring method; Rule of Thumb: Use a rule of thumb derived from benefits on household expenditure, income and employment rate that are reported in academic or grey literature. For energy-access project assessments, collect data on the number of households and the household members involved in the project who got access to clean cookstoves or lighting equipment.

Intermediate monitoring method; Survey: Information to monitor expenditure on lighting, household income and employment of males and females can be gathered through surveys, in which households are questioned on their income, expenditures and their involvement in economic activities before and after the project intervention. Information on the establishment of new businesses requires collecting detailed data with businesses that received access to electricity because of the project.

5.4 Impact monitoring methods: Good health and well-being (SDG 3)

Metric: Decrease in indoor air pollution

Simple monitoring method; Rule of Thumb: Use a rule of thumb derived from the documented reduction in indoor air pollutant levels reported in academic or grey literature. For energy-access project assessments, make assumptions on the *average baseline situation* (defined as the situation that would have occurred in the absence of an energy-access project) and the number of distributed clean-cooking devices and/or supplied lighting options. There is no need to collect data at the household level. Data from retailers or distributors can be used for the number of clean-cooking stoves and lighting equipment sold or distributed within the project.

Intermediate monitoring method; Comparing publicly available emission levels: Another option in the case of cookstove interventions is to take emissions for specific technologies as a proxy for indoor air pollution levels. The Global Alliance for Clean Cookstoves maintains a database with laboratory and field-testing data on the performance of cookstoves and fuel products. This includes indoor emissions levels of carbon monoxide and $PM_{2.5}$ for a large variety of cookstoves.[9] These emissions data can be combined with data on emissions for the baseline to arrive at an indicator for the reduction of indoor air pollution. This approach is less accurate than modelling because the assumed emissions levels include all kinds of assumptions on cooking practices. In this case, a simple survey can be used to collect the following data on the household level:

- Baseline: applied cooking fuel
- Baseline: applied cooking technology
- Project: distributed clean cooking technology
- Project: number of households that use the technology.

Advanced monitoring method; Modelling: The impact of the introduction of clean-cooking techniques on indoor air pollution can be modelled also by combining publicly available performance data for applied technologies with information gathered through surveys. The global database on the performance of cookstoves and fuel products, including indoor emissions levels, can be used. Combined with data on the baseline situation (tier 0)[10] and local circumstances, the indoor concentration of carbon monoxide and $PM_{2.5}$ can be calculated. This is not a straightforward exercise, however, because it requires complex calculations and either collecting detailed data or making assumption on:

- Kitchen volumes
- Air exchange rates

[9] See http://catalog.cleancookstoves.org/stoves

[10] See for example WHO Global database of household air pollution measurements.

- Ambient air pollutions levels
- Fraction of emissions entering the room.

Advanced monitoring method; Measurements: The decrease in indoor air pollution is typically expressed in terms of 24 or 48 hours mean value of indoor concentrations of carbon monoxide and $PM_{2.5}$. The emphasis for clean cooking projects is on kitchen-level values. Indoor concentrations of carbon monoxide and $PM_{2.5}$ can be measured among a representative group of participants, before and after a project intervention. The actual measurement of indoor air pollutions can be costly, however (see, for example, Edwards and others, 2007, and Naumhof, 2005).

Metric: Occurrence of diseases related to indoor air pollution

Simple monitoring method; Rule of Thumb: Apply a rule of thumb derived from documented reductions in the occurrence of respiratory disease symptoms and eye infections reported in academic and grey literature. For energy-access project assessments, data need to be collected on the number of people per household involved in the project.

Intermediate monitoring method; Survey: The occurrence of respiratory disease symptoms and eye infections can be monitored using standardized surveys in which household members are questioned on the frequency of respiratory disease symptoms and the use of medication to treat these symptoms.[11]

Advanced monitoring method; Modelling: Health benefits can be calculated making use of an integrated exposure response model. In principle, these models use the outcome of indoor air pollution calculations described in the previous section as the input to estimate the risk to develop diseases related to indoor air pollution. For example, the online tool HAPIT can be used to calculate averted DALYs and death for five diseases (including respiratory diseases) resulting from a decrease of exposure to $PM_{2.5}$ (Pillarisetti, A et al, 2016)[12]. Likewise, models for exposure to carbon monoxide are available. As noted in the previous section, modelling is not a straightforward exercise and can be complex and time consuming. It requires complex calculations and the collection of detailed data or assumptions.

Metric: Occurrence of accidents

Simple monitoring method; Rule of Thumb: Apply a rule of thumb derived from documented reductions in accidents reported in the academic and grey literature. In this case, data need to be collected on the number of households and members per households involved in the project.

Intermediate monitoring method; Survey: Monitoring information on the occurrence of accidents, either related to cooking, lighting or the use of electricity, is mostly gathered through surveys. Households are surveyed on their involvement in energy-related accidents and asked about the causes (such as an accident due to use of diesel, firewood, charcoal, paraffin, kerosene and/or electrical short-circuit).

5.5 Impact monitoring methods: Quality education (SDG 4)

Metric: Time for homework

Simple monitoring method; Rule of Thumb: Apply a rule of thumb derived from documented increases in additional time spent on homework within projects in comparable circumstances reported in academic and grey literature. For energy-access project assessments, data need to be collected on the number of school-going children per household involved in the project.

[11] See an example questionnaire at https://data.mcc.gov/evaluations/index.php/catalog/133/download/587 (section 7).

[12] See https://householdenergy.shinyapps.io/hapit3/.

Intermediate monitoring method; Survey: Monitoring information of time spent on homework by children participating in the project is usually gathered through surveys in which households are questioned on how children spent their time. This self-reporting can be shaped in various ways:

- Households are surveyed before and after the project intervention on the number of children in the household attending school to provide an estimate on the amount of time the children spent on homework.
- Households are approached to keep detailed time records on how members spent their time, for example, for a full week (this provides a broader picture on the way time is spent in households and not just on homework).

Metric: Schooling

Simple monitoring method; Rule of Thumb: Apply a rule of thumb derived from documented enhancements of school results within projects in comparable circumstances reported in the academic and grey literature. For energy-access project assessments, data need to be collected on the number and age of school-going children per household involved in the project.

Intermediate monitoring method; Survey: Information on schooling can be gathered by surveying households with children attending school who are participating in the project. Information is gathered on the number of children who had enrolled and finished school and on the number of years spent at school. The impact on schooling probably will not fully materialize before terminal evaluation of the project because households probably first need to generate additional income to pay for more schooling.

5.6 Impact monitoring methods: Gender equality (SDG 5)

Metric: Increase in time for activities other than household chores

Simple monitoring method; Rule of Thumb: Apply a rule of thumb derived from available literature on the documented time savings resulting from access to electricity and clean cooking. For energy-access project assessments, data are collected on the number of involved households and household members.

Advanced monitoring method; Detailed panel survey: Information on time spent on daily activities for various household members (with a focus on women) participating in the project is usually gathered through self-reporting, which can be shaped in various ways:

- Households are surveyed at one point to provide an estimate on the daily and weekly time spent on chores, leisure and economic activities.
- Households are approached to keep detailed time records on how members spend their time, such as for a full week.

5.7 Examples of monitoring approaches

The following tables, Tables 5 to 9, present several examples of impact assessment where different types of monitoring approaches were used to measure social and economic benefits of electricity access and clean cooking projects. Annex A illustrates possible monitoring of social and economic benefits of an energy access project in the design of a survey for ex-ante and ex-post analysis.

