

The Economics of Affordability Support for Energy Access

Discussion Paper

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No AI was used in this report.



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Abbreviations

AECF	Africa Enterprise Challenge Fund
BDH	Bono de Desarrollo Humano
BGFA	Beyond the Grid Fund Africa
BGFZ	Beyond the Grid Fund Zambia
CAD	Cadastral Unico
CCA	Clean Cooking Alliance
CCT	Controlled cooking tests
DRE	Distributed renewable energy
EPC	Electric pressure cooker
EU	European Union
EV	Electric vehicle
GDP	Gross domestic product
HS code	Harmonized System Code
IBT	Increasing block tariffs
ICS	Improved cook stove
IEA	International Energy Agency
IFC	International Finance Corporation
LMIC	Low- and middle-income countries
LPG	Liquefied petroleum gas
KEREA	Kenya Renewable Energy Association
KOSAP	Kenya Off-Grid Solar Access Project
KSH	Kenyan shilling
MCFA	Modern Cooking Facility for Africa
MECS	Modern Energy Cooking Services
NEFCO	Nordic Environment Finance Corporation
NSNP	Kenya's National Safety Net Programme
OGS	Off-grid solar
PAYGo	Pay-as-you-go
PMUY	Pradhan Mantri Ujjwala Yojana
PURE	Productive use of renewable energy
RBF	Results-based finance
RVO	Rijksdienst voor Ondernemend Nederland
SDG	Sustainable Development Goal
SHS	Solar home system
SSA	Sub-Saharan Africa
VAT	Value added tax
WTP	Willingness to pay

Executive Summary

This study was commissioned by MECS, IEA and CCA to explore evidence on what affordability means and how it can best be addressed to accelerate access to clean cooking technologies. It draws on evidence from utility scale electricity networks, off-grid electricity access and clean cooking access. Its aim is to summarise the various approaches to providing affordability support mechanisms across the energy access sector and to summarise the range of evidence on the effectiveness of the range of different possible mechanisms.

It identifies and discusses evidence on the effectiveness of 10 affordability support mechanisms. This includes seven supply-side mechanisms which help buy down the cost to serve for companies, resulting in increased service provision to communities that would otherwise not be served, or price reductions for end users. It also includes three demand side mechanisms which do not affect product prices, and instead boost the ability of customers to pay to connect to, acquire, and use energy technologies.

Affordability is driven by both ability and willingness to pay. Ability to pay is often relatively easier to observe, as it can be proxied by income levels or consumptions expenditure. Willingness to pay is much more complex and depends on consumer preferences and on the availability and quality of alternatives. In particular, ability and willingness to pay may be lower in (typically rural) regions where firewood can be freely collected (or for a nominal fee).

Timing matters – customers must be able to afford initial payments, and ongoing usage fees.

Three tenets of affordability must be met for households to be able to sustainably adopt clean cooking technologies: (1) they must be able to afford the upfront cost, (2) they must be able to afford ongoing costs (in general), and (3) they must be able to afford the increment of ongoing costs as they arise – i.e. they must have enough income (or ability to save) at the right point in time to pay for access to fuel / usage which may come in the form of occasional and relatively large payments.

The socioeconomic value of clean cooking will often exceed the internal value of adopting households. Affordability relates only to the value of access to clean cooking which is fully internalised to the household and which can be translated into a monetary value. Other – often highly valuable – outcomes of clean cooking adoption will not affect affordability if they do not result in more income or cash savings to households. This includes environmental externalities such as reduced greenhouse gas emissions which benefit all of us on the planet, but do not directly put cash into the pocket of households to enable them to buy a clean cooking product (unless for example carbon credits are sold and the revenue passed on to households).

While there are commonly used metrics to benchmark affordability, what people are able to pay in practice is highly context specific. Commonly used affordability benchmarks include thresholds such as 5% to 10% of consumption expenditure, or assessments of baseline energy access expenditure on alternative technologies. The former in particular is also commonly used in energy systems models as a proxy for ability to pay and to determine the optimal (least cost, and affordable) technology transition pathways. However, in practice affordability is complex and needs to take into account willingness to pay and stacking of multiple technologies.

The effectiveness of each of the 10 affordability support mechanisms is assessed. Evidence is presented on the impact of the support mechanisms on sustained uptake, distributional impacts, leakage and market developments. It is hard to draw clear conclusions on effectiveness as all these mechanisms can be effective in different contexts.

This research yielded the following overall findings:

- **It is extremely difficult to affordably switch from freely collected biomass to purchased clean fuels, for the poorest households.** Even large fuel subsidies will result in increased expenditure for households that likely have little to spare. Affordability of clean cooking technologies is likely to be more feasible to achieve for a middle customer segment – the poor but not the poorest – it is for this customer segment where there is most potential for (limited size and duration) affordability support mechanisms to drive sustained uptake in clean cooking technologies.
- **Different mechanisms and delivery modalities will be needed depending on the context.** There is no “first-best” solution per country or customer segment. Even within a country there can be different ideal transition pathways per region or income deciles, depending on socio-economic, infrastructural and governance factors.
- **The mechanisms have widely varying magnitudes in terms of their potential impact on affordability and therefore on sustained adoption.** For example, VAT exemptions typically act upon 10-20% of product price at the point of purchase, whereas outcome-based finance can provide revenues of multiple times the product price per year. These figures provide thresholds to the level of support that can be achieved through each mechanism.
- **A key question is who funds affordability mechanisms and who bears pricing risks.** They can be funded through cross-subsidies, government resources or development partners, where the funder bears the cost and risk of the programme.
- **Energy system models are well suited to estimating clean cooking pathways, but less so for designing affordability support mechanisms.** Data on affordability estimates is scarce and it can be difficult to predict uptake behaviour of households, especially as many will continue to stack multiple fuels.
- **Untargeted mechanisms, such as universal price subsidies and preferential tariffs, are likely to benefit relatively wealthier customer segments.** This is because these groups have higher access to and consumption of energy. Therefore untargeted mechanisms will tend to be less equitable, more expensive and less efficient than their well-targeted counterparts. On the other hand, targeted mechanisms may increase complexity and implementation costs, so should not be viewed as a costless silver bullet appropriate in all contexts.

