CDM-SSCWG54-02

Concept note

Analysis of eligibility of shift from NRB to LPG under AMS-I.E. and AMS-II.G.

Version 01.0

United Nations
Framework Convention on
Climate Change

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1. Procedural background

1. The Executive Board of the clean development mechanism (CDM) (hereinafter referred to as the Board), at its ninety-third meeting (EB93), adopted the workplan of the Small-Scale Working Group (SSC WG) for 2017, which mandated the SSC WG to prepare an analysis of potential areas of improvements of "AMS-I.E.: Switch from non-renewable biomass for thermal applications by the user" and "AMS-II.G.: Energy efficiency measures in thermal applications of non-renewable biomass" followed by actual proposals for revision of these methodologies.

2. The Board, at its ninetieth meeting (EB90), also requested the SSC WG to conduct further analysis regarding the eligibility of shift from non-renewable biomass (NRB) to low-carbon intensive fossil fuels such as liquefied petroleum gas (LPG) in AMS-I.E. and AMS-II.G.

2. Purpose

3. The purpose of this concept note is to analyse the issues associated with the potential inclusion of measures for shifting from NRB to LPG in AMS-I.E. and AMS-II.G. The analysis also takes into account other issues under consideration for the revision of these methodologies.

3. Key issues and proposed solutions

3.1. Relevant CMP decisions related to cookstove methodologies

4. Through paragraph 7(a) of decision 17/CP.7, the Conference of the Parties (COP) decided that the eligibility of land use, land-use change and forestry project activities under the CDM is limited to afforestation and reforestation.

5. In accordance with request of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) at its third session through its decision 2/CMP.3[1], the Board, at its thirty-seventh meeting, approved the revised simplified methodologies AMS-I.E. and AMS-II.G.

3.2. Climate impacts of fuels use for cooking

6. Climate impacts of NRB use for cooking depends on CO_2 and methane emitted. Other co-emitted gases and particles (short-lived climate pollutants such as black carbon[2]) will also

[1] FCCC/KP/CMP/2007/9/Add.1 (http://unfccc.int/resource/docs/2007/cmp3/eng/09a01.pdf)
24. Requests the Executive Board to approve, at its first meeting in 2008, the simplified methodologies for "Switch from non-renewable biomass for thermal application by the user" and "Energy efficiency measures in thermal applications of non-renewable biomass", as recommended by the Executive Board, for use for clean development mechanism project activities, as contained in annexes 3 and 4 to document FCCC/KP/CMP/2007/3 (Part II), incorporating the necessary changes to ensure that the application of these methodologies introduces new or improves existing end-user technologies and that, in the case of the methodology "Energy efficiency measures in thermal applications of nonrenewable biomass", the baseline energy efficiency is measured or is based on referenced literature values;

[2] It is estimated that household use of solid fuels emits around 25% of the global total of black carbon. In Africa and Asia regions it is thought to be even higher i.e. 60-80% from coal and biomass burning.

contribute to emissions, however they are currently not included under “Kyoto gases”. The total emissions from a cooking appliance depends mainly on the type and amount of fuel required. The latter is a function of cookstove efficiency which is dependent on combustion performance, calorific value of the fuel and the heat transfer efficiency to the pot.

7. Although renewable wood (e.g. agricultural residues) are considered CO_2 neutral, traditional and even improved/advanced biomass stoves are found to have a lower thermal efficiency (in the range of 12-25% efficiency) as compared to gaseous fuel technologies. Typical efficiencies of common fuels are included in Table 1 below compiled in O’Sullivan and Barnes (2007)[3] as cited in Bruce et al. (2017)[4]. LPG stoves typically have 45-60% efficiencies across a wide range of conditions. Although some fan-assisted advanced biomass cookstoves have shown efficiencies of 30-55% under laboratory conditions, there is limited information on their long term performance in everyday use. Available studies often show efficiencies below 25% on account of many factors including maintenance pending further development of technology, training and capacity development.