Table 5 Example of Basic Scoring Approach

Example	Description
1. Monitoring and Evaluation in Rural Electrification Projects: A Demand-Oriented Approach (World Bank, 2003)	The main purpose of this report was to develop a general methodology to monitor and evaluate rural electrification projects. The four-level scoring matrices, ranging from zero to three, are used to aid the assessor/interviewer during household observations to evaluate the technical quality of electricity system installations, as

	well as their social potential benefits including children education, health care and safety, and domestic productivity.

Table 6 Examples of Rule of Thumb Approach

Example	Description
1. The Impact of Improved Clean Cookstoves on Households in Southern Haiti (Sagbo and Kusunose, 2015)	This paper applied a simple t-test and propensity score matching methods in order to evaluate the effects of the use of improved cookstoves on household fuel expenditure in Southern Haiti. After gathering data from 146 households, the results revealed that using improved cookstove can reduce household fuel expenditure by 16.1 cents/day per household. We can use this as a rule of thumb when calculating future clean cooking projects in Haiti.
2. Gender and Livelihood Impacts of Clean Cooking in South Asia (Global Alliance for Clean Cookstoves, 2014)	The key findings from this research showed that women spend about 4 hours a day when using traditional cookstoves; however, with improved cookstoves, they can save up to 70 minutes per day. This conclusion can be used as a rule of thumb when distributing improved cookstoves in South Asia to determine the additional time available for other activities for female household members.

Table 7 Examples of Survey Approach

Example	Description
1. Peru: National Survey of Rural Household Energy Use (ESMAP, 2010)	The national survey of rural household energy use was carried out in seven regions of Peru to gain a better understanding of the existing and potential users of electricity in rural areas. The survey provided data on rural household energy use and expenditures, use by rural households of electricity from the grid, and use by rural households of off-grid electricity.
2. Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits (ESMAP, 2002)	The study collected survey data from four regions located on the island of Luzon in the Philippines, where 28% of households in the sample lacks electricity. The survey's aim was to develop a practical method by which to measure the benefits of rural electrification, focusing on quality of life, educational effects, and other relevant factors.
3. Energy Need Assessment and Preferential Choice Survey of Matipukur Village in Bangladesh (Akter, 2015)	The survey was designed to assess the rural household energy demand in Matipukur, Bangladesh. The questionnaire provided data on energy and water needs, fuel type use, energy consumption pattern, and biogas potential in the village. It was created in both English and Bengali.

Table 8 Examples of Modeling Approach

Example	Description
1. Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits (ESMAP, 2002)	Apart from gathering data using household energy surveys, the modeling method was also applied in this study to determine the effects of rural electrification on children's reading and studying.

2. The Impact of Access to Electricity on Education: Evidence from Honduras (Squires, 2015)	This paper examined the electrical expansion in Honduras from 1992 to 2005 in order to estimate the impact of electricity access on educational attainment. The study used a Cox Proportional Hazard model to predict the percentage of students who would drop out with and without access to electricity.
3. Rural Electrification and Female Empowerment in Iran: Decline in Fertility and Rise of Literacy (Salehi-Isfahani and Taghvatalab, 2008)	This paper examined the impact of electricity expansion to rural areas on two important determinants of women's empowerment: fertility and literacy. The study used difference-in-difference (DID) and instrumental variables (IV) methods to measure the impact of the extension of electricity to rural areas on village-level child women-ratios and female literacy rates.

Table 9 Example of Measurement Approach

Example	Description
1. Indoor Air Quality and ventilation assessment of rural mountainous households of Nepal (Parajuli, Lee, and Shrestha, 2016)	Indoor air quality (IAQ) was assessed by continuous monitoring of the $PM_{2.5}$ and CO concentrations for 24 hours in a sampled household in Nepal, with a total of 32 sampled measurements in 16 households. The assessment was conducted based on daily use of stove preparing three meals (2 major meals in the morning and evening and 1 short meal in the afternoon). This monitoring system was developed to find and compare general IAQ produced by both improved cookstove and traditional cookstove.

6 Case studies

Using two typical UNDP projects in Asia, this chapter illustrates how the methodology developed in this study can be applied and how it is helpful for improving the monitoring of social and economic benefits of energy access projects.

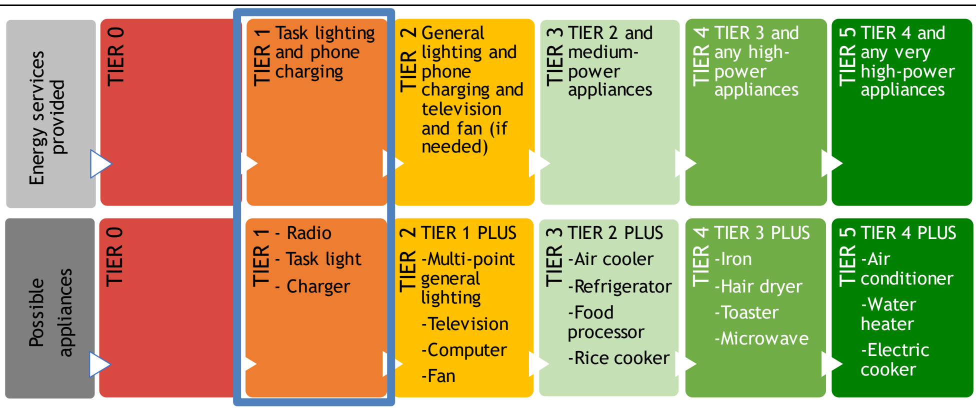
6.1 Case 1: Development of sustainable renewable energy generation in Bangladesh

Project period	2014–2018
Sources	Project document, mid-term evaluation (November 2017) and 2017 project implementation review reports.
Project objective	Reduction in the annual growth rate of greenhouse gas emissions from fossil fuel-fired power generation through the exploitation of Bangladesh's renewable energy resources for electricity generation.
Intended project outcome 1 (among others) [a)]	Diffusion of solar photovoltaic lanterns, with a capacity up to 10 watt peak (Wp), with the aim to provide a minimum of 1,200 lumen hours per day of lighting service along with mobile charging facility. Initial distribution of 133,000 solar lanterns in the first and second years and cumulatively more than 420,000 solar lanterns by the fifth year. [b)]
Type of project	Access to electricity
Baseline	Households with no access to electricity (tier 0)

Level of energy access after project intervention

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Capacity	No electricity	Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2000 W
Availability (hours/day)		Min 4		Min 8	Min 16	Min 23
Availability (hours/evening)		Min 1	Min 2	Min 3	Min 4	
Reliability					Max 14 disruptions per week	Max 3 disruptions per week of total duration < 2 hours
Quality					Voltage problems do not affect use of desired appliances	
Affordability				Cost of standard consumption package of 365 kWh/year < 5% of household income		
Legality					Legal payment of bill demonstrated	
Health and safety					Absence of accidents	

