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Review of the implementation of the 2030 Agenda for Sustainable Development in Asia and the Pacific: energy

Universal access to energy in Asia and the Pacific: evidence-based strategies to achieve empowerment, inclusiveness and equality through Sustainable Development Goal 7

Note by the secretariat

Summary

The present document contains a review of the evidence on how the achievement of access to modern energy under Sustainable Development Goal 7 in Asia and the Pacific can help reduce inequality through empowerment and inclusion, particularly among those populations that are most at risk of being left behind. Based on trends, evaluations and case studies in access to electricity and clean cooking fuels, the present document identifies strategies to attain universal energy access that bolsters economic and social development while combating rising inequality. It provides a basis for member States to reflect on key policies and programming to enable universal access to modern energy and unlock associated benefits.

The Economic and Social Commission for Asia and the Pacific may wish to review the present document and provide guidance for the future work of the secretariat.

I. Introduction

1. Over the past two decades, while inequality between countries in Asia and the Pacific has fallen, inequality within countries has risen on average. Standards of living have improved and the middle class has expanded in large economies, such as China, however, in many countries, income is becoming increasingly concentrated among a small proportion of the population representing top earners. Low-income populations may experience slower wage growth than those with high incomes. This is particularly problematic considering that current trends in inequality are not limited to income; they extend to such amenities as health care, education, social safety nets and so forth.[1]

* Reissued for technical reasons on 24 April 2019.

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1 *Inequality in Asia and the Pacific in the era of the 2030 Agenda for Sustainable Development*, (United Nations publication, Sales No. E.18.II.F.13).

2. The 2030 Agenda for Sustainable Development and the Paris Agreement provide a blueprint for development, including ending poverty, fighting inequalities and tackling climate change. Sustainable Development Goal 7 on access to modern energy is particularly relevant in this regard because energy is a precursor to many development benefits, and it is critical to the achievement of the other Sustainable Development Goals. Reliable access to energy services is key to enabling education, health care, communication, transportation and economic productivity. With an emphasis on those who are most at risk of being left behind, the present document focuses on two elements of Goal 7: universal access to electricity services and universal access to clean cooking fuels.

3. The present document contains an assessment of the value of access to electricity and clean cooking fuels to improve social welfare and combat inequality based on evidence from existing studies. Based on that evidence, it also provides recommendations on designing, implementing and financing energy access policies and programming to enhance social welfare and combat inequality.

II. Electricity access: evidence and lessons learned on achieving universal access for social betterment

A. Current status and trends

4. While there is no internationally adopted definition, the International Energy Agency defines household electricity access as "having initial access to sufficient electricity to power a basic bundle of energy services – at a minimum, several lightbulbs, task lighting (such as a flashlight), phone charging and a radio – with the level of service capable of growing over time."[2] Based on this definition, as of 2016, the data and analysis of the Economic and Social Commission for Asia and the Pacific (ESCAP) indicates that 7 per cent of the population of the Asia-Pacific region (325 million people) were living without access to basic electricity services.

5. Current access deficits are primarily concentrated in South and South-West Asia, South-East Asia, and the Pacific. As shown in figure I, in South and South-West Asia, there are 255 million people without electricity access, amounting to 13 per cent of the population of the subregion. In South-East Asia, 48 million people (7 per cent of population) are without access. In the Pacific, there are 7 million people without electricity access, which represents almost 17 per cent of the population. The East and North-East Asia subregion has near universal access with only 1 per cent of the population (16 million people) unconnected. While North and Central Asia have attained universal electricity access, there remain issues in reliability, with some countries experiencing frequent blackouts.

[2] International Energy Agency, *World Energy Outlook 2018* (Paris, 2018).

Figure I
People without access to electricity in Asia and the Pacific by subregion

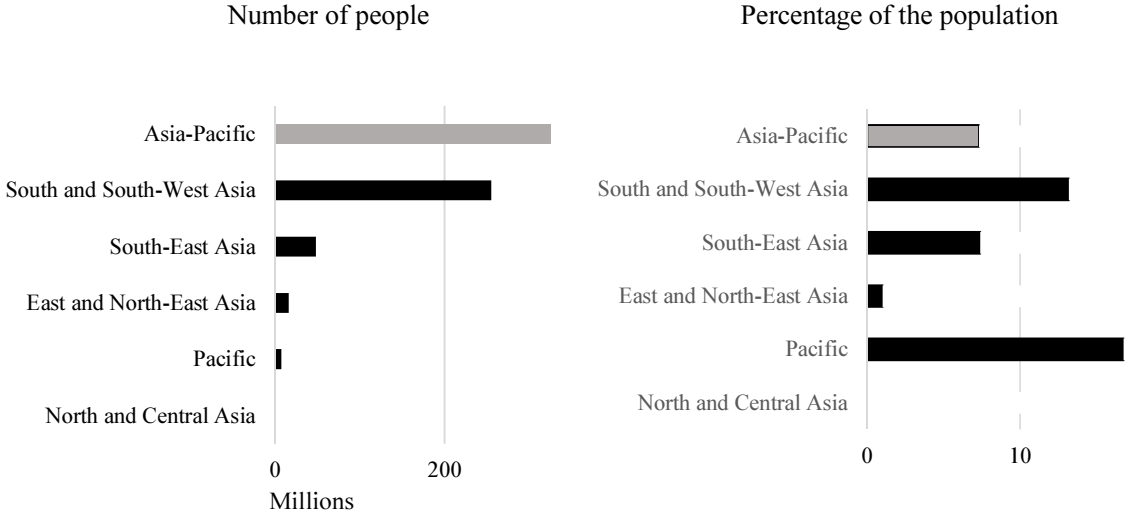
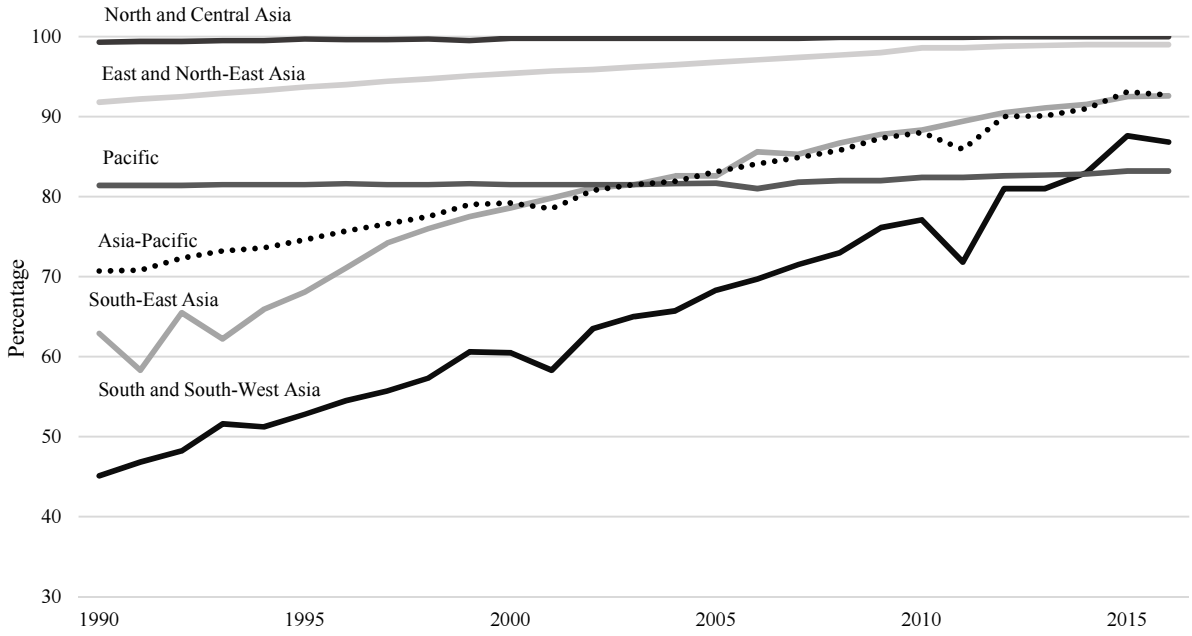