Table 1. Typical efficiencies of common fuels

Fuel source	Energy content (MJ per kg)	Conversion efficiency (%)	Useful energy at final consumption stage of cooking (MJ per kg)	Approximate quantity of fuel necessary to provide 5 Gigajoules of useful energy for cooking (Kilograms)
LPG	45.5	60	27.3	180
Natural gas	38 MJ/M^3	60		219 M^3
Kerosene (pressure)	43.0	55	23.6	210
Kerosene (wick)	43.0	35	15.1	330
Biogas (60% methane)	22.8 MJ/M^3	60		365 M^3
Charcoal (efficient)	30.0	30	9.0	550
Charcoal (traditional)	30.0	20	6.0	830
Bituminous coal	22.5	25	5.6	880
Fuelwood (efficient), 15% moisture	16.0	25	4.0	1250
Fuelwood (traditional), 15% moisture	16.0	15	2.4	2000
Crop residue (straw, leaves, and grass), 5% moisture	13.5	12	1.6	3000
Dung, 15% moisture	14.5	12	1.7	2900

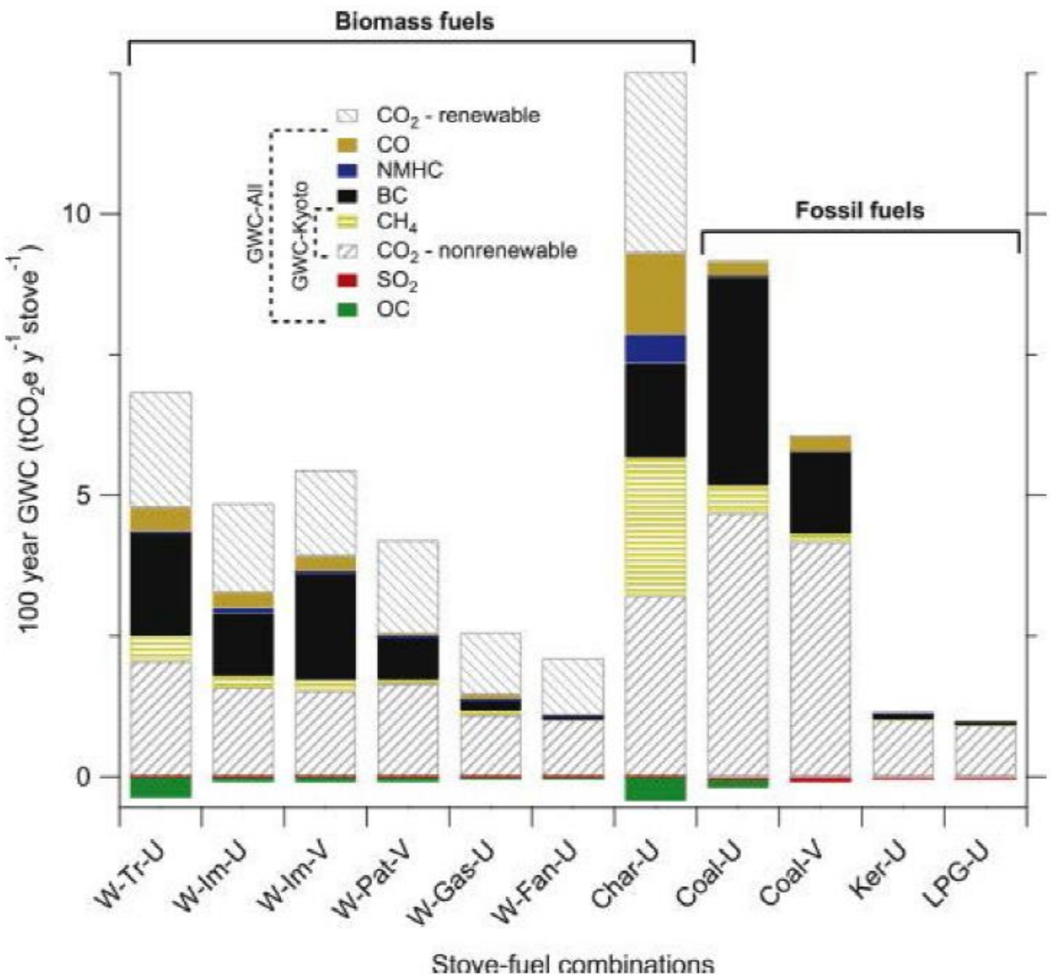
Source: Bruce et al. (2017)

[3] O’Sullivan K, Douglas B. Energy Policies and Multitopic Household Surveys Guidelines for Questionnaire Design in Living Standards Measurement Studies. Washington, DC: World Bank; 2007.