Level of access to energy services after project intervention

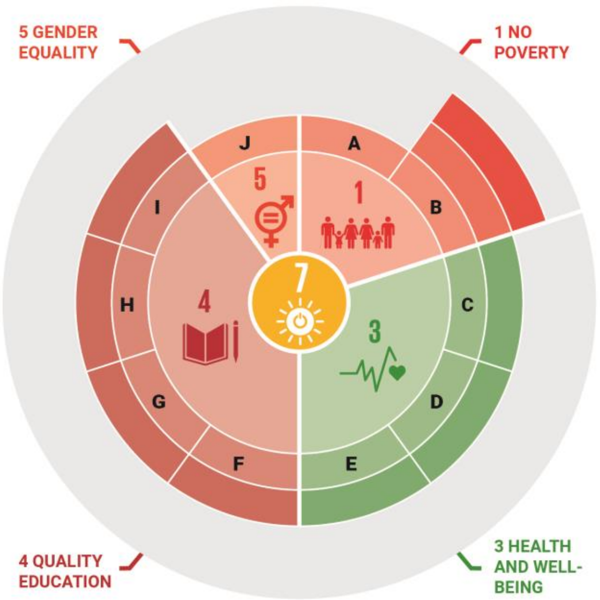


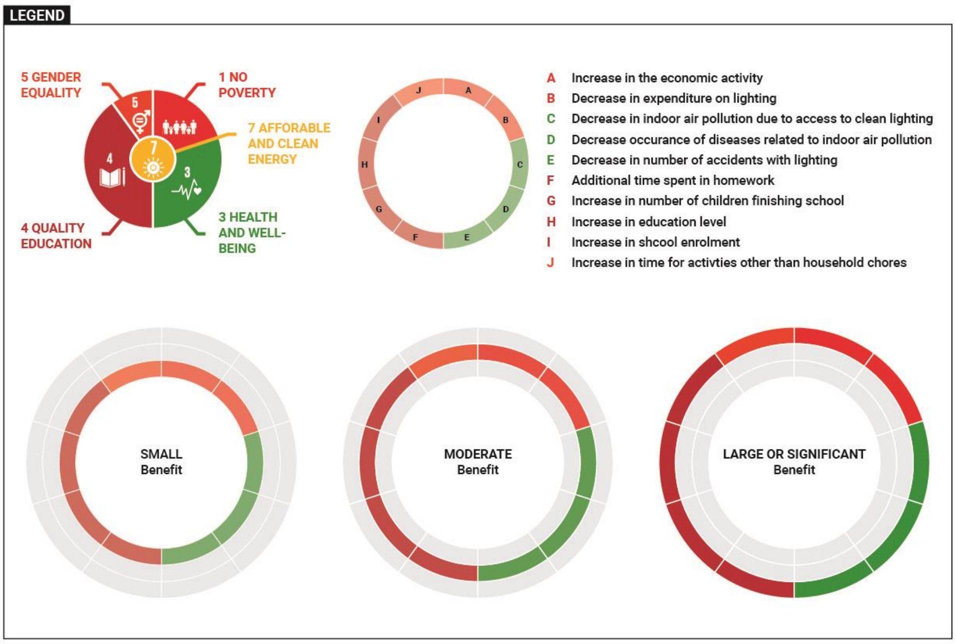
Notes:

a = This overview works with one of the intended project outcomes as an example to show how the degree of social and economic benefits can be mapped. The project targeted multiple outcomes through various energy systems and services directed at different groups of households. For each intended outcome, a separate assessment is

<table>
<tr><td colspan="2">required on the social and economic benefits because the activities lead to different levels of access to energy and energy services.
b = These are the data taken from the project document drafted at the start of the project. The mid-term evaluation included a proposed revised results framework with different numbers.</td></tr>
<tr><td>Basic scoring of social and economic benefits</td><td>

Tier 1: Task Lighting and Phone Charging





The radar chart shows that based on findings from the literature evaluated in this study:

- A **moderate benefit can be anticipated on poverty reduction** due to a decrease on expenditure for lighting.
- A **small benefit can be anticipated on health** due to a decrease of indoor air pollution and related diseases.
- A **small benefit can be anticipated on education**.

</td></tr>
<tr><td>Available monitoring information</td><td>The 2017 project implementation review report states that in total 1,230 solar photovoltaic lanterns were distributed through the project, displacing 2.6 litres of fuel monthly per household.</td></tr>
</table>

<table>
<tr><td>Observations and recommendations</td><td>
The available information in the project file is insufficient to determine the social and economic benefits beyond the basic level.
An estimate of the decrease in expenditure for lighting by households can be determined through a rule of thumb approach. The project file states that due to the distribution of solar lanterns, households on average saved 2.6 litres of fuel per month. Combined with data on the average costs for fuel in this region of Bangladesh, the total reduction in expenditure on fuel used for lighting can be determined. However, these are average values, which do not provide insight on differences between households. And these calculations do not provide insight on the net impact on household expenditure because possible additional expenses for use or purchase of the solar lanterns were not accounted for. A more accurate insight on the benefits of distributing solar lanterns on household expenditure for lighting and the net impact on household expenditure can be gained through surveys among a cross-section of the 1,230 households who received the solar lanterns. These surveys should include questions on total household income and expenditure, expenditure for lighting and average price paid for fuel, among other topics. In the ideal case, a survey is done before and after distribution of the solar lanterns to enable comparison before and after project intervention.
Because the benefits on health are expected to be small, a rule of thumb is the most obvious approach. This requires measuring the number of solar lanterns distributed and evaluating information on similar projects reported in academic and grey literature on reductions of carbon monoxide and PM2.5 levels and a reduction on the number of accidents due to lighting.
Because the benefits on education are also expected to be small, a rule of thumb is the most obvious approach. This requires measuring the number of solar lanterns distributed and evaluating information on similar projects reported in academic and grey literature on the benefits from additional hours per day spent on homework, the number of children finishing school per year, years at school and the number of children enrolling in school per year.
In case a survey is conducted, for example, to determine impact on expenditure for lighting, questions on education and occurrence of accidents with lighting can easily be added without much additional cost.
</td></tr>
<tr><td>Intended project outcomes #2 (amongst others)</td><td>The MW of renewable on-grid and off-grid projects installed: Off-grid projects include a total of 134 nano grids powered by solar panels or other sources of renewable energy, with each nano grid supplying solar power or other forms of renewable energy to six households for LED lighting, fans and an irrigation pump.</td></tr>
<tr><td>Type of project</td><td>Access to electricity</td></tr>
<tr><td>Baseline</td><td>Households with no access to electricity or who lack access of sufficient quality (tier 0/1)</td></tr>
<tr><td>Level of energy access after project intervention</td><td>
<table>
<tr><th></th><th>TIER 0</th><th>TIER 1</th><th>TIER 2</th><th>TIER 3</th><th>TIER 4</th><th>TIER 5</th></tr>
<tr><td>Capacity</td><td>No electricity</td><td>Min 3 W</td><td>Min 50 W</td><td>Min 200 W</td><td>Min 800 W</td><td>Min 2000 W</td></tr>
<tr><td>Availability (hours/day)</td><td></td><td colspan="2">Min 4</td><td>Min 8</td><td>Min 16</td><td>Min 23</td></tr>
<tr><td>Availability (hours/evening)</td><td></td><td>Min 1</td><td>Min 2</td><td>Min 3</td><td colspan="2">Min 4</td></tr>
<tr><td>Reliability</td><td></td><td></td><td></td><td></td><td>Max 14 disruptions per week</td><td>Max 3 disruptions per week of total duration < 2 hours</td></tr>
<tr><td>Quality</td><td></td><td></td><td></td><td></td><td colspan="2">Voltage problems do not affect use of desired appliances</td></tr>
<tr><td>Affordability</td><td></td><td></td><td></td><td colspan="3">Cost of standard consumption package of 365 kWh/year < 5% of household income</td></tr>
<tr><td>Legality</td><td></td><td></td><td></td><td></td><td colspan="2">Legal payment of bill demonstrated</td></tr>
<tr><td>Health and safety</td><td></td><td></td><td></td><td></td><td colspan="2">Absence of accidents</td></tr>
</table>
</td></tr>
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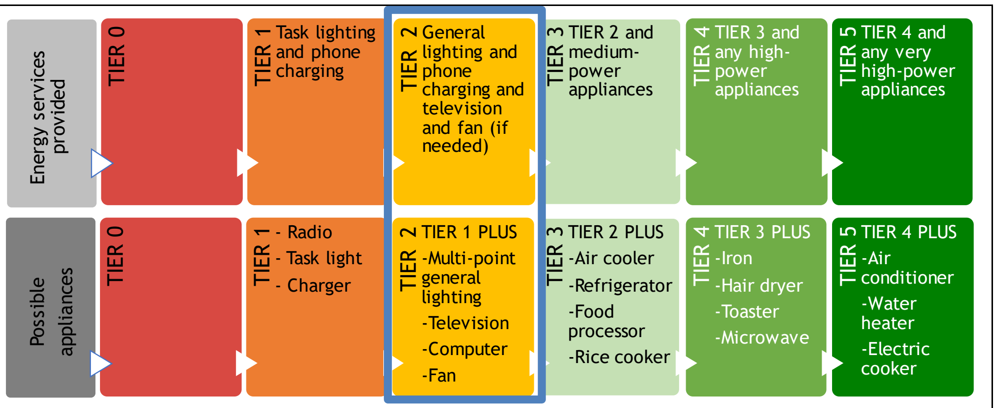
<tr>
<td>Level of access to energy services after project intervention</td>
<td>