This initial paper identifies ten priority areas for further research:

- Defining affordability in different contexts, and developing better affordability metrics to reflect contextual nuances in willingness to pay.
- A better understanding of what affects willingness to pay, technology stacking, and implications for sustained adoption and usage.
- Generating more datapoints on price elasticity of demand in different contexts, and setting appropriate subsidy levels.
- Differentiating between internalized value to households and external benefits which are valuable but do not make clean cooking technologies more affordable.
- Structured evaluations of the impact of affordability support mechanisms on sustained energy access, and when a subsidy exit plan is feasible (or desirable).

- More published data and studies on the magnitude of delivery costs for different affordability support mechanisms.
- How (short-term or sustained) tax reductions affect the (sustained) uptake of clean cooking solutions, and net fiscal outcomes for governments.
- Developing a decision tree or framework to guide when different subsidy mechanisms should be used, in different contexts.
- Extending the data in existing energy system models to integrate a more detailed understanding of affordability.
- Structured trials to explore the welfare outcomes of conditional energy subsidies, versus unconditional cash transfers.

1. Introduction

Objectives

This report is an initial study as part of a broader research initiative on affordability, and highlights research gaps and further research needs. It was commissioned by MECS, CCA and IEA, to provide an initial review of the current state of knowledge and discusses where further research is needed.

It looks at evidence on affordability of utility scale electricity, as well as both electricity access and clean cooking. The objective is to draw lessons on what affordability means, how it can be assessed, and what affordability support mechanisms can be used to accelerate adoption of clean cooking technologies.

Energy access affordability context

There remains a persistent gap in electricity access and in clean cooking access, particularly in Sub-Saharan Africa. In 2022, the number of people without electricity increased for the first time in over a decade, as population growth outgrew new connections.¹ In Sub-Saharan Africa (SSA), as many people lacked electricity access in 2023 as in 2010 – 565 million people. The SSA clean cooking gap has fallen from 1.8 billion people in 2010 to 1.1 billion in 2023, driven by urbanisation and improvement in urban clean cooking access (up from 9% to 21%); while rural access to clean cooking remains at just 6.5%.²

While the SDG7 indicators measure (binary) access to clean and modern energy, there also remains a gap in moving to higher tier solutions. While much of the gap in energy access – both electricity and cooking – is concentrated in Sub-Saharan Africa, it would be misleading to conclude there is no affordability challenge in other regions. While almost all countries outside Sub-Saharan Africa report near 100% access to an electricity supply that meets the threshold for SDG7 “Tier 1” energy access, there are many parts of the world where that supply remains limited in terms of power available, and especially in terms of reliability. The same is true for clean cooking where there is a spectrum of clean cooking solutions, many of which remain unaffordable to populations even after they have met the binary definition for clean cooking access.

The major barrier to closing the gap is affordability. Energy access is out of reach for a large part of the population; with (unsubsidised) pay-as-you-go (PAYGo),³ 80% of those currently without access to electricity would not be able to afford even a Tier 1 solar home system.⁴ Affordability is the primary barrier to clean cooking uptake too; at current prices adopting a clean cooking solution would exceed 10% of monthly income for nearly 600 million people in sub-Saharan Africa.⁵

Two key differences set apart clean cooking affordability from electricity access affordability. First, in many regions, the alternative to clean cooking is free (or nominal cost) cooking on three-stone fires using traditional biomass sources (such as firewood). This means the transition onto a clean cooking ladder often starts competing against a very low-cost alternative. Second, cooking is

¹ SDG7 Tracking data, [Link](#)

² SDG7 Tracking data, [Link](#)

³ PAYGo allows customers to spread costs over time, as they use their system. It is typically structured with an upfront deposit of 10% to 20% of the price, with the remainder repaid over 12 to 24 months (including the additional cost of effectively providing consumer finance)

⁴ ESMAP (2024) “Off-grid Solar Market Trends Report 2024”, [Link](#)

⁵ IEA (2025) “Universal Access to Clean Cooking in Africa – Progress update and roadmap for implementation”, [Link](#)

a necessity – households across the world cook every day (or almost), so there is no alternative equivalent of just “going without”. Compared to electricity access, there is no real free alternative to provide lighting, and there is an option of households not accessing lighting (or other services that electricity can power) once the sun goes down at least some days each week.

Methodology and structure of this report

This report reviews evidence on the effectiveness of affordability support mechanisms to support energy access. It maps out a representative set of affordability support mechanisms, and assesses their effectiveness in delivering sustained access, including consideration of targeting and delivery approaches. The 10 affordability support mechanisms represent a broad spectrum of supply and demand side mechanisms, although there are many variants and sub-categories within some of those mechanisms; especially on the supply side where there is a wide range of sophisticated ways companies can be financed to boost affordability for end users.