[4] Bruce NG, Aunan K, Rehfuess EA, Liquefied Petroleum Gas as a Clean Cooking Fuel for Developing Countries: Implications for Climate, Forests, and Affordability, Materials on Development Financing, No. 7, March 2017, KfW Development Bank, Frankfurt, Germany.

8. Figure 1 below shows emissions for a range of solid biomass fuel stove types including wood and charcoal, coal, kerosene and LPG, compiled in Grieshop et al. (2011)[5] from five studies on cooking stoves carried out in India, China and Mexico as cited in Bruce et al. (2017)[4].

Figure 1. Climate impact of stove/fuel combinations



Acronyms: W=wood, Tr=traditional stove, U=unvented (i.e. stove no chimney); Im=improved stove; Pat=Patsari improved stove; V=vented (i.e. stove with chimney); W-Gas= wood gasifier (advanced) stove; W-Fan= wood fan-assisted (advanced) stove; Char-U=charcoal stove; Kero-U=kerosene wick stove, LPG-U= LPG metal stove. BC=black carbon, CO=carbon monoxide, CO_2=carbon dioxide, CH_4=methane; NMHC=nonmethane hydrocarbons, OC=organic carbon, SO_2=sulphur dioxide).

Source: Bruce et al. (2017)

9. The following points apply to the information provided in the figure above:

(a) For biomass (wood and charcoal) fuel, it is assumed that 50% is renewable – the upper cross-hatched sections of the bars;

[5] Grieshop A, Marshall J, Kandlikar M. Health and climate benefits of cookstove replacement options. Energy Policy 2011; 12(12): 7530-7542.

(b) In the key, the GWC-Kyoto legend identifies the gases, CO_2 and CH_4 which are emitted from cookstoves and contribute to warming, and are included in the Kyoto Protocol. The GWC-All legend identifies all climate forcing pollutants considered in this analysis. The renewable portion of CO_2 from biomass is separate, as this does not contribute to climate change;

(c) The negative (green and red) components at the lower end of some of the bars represent the cooling effects of OC and SO_2, respectively.

10. The paper concludes that even when the assumed 50% renewable portion of CO_2 emission from solid biomass stoves are taken into account, LPG has a similar or even lower climate impacts than the most advance biomass stoves currently in the market.

11. Under the approved methodologies AMS-I.E. and AMS-II.G., an fNRB emission factor ("substitution fuels likely to be used by similar users") has been introduced based on a reference in response to paragraph 7(a) of decision 17/CP.7 (i.e. the eligibility of land use, land-use change and forestry project activities under the CDM is limited to afforestation and reforestation). Currently the emission factor has a value of 81.6 t CO_2/TJ, but the SSC WG is considering to recommend a revised value of 74.7 tCO2/TJ, based on the global average ratio of cooking fuels.

12. Emission factors for several fossil fuels are compared with wood and NRB under AMS-I.E./AMS-II.G. in the Table 2 below.

Table 2. Emission factors used for different fuels

Fuel	Emission factor (tCO2/TJ)[6]	Source
Wood	112	IPCC default[7]
Coal	96	AMS-I.E./AMS-II.G. and IPCC default
Kerosene	71.5	AMS-I.E./AMS-II.G. and IPCC default
LPG	63.0	AMS-I.E./AMS-II.G. and IPCC default
NRB under AMS-I.E./AMS-II.G.	81.6 (74.7)	AMS-I.E./AMS-II.G.

3.3. Energy access projections

13. A growing number of countries are planning for scaling up LPG as a cooking fuel in the context of the Sustainable Energy for All (SE4ALL) and Sustainable Development Goal (SDG) 7 of universal access to modern energy, economic development, forest protection and for reducing the health burden from household air pollution due to biomass and kerosene fuel use. Appendix includes a description of current status of fuel use for cooking

[6] These emission factors are based on the calorific value of the fuels, which represent the maximal amount of heat each fuel is able to release in a complete combustion. However, the net heat effect for the final service (cooking) is highly dependent on the prevailing conditions and efficiencies of the utilized devices.