In addition to lighting and fans, access is provided to an irrigation pump.

</td>
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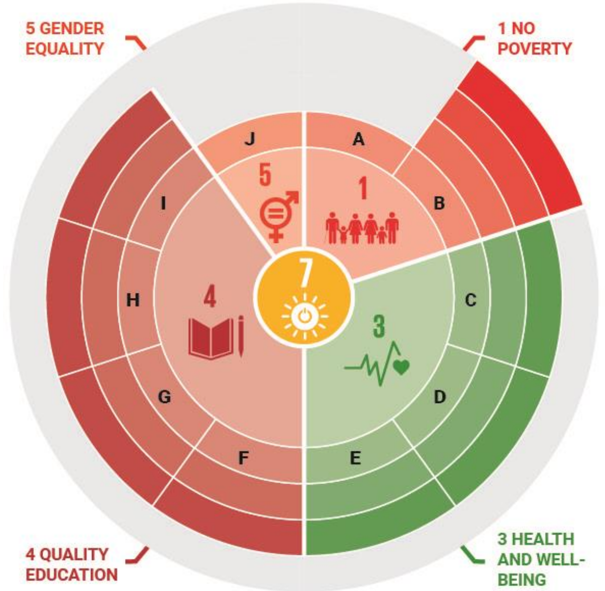
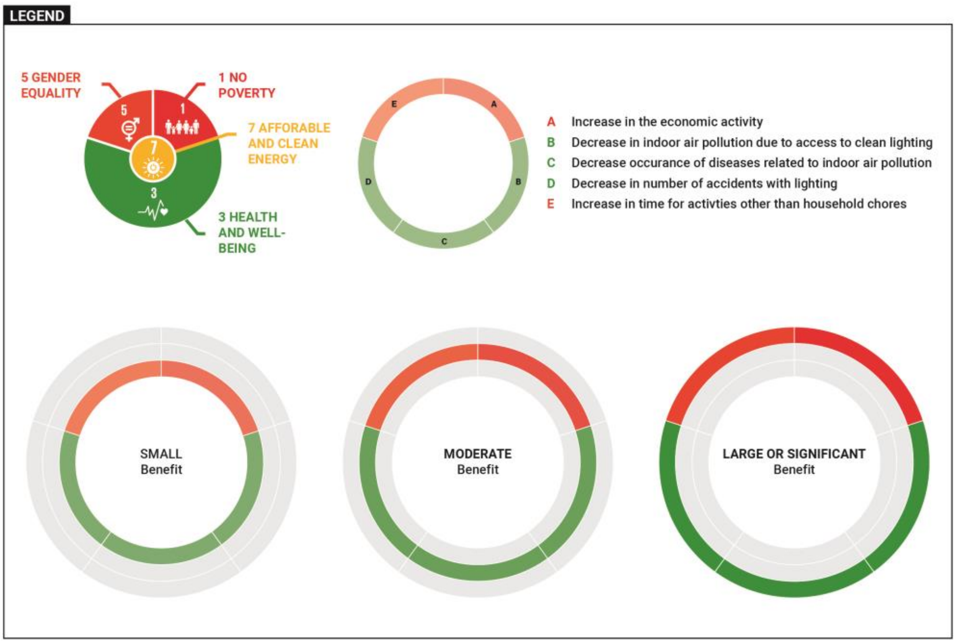
<tr>
<td>Basic scoring of social and economic benefits</td>
<td>

Tier 2: General Lighting and Television and Fan





The radar chart shows that based on findings from the literature evaluated in this study:

</td>
</tr>
</table>

	• A large or significant benefit can be anticipated on poverty reduction due to a decrease on expenditure for lighting. • A moderate benefit can be anticipated on health due to a decrease of indoor air pollution and related diseases. • A moderate benefit can be anticipated on education. • A small benefit can be anticipated on the increase in economic activity.
Available monitoring information	The progress reports provide information on the MW installed but no data on the number of households reached or the number of supplied LED lights, fans and irrigation pumps.
Observations and recommendations	• The available information in the project file is insufficient to determine the social and economic benefits beyond the basic level. • An **estimate of the decrease in expenditure for lighting by households can be determined through a rule of thumb approach**. This requires gathering information or making assumptions on: (i) the baseline situation (how was lighting provided before the introduction of the nano grid; (ii) average costs for lighting before and after project intervention; (iii) the number of households supplied with LED lights. Again, keep in mind that (i) these are average values, which do not provide insight on differences between households; and (ii), these calculations do not provide insight on the net impact on household expenditure, because possible additional expenses for use or purchase of the nano grid and LED lights are not accounted for. A more accurate insight on household expenditure for lighting and the net impact on household expenditure can be gained through surveys among a cross-section of participating households. These surveys should include questions on total household income and expenditure, expenditure for lighting before and after project intervention and average prices paid for fuel, among other topics. • **Benefits on health can be determined through a rule of thumb approach**. This requires evaluating information on similar projects reported in the academic and grey literature on reductions of carbon monoxide and PM2.5 levels and reductions on the number of accidents due to lighting. A more advanced approach would be to survey a cross-section of participating households on the occurrence of diseases related to indoor air pollution and accidents with lighting before and after project intervention. When organizing questions on the occurrence of diseases related to indoor air pollution, information also needs to be gathered on (changes in) cooking practices (because this can have a significant impact on indoor air pollution levels) and the possible use of traditional lighting sources (in addition to the supplied LED lights). • **Benefits on education can be determined through a rule of thumb approach**. This requires evaluating information on similar projects reported in academic and grey literature on the benefits due to additional hours per day spent on homework, the number of children finishing school per year, years at school and the number of children enrolling in school per year. A more accurate approach requires surveying before and some years after the project intervention, in which households are questioned on the number of school-going children in their household, hours per day spent on homework, number of children finishing school and number of years at school.