The findings are based on a desk-based literature review supported by six national examples of implementation of affordability support mechanisms. Literature from the energy access and clean cooking space, on an array of affordability support mechanisms, was included. The literature review started from a longlist of pre-identified sources including input from the MECS/CCA/IEA client team. The list was then extended through online searches and by identifying relevant references within the starting longlist of papers. The initial longlist comprised 63 papers, of which 36 were peer-reviewed (or under review), and 27 were grey literature. Each paper was mapped against criteria relevant to the sections of this report, i.e. to identify how affordability was assessed, what affordability support mechanisms were described, and what evidence there was on effectiveness and distributional impacts. The reference list was subsequently expanded to help fill information gaps to a total of 191 sources, including news articles, industry reports and databases. Finally, alongside the literature review, six national case studies are included to highlight practical experience of measures seeking to address affordability barriers to provide sustained access to clean and modern electricity, or cooking.

The remainder of the report is structured as follows:

- **Section 2** presents a discussion on how affordability is assessed in energy access contexts.
- **Section 3** shows the categorisation of affordability support mechanisms.
- **Section 4** discusses the effectiveness of these mechanisms and targeting approaches.
- **Section 5** sets out implementation considerations.
- **Section 6** sets out the broader finances of affordability support.
- **Section 7** lists the data availability and energy system modelling capacity.
- **Section 8** summarises the key research findings and research gaps.

2. Affordability in Energy Access Contexts

Affordability is a nebulous concept with no one-size-fits-all definition. What people pay for a product or service depends on their willingness to pay; that is the (subjective) value of that product or service to them. A major driver of willingness to pay is of course ability to pay – you cannot be willing to pay money that you do not have. In the context of energy access this is especially relevant; households in nations with higher GDP are more willing to pay for higher quality energy access such as full grid connections, electric appliances, and cleaner cooking using gas and electricity.

As nations get richer, they naturally transition to cleaner cooking technologies. While 79 countries have made a full or almost complete transition to clean cooking,⁶ 121 remain at least to some extent dependent on polluting cooking fuels.⁷ The countries that have completed the transition have an average annual GDP per capita of \$40,000, compared to \$4,300 for countries still in transition.⁸ Countries with above average energy subsidies (such as for LPG which is used for cleaner cooking technologies) tend to achieve clean cooking adoption at lower income levels.⁹

This remainder of this section is as follows: it first defines the key tenets of clean cooking access (Section 2.1), then the commonly used benchmarks for affordability (Section 2.2), then the implications of fuel stacking for affordability assessments (Section 2.3). Section 2.4 then discusses evidence on the price sensitivity of households for energy access technologies.

2.1. Affordability tenets

Access to clean cooking relies on households being able to afford both the initial cost of access to cooking technologies, and the ongoing usage costs. This can be summarised as three tenets of affordability, all of which need to be addressed for sustained adoption of clean cooking (Table 1).

Table 1: The three tenets of clean cooking affordability

	Tenet	Possible solutions
	Tenet 1 – upfront cost. The first barrier is the initial cost of acquiring the new technology. This could be a connection fee to infrastructure, or the cost of purchasing new equipment such as cookers or stoves, and any accessories needed to use them.	Spreading upfront payments, such as through the PAYGo business model, providing highly subsidised equipment and recovering the costs through ongoing usage charges, or on-bill finance such as the Kenya Stima loan where the consumer can finance the connection cost.
	Tenet 2 – ongoing cost. The second barrier to sustained adoption is the cost of usage, such as purchasing LPG cylinder replacements/refills, improved biomass pellets, or electricity unit tariffs.	Subsidies, which could be temporary to cover initial adoption (such as the PMUY programme in India where beneficiaries received an advance payment to fully cover the price of one LPG cylinder refill), or permanent to bridge a long-term affordability gap such as long-term LPG subsidies.

⁶ “Almost complete” means here that less than 2% of the population has a primary reliance on polluting fuels and technologies.

⁷ Noting different reports have slightly different methodologies to define and estimate clean cooking access and are not always comparable across different sources. Here, the purpose is to show the (broad) scale of the clean cooking transition and what this means in terms of the need for and design of affordability support mechanisms.

⁸ WHO (2023) “Cooking fuels: population with primary reliance on polluting fuels and technologies for cooking, proportion (%)”, [Link](#) and World Bank (2023) “GDP per capita (current US\$)”, [Link](#)

⁹ Pengwern Associates (2025) “Ensuring the Sustainability of Clean Cooking Programs: Identifying good practices in subsidy provision”, [Link](#)



Tenet 3 – ongoing cost – transaction size and timing. The third barrier is matching purchase increments to income. In low-income contexts, occasional high costs may deter clean cooking usage compared to more frequent lower costs.

e.g. smaller LPG cylinders, metered LPG cylinders, PAY-Grow for solar irrigation to allow farmers to overpay around harvest seasons.

Source: Greencroft Economics

The first tenet (upfront cost) comprises (1) connection costs to infrastructure and (2) the cost of acquiring appliances. These costs are often (but not always) borne by different parties. For example, for e-cooking customers typically bear the cost of buying electric cooking appliances, while governments are often responsible for providing connections to the national electricity grid.

For the third tenet (transaction size), and to a certain extent the first tenet (upfront cost), the barrier is liquidity rather than ability to pay. The hypothesis is that households would be willing to pay to adopt and use the technology, but they are unable to save or access affordable consumer finance to purchase them given the large transaction amounts. Because either their income is irregular throughout the year (for example related to harvest seasons), or because ongoing costs are in occasional large increments, usage cannot always be paid out of e.g. weekly income and would require households to save up to pay for even ongoing usage. One solution is to spread payments, potentially with flexibility for over- and under-payments to match when they have income. However, doing so unavoidably raises costs, as it requires both more expensive technologies, and for companies to raise bridge finance to cover the gap between when they incur costs (upfront) and when they recover revenues (later, also with non-payment risk). This results in a price premium that tends to disproportionately affect poorer, more marginalised consumers.¹⁰

Liquidity constraints for upfront costs seem to be more important than for ongoing costs.