[7] <http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf>.

and future projections, cost and quality considerations drawn from reports of IEA and UN agencies.

3.4. Life Cycle Assessments of LPG vs. other cooking fuels

14. The recently published report (Bruce et al, 2017)[4] shows that switching to LPG in cookstoves would result in emissions decrease under certain conditions, even though LPG is a fossil fuel, based on the studies of Life Cycle Assessment (LCA) conducted by US EPA.[8] In the LCA studies, the total emissions related to feedstock production, fuel processing, distribution and cookstove use were compared among different cookstove fuels (e.g. coal, LPG, kerosene, electricity, dung, charcoal, firewood). In case of India, the LCA results showed that LPG has less emission impacts than firewood (LPG has 292 to 303 kgCO2eq/GJ delivered heat for cooking, while firewood has 539 kgCO2/GJ delivered heat for cooking).

3.5. LPG programmes in other offset schemes

15. In voluntary schemes (e.g. Gold Standard carbon credit mechanism), several LPG programmes have been planned/implemented, e.g.:

(a) The Darfur Low Smoke Stoves Project implemented by Practical Action and CarbonClear Ltd: The project has distributed about 9000 LPG cookstoves since 2010. This project received a Lighthouse Project award from the UNFCCC in 2013;[9]

(b) Expanding access to LPG in Burkina Faso through microfranchised distribution, implemented by the French NGO (Entrepreneur du Monde);[10]

(c) Expanding access to LPG in Haiti through microfranchised distribution, implemented by the French NGO (Entrepreneur du Monde).[11]

3.6. Recommendation

16. Based on the analysis above, even when a conservative fNRB factor is considered, shifting from NRB to LPG would result in emission reductions in many instances, because of a significant difference on efficiency between the biomass stoves and LPG stoves (as shown in Table 1, the thermal efficiency for LPG cookstove is reported around 45 to 60 %, whereas the thermal efficiency for traditional/improvedbiomass cookstove is around 12 to 25 %).

17. Table 3 below compares CO_2 emissions to produce 1 GJ of cooking heat in the baseline (traditional/improved biomass stove using NRB) and in the project (LPG stove). If an

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[8] Cashman S, Rodgers M, Huff M, Feraldi R, Morelli B. Life Cycle Assessment of cookstove fuels in India and China. Washington, DC U.S. Environmental Protection Agency; 2016.

[9] <https://mer.markit.com/br-reg/public/project.jsp?project_id=103000000002416>.

[10] <https://mer.markit.com/br-reg/public/project.jsp?project_id=103000000001784>.

[11] <https://mer.markit.com/br-reg/public/project.jsp?project_id=103000000005557>.

emission factor of 74.7[12] tCO2/TJ is taken for the baseline and 63.0 tCO2/TJ is used for the project, then 298 kgCO2/GJ minus 126 kgCO2/GJ could be credited as a result of installing LPG stove.

Table 3. CO_2 emissions in the baseline (traditional/improved biomass stove) and project (LPG stove)

	Emission factor (tCO2/TJ)	Thermal efficiency	Resulting CO_2 emissions
Baseline emissions			
Traditional/improved biomass stove	81.6	25%	81.6 ÷ 25% = 326 kgCO2/GJ
	74.7[12]	25%	74.7 ÷ 25% = 298 kgCO2/GJ
	63.0	25%	63.0 ÷ 25% = 252 kgCO2/GJ
Project emissions			
LPG stove	63.0	50%	63.0 ÷ 50% = 126 kgCO2/GJ

18. Therefore, the SSC WG proposes to develop a new Type II methodology for project activities switching from NRB to LPG, using an approach to quantify emission reductions based on the efficiency improvement (not on the fuel switch).

3.7. Potential co-benefits

19. A switch to LPG can bring about several social, economic, environmental and health benefits[4], for example:

(a) Significant direct health benefits from substantially reducing exposure to household air pollution from burning of solid fuels and kerosene;

(b) A reduction in emissions of other climate active pollutants such as methane, black carbon and organic carbon released by inefficient sold fuel stoves;

(c) A reduction in women and children's labour time in fuel collection and cooking, opening up opportunities for greater engagement with education and the labour market.