Figure II
Progress in the percentage of the population with electricity access by subregion



6. The region is making strong progress in addressing electricity access; however, greater action is needed to close the gap. As shown in figure II, from 1990 to 2016, access across the Asia-Pacific region increased by more than 20 percentage points (from 72 to 93 per cent), demonstrating vast improvement, even as populations grew. An estimation of future progress based on current policies shows that the region will attain access for 98.7 per cent of the population by 2030.[3] While this represents a vast improvement, it would still leave over 66 million people without access. In recent years, progress has been particularly strong in countries, including India and Bangladesh, where government-led programmes have helped electrify many villages.[4,5] Despite this positive trajectory, simultaneous increases in income inequality have left those without access to electricity even further behind. While early progress driven by grid extension advanced quickly, it is much more time-consuming and costly to reach populations in remote geographic locations that lack infrastructure.

7. While access is frequently treated as a binary variable, this measure is inadequate because it does not capture the nuances of access quality. In some cases, whole villages may be listed as electrified when only a small percentage has access, or when access is available but too expensive for many households to afford. In many countries, service is unreliable due to frequent power cuts, or it is limited to only support minimal necessities, such as lights. Rather than treat energy access as a binary variable, the multi-tier framework proposed by the World Bank provides a more nuanced measure of electricity quality.[6] The multi-tier framework takes into consideration the number of hours electricity is available, how affordable it is and how many appliances households could likely operate. A better understanding of the quality of service is crucial to enabling productive use of electricity for social benefit.[7] Due to data limitations, the present document often refers to the binary access framework but explores nuances of access quality where data are available.

B. Evidence on the impact of electricity access

8. While much has been written on the socioeconomic benefits of electricity access, there is little rigorous evidence of the real-life impact. Many studies compare the outcomes of people with and without access to electricity, but they do not account for other differences between these groups. Populations with electricity access tend to be wealthier, hence positive outcomes cannot be attributed solely to electricity. Other studies examine socioeconomic outcomes before and after electrification without accounting for other factors, such as macroeconomic factors or accompanying infrastructure development, that might have contributed to any detected improvements. Impact evaluation is a specific type of analysis that addresses these issues by using a counterfactual,

[3] ESCAP, "Percentage population with access to electricity in Asia and the Pacific, 1990–2016", Asia Pacific Energy Portal. Available at https://asiapacificenergy.org/#main/lang/en/graph/1/type/0/sort/0/time/[1990,2016]/indicator/[4128:2554]/geo/[SSWA,NOCA,PACI,SOEA,ENEA]/legend/1/inspect/0 (accessed on 14 March 2019).

[4] "India to achieve universal household electrification by January-end", *Economic Times (Mumbai)*, 20 January 2019.

[5] "PM: we will illuminate every household", *Dhaka Tribune*, 6 February 2019.

[6] World Bank, *Beyond Connections Energy Access Redefined – Conceptualization Report* (Washington D.C., 2015).

[7] ESCAP, *Inequality of Opportunity in Asia and the Pacific: Clean Energy* (ST/ESCAP/2818).

which is an estimation of what the outcomes would likely have been in the absence of a programme. These studies go beyond describing and measuring impacts; they seek to understand the role of the programme in producing these impacts. Using a range of methodologies, impact evaluations can establish causal attribution and pinpoint and quantify the benefits of a specific programme. The present document focuses on the quantitative findings of impact evaluations to ascertain the demonstrated real-life impacts of energy access.

9. Based on a review of impact evaluations in Bangladesh, Cambodia, India and Viet Nam, the present document finds that, in many cases, electricity access programmes increased income, improved primary and secondary education and reduced poverty. While electricity access improves social welfare for all households, ensuring that benefits are distributed equitably requires targeted programming. These results are consistent with development literature and are summarized in table 1. Research by the United Nations Development Programme (UNDP) suggests that as households attain access to more appliances and stronger electricity, their socioeconomic benefits progressively increase.[8]

1. Economic impacts

10. One study of 50 rigorous impact evaluations of policies and programmes around the globe to either introduce or improve electricity found on average that electrification programmes had increased income by approximately 30 per cent and increased employment by approximately 25 per cent, holding all else constant.[9] Specific impacts, however, varied widely by study and country context.

11. Income improvements were seen at the household level as well as for local small and medium-sized enterprises. Evidence suggests that this occurs through four main pathways. First, electric lighting can increase hours of productivity.[10] Second, households with access to radios, television and mobile phones can have better economic opportunities, such as opportunities for employment and entrepreneurship and access to information about prices. Third, households and firms may invest in electrical equipment to support income-generating activity, such as agricultural machines or equipment for entrepreneurial activity. Fourth, depending on the programme and context, electrification may reduce expenditures on more expensive fuels, such as kerosene.[11] In 2018, UNDP found that as households attain better electricity and more appliances, the economic benefits continue to improve incrementally. Improvements to economic activity are only seen in households that have enough electricity for medium-power appliances (tier 3 in the multi-tier framework). These benefits further improve as the household attains high-power and very high-power appliances (tier 4 and tier 5).

[8] UNDP, "Energy access projects and SDG benefits", UNDP Discussion Paper (Bangkok, 2018).

[9] Raul Jiminez, "Development Effects of Rural Electrification", Policy Brief, No. 261 (Washington, D.C., Inter-American Development Bank, 2017).

[10] World Bank, *Gender, Time Use, and Poverty in Sub-Saharan Africa* (Washington, D.C., 2006).

[11] Shahidur R. Khandker, Douglas F. Barnes and Hussain A. Samad, "Welfare impacts of rural electrification: a panel data analysis from Vietnam", *Economic Development and Cultural Change*, vol. 61, No. 3 (April 2013).