Multiple studies have found the upfront cost of equipment to hinder LPG adoption.^{11,12} Research on pay-as-you-go (PAYG) LPG pilots showed that the PAYG business model succeeded in making LPG affordable to those who otherwise were unable to afford the transition to the fuel. Metered data sets showed small, frequent fuel purchases that mirrored the purchasing patterns of charcoal, suggesting that the simultaneous addressing of upfront cost and transaction size can be critical to the technology's success.¹³ However, a study in Tanzania that experimented with a savings lockbox for LPG refills found it had no impact on the frequency of charcoal or LPG use.¹⁴

2.2. Affordability benchmarks and frameworks

2.2.1. How to measure affordability

Affordability is multidimensional and measuring affordability relies on being able to estimate ability and willingness to pay, as well as applying the affordability tenets introduced above. A technology that looks affordable based on ability to pay may fall short on willingness to pay, while a potential customer may in principle value a service enough to be willing to pay, but struggles to save up to meet a high upfront cost (tenet 1), or to make occasional large payments (tenet 3).

¹⁰ Perros et al. (2024) "Towards responsible and fair pay-as-you-go energy access in sub-Saharan Africa", [Link](#)

¹¹ Gould & Urpelainen (2018) "LPG as a clean cooking fuel: Adoption, use and impact in rural India", [Link](#)

¹² Giordano et al. (2018) "Fuelling the change: The journey from biomass to modern source", [Link](#)

¹³ Perros (2022) "The potential for pay-as-you-go liquefied petroleum gas to accelerate access to clean cooking in Rwanda and Kenya", [Link](#)

¹⁴ Gill-Wiehl et al. (2025) "Deconstructing the (un)affordability of clean cooking fuels through a randomised controlled trial in rural Tanzania", [Link](#)

While ability to pay is often relatively easy to observe or proxy, willingness to pay is much more complex. Households do not decide what goods and services to purchase based on their income level and on prices alone. Willingness to pay depends on a wide range of factors including convenience, and the quality of the product (e.g. taste of food, types of food being cooked, safety of preparation). Willingness to pay of course depends on the price of available alternatives – including when there may be free (or near free) alternatives such as gathering biomass. Finally, risk also matters; a household may be willing to adopt and use LPG if prices are guaranteed to be kept low, but not prepared to take the risk of facing free-market commodity prices.

The affordability of a product, and the socioeconomic value of a product, can be far apart.

Affordability is an internal consideration to a household, based only on their (financial) ability and willingness to pay for a product. The socioeconomic value of that same product could be very different, due to factors not internalised in this decision-making process. For example, benefits which accrue to others beyond the household unit such as reducing degradation of the local environment or decreased global greenhouse gas emissions; since the household does not retain (all of) these benefits, they will be undervalued in their willingness to pay. Even benefits which the household does retain may not be fully reflected in willingness to pay, especially where they accrue in the (distant) future, where there is significant uncertainty, or where the benefits may be valuable but not monetizable, such as improved long-term health. This higher socio-economic value is a justification for use of public funding to ensure these benefits are factored into a household's choices.

2.2.2. Examples of (partial) affordability metrics

A representative threshold of 5% to 10% of consumption expenditure is often used as a benchmark for affordable energy expenditure (as a proxy for ability to pay). This threshold of consumption expenditure should include both the upfront and ongoing costs; for example, the IEA measures affordability as the ratio between the cost of a stove plus one year of fuel to household income.¹⁵ The 5% threshold is often used to define energy poverty in richer nations, and often varies widely in practice; the first 15 members of the EU spend on average 4% on energy, whereas for newer member states the average is over 10%.¹⁶

In Sub-Saharan Africa, almost half the population would need to spend more than the 10% of their annual income to adopt clean cooking.¹⁷ Affordability varies significantly by fuel type; LPG is affordable and available for half of the population, and electricity for nearly 40%. This depends highly on geography, where LPG is most affordable in coastal zones, and electricity typically concentrated around capital cities. Improved cookstoves are the most affordable technology, and are in reach for 82% of households.¹⁸ For households that purchase fuel, higher efficiency stoves can yield fuel savings and a switch to clean cooking pays off over the lifetime of the stove. However, rural households that collect free biomass fuel do not experience monetary savings, and households do not always highly value time savings or longer term health benefits.¹⁹

Actual expenditure on energy access varies widely in lower-income countries. In Tanzania household expenditure on fuel averages 5%, In Indonesia households spend 3% of monthly

¹⁵ IEA (2025) "Universal Access to Clean Cooking in Africa: Progress update and roadmap for implementation", [Link](#)

¹⁶ Deller & Waddams (2015) "Affordability of utilities' services: extent, practice, policy – Research Paper 2: Utility Affordability in the EU, Based on Eurostat and ITU Data", [Link](#)

¹⁷ IEA (2025) "Universal Access to Clean Cooking in Africa: Progress update and roadmap for implementation", [Link](#)

¹⁸ IEA (2025) "Universal Access to Clean Cooking in Africa: Progress update and roadmap for implementation", [Link](#)