6.2 Case 2: Promoting renewable energy in Mae Hong Son Province in Thailand

Project period	2011—2017
Source	Terminal evaluation draft, November 2017.
Project objective	Overcome barriers to the provision of renewable energy services in integrated provincial renewable energy programmes in Thailand.
Intended project outcome 1 (among others)	Appropriate improved cookstoves successfully identified and demonstrated in 10 villages by end of 2016 (50 systems).
Type of project	Access to clean cooking
Baseline	

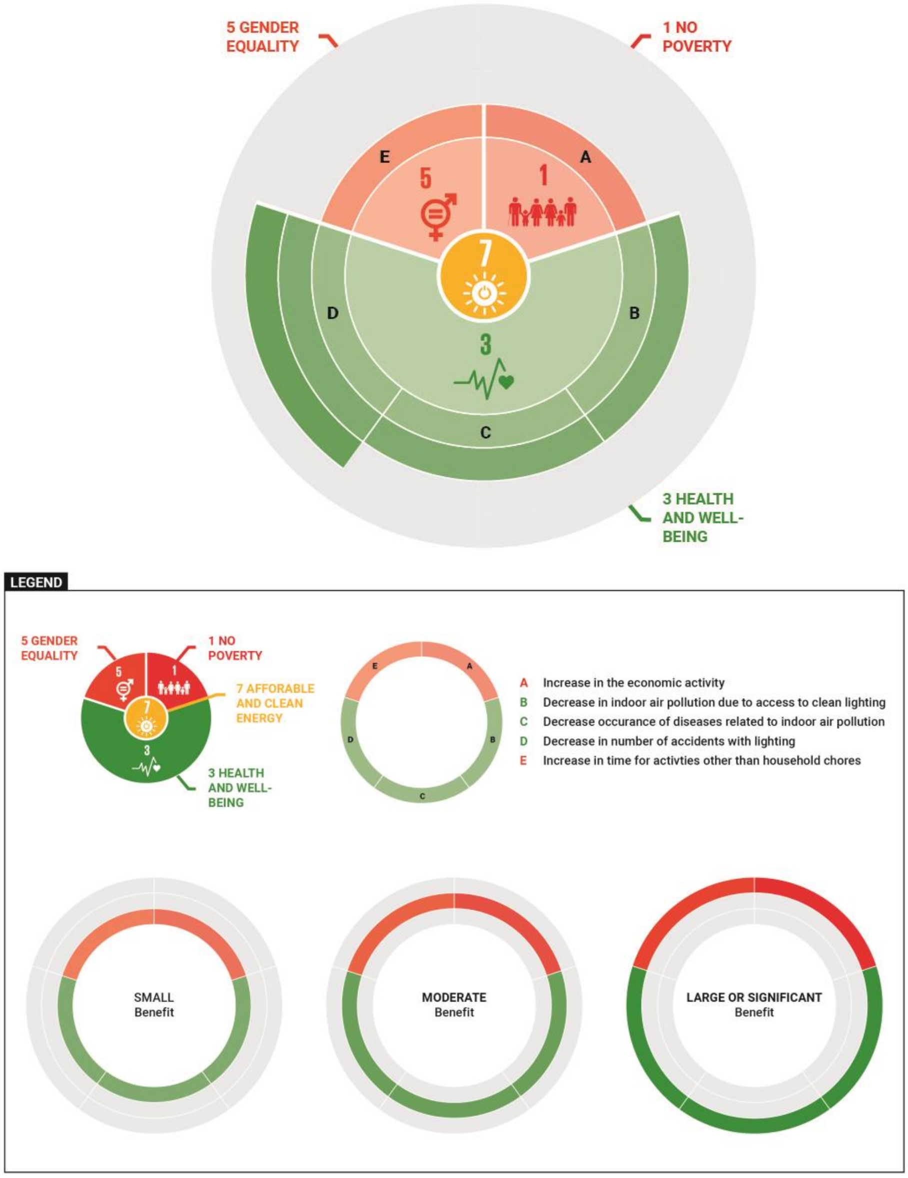
	Households making use of forest wood for cooking (tier 0)

Level of access to clean cooking after project intervention

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Availability of primary fuel	Availability inadequate				Available at least 80% of the year	Available all year
Quality of primary fuel: Variations in heat rate that affects ease of cooking	Low quality				High quality	
Affordability	Primary solution not affordable				Levelized cost < 5% of household income	
Convenience: Fuel acquisition & preparation time (hours/week)			< 7	< 3	< 1.5	< 0.5
Convenience: Stove preparation time (minutes/meal)			< 15	< 10	< 5	< 2
Health and safety	Self-made stove	Manufactured stove	Biogas/LPG/electricity/natural gas stoves			

Basic scoring of social and economic benefits

Tier 1: Legacy and Basic Improved Cookstoves



The graph shows that based on finding from the literature evaluated in this study:

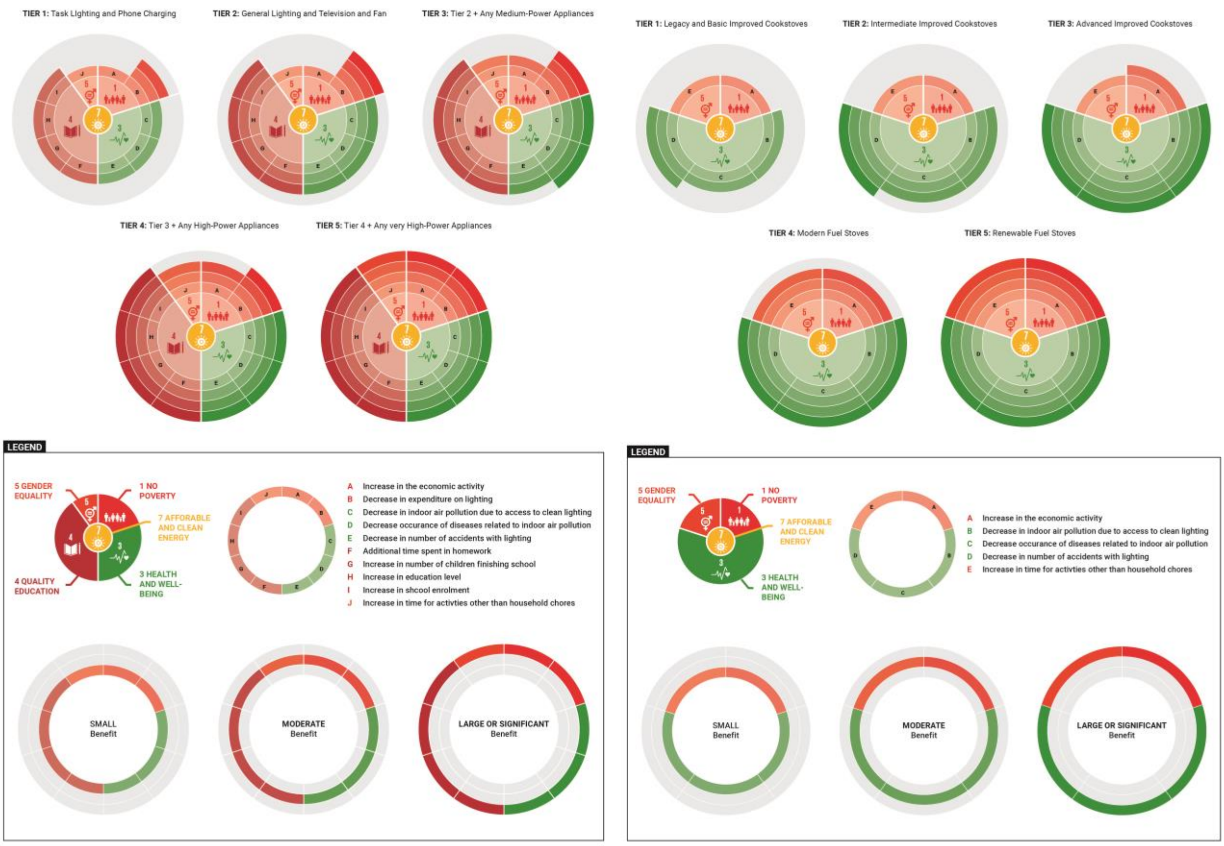
- Significant benefits can be anticipated on a decrease in the number of accidents related to cooking.