Table 1
Electricity access impact evaluations in selected countries

Country	*Impacts*			
	Income	*Education*	*Inequality*	*Poverty*
Bangladesh[a]	21 per cent increase in household income†	Girls: Extra 12 minutes study per day† and 2 extra months of schooling† Boys: Extra 22 minutes study per day† and 3 extra months of schooling†	Richer households benefit more from electrification than poorer households	Poverty decreased by 1.5 percentage points per year†
Cambodia[b]	16.6 per cent increase in daily per capita consumption†	8.5 month increase in total schooling† and 7 per cent increase in ever having been enrolled†	Richer households benefit more from electrification than poorer households	-
India[c]	38.6 per cent increase in household income†	Girls: 7.4 per cent more likely to have enrolled† and 6 extra months of schooling† Boys: 6 per cent more likely to have enrolled† and 3.6 extra months of schooling†	Richer households benefit more from electrification than poorer households	Poverty decreased by 13 percentage points in total†
Viet Nam[d]	28 per cent increase in household income†	Girls: 9 per centage points more likely to have enrolled† and no change in total schooling Boys: 6.3 per centage points more likely to have enrolled† and 1.4 extra months of schooling†	Richer households benefit more from electrification than poorer households	-
General trends	⬆	⬆	⬆	⬇

[a] Shahidur R. Khandker, Douglas F. Barnes and Hussain A. Samad, "The welfare impacts of rural electrification in Bangladesh", *Energy Journal*, vol. 33, No. 1 (2012).

[b] Chan Hang Saing, "Rural electrification in Cambodia: Does it improve welfare of households?", *Oxford Development Studies*, vol. 46, Issue 2 (June 2017).

[c] Shahidur R. Khandker, Douglas F. Barnes and Hussain A. Samad, "Who benefits most from rural electrification? – evidence in India", Policy Research Working Paper, No. 6095, (Washington, D.C., World Bank, 2012).

[d] Shahidur Khandker, Douglas F. Barnes and Hussain A. Samad, "Welfare impacts of rural electrification: a panel data analysis from Vietnam", *Economic Development and Cultural Change*, vol. 61, No. 3 (April 2013).

12. Impact evaluations in Bangladesh, Cambodia, India and Viet Nam all found rural electrification programmes to provide statistically significant† improvements to economic development as detailed in table 1. Saing's 2017 study in Cambodia found that rural electrification increased daily per capita consumption, a good proxy for income, by 16.6 per cent,† and studies in other countries have shown an increase in household income ranging from 21 to 38.6 per cent. Interestingly, Khandker's 2012 study in India found that the increase was primarily due to non-farm income. The study additionally found that labour supply increased by 17 per cent for women compared to 1.5 per cent for men, possibly due to women spending less time collecting biomass for fuel.† The vast increase of women in the labour supply suggests that electrification can indeed support gender equality and women's empowerment by freeing up time for women to participate in income-generating activity.

2. Education impacts

13. With regards to education, electricity provides benefits through two main pathways. First, electric lights allow children to study more during the evenings. Second, the improvement in productivity may reduce the amount of time that children would otherwise have spent helping parents with housework or other activities.

14. Examining cases in Asia, all four studies found that rural electrification significantly improved education outcomes, but the magnitudes of change were quite small. Across studies described in table 1, the likelihood of school enrolment increased by 6–9 per cent as a result of electrification, while total amount of schooling increased by 1.5–8.5 months. Interestingly, the studies in Cambodia and Bangladesh found that rural electrification benefited boys more than girls, while the study in India found girls to benefit more than boys; interestingly, Khandker's 2013 study in Viet Nam found that girls who did not have electricity in their homes, but lived in communes that had electricity, attained almost a full year of additional schooling. This suggests that electricity provision to neighbours and public facilities had positive spillover effects to unelectrified households. Additional study may be needed to examine how to maximize these education benefits and ensure that they empower girls.

3. Inequality

15. With regard to inequality, there are three main concerns. First, the decision on where to pursue rural electrification is often biased towards wealthier communities that either have greater political voice or more economic promise. For example, Saing's 2017 study in Cambodia found that the national electrification strategy favoured areas with the most promise of economic development, which were likely those areas that had higher income to begin with. Similarly, grid extension interventions generally reach those who are located closest to the grid first, although those in remote areas may be more in need. This prioritization framework is not inherently problematic if there is a broader vision to reach universal access, but if the poorest areas remain unelectrified, these communities will unfortunately fall even further behind with little means to advance economically. A second inequality concern is that once a village has been electrified, the poorest households may not be able to afford the connection fee to take advantage of the service. Fortunately, there is some evidence that households in electrified communities may benefit from community facilities, such as improved schools and hospitals, public street lights or facilities at the homes of neighbours. The third inequality concern is that households that possess better appliances, such as lamps, radios,

† Statistically significant at least at the 90 per cent confidence interval level.

mobile phones, televisions, refrigerators, cooking appliances or fans, tend to benefit more than those without. Naturally, these households are better able to utilize energy services, possibly to support income-generating activity. Households that cannot afford to buy and operate as many appliances have less to gain from electrification.

16. As shown in table 1, all four impact evaluations found that rural electrification benefited wealthier households more than poor households. The studies used a methodology of disaggregating income benefits by income quantile at baseline. Accordingly, studies found that households in higher income quantiles benefited more than those in lower income quantiles. For example, from Khandker's 2012 study in Bangladesh, among the highest income quantile (eighty-fifth percentile) the impact of electrification on household income was almost double that for the lowest income quantile (fifteenth percentile). Interestingly, the study in Viet Nam found that while wealthier households benefited more from household electricity access, poorer households benefited more from commune-level access. This suggests that spillover effects were stronger among poorer populations.

17. The 2012 studies by Khandker and others of Bangladesh and India also examined poverty, finding that rural electrification decreased poverty by 1.5 percentage points per year in Bangladesh and by 13 percentage points in total in India.

18. In sum, the studies demonstrate that rural electrification significantly increased household incomes. Although improvements were seen at all levels, wealthier households tended to benefit more than poorer households, likely because they were able to purchase more electricity and utilize more appliances. Rural electrification also significantly benefited primary and secondary education, though by a small magnitude. In some cases, impact varied for boys and girls.

III. Clean cooking: evidence and lessons learned on promoting clean cooking for social good

A. Current status and trends

19. While attaining universal access to electricity remains a challenge, improving access to clean cooking fuels is even more difficult. Currently, 45.4 per cent of the Asia-Pacific region, or approximately 2 billion people, lack access to clean cooking and use unclean fuels and technologies that have detrimental impacts on health and the environment. Collectively, China and India have approximately 1.4 billion people who lack access to clean cooking fuel and account for two thirds of the deficit in the region. As shown in figure III, there are deficits in clean cooking access in all subregions, and the deficit is highest in South and South-West Asia in terms of both percentage (60 per cent) and absolute population (more than 1 billion people). East and North-East Asia has the next largest population without access to clean cooking at 605 million people, or 37 per cent of the population. In South-East Asia, 287 million people or 45 per cent of the population lacks clean cooking access. In North and Central Asia 11 million people, or roughly 5 per cent of the population remains without access. Lastly, while only 9 million people in the Pacific lack access, this accounts for 22 per cent of the population.