20. Based on the analysis, it would be useful to develop a new methodology which allows switching from NRB to LPG.

4. Impacts

21. The development of a new methodology for switching from NRB to LPG will broaden options for cleaner cooking, and it will facilitate the implementation of CDM project activities and component project activities (CPAs) in household cookstove sector, which have strong relevance for the least developed countries (LDCs) and other regions that are underrepresented in the CDM.

[12] Revised emission factor of 71.4, based on the global average ratio of cooking fuels, i.e. 35 per cent for coal, 2 per cent for kerosene and 63 per cent for LPG (only the ratio of fossil fuels used for cooking) is currently under consideration by the SSC WG.

5. Subsequent work and timelines

22. If the Board were to accept the proposed approach to quantify emission reductions for switching from NRB to LPG, the Meth Panel will continue further work to develop a new methodology, following the “procedure for development, revision and clarification of baseline and monitoring methodologies and methodological tools”.

6. Recommendations to the Board

23. The SSC WG recommended that the Board consider this concept note and provide guidance regarding development of a new methodology for switching from NRB to LPG.

Appendix. Status of global fuel use for cooking and future projections

1. According to the “Universal Modern Energy Access Case” (UMEAC)[13] of International Energy Agency (IEA), there will be a large shift from biomass to LPG globally. By 2030, UMEAC targeted to provide 100% access to LPG cookstoves in urban areas and 30% access to LPG cookstoves in rural areas as shown in the Table 1 below.

Table 1. Targets in the Universal Modern Energy Access Case

	2015		2030	
	Rural	**Urban**	**Rural**	**Urban**
Access to clean cooking facilities	Provide 800 million people with access to LPG stoves (30%), biogas systems (15%) or advanced biomass cookstoves (55%)	Provide 200 million people with access to LPG stoves	100% access to LPG stoves (30%), biogas systems (15%) or advanced biomass cookstoves (55%)	100% access to LPG stoves

Source: IEA, UNDP, and UNIDO (2010)

Note: LPG stoves are used as a proxy for modern cooking stoves, also including kerosene, biofuels, gas and electric stoves. Advanced biomass cookstoves are biomass gasifier-operated cooking stoves which run on solid biomass, such as wood chips and briquettes. Biogas systems include biogas-fired stoves. The concept of improved cookstoves under AMS-I.E. and AMS-II.G. in this document is quite different from the term “advanced biomass stoves”, which are gasifiers based on woodchips or briquettes. Any woodfuel based cookstove with the initial efficiency higher than 20% are eligible under AMS-I.E. and AMS-II.G. for CDM.

2. According to the latest World Energy Outlook 2016[14], the number of people without access to clean cooking facilities decreases by 200 million by 2030, but the adoption of clean cooking facilities struggles to keep pace with population growth in many of the countries concerned. Of those that gain access, three-quarters do so via LPG cookstoves, mainly in urban areas because of the relative ease of establishing fuel supply networks. In rural areas, the most common route to access is via improved biomass cookstoves: solid biomass remains a major fuel for residential use in our projections. Developing countries in Asia will have 1.5 billion people without clean cooking access in 2030, over one-third of the population at that time. Even in China, where universal electrification is already complete, around 450 million people still rely on the traditional use of biomass for cooking today and this is projected to remain the case for 250 million people in 2030. In sub-

[13] IEA, UNDP, and UNIDO (2010): Energy Poverty: How to make modern energy access universal?

[14] World Energy Outlook 2016 (IEA) (available at: <http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessprojections/)>.

Saharan Africa, the shift to cleaner forms of cooking is not rapid enough to keep up with the rise in population, and so the number of people without clean cooking access increases by 2030, to over 800 million, before starting to decline gradually through to 2040 (See Table 2 below).