	• Small benefit can be expected due to a decrease in indoor air pollution and occurrence of diseases related to indoor air pollution.
Available monitoring information	The terminal project evaluation report did not include information on the actual number of distributed improved cookstoves. The project report offers information on the number of improved cookstoves that have been produced.
Observations and recommendation s	• The available information in the project file is insufficient to determine the social and economic benefits beyond the basic level. • An **estimate on a decrease in the number of accidents with cooking can be determined through a rule of thumb approach**. This requires evaluating information from similar projects reported in academic and grey literate on reductions on the number of accidents due to cooking. A more advanced approach would be to survey a cross-section of participating households on the occurrence of accidents with cooking before and after project intervention. • Because the benefits due to a decrease in indoor air pollution and related diseases are expected to be small, **a rule of thumb is the most obvious approach**. This requires evaluating information on similar projects reported in academic and grey literate on reductions of carbon monoxide and PM2.5 levels and a reduction on the number of accidents due to lighting. In case a survey is conducted to determine the impact on the number of accidents with cooking, questions on occurrence of diseases related to indoor air pollution can easily be added.

7 Conclusions and recommendations

The analysis of expected impact of energy access projects showed that there can be a strong relationship between the level (or "tier") of energy access and the expected impact on SDG1, SDG3, SDG4 and SDG5. This is equally valid for electricity access as well as access to clean cooking, although the impact will show in different ways. The analysis expressed these different levels of impact along the levels of energy access by means of "radar charts", where the wedges stand for SDG1, SDG3, SDG4 and SDG5. For the wedges SDG1, SDG3 and SDG4, two to four sub-segments could be identified, thereby showing a more refined analysis of impact for these SDGs.

Figure 12: Degree of expected benefits for SDG1, SDG3, SDG4 and SDG5 of five tiers of access to electricity-access (left) and access to clean cooking (right), compared to tier 0 (no electricity access/traditional biomass)



In order to monitor the impact of energy access projects with regard to its effect on SDG1, SDG3, SDG4 and SDG5, there are several approaches possible, varying from simple monitoring to advanced monitoring methods. It may be obvious that the more advanced the monitoring method, the more detailed and reliable information can be obtained. At the same time, more advanced monitoring will require more time and resources and thus a balance will need to be sought for each project to find an optimum within the constraints of the project. Table 10 shows an overview of monitoring approaches, varying from simple to advanced monitoring methods.

Table 10 Overview of monitoring approaches, varying from simple to advanced

	Approaches
↑ Simple	*Basic scoring:* Apply basic scoring of expected impact with "radar charts" presented in this study —at four levels—based on observed social and economic benefits highlighted in the academic and grey literature for different levels of access to electricity and clean-cooking solutions.
	Rule of thumb: Apply a rule of thumb is a straightforward approach in which observed impact factors reported in academic or grey literature are combined with basic data gathering on the project level or making use of publicly available statistics. This entails working with average impacts resulting from projects executed in divergent circumstances. In this approach, however, calculations are surrounded by large uncertainties.
	*Surveys:** Surveys are widely used to collect data on social and economic impacts. These can range from basic surveys, with a limited number of questions, to detailed surveys for scoring the baseline situation and project outcomes.
	Modelling: Modelling can, for example, be applied to assess economic or health impacts. Models include simplified or generalized benefit pathways derived from huge amounts of data. Combined with specific local or regional data, these models can be used to calculate economic or health impacts. Modelling is not a straightforward exercise because it requires running complex models and either collecting detailed data or making plausible assumptions.
Advanced ↓	*Measurements:* Measurements are the most detailed and most precise way to determine socioeconomic benefits. Measurements, however, can be costly because they require a well-prepared monitoring protocol, installation of measuring equipment and longer-term measurements to attain reliable results.

Note: *) In the ideal case, surveys are carried out twice: before (ex-ante) and after the project intervention (ex-post). Another option is to carry out a survey after project invention among the participants and compare these results with data gathered from a group of non-participants. The last option is more challenging because observed differences can be the result of other factors than the project intervention. In case the project includes a large number of households, a random sample of households should be used. This sampling needs to be carefully designed to ensure that the sample is representative for the whole group of project participants.

If there is no budget reservation in the project for monitoring impact, then the basic scoring approach with radar charts as presented in this study can be the minimum level of indicating expected impact and can be useful in:

- Identifying the type and size of social and economic benefits associated with energy-access projects and
- Indicating the importance of monitoring to free up resources for activities that need to be incorporated in the project to gather data to monitor relevant metrics.

If the energy access project has limited resources available for monitoring the impact on SDG1, SDG3, SDG4 and/or SDG5, then the "Rule of Thumb" approach can help in getting an indication of impact by means of multiplying simple observations (e.g. number of households affected by the project, number of children affected by the project) with previously observed impact factors.

In case of time and resources available for more serious monitoring, conduct of surveys ex-ante and ex-post project intervention can give good indications of impact of the energy access project towards the goals of the SDG1, SDG3, SDG4 and/or SDG5. An example of possible content of a survey can be found in Annex A.

More advanced monitoring methods comprise of modelling exercises and measurements. In case energy access projects have a project component that is specifically aiming for certain impact, e.g. improved indoor climates, then it can be justified to use project budget for advanced monitoring by means of e.g. indoor air quality measurements, ex-ante and ex-post project intervention.

Four recommendations for UNDP country offices emerged through this analysis:

- Promote the use of the basic scoring charts for energy-access projects **to identify type and size of social and economic benefits associated with energy-access projects** and the importance of monitoring impacts
- Promote the use of the basic scoring charts for energy-access projects to **explain the importance of realising full energy access up to Tier 5 level** since only then the full benefits for other SDGs will be realised.
- **Identify and apply an impact assessment monitoring approach as early as the inception phase** of a project to ensure that the social and economic benefits are properly monitored from the start of each project.
- Gather **feedback on the usefulness of impact assessment and different levels of monitoring (simple to advanced)** as well as problems encountered when gathering information on the social and economic indicators for energy-access projects to further develop mechanisms for assessing the social and economic benefits of completed energy-access projects.

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Annex A: Survey design for social and economic impact assessment of energy access project

A.1 Survey Design, Implementation, and Analysis

This Annex presents an example of procedures designed to obtain the required information on rural household energy use and analyse the degree of social and economic benefits of an electricity-access project. For this project, a detailed household energy survey was developed as the preferred monitoring approach since it can capture all the necessary aspects from the multi-tier matrices based on the respondent's experience, attitude, and awareness. Moreover, many attributes of energy, which include affordability, legality, and health and safety, can only be calculated through conducting household energy surveys.

The following key steps are applied in order to assess the current status of rural electrification in the project and monitor the project's degree of social and economic benefits:

1. Understand the project's baseline situation
2. Define survey objective
3. Design household energy survey
4. Collect data from rural households
5. Analyze the final survey results

A.2 Survey Objective

The overall objective of this household energy survey is to measure the degree of social and economic benefits as a result of the expansion of rural renewable energy services in the project. The baseline survey will be designed to assess the baseline status of rural electrification, including the demand and energy use. Once the project has been implemented, the same survey will be repeated to measure its direct benefits and productivity.