Figure III
People without access to clean cooking in Asia and the Pacific by subregion

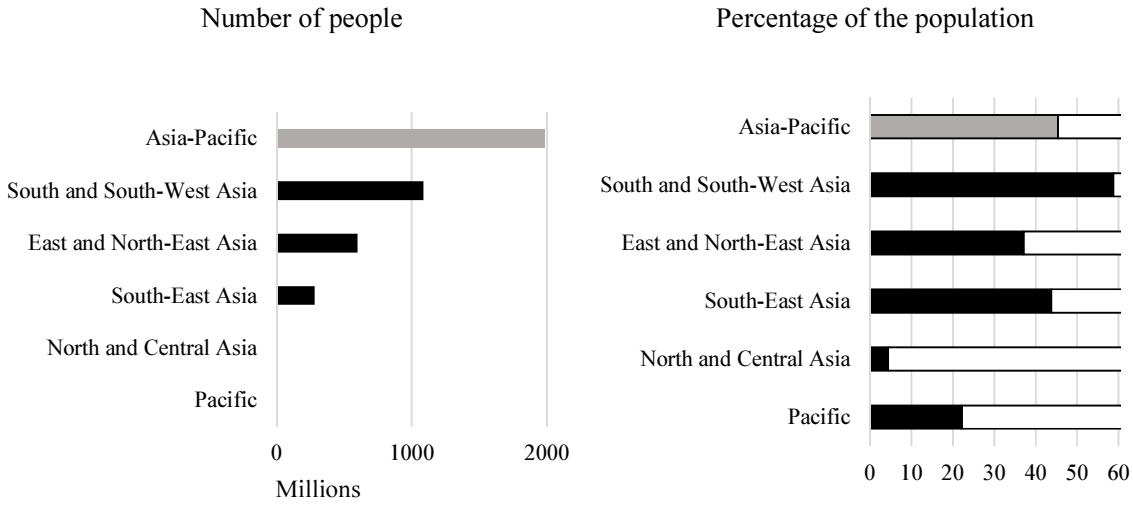
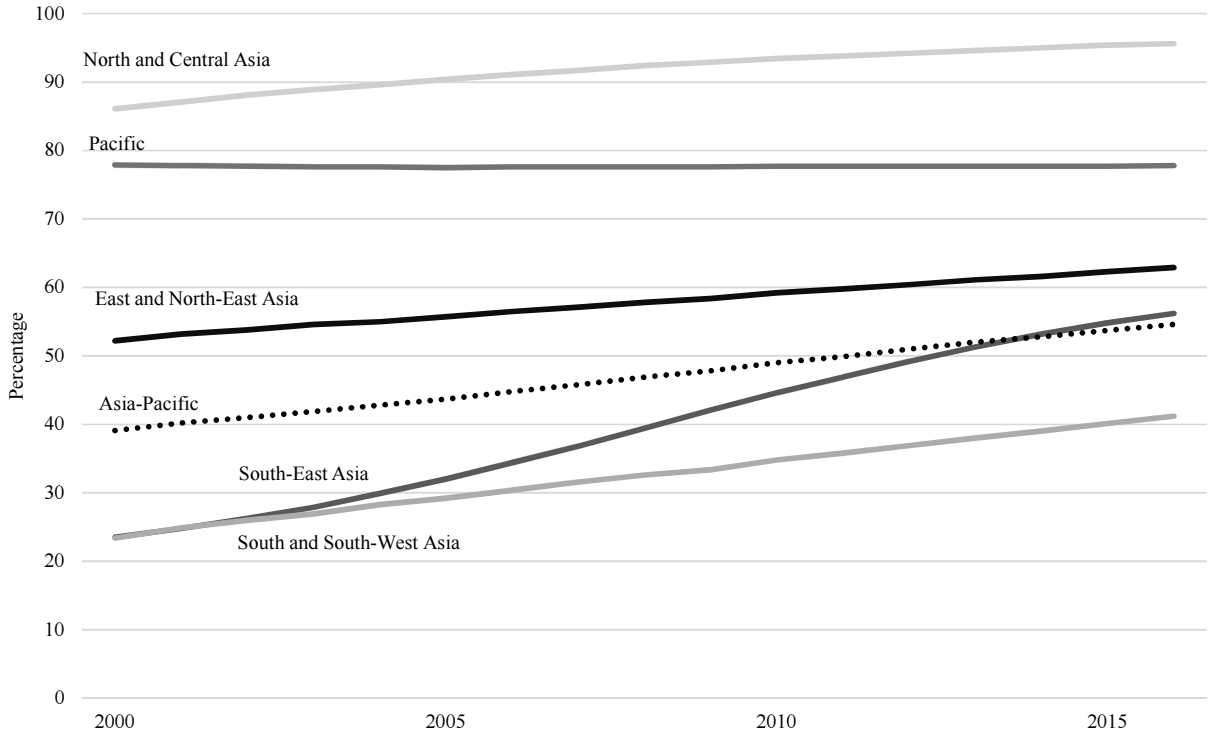


Figure IV
Progress in the percentage of the population with access to clean cooking by subregion



20. As shown in figure IV, over the 16 years from 2000 to 2016, clean cooking access in the Asia-Pacific region increased from 39.1 per cent to 54.6 per cent. This progress is insufficient for attaining universal access by 2030 in line with Goal 7. An estimation of future progress predicts that, based on current policies, the region will attain clean cooking access for 67.7 per cent of the population by 2030.[12] Drastic policy action is needed to attain universal access.

B. Evidence on the impact of clean cooking

21. Globally, cooking with open fires or simple stoves fuelled by kerosene, coal or biomass, such as wood, dung and agricultural residues, leads to almost 4 million premature deaths per year. Inefficient cooking practices and the subsequent pollution have negative health impacts including pneumonia, stroke, ischaemic heart disease, chronic obstructive pulmonary disease and lung cancer. Women are at particularly high risk since in many countries they bear the primary responsibility for cooking. Children are also at high risk, as indoor air pollution almost doubles their risk of pneumonia.[13]

22. Gathering fuel also presents significant challenges. It consumes considerable time, particularly for women and children who tend to be the primary gatherers. This limits time that may have been spent on other productive activities, such as income generation and education. Carrying heavy fuels, such as wood, can increase the risk of musculoskeletal damage. In less secure environments, fuel gatherers may risk injury or violence.[14]

23. Much like electricity access, clean cooking access is strongly interlinked with other important Sustainable Development Goals, namely Goal 3 on ensuring healthy lives and promoting well-being, Goal 5 on empowering women and girls, Goal 13 on combatting climate change and Goal 15 on sustainably managing forests and halting land degradation. These interlinkages and their pathways are displayed in detail in table 2.