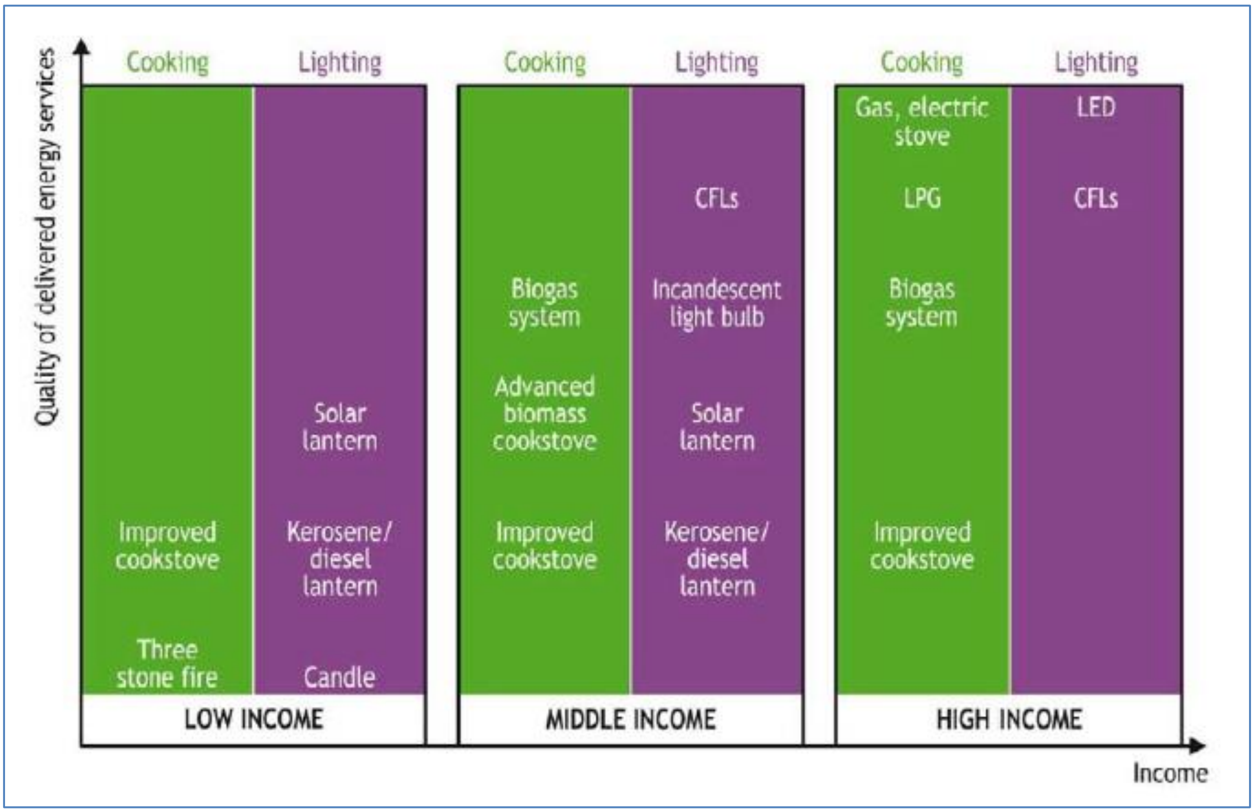
Table 2. Population without access to modern energy services in the New Policies Scenario (million people)

	Without access to electricity			Without access to clean cooking facilities		
	2014	2030	2040	2014	2030	2040
Africa	634	619	489	793	912	849
Sub-Saharan Africa	633	619	489	794	908	844
Developing Asia	512	166	51	1 923	1 600	1 242
China	0	0	0	453	265	200
India	244	56	5	867	763	534
Latin America	22	0	0	75	65	60
Middle East	18	0	0	8	8	8
World	**1 186**	**784**	**541**	**2 799**	**2 585**	**2 159**

Source: World Energy Outlook (2016)

3. Figure 1 below provides an illustration of the quality of energy services for cooking and lighting as income rises at the household level. The figure is reflective of energy consumption in rural households, but some of the principles also apply to peri-urban and urban households. The concept of a simple “energy ladder”, with households moving up from one fuel to another, does not adequately portray the transition to modern energy access, because households use a combination of fuels and technologies at all income levels. This use of multiple fuels is a result of their differing end-use efficiency, of affordability and of social preferences, such as a particular fuel for cooking. Moreover, use of multiple fuels improves energy security, since complete dependence on a single fuel or technology leaves households vulnerable to price variations and unreliable service.