¹⁹ IEA (2025) "Universal Access to Clean Cooking in Africa: Progress update and roadmap for implementation", [Link](#)

expenditure on LPG (the primary cooking fuel), whereas in Ecuador it is only 0.5%.^{20,21,22} In India, a rural household spent 7% of their monthly income on LPG when it was subsidised, which would rise to 9% with the removal of subsidies.²³ For poorer population segments, expenditure on energy can be significantly higher; comprising up to 20% of household budgets.²⁴ This is true in European countries where poorer segments have such a high burden, such as in Poland and France.²⁵

In developing economy settings, affordability may be better assessed by reference to current expenditure on energy access. This is a proxy for ability to pay, and a lower bound for willingness to pay. This is the common definition adopted by those in the pay-as-you-go LPG sector, who purposefully set their fuel margins to undercut the cost of cooking with charcoal.²⁶

There is no clear understanding of what constitutes an affordable transition to clean fuels for rural agrarian households currently cooking with freely-gathered biomass. For this reason, clean cooking transitions often start with improved cookstoves in rural areas, which continue to use free biomass as their fuel. However, this is at odds with longer term clean cooking ambitions; for example the IEA's 2050 vision for clean cooking does not include any charcoal or wood use.²⁷ Switching to clean fuels is extremely challenging in poor rural communities where the opportunity costs of spending time on cooking / collecting fuel are often not highly valued (due to a relative abundance of labour, limited employment opportunities and undervaluation of women's time).²⁸ Nonetheless, policy makers estimate large benefits from switching to cleaner fuels, with for example 1.5 million fewer premature deaths annually, 1.5 hours of time saved daily, and reduced greenhouse gas emissions of 1.25 Gt CO₂-eq annually.²⁹ However, as noted above, high socioeconomic value does not translate into affordability, if the benefits do not accrue as financial benefits to households.

2.3. Fuel stacking

Fuel stacking is important in maintaining affordability and contributes to household resilience.

In many households, especially in low- and middle-income countries (LMICs), it is the reality of how people cook, and a transition to clean cooking is rarely complete, as polluting fuels continue to be used alongside clean fuels.³⁰ Fuel prices can vary enormously across regions and across time, as demonstrated for example in Nairobi in Figure 1, where the cost of cooking with LPG varied from 340 to 580 KSH (71%) between 2019 and 2023, at times being the cheapest clean fuel and at others the most expensive.³¹ This underlines how both global events and local policies can have a major

²⁰ Tunguhole et al. (2025) "Household cooking energy transition in Tanzania: The interplay between energy accessibility, affordability and reliability in the shift to clean fuels", [Link](#)

²¹ Thoday et al. (2018) "The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion", [Link](#)

²² Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

²³ Mani et al. (2021) "State of Clean Cooking Energy Access in India", [Link](#)

²⁴ Berkhouwer & Dean (2019) "Credit and attention in the adoption of profitable energy efficient technologies in Kenya", [Link](#)

²⁵ Antunes et al. (2023) "Energy affordability across and within 26 European countries: Insights into the prevalence and depth of problems using microeconomic data", [Link](#)

²⁶ Perros et al. (2024) "Stakeholder perspectives on the future of clean cooking in sub-Saharan Africa and the role of pay-as-you-go LPG in expanding access", [Link](#)

²⁷ IEA (2023) "A Vision for Clean Cooking Access for All", [Link](#)

²⁸ Rehfuess et al. (2014) "Enablers and barriers to large-scale uptake of improved solid fuel stoves: A systematic review", [Link](#)

²⁹ IEA (2025) "World Energy Outlook 2025", [Link](#)

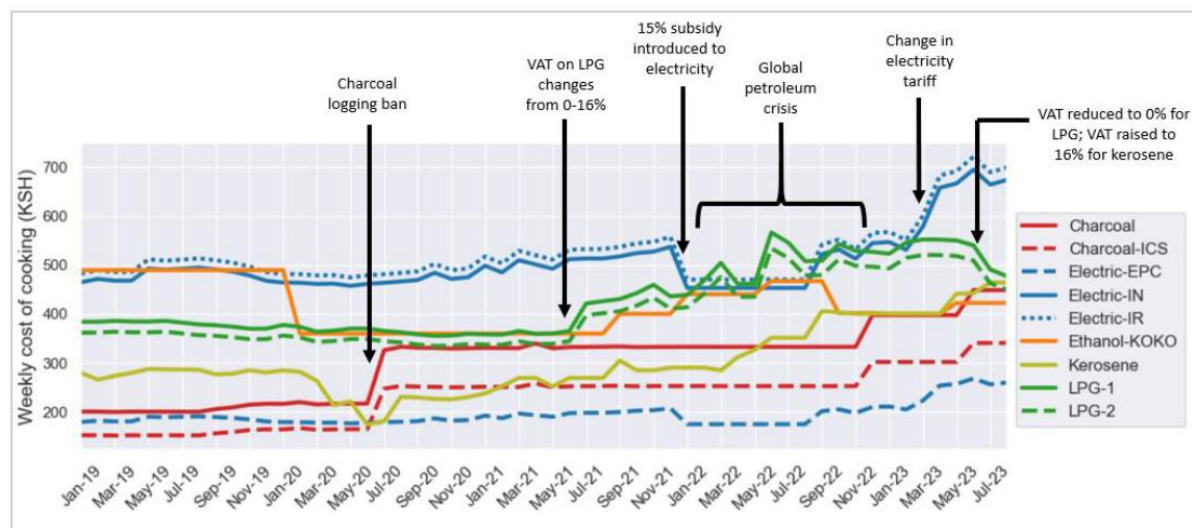
³⁰ Shankar et al. (2020) "Everybody stacks: Lessons from household energy case studies to inform design principles for clean energy transitions", [Link](#)

³¹ Perros et al. (2023) "Controlled cooking tests comparing the financial, energy and time costs of different food and stove combinations in Nairobi, Kenya" [Link](#)

impact on the affordability of different solutions. Stacking multiple technologies allows households to continue to cook even if one fuel surges in price.