[12] ESCAP, "Percentage population with access to clean cooking in Asia and the Pacific, 2000–2016" Asia Pacific Energy Portal. Available at https://asiapacificenergy.org/#main/lang/en/graph/1/type/0/sort/0/time/[2000,2016]/indicator/[5069:2554]/geo/[SSWA,NOCA,PACI,SOEA,ENEA]/legend/1/inspect/0 (accessed on 14 March 2019).

[13] World Health Organization, "Household Air Pollution and Health Fact Sheet", 8 May 2018.

[14] Rema Hanna, Esther Duflo and Michael Greenstone, "Up in smoke: the influence of household behavior on the long-run impact of improved cooking stoves", *American Economic Journal: Economic Policy*, vol. 8, No. 1 (February 2016).

Table 2
Sustainable Development Goals of particular relevance to clean cooking programmes

Sustainable Development Goal		*Relevant target*
3	Health and well-being	Reduce under-5 deaths Reduce illness and early death due to air pollution
5	Empowering women and girls	Improved access to enabling technologies
7	Access to reliable, efficient and modern energy	Affordable, reliable and modern energy
13	Combat climate change	Implement climate measures into national policies
15	Sustainably manage forests and halt land degradation	Reduce deforestation Reduce land degradation and desertification

Source: Joshua Rosenthal and others, "Clean cooking and the SDGs: integrated analytical approaches to guide energy interventions for health and environment goals", *Energy for Sustainable Development*, vol. 42 (February 2018).

24. Cooking is a cultural experience, deeply rooted in tradition and local behaviour. Effecting change in cooking practices can be challenging, and in order to be successful, policies and programmes should account for local customs. Clean cooking requires a greater level of behaviour change than does rural electrification; accordingly, inclusive processes tend to yield greater success.

25. Some of the technologies used to address clean cooking gaps include electric cookstoves, biogas digesters, liquefied petroleum gas stoves and improved cookstoves. The present document contains an investigation of the pros and cons of some of these technologies, including their demonstrated impact on social well-being based on impact evaluations.

26. There is very little empirical evidence on the demonstrated impacts of clean cooking solutions in real-life settings, and estimated results are often based on laboratory results or theoretical conditions that are not replicable in the field. Additionally, there have been few concerted national efforts to implement comprehensive clean cooking strategies. While many countries in the region have targets for electricity access, renewable energy, energy efficiency and carbon emissions, few countries have set targets for clean cooking. Clean cooking initiatives often take place at the project level with funding from donor agencies and without coordination with larger national plans.[15] There have been some exceptions in recent years, however, namely in India and Indonesia, where the Governments implemented large-scale liquefied petroleum gas projects to provide clean cooking solutions.

[15] *Energy Transition Pathways for the 2030 Agenda in Asia and the Pacific: Regional Trends Report on Energy for Sustainable Development 2018* (United Nations publication, Sales No. E.18.II.F.14).

27. The existing body of literature includes numerous impact evaluations of improved cookstoves, a few on liquefied petroleum gas interventions and biogas digesters and very few on electric cooking. Outcomes most frequently examined include health outcomes, cost outcomes and fuel usage outcomes. Many evaluations also assess the uptake and use of cleaner cooking options because achieving uptake is often the greatest challenge. Information from evaluations and qualitative research studies are provided to investigate the efficacy of each of these technologies.

1. Electric cookstoves

28. Electricity is rarely used for cooking in rural areas because it is almost always too expensive, particularly if biomass may be gathered for free. Electric appliances, such as electric cookstoves or rice cookers, may also be prohibitively expensive. In areas where there are frequent blackouts, electric cooking may not be feasible and may even be dangerous if connections are poor. Culturally, many people say that food tastes better when cooked over wood or charcoal. Some communities oppose cooking with electricity for spiritual reasons.[16]

2. Improved cookstoves

29. Improved cookstoves have been widely promoted by donor agencies and implementers in recent years largely because they mimic the cooking style of traditional stoves. They use the same fuels, namely wood, but are much more efficient and less polluting.[17] Although improved cookstoves have been criticized from an environmental standpoint, they are easy to deploy and present a potential temporary solution for remote areas that are hard to reach by other methods. Hanna and others 2016 state that there has been minimal rigorous evidence of the real-life impacts of improved cookstoves on health and social welfare, and unfortunately, their effectiveness is often overstated based on tests in laboratory-like settings that are not replicable in the field.

30. Evaluations show that the impact of improved cookstoves on health is often much smaller than anticipated. For example, the study by Rosenthal and others 2018 found that distributing improved cookstoves initially decreased smoke inhalation but benefits disappeared after two years, and there were no detectable improvements to health or indoor air quality in the long run. According to Hanna and others 2016, this is because improved cookstoves are damaged easily and require maintenance, and they also require behaviour change in terms of cooking technique. Many households did not use the improved cookstoves much to begin with, and usage further declined over time as households failed to make the maintenance investments needed to keep them operational. Similarly, other interventions studied have failed to achieve recommended reductions in levels of fine particulate matter (PM2.5).[18]

[16] World Bank, *The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits* (Washington D.C., 2008).

[17] Joshua Rosenthal and others, "Clean cooking and the SDGs: integrated analytical approaches to guide energy interventions for health and environment goals", *Energy for Sustainable Development*, vol. 42 (February 2018).

[18] Ther W. Aung and others, "Health and climate-relevant pollutant concentrations from a carbon-finance approved cookstove intervention in rural India", *Environmental Science & Technology*, vol. 50, No. 13 (5 July 2016).

31. There is, however, some evidence that improved cookstove interventions can be beneficial if accompanied by training for the beneficiaries, free repairs and continuous support to ensure proper use and maintenance.[19] The study by Rosenthal and others 2018 state that given its high cost, this level of support is not typical in programmes and may not be the most cost-effective option.

3. Biogas digesters

32. Biogas digesters present a strong clean cooking option. According to *Energy Transition Pathways for the 2030 Agenda in Asia and the Pacific*, they are relatively cheap to operate and provide agricultural co-benefits. The digesters produce bioslurry, a byproduct which may be used as organic fertilizer. The primary limitation of biogas digesters is that they require the regular presence of cattle or poultry. Additionally, there is cultural resistance as some communities consider it unclean to cook using biogas. In areas where cattle farming is common, biogas digesters could be highly beneficial, and awareness campaigns could help promote usage. Biogas has long been promoted in China and India, and more recently in Bangladesh, Cambodia, Indonesia, Nepal, Pakistan and Viet Nam.