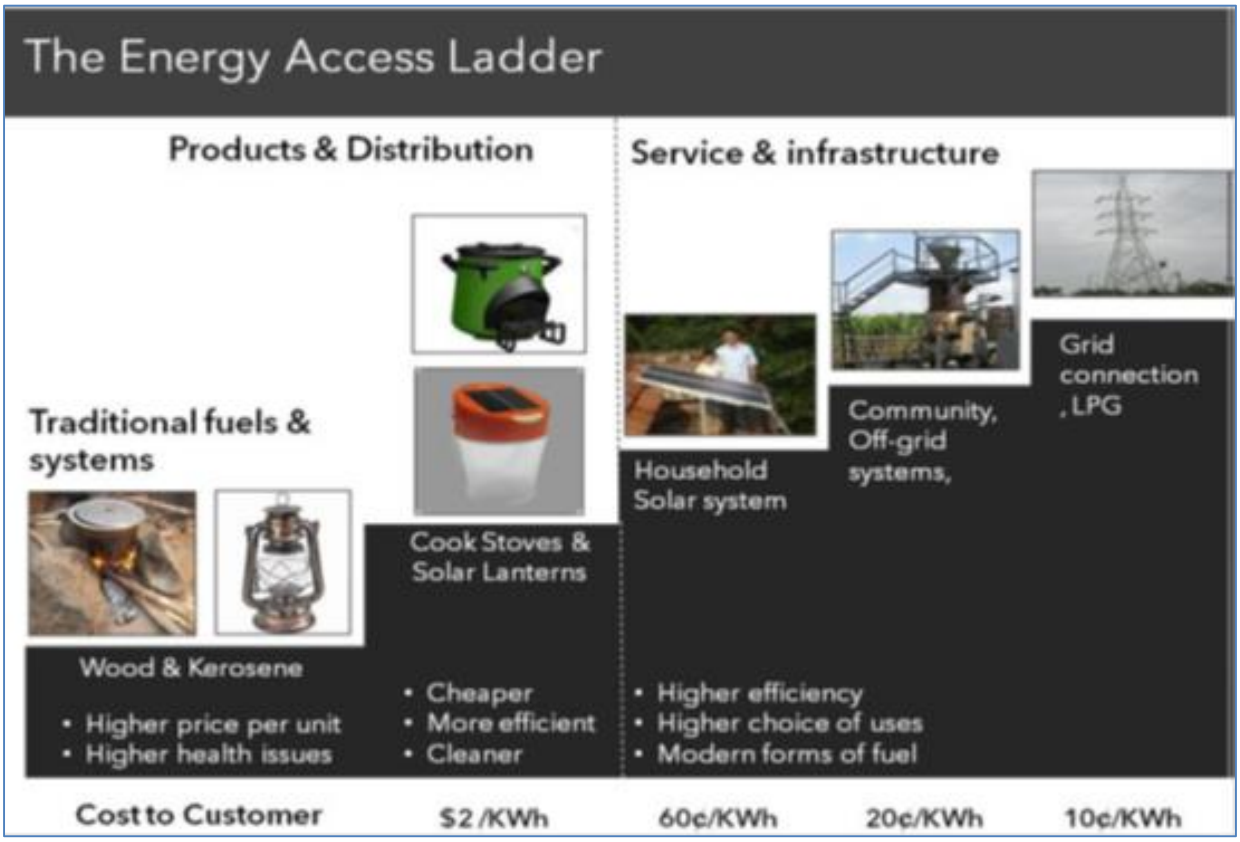
Figure 1. The quality of energy services and household income



Source: IEA, UNDP, and UNIDO (2010)

4. The indicator of the quality of delivered energy services on the vertical axis in Figure 1 is designed to capture a variety of dimensions, including cleanliness, efficiency and affordability. Because of the amount of energy delivered from traditional technologies, such as a three-stone fire or kerosene/diesel lanterns, is much lower than that from modern services, such as electricity, poor households pay a much higher share of their income on energy services, as indicated in Figure 2 below.

Figure 2. The Energy Access Ladder



Source: UN Foundation (2014)

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