A.3 Survey Design

In the following example, five possible modules are presented that field interviewers need to complete for each household visit. For any real life application, a selection can be made from these five modules, depending on relevance for the particular project.

Core Module 1: Interviewer Information – Interviewers play a crucial role in the data collection process. At each location, they will manage the survey by informing household members on the purpose of the visit, observing the household, asking the respondent questions, and clarifying any inquiries he/she might have. Therefore, it is equally important to obtain general information on the interviewers such as their names and supervisors, as well as the duration to complete each visit.

Core Module 2: Household Information – This following module provides fundamental information on the house, household, and its household members. This includes home address and number of rooms, and name, sex, and occupation of the respondent and each of the other household members. Similar to the first module, this module should be completed at the start of the survey in order to determine who the respondent is and to whom all the other modules will apply.

Core Module 3: Electricity Supply – The third module presents a series of electricity supply-related questions in order to determine the household's main source of energy. If the respondent's household is connected to grid electricity, further questions on its reliability and legality will be asked. All respondents will then go through a list of other sources of energy such as kerosene, LPG, and solar PV home systems to determine the alternatives that each household usually depends on.

Core Module 4: Electricity Services – In this module, the respondent will specify all the electric appliances his/her household uses on a regular basis, including a number of each item owned, its capacity rating (if possible), and number of hours used during both day and night time. This aims to determine the actual use of energy services.

Core Module 5: Measuring the Impacts on SDGs - The final module's main purpose is to evaluate the social and economic benefits in terms of SDGs 1, 3 to 5 mentioned in Section 3.4, which are related to poverty, well-being, education, and gender equality. It begins with a set of questions addressing each of the indicators, followed by a number of statements to which the respondent rates his/her level of agreement in order to measure the attitude on each SDG. These act as additional monitoring information and the difference between the baseline and final surveys data will determine the direct benefits created by the project.

A.4 Household Data Collection

The next step after completing the household energy survey is to conduct it on the field. The survey should cover a sufficient and equal amount of sample size per area to represent reliable estimations of the survey population. The field interviewers, who will check and collect data from the respondent, should randomly select their samples from households that are varied in terms of size and geographical area, as well as those with and without grid-electricity access.

A.5 Survey Analysis

Apart from overall analysis, the total survey results can also be evaluated at a disaggregated level, or into smaller categories. This allows data analysts to examine the characteristics of each household and its energy use more closely, address possible trends, and expose any hidden deficiencies in electricity access at a specific geographic location. These indicators that can be calculated in terms of ratio or percentage are:

Core Module 2: Household information
- Number of household members
- Female- to male-headed household
- Highest education level in each household

Core Module 3: Electricity supply
- Households with and without access to grid electricity
- Tier levels of each Attribute of electricity supply
- Types of energy sources used

Core Module 4: Electricity services
- Tier levels of electric appliances ownership

Core Module 5: Measuring the impacts on SDGs
SDG 1-No poverty:
- Monthly household income and expenditure by region
- Types of income-generating activity
- Average number of hours work per week (by sex and age)

SDG 3-Health and well-being:
- Smoking to non-smoking household members
- Types of illnesses
- Types of accidents
- Number of days children missed school due to illness/accidents

SDG 4-Education:
- Number of children in school
- Children's education level
- Average hours children spent on reading/homework at night

SDG 5-Gender equality:
- Number of hours men and women spent on chore and non-chore activities
- Number of hours men and women spent on leisure activities

A.6 Survey on Social and Economic Benefits of Energy-Access Project

Module 1: Interviewer Information

Interviewer:		Supervisor:
Date:	Start Time:	End Time:

Module 2: Household Information

Address:	State:
Number of Household Members (Total/Men/Women/Children):	
Education Level (Highest in Household):	
Number of Rooms in House:	

Respondent:

1. First Name:		Last Name:
Sex:	Age:	Occupation:

Other household members:

2. First Name:		Last Name:
Sex:	Age:	Occupation:
Relationship with head of household:		

3. First Name:		Last Name:
Sex:	Age:	Occupation:
Relationship with head of household:		

4. First Name:		Last Name:
Sex:	Age:	Occupation:
Relationship with head of household:		

5. First Name:		Last Name:
Gender:	Age:	Occupation:
Relationship with head of household:		

6. First Name:		Last Name:
Sex:	Age:	Occupation:
Relationship with head of household:		

7. First Name:		Last Name:
Sex:	Age:	Occupation:
Relationship with head of household:		

Module 3: Electricity Supply

Does your home have access to grid electricity? (Please circle)	Yes	No

If no:

Please indicate whether the following statements are major, minor, or no reason to explain why the household is not connected to the grid?			
1. Electricity is not available in my area	Major	Minor	No Reason
2. Our household cannot pay the connection fee	Major	Minor	No Reason
3. Our household cannot pay the cost of house wiring	Major	Minor	No Reason
4. Our household cannot afford the monthly payment	Major	Minor	No Reason
5. Our household cannot afford to buy electrical equipment	Major	Minor	No Reason
6. We are satisfied with present energy source	Major	Minor	No Reason
7. We do not see any application of electricity	Major	Minor	No Reason
8. Other reason (Please specify):	Major	Minor	No Reason

If yes:

Reliability:

How many hours per day does your home typically have electricity service?	
How many days per month does your home typically have electricity service?	
Over the past 12 months, how many months has your home had electricity service?	

Have you ever had any unscheduled outages (more than 30 minutes)?	Yes	No
How many outages did you have in the past 3 months?		
How many outages did you have in the past month?		
How many outages did you have in the past week?		

Legality:

To whom do you pay the electricity bill? (Choose one)	
Directly to the distributing company ☐	Included in rent ☐
To the neighbor or relative ☐	Landlord ☐
None ☐	Other (Specify): ☐
How often do you pay for electricity?	
Twice a month ☐	Monthly ☐
Every other month ☐	Other (Specify): ☐
How many households are sharing the electricity bill?	

Information on the latest electric bill (if available):

Total days for last electric bill	
Total amount charged for last bill (in Kyat)	
Total kilowatt hours consumed for last bill	

Other energy sources:

Are the following energy sources used in your home?

2. Kerosene	Yes	No
3. Candle	Yes	No
4. Dry-cell Batteries	Yes	No
5. Car Batteries	Yes	No
6. LPG	Yes	No
7. Solar PV Home System	Yes	No
8. Firewood	Yes	No
9. Animal Dung	Yes	No
10. Crop Residue	Yes	No
11. Charcoal	Yes	No
13. Other (Please Specify):	Yes	No

Module 4: Electricity Services

4.1 Electric Appliances Ownership

			If yes,			
Do you have the following appliance?			How many owned?	Capacity rating in Watt (W)	Avg. hours used per day	Avg. hours used per night
Tier 1						
1. Radio	Yes	No				
2. Task light	Yes	No				
3. Charger	Yes	No				
Tier 2						
4. Television	Yes	No				
5. Computer	Yes	No				
6. Fan	Yes	No				
Tier 3						
7. Air cooler	Yes	No				
8. Refrigerator	Yes	No				
9. Food processor	Yes	No				
10. Rice cooker	Yes	No				
11. Water pump	Yes	No				
12. Freezer	Yes	No				
Tier 4						
13. Iron	Yes	No				
14. Hair dryer	Yes	No				
15. Toaster	Yes	No				
16. Microwave	Yes	No				
17. Washing machine	Yes	No				
Tier 5						
18. Air conditioner	Yes	No				