33. An impact evaluation in East Java found that owners of biogas digesters were less likely to purchase firewood by 9–14 percentage points (though this was not statistically significant), and they were less likely to purchase liquefied petroleum gas by 55 percentage points.[20,†] Digester owners experienced a reduction in total monthly energy expenditure by the equivalent of $3–$5, and they self-reported a reduction in indoor air pollution.[†] Time spent foraging for wood decreased by four hours per week, which would potentially free up time for income generating activity. Other studies have similarly found biogas digesters to reduce energy expenditure and firewood consumption.[21] One obstacle is that, much like improved cookstoves, biogas digesters require maintenance, are difficult to set up and can be damaged easily. Unlike improved cookstoves, however, households that had biogas digesters stated that biogas was their primary cooking fuel. This suggests that where biogas is technically feasible, its adoption may be more promising.

4. Liquefied petroleum gas

34. Based on the study by Rosenthal and others 2018 on clean cooking, there is growing consensus that liquefied petroleum gas is the superior option for both improving health and mitigating climate change. Much of Latin America has already converted to liquefied petroleum gas and natural gas for cooking, whereas fewer countries in the Asia and the Pacific and Africa have adopted these cleaner cooking fuels in rural areas. The main impediment is the lack of infrastructure and transportation to enable regular distribution channels. Based on a study in India, liquefied petroleum gas was well regarded by rural communities. It had high adoption rates and held great potential for improving health and reducing emissions and local air pollution. The users did, however,

[19] Tone Smith-Sivertsen and others, "Effect of reducing indoor air pollution on women's respiratory symptoms and lung function: the RESPIRE randomized trial, Guatemala", *American Journal of Epidemiology*, vol. 170, Issue 2 (15 July 2009).

[20] Arjun S. Bedi, Robert Sparrow and Luca Tasciotti, "The impact of a household biogas programme on energy use and expenditure in East Java", *Energy Economics*, vol. 68 (October 2017).

[21] Arjun S. Bedi, Lorenzo Pellegrini and Luca Tasciotti, "The effect of Rwanda's biogas program on energy expenditure and fuel use," *World Development 67* (2015).

engage in fuel stacking; they used various cooking fuels simultaneously. For example, many users suggested that they used liquefied petroleum gas for preparing tea and snacks but used unsustainable biomass and traditional stoves to cook meals which required more fuel.[22] Because of its popularity, if it were possible to overcome the obstacles of transport and affordability, uptake of liquefied petroleum gas would likely be strong. However, addressing fuel-stacking would require targeted solutions.

35. A critical finding across studies is that one of the most important determinants of uptake is the comparative cost of other cooking fuels. When the price of kerosene or wood decreased, households were more likely to use them to supplement, or even substitute entirely, for cleaner options. The study by Bedi and others 2017 states that fuel stacking is the prevailing norm because few households stop using the less sustainable methods entirely even when adopting new technologies, such as liquefied petroleum gas or biogas. According to Hanna and others 2016, biomass is often procured through a combination of collection and purchase. Using cleaner fuels could free up valuable time, particularly for women, thus creating more time for income-generating activity. By undervaluing women's time, households may miss out on valuable opportunities for economic advancement. In this regard, coupling clean cooking solutions with programming for women's entrepreneurship could help to raise awareness of this unrealized potential and encourage the use of cleaner cooking technologies.

36. Based on the evidence from Rosenthal and others 2018, health outcomes and environmental impacts are most likely to improve when clean cooking programmes focus on clean fuels, such as liquefied petroleum gas, electricity, biogas or ethanol. This paradigm has been summarized as "making the clean available instead of trying to make the available clean".[23] That said, the best technology for a community will also depend on locally available resources as well as the social and cultural context. Recent initiatives to promote liquefied petroleum gas, including large campaigns in India and Indonesia, hold promise, as stated by Gould and Urpelainen 2018 and Thoday and others 2018.[24] However, Gould and Urpelainen 2018 further suggest that limitations in infrastructure and transportation make liquefied petroleum gas challenging in certain regions. Although fuel stacking is the prevailing norm, evidence suggests that households express high satisfaction with liquefied petroleum gas stoves and continue to use them. Where technically feasible, biogas digesters also have high uptake. Preliminary evidence suggests that both liquefied petroleum gas and biogas are cleaner in practice than improved cookstoves. While improved cookstove interventions perform very well in laboratory settings, Hanna and others 2016 state that results may be weaker in practice due to user error and extensive maintenance requirements.

[22] Carlos F. Gould and Johannes Urpelainen, "LPG as a clean cooking fuel: adoption, use, and impact in rural India", *Energy Policy*, vol. 122 (November 2018).

[23] Kirk R. Smith and Ambuj Sagar, "Making the clean available: escaping India's chuhla trap", *Energy Policy*, vol. 75 (December 2014).

[24] Katharine Thoday and others, "The mega conversion program from kerosene to LPG in Indonesia: lessons learned and recommendations for future clean cooking energy expansion", *Energy for Sustainable Development*, vol. 46 (October 2018).

IV. Financing and planning for energy access: reallocating resources for sustainability and equity

37. One of the greatest challenges in funding both electricity access and clean cooking is that they require large upfront investments, and those who remain without access have the least ability to pay. Because access is a public good that often has high fixed costs, solutions require public sector funding. That said, the private sector is often better placed to find innovative least-cost solutions that best meet specific community needs. Governments, donors, the private sector, non-governmental organizations and civil society organizations can all play valuable roles in reaching the last mile, and good coordination between these entities would maximize impact.

A. Governance and planning

38. National energy planning strategies frequently take a top-down approach; however, in some cases a bottom-up approach could also be beneficial. Plans are often prepared based on historical records, so communities that have been left out of electricity access planning in the past continue to be left out.[25] Many of the people who currently lack access live in countries that have practised conventional energy planning for years. Assessing the true demands in these communities and incorporating them into national planning will be a first step to attaining universal access. Policymakers may conduct survey-based forecasting or end-use modelling to account for needs at the grassroots level. This requires a great deal of data, so Governments may consider incorporating energy questions into census surveys and/or collaborating with companies or non-governmental organizations that collect energy data.

B. Private sector involvement

39. According to Odarno and others 2017, a company in India developed a bottom-up, demand-driven approach, called ecosystem analysis, for expanding electricity access. This model included household surveys, focus group discussions and interviews with community members to develop customized solutions, such as an affordable pay-as-you-go solar home system, and innovative appliances, such as solar-based sewing machines and water purification technologies. This demonstrates that innovative financing schemes and bottom-up planning can help decision makers better address the energy needs of the poor. While the private sector tends to be better at finding effective, least-cost solutions, providing last-mile energy solutions often costs more money than it generates, making it impossible to achieve universal access without public sector funding or aid.