Many affordability assessments and models such as controlled cooking tests (CCTs) implicitly assume a complete switch from previous cooking methods. This misses the nuances of fuel stacking and risks overstating budgets available for clean cooking adoption. A forthcoming analysis of cooking practices in Kenya finds that while exclusive use of induction stoves would increase the overall cost of cooking for most Kenyan consumers, partial adoption would save money.³²

Figure 1: Fluctuations in weekly cost of cooking fuels, Kenya, 2019-2023



Source: Perros et al. (2023) [Link](#)

2.4. Price sensitivity of households for energy access technologies

The extent to which affordability support mechanisms are likely to be effective depends on sensitivity to price changes. When affordability is the primary barrier, the magnitude of required changes to prices across all three tenets to result in sustainable technology adoption are unknown and likely to be highly context-specific.

A key nuance that separates the price sensitivity of clean cooking and electricity access is that all households cook every (or most) days. In general, cooking is an activity that households will undertake, whereas access to lighting and electrical appliances is not a necessity in the same way. So, expenditure on clean cooking either substitutes previous spending on other cooking technologies, or means an increase in spending on an activity that would have been carried out at less expense. Electricity access is somewhat different, in that it often represents an increase in use of lighting, radio, or electrical appliance usage that would not have occurred prior to access to a clean and modern electricity technology. While households will often be using other forms of lighting (candles, kerosene) or paying to charge their phone, this can often be more easily reduced when needed and may not represent a consistent daily activity in the way cooking does.

Price elasticity of demand for energy is not a constant single number and depends both on the technology and the consumption level of households. Price elasticity – that is the sensitivity of demand for a product – is not constant (except in very rare circumstances), and will vary as a

³² Perros (2026) "Kenya eCooking Price Parity Project", under review

product penetration increases. Customers may be very price sensitive at low consumption levels, and then much less responsive to price changes at higher consumption levels, or vice versa.

There appears to be higher price elasticity for the initial connection or acquisition of an energy source. Adoption of improved cooking solutions is often low initially because demand is very price sensitive, especially among the poor. This is caused by liquidity constraints exacerbated by variable incomes and uncertainty about the new option.^{33,34,35} Similarly, the price elasticity of demand for solar home systems kits with a television is substantially more elastic than for entry-level solar energy kits, as they are more of a luxury good.³⁶

Price elasticity for ongoing usage appears to be relatively lower.³⁷ Demand for clean fuels among higher income households that have (at least partially) transitioned to cleaner fuels is highly inelastic, such that they capture a larger share of energy subsidy benefits than those poorer households with elastic demand.³⁸ Demand for electricity usage is also often relatively inelastic, since households use energy to meet defined needs, and do not necessarily increase usage when access is cheaper. Electricity usage appears to be highly price inelastic and cross price elasticities with alternative energy sources are non-significant.³⁹ This is because households, once they have access to an electricity connection, tend to use it only for what they need – so price reductions may not increase consumption significantly (but instead deliver savings to users).⁴⁰

Elasticity is however relatively higher between competing cooking technologies. The demand for cleaner cooking can be highly price elastic, especially where there are free or cheap substitutes such as firewood, charcoal, and kerosene. Compared to the electricity example given above, kerosene use is much more sensitive to pricing, while firewood and charcoal are much less price sensitive,⁴¹ probably as these are used as a baseline so demand is more driven by the prices of (higher tier) alternatives.

The evidence on the relationship between fuel price and stove uptake is mixed. For example, when ATEC piloted providing usage-based rebates to induction stove customers in multiple markets under their cook-to-earn (C2E) model (see Case Study 1),⁴² they found that enrolling new customers in C2E resulted in 38% higher usage in Bangladesh and 56% higher usage in Cambodia. The effect was smaller for existing customers, with C2E boosting usage by 21% in Bangladesh and just 1% in Cambodia. ATEC hypothesised that the larger effect sizes in Bangladesh may mirror the larger relative size of the rebates. The 2021 spike in global LPG prices led to backsliding to use of charcoal and firewood in Nigeria, Rwanda, Brazil, Vietnam and Kenya.⁴³

³³ Das et al. (2022) "Taxes and Subsidies and the Transition to Clean Cooking: A Review of Relevant Theoretical and Empirical Insights", [Link](#)

³⁴ Gill-Wiehl et al. (2021) "Is clean cooking affordable? A review", [Link](#)

³⁵ Practical Action (2023) "Can market mechanisms facilitate energy access for people living in extreme poverty? Findings and recommendations", [Link](#)

³⁶ Fetter & Phillis (2019) "The True Cost of Solar Tariffs in East Africa", [Link](#)

³⁷ Pueyo et al. (2013) "The Evidence of Benefits for Poor People of Increased Renewable Electricity Capacity: Literature Review", [Link](#)

³⁸ Das et al. (2022) "Taxes and Subsidies and the Transition to Clean Cooking: A Review of Relevant Theoretical and Empirical Insights", [Link](#)

³⁹ Pueyo et al. (2013) "The Evidence of Benefits for Poor People of Increased Renewable Electricity Capacity: Literature Review", [Link](#)

⁴⁰ Qeque et al. (2022) "The Relationship between Electricity Prices and Household Welfare in South Africa", [Link](#)

⁴¹ Pueyo et al. (2013) "The Evidence of Benefits for Poor People of Increased Renewable Electricity Capacity: Literature Review", [Link](#)

⁴² ATEC & MECS (2023) "Paying people carbon credits based on usage data", [Link](#)

⁴³ Perros & Shupler (2022) "Gas prices: as cooking fuels become more expensive, people are turning to dirtier alternatives", [Link](#)

3. Affordability Support Mechanisms

3.1. Categorisation of affordability support mechanisms

We categorise affordability support mechanisms as either supply-side or demand-side mechanisms. The structure below splits the mechanisms according to the following definitions (noting different stakeholders may use different definitions), while Table 2 presents a list of overarching affordability support mechanisms, many of which have sub-categories.