19. Water heater	Yes	No				
20. Electric cooker	Yes	No				
21. Space heating	Yes	No				
22. Vacuum cleaner	Yes	No				
Other						
23. Other appliance:	Yes	No				

Have your electric appliances had any experience with motor overheating?	Yes	No
Have your electric appliances had any experience with burned wires?	Yes	No

4.2 Lighting

Do you use light bulbs in your household?	Yes	No

If yes:

Incandescent Bulbs:

Size	Number of bulbs	Avg. hours used per day?	Avg. hours used per night?
25 W			
40 W			
50 W			
60 W			
100 W			
Other (Please specify):			

Fluorescent Tubes (Straight and Circular):

Size and Type	Number of bulbs	Avg. hours used per day?	Avg. hours used per night?
10 W straight			
20 W straight			
40 W straight			
22 W circular			
32 W circular			
Other (Please specify):			

Compact Fluorescent Tubes:

Size	Number of bulbs	Avg. hours used per day?	Avg. hours used per night?
Less than 12 W			
12 W			
18 W			
20 W			
25 W			

Other (Please specify):			

Module 5: Measuring the Impacts on Sustainable Development Goals (SDGs)

5.1: SDG 1-No Poverty

5.1.1 Household Income

Average Monthly Household Income (in Kyat)		
Do You Have a Regular Source of Income?	Yes	No

Income Activities:	Main Source of Income?		Average Income Amount
1. Agricultural activities	Yes	No	
2. Livestock activities	Yes	No	
3. Fisheries	Yes	No	
4. Non-agricultural Employment	Yes	No	
5. Government subsidy/pension	Yes	No	
6. Remittance from relatives or friends	Yes	No	
7. Business income	Yes	No	
8. Rental income	Yes	No	
9. Other (Please specify):	Yes	No	

On average, how many hours does your household work per week?	
Male(s)	
Female(s)	
Children (14 or younger)	

5.1.2 Household Expenditure

Average Monthly Household Expenditure (in Kyat)	

Previous Month's Expenditure:

1. Food for Household Members	
2. Water, Telephone, and Transport	
3. Home Maintenance and Repair	
4. Household Expenditure for Personal Hygiene	
5. Recreation Activities and Entertainment	

Previous 3 Months' Expenditure:

6. Healthcare	
7. Education (tuition, school supplies)	
8. Transfer Expenditure (pension, remittances to other family members)	
9. Clothing and Shoes	

Previous 12 Months' Expenditure:

10. Furniture, Appliances, and Utensils	

5.1.3 Attitude on Income

1. The monthly electric bill is or would be a financial burden for my family.

Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

2. Compared to 10 years ago, life is better today.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

3. Compared to 5 years ago, life is better today.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

4. Compared to last year, life is better today.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

5. I am optimistic that life will get better in the future.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

5.2: SDG 3-Good Health and Well-being

5.2.1 Health

Do you smoke?	Yes	No
Does any other member of the household smoke?	Yes	No

Number of workdays lost due to illness during the past 3 months?	
Number of school days lost due to illness during the past 3 months?	

Over the past 3 months, did your household suffer from the following symptoms/illnesses?			If yes, how many times?
1. Coughing	Yes	No	
2. Wheezing	Yes	No	
3. Shortness of breath	Yes	No	
4. Intermittent fever	Yes	No	
5. Diarrhea	Yes	No	
6. Eye infection	Yes	No	

Over the past 3 months, did your household suffer from the following accidents?			If yes, how many times?
1. Fire	Yes	No	
2. Burns	Yes	No	
3. Electrocution	Yes	No	
4. Spilled fuel	Yes	No	
5. Broken glass from lamps or/and candles	Yes	No	

5.2.2 Attitude on Health

1. Lighting with kerosene can cause health problems.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

2. Lighting with diesel fuel can cause health problems.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

3. Indoor air pollution (from smoking or cooking) can cause health problems.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

4. When going to health clinics, doctors can treat your household members immediately.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

5.3: SDG 4-Quality Education

5.3.1 Education

Do you have children still in school?	Yes	No
How many members enrolled in school?		
How many members finished school?		

If yes:

Child #1 Age: Sex:	Male	Female
What is his/her current level of education? (Choose one)		
Preschool ☐	Primary school ☐	High school ☐
Vocational ☐	College ☐	Postgraduate ☐
How many hours per week did he/she spend on school?		
How many days a month did he/she spend on school?		
How many months a year did he/she spend on school?		
Last week on average, how many hours did he/she spend reading/completing homework during the day?		
Last week on average, how many hours did you spend reading/completing homework during the night?		

Child #2 Age: Sex:	Male	Female
What is his/her current level of education? (Choose one)		
Preschool ☐	Primary school ☐	High school ☐
Vocational ☐	College ☐	Postgraduate ☐

How many hours per week did he/she spend on school?	
How many days a month did he/she spend on school?	
How many months a year did he/she spend on school?	
Last week on average, how many hours did he/she spend reading/completing homework during the day?	
Last week on average, how many hours did you spend reading/completing homework during the night?	

Child #3 Age: Sex:	Male	Female
What is his/her current level of education? (Choose one)		
Preschool ☐	Primary school ☐	High school ☐
Vocational ☐	College ☐	Postgraduate ☐
How many hours per week did he/she spend on school?		
How many days a month did he/she spend on school?		
How many months a year did he/she spend on school?		
Last week on average, how many hours did he/she spend reading/completing homework during the day?		
Last week on average, how many hours did you spend reading/completing homework during the night?		

5.3.2 Attitude on Education

1. In the household, it is very easy to read in the evening.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

2. Our household is happy with the lighting system we currently have in our home.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

3. Reading with electrical light is better than with the light of candles or lamps.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

4. Having electricity in a household is important for children’s education.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

5. Because of good light, children would study more at night.		
Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

6. My children study during the evening even after it is dark outside.

Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

5.4: SDG 5-Gender Equality

5.4.1 Safety

Does your household leave lights on throughout the entire night for security purposes?	Always	Sometimes	Never
Does your household leave lights on throughout the entire night for your livestock and crops?	Always	Sometimes	Never
Does your household use any form of lighting for household work at night?	Always	Sometimes	Never

5.4.2 Household activities

<u>For Male Household Member:</u>

How many hours did you spend on the following activities yesterday?	
1. Cooking	
2. Washing (clothes, tools)	
3. House cleaning	
4. Repairing	
5. Shopping	
6. Water fetching	
7. Collecting fuel	
8. Hobbies	
9. Sleeping	
10. Other (please specify):	

How many hours a week do you spend on watching TV?	
How many hours a week do you spend on listening to radio?	

<u>For Female Household Member:</u>

How many hours did you spend on the following activities yesterday?	
1. Cooking	
2. Washing (clothes, tools)	
3. House cleaning	
4. Repairing	
5. Shopping	
6. Water fetching	
7. Collecting fuel	
8. Hobbies	
9. Sleeping	
10. Other (please specify):	

How many hours a week do you spend on watching TV?	
How many hours a week do you spend on listening to radio?	

5.4.3 Attitude on Safety and Gender

1. Men feel safe in the house in the evening.

Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

2. Women feel safe in the house in the evening.

Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

3. Men feel safe outside our house in the evening.

Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

4. Women feel safe outside our house in the evening.

Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

5. We often receive guests in the evening after it is dark outside.

Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

6. Having electricity in the households reduces the time on domestic tasks and care of the children for women.

Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	

7. Having electricity in the households increases the time on hobbies and leisure activities for women.

Strongly disagree ☐	Disagree ☐	Agree ☐
Strongly agree ☐	Does not know ☐	