C. Financing universal access

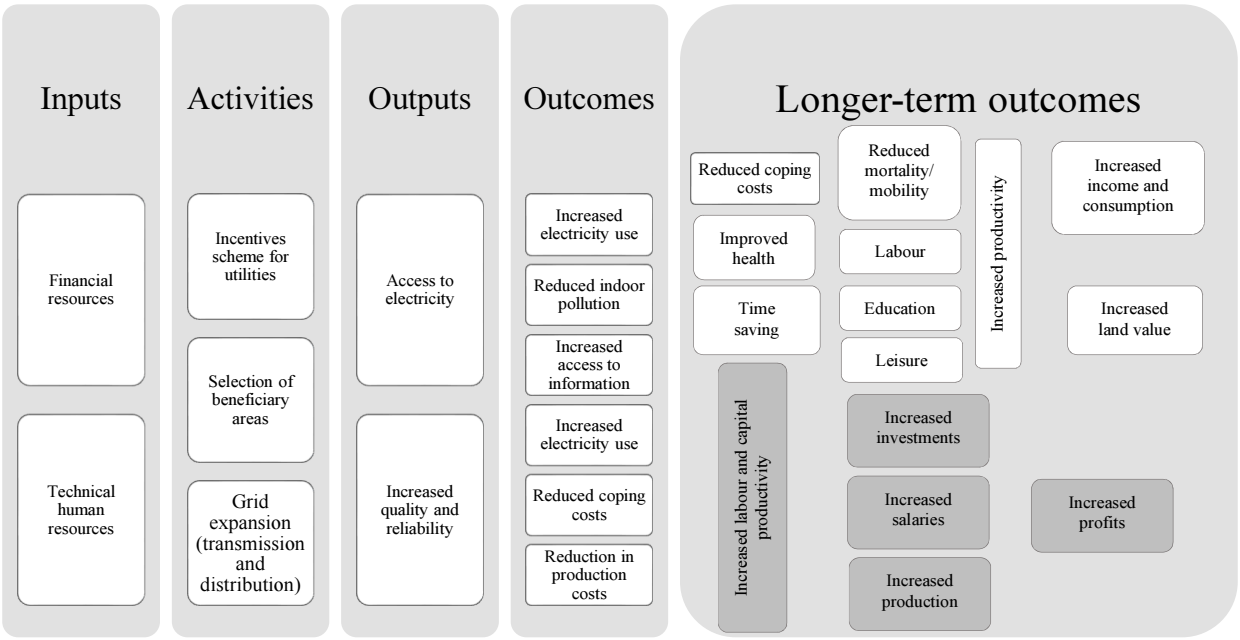
40. Many Governments provide subsidies, either to energy companies or directly to consumers in order to expand access and make energy affordable. While subsidies can be highly effective, bottom-up planning and ongoing monitoring would help ensure that implementation is effective and that the subsidies are progressive and not regressive. Studies show that in some cases, subsidies have been set too low to benefit those in need, while in other cases,

[25] Lily Odarno and others, “Strategies for expanding universal access to electricity services for development”, Working Paper (Washington D.C., World Resources Institute, 2017).

though policies were appropriate, beneficiaries suffered from intermittent service and extortion by intermediaries.[26] Better monitoring of implementation would help to correct such issues. From the development standpoint, as demonstrated by the studies highlighted in the present document, both electricity access and clean cooking provide many benefits in terms of income, health, education and women's empowerment.

41. Figure V displays a logical framework of how financial resources and technical human resources for energy access can ultimately lead to long-term benefits. By better presenting these benefits, electricity planners can build a strong case for development assistance to further support funding. Funding from Governments and donors will be particularly important for mini-grid and off-grid solutions.

Figure V
Causal grid from electricity to development



Source: Raul Jiminez, "Development effects of rural electrification", Policy Brief, No. 261 (Washington, D.C., Inter-American Development Bank, 2017).

42. According to the *World Energy Outlook 2018*, the least expensive way to attain universal electricity access in many areas will be through renewables, based on the declining costs of solar power, which may be used for mini-grid and off-grid solutions. These solutions, however, require more innovative and targeted financing schemes. Public-private partnerships can bring together public resources, development interests and technological know-how to implement better solutions.

[26] Ishmael Edjekumhene, Martin Bawa Amadu and Abeeku Brew-Hammond, "Power sector reform in Ghana: the untold story" (Accra, Kumasi Institute of Technology and Environment, 2001); and Abhishek Jain and others, *Access to Clean Cooking Energy and Electricity Survey of States* (New Delhi, Council of Energy, Environment and Water, 2015).

43. Public-private partnerships are well regarded for attaining energy access because they "have the ability to produce higher quality services at a lower cost than either public or private partners can do in isolation".[27] One company in Bangladesh, provides rural electricity through solar home systems and clean cooking solutions through biogas digesters and improved cookstoves. During its first seven years, the initiatives were largely funded by development assistance donors, but since then 90 per cent of revenue has come from customers purchasing energy. Part of what led to its success was partnerships with local stakeholders, including non-governmental organizations and civil society organizations to fully understand the needs of the end users. The company demonstrated that while last-mile problems do require some public funding, well-planned models can minimize the costs and ensure the long-term sustainability of projects, even with renewable energy.

44. ESCAP pioneered a programme for widening access to energy services with locally available renewable energy resources for the rural poor through the innovative approach of the Pro-poor Public-Private Partnership initiative. Programmes launched in Indonesia and Nepal focused on mobilizing communities at the grassroots level and innovative programme financing from the private sector.

45. Making renewable energy affordable is an important concern in the Pacific subregion. Off-grid and mini-grid solutions are critical in small island developing States where extending grid infrastructure is not financially feasible given the low demand and sparse population. Despite the high proportion of the population living in small islands, a centralized approach to electricity infrastructure has been taken to date, which has focused on building large grids in a few major cities. Though government subsidies would be a valuable tool to incentivize off-grid and mini-grid solutions, current energy subsidies are geared toward helping those with grid access to attain cheaper energy, rather than helping those without access.[28] Moreover, many of these subsidies are offered at the same rate for all households, regardless of income, meaning that rich households benefit more than poor households since they purchase more energy. To address equity issues and build toward attaining universal access, policymakers may consider restructuring these regressive subsidies to benefit those who are most in need.

D. Making energy affordable

46. In addition to making energy available, policymakers may undertake programmes to make it more affordable, for example, by providing subsidies or free connections for low-income households. Energy efficiency is also an important component of both reducing energy costs for the poor and promoting Sustainable Development Goal 7. Although efficient appliances generally save money in the long run, upfront costs are often too high for the poor. Energy service companies can help to identify missed opportunities and provide loans for low-income households to buy appliances, such as energy efficient lightbulbs, that provide long-term savings.

[27] ESCAP, *Partnerships for Universal Access to Modern Energy Services: A Global Assessment Report on Public-private Renewable Energy Partnerships* (ST/ESCAP/2664).

[28] Matthew Dornan, "Access to electricity in small island developing States of the Pacific: issues and challenges", *Renewable and Sustainable Energy Reviews*, vol. 31 (March 2014).