- Supply side subsidies: which increase the accessibility of products into new areas and/or reduce their price, by lowering the costs of supply such that providers offer lower prices than they would otherwise have been able to do.
- Demand side subsidies: which do not impact on the price of the service but boost the customers' ability to pay for those services.

This distinction is used here as it may matter in terms of consumer expectations and behavioural change. In one mechanism – supply side subsidies – customers do not face (and do not see) the cost-reflective price, as the price has been lowered by the affordability support mechanism. In the other – demand side subsidies – they do see the cost-reflective price but their ability to pay that price is enhanced by a transfer to the consumer.

Each of the mechanisms have a range of delivery mechanisms, which would have different pre-requisites. For example, for 'D1 – cash transfers', could be delivered as physical cash, bank transfers, mobile money payments, vouchers (e.g. Peru LPG subsidies),⁴⁴ or pre-paid cards (e.g. El Salvador where LPG subsidies were delivered to pre-paid cards).⁴⁵ On-bill financing may be an option for customers with a recurring bill (e.g. to a utility company), and could be used to spread customer payments or offer bill reductions in reward for adoption or usage patterns (D2 and D3).

Table 2: Supply and demand side affordability support mechanisms

Type	#	Support mechanism
Supply side	S1	Concessional corporate finance
	S2	Tax reductions and exemptions
	S3	Outcome-based revenues / finance
	S4	Price caps
	S5	Universal price subsidy
	S6	Preferential tariffs
	S7	Subsidised common infrastructure
Demand side	D1	Cash transfer (ex ante)
	D2	Rebates (ex post)
	D3	Concessional consumer finance

Source: Greencroft Economics

⁴⁴ IISD (2016) "International Experiences With LPG Subsidy Reform", [Link](#)

⁴⁵ Kojima (2021) "Subsidised bottled gas: Approaches and effects on household use", [Link](#)

3.1.1. Supply side

S1: Concessional corporate finance (e.g. grants or concessional loans)

This affordability support mechanism encompasses a range concessional finance provided to companies to reduce their cost to serve. It includes any concessional finance prior to deployment of systems; from non-refundable grants, to concessional debt or equity, to de-risking mechanisms such as guarantees. Within the scope of this paper we do not unpick the many ways a company can be financed.⁴⁶ As illustrative examples, this would include the non-reimbursable grants for innovation and scale up provided by, for example, AECF Africa and EEP Africa, the upfront components of some RBF programmes such as BGFA's award of up to 30% upfront for some companies to help them prepare to scale (which are accompanied by the remaining 70% as post-sale RBF, i.e. S3), to concessional loans such as the IFC loan in Colombia to connect an estimated 35,000 families to the natural gas distribution network.⁴⁷

S2: Tax reductions and exemptions

Reductions in or exemptions from taxes such as VAT, import duty, excise duties etc. are a common tool to reduce the cost to serve of companies. They are a common mechanism used to keep prices of essential goods and services low, with many regimes offering lower rates of VAT or zero-rating certain product categories. They are sometimes applied to energy access products, although not consistently and, even within a jurisdiction, policies can change quickly.

Since 2024, seven countries made changes to their VAT or tariffs for clean cooking equipment or fuel. Kenya reduced its VAT on denatured bioethanol to zero in 2025. Nigeria exempted LPG and biogas – along with related equipment such as conversion kits, biogas digesters, compressors, and clean cooking accessories – from VAT. Uganda removed VAT from biomass pellets and from bioethanol and ethanol stove components, and Tanzania has announced plans to lower taxes and levies on clean cooking appliances and energy-efficient stoves.⁴⁸

S3: Outcome-based revenues/ finance

These are revenue sources accruing to energy access providers post-sale, based on products or services delivered. They are different from S1 in that: (1) they do not typically come with a stake in the company or recourse, and (2) payment is only made after the product or service is delivered. The most common forms of such finance are results based finance (RBF) programmes, and carbon credit revenues. There are many examples of such mechanisms from the energy access sector, including EnDev RBF for standalone solar and clean cooking in many countries, carbon credit programme where payout is based on emissions reductions, and BGFA and MCFA results-based finance. There are other payment-for-outcome models emerging, with payments made for example for delivering defined environmental or social outcomes.⁴⁹

Clean cooking carbon credits have been growing, with most issues in Sub-Saharan Africa. A rapid analysis from UC Berkeley's Voluntary Registry Offsets Database shows 344 projects with a clean cooking component with 53 million credits issued between 2011 and 2025. Carbon credit

⁴⁶ For more discussion and examples of concessional finance to energy access companies see for example: Lighting Global / ESMAP (2024) "Designing Responsible End-User Subsidies for Energy Access", [Link](#); ESMAP (2020) "Funding the Sun: New Paradigms for Financing Off-Grid Solar Companies", [Link](#);