E. Prioritizing between clean cooking technologies

47. The *World Energy Outlook 2018* estimates that in more than half of cases they considered, the most cost-effective solution will be liquefied petroleum gas and in the remaining cases, improved cookstoves will be most cost-effective. The business case for liquefied petroleum gas may be even stronger considering that improved cookstoves require costly monitoring and maintenance to attain development benefits. In light of the evidence on the limitations of improved cookstoves, biogas digesters may provide a better option in areas where there are a lot of cattle, though improved cookstoves, implemented appropriately may present a strong temporary solution.

48. Like electricity, clean cooking solutions may not be profitable, so funding from Governments and donors will be important during early adoption. For example, one study found that biogas digesters would ultimately have a payback period of 30 years, while the technology lifetime was only 20 years. Clearly, this would not be a worthwhile investment for rural farmers. In this case, beneficiaries received subsidies and interest-free loans, which reduced the payback period to just 10 years, making this a worthwhile investment.[29] This demonstrates that public sector funding, either from Governments or donor agencies is often needed to effectively distribute clean cooking solutions. Ideally, research and development will gradually reduce these technology costs, making them financially sustainable.

49. Feasibility studies and cost-benefit analyses are critical tools for determining the best clean cooking solution. For example, the cost of an improved cookstove can range from $12.50 to $150.[30] Conducting cost-benefit analyses to determine the most efficient solution will be critical, particularly considering that improved cookstove interventions also require costly follow-up to produce results.

50. In recent years, there have been more government-implemented clean cooking programmes, such as those in India and Indonesia. In 2015, India implemented a particularly innovative programme known as the GiveItUp campaign, which appealed to wealthy households to voluntarily give up their liquefied petroleum gas subsidy in order to benefit poor families. In the first year of the programme, approximately 11 million liquefied petroleum gas users voluntarily relinquished their subsidies and enabled the government to provide free connections for 20 million women in families living below the poverty line in rural areas.[31] The success of this campaign demonstrates that while removal of subsidies may be politically unpopular, policymakers may pursue innovative schemes by appealing to people's desire to help others. In Indonesia, a megaproject undertaken from 2007 to 2009 replaced kerosene with liquefied petroleum gas for cooking fuel by gradually eliminating kerosene subsidies and offering families free liquefied petroleum gas cylinders and equipment. The programme ultimately increased the number of liquefied petroleum gas stoves in use from 3 million to 43 million. The ideal solution depends on local perspectives and what will be most well received.

[29] Bedi, Sparrow and Tasciotti, "The impact of a household biogas in East Java".

[30] Khandker, Barnes and Samad, "Who benefits most from rural electrification?"; and Smith-Sivertsen and others, "Reducing indoor air pollution on women's respiratory symptoms".

[31] "PM Narendra Modi to Launch Rs 8,000 crore scheme for free LPG connections to poor", *Economic Times (Mumbai)*, 22 April 2016.

V. Role of the Commission in supporting energy access

51. With the aim of ensuring access to affordable, reliable, sustainable and modern energy for all in Asia and the Pacific, ESCAP provides regional support on energy access issues in intergovernmental processes, research and capacity-building.

52. The work of the Commission has focused on the following: social issues, including gender and inequality; regional cooperation to promote energy connectivity and knowledge-sharing; a comprehensive approach, examining interlinkages between Sustainable Development Goal 7 and the other Sustainable Development Goals; and follow up and review of progress on achieving Goal 7. The present section outlines some of the services that ESCAP provides to member States in support of universal energy access.

53. The work of ESCAP to achieve empowerment, inclusiveness and equality through Sustainable Development Goal 7 benefits from the intergovernmental structure of the Commission, including the Asian and Pacific Energy Forum and the Committee on Energy. In response to the Ministerial Declaration of the Second Asian Pacific Energy Forum,[32] ESCAP is developing the national expert Sustainable Development Goal tool for energy planning, a tool to help policymakers evaluate energy policy options, model different scenarios and make evidence-based decisions about the best pathways forward. ESCAP is currently working with three pilot countries – Bangladesh, Georgia and Indonesia – to develop country-specific projections that will help inform decisions. One of the unique qualities of the national expert Sustainable Development Goal tool for energy planning is that it quantifies interlinkages among the Sustainable Development Goals that affect the demand for and supply of energy.

VI. Conclusions and policy recommendations

A. Maximizing impact and ensuring equity

54. Bundling electrification services with other amenities, services, or plans to improve public amenities, such as information and communications technology, can magnify impact. Electricity access is only as beneficial as the amenities it supports. While electricity is critical to the operation of schools and hospitals, providing service does not guarantee that health care and education will improve. Benefits sometimes have differential impacts by gender. Among children, targeted initiatives may be taken to ensure that girls benefit at least as much as boys, particularly with regard to education. This may take the form of media campaigns to encourage girls' schooling or cash transfer programmes to keep children in school. Similarly, at the household level, to boost economic productivity, the poorest households may be offered subsidized appliances or other benefits.

55. Maintaining and continuing to improve electricity quality is critical to fully realize potential benefits. Evidence has shown that economic and social benefits continue to improve incrementally as electricity quality improves. Ensuring better quality electricity will be critical to fully unleash potential benefits.

56. Selecting technology based on evidence and evaluation can help boost the uptake of clean cooking technologies. Evidence has shown that technology

[32] ESCAP/74/27/Add.1, para 16.

is rarely used exactly as it is intended, and real-life impacts of clean cooking solutions vary significantly from the intended results. Monitoring and researching rural cooking fuel practices would help to better inform policies and programmes for clean cooking uptake. Furthermore, deeper analysis of long-term impacts on health and income would shed light on what types of programmes are likely to be successful.

B. Equitably financing access

57. Bottom-up energy access planning can help meet the needs of those who are most at risk of being left behind. Methods for bottom-up energy demand forecasting give voice to those communities that currently lack access and provide policymakers with better information and data about their needs. Using a participatory process with targeted initiatives to involve women and marginalized groups may help to ensure social inclusion. One option to support bottom-up planning is to include energy-related questions in census surveys. This can help inform policy decisions that meet the unique energy needs of communities that currently lack access.

58. To increase access among low-income populations, subsidies may be directed to benefit those most in need. Current subsidies are often directed toward those who already have access and may disproportionately benefit the wealthy who use more energy. Directing subsidies toward those most in need, particularly in inaccessible rural areas, would contribute toward universal access.

59. Collaboration among Governments, donors, the private sector and civil society organizations can help minimize programming costs while maximizing social benefits. Based on the demonstrated development benefits of access to electricity and clean cooking, Governments may do well to collaborate with donors, private companies and implementers for superior solutions. While national Governments are best placed to incentivize the changes necessary to provide access to new areas, donors can provide funding and protect important development interests, the private sector can find effective least-cost solutions and civil society organizations can provide the grassroots insights to ensure programme success.