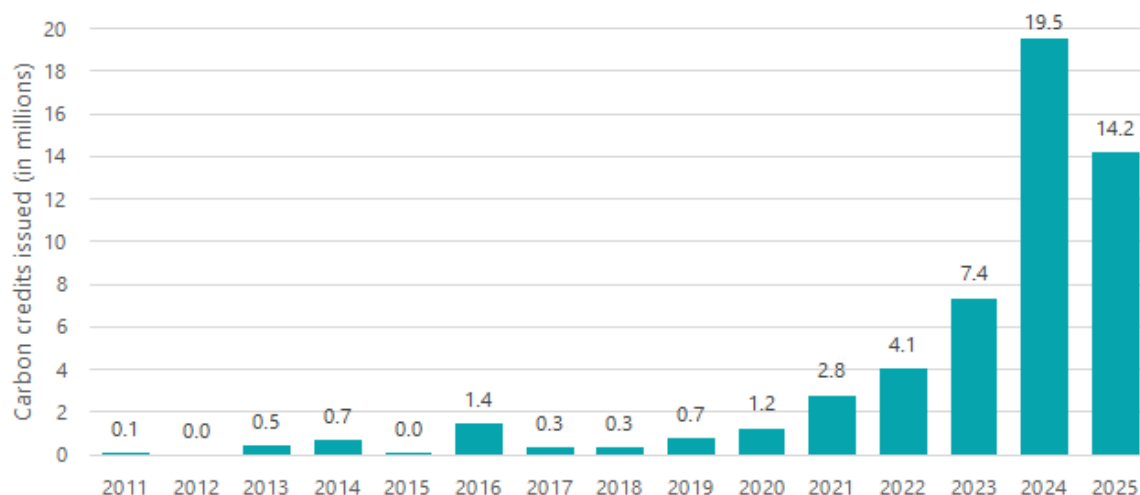
⁴⁷ The Global Partnership on Output-Based Aid (2010) "Annual Report 2009", [Link](#)

⁴⁸ IEA (2025) "Universal Access to Clean Cooking in Africa: Progress update and roadmap for implementation", [Link](#)

⁴⁹ For example Osprey Foundation as the outcome purchaser for Sistema.bio's "clean impact bond", which also enabled it to raise ex ante financing (S1) from DFIs. Mote information at IFC (2023) "Clean Impact Bond: Mobilizing Finance for Clean Cooking", [Link](#)

issuances have grown steadily year-on-year since 2018, and more than doubled between 2023 and 2024 (Figure 2). India had the highest number of projects by country (14%), but the total number of credits only represents 8% of total credits issued. 79% of credits were issued in Sub-Saharan Africa. In the region, Mozambique, Kenya and Nigeria had the highest absolute number of projects but most credits were issued in Rwanda and South Africa.

Figure 2: Clean cooking carbon credits issued



Source: Greencroft Economics based on UC Berkeley (2025) "Voluntary Registry Offsets Database v2025-10", [Link](#)
 Note: The data is updated until October 31, 2025.

S4: Price caps

Price caps are a supply-side tool where the price offered to end-users is capped. Consumers face the capped price; they do not see the (pre-subsidy) cost-reflective price. The funder covers the difference between the capped price and the market price. Price caps can be administered to upfront or ongoing costs. In the former, the upfront cost of stoves/appliances or connection can be capped, and can even be provided for free to boost uptake (in which case the price is capped at zero). The price of ongoing costs can also be capped, which then works in a similar way as universal or preferential price subsidies (see the two sections below). In the case of ongoing usage price caps, the policy objective is often to shield customers from external commodity price volatility (e.g. global LPG prices), instead transferring this risk to the government (or other external subsidy provider).

S5: Universal price subsidy

Universal price subsidies are price discounts on ongoing costs for the whole population. These are costly as all consumers are eligible and they can be in place for a long time; a significant financial burden that is politically difficult to remove. These are widely used in developing regions, with universal price subsidies on fuels such as petrol, diesel and LPG (including examples of LPG subsidies to boost clean cooking in India, Indonesia and Ecuador).

S6: Preferential tariffs

Preferential tariffs consist of charging lower prices for certain groups of people. This approach is common in utility-scale electricity, where many utilities offer "lifeline tariffs", initial "free block" tariffs, or discounts based on income levels / or for recipients of social security. For example, Brazil offers lower tariffs for electricity for households with low-incomes or protected characteristics under

its 'social tariff' programme (see Case Study 2). In France and Belgium, there are preferential electricity tariffs for low-income households (financed through cross-subsidy). In Rwanda, clean cooking company Inyenyeri charges urban customers full price for improved cookstoves and fuel, but provides stoves for free to rural consumers in return for a commitment to supply Inyenyeri with fuel feedstock.⁵⁰

S7: Subsidised common infrastructure

This category refers broadly to subsidies provided to establish affordable access to common infrastructure. This means subsidising parts of the value chain which multiple upstream or downstream companies share access to.

The energy transition in mature markets (e.g. Europe and the US) has been underpinned by public sector infrastructure development and subsidies. In the UK much of the common infrastructure for water, energy, and telecoms networks was initially established with substantial public funding. The National Grid operates the electricity transmission grid across England and Wales, while the remainder of the sector has been unbundled such that upstream power generating companies can sell into the main grid, while downstream retailers can draw power from the grid to sell to customers. There are now 23 domestic retailers and 72 business retailers.⁵¹ In the telecoms sector the backbone fibre network is owned and operated by a few large companies, e.g. BT Openreach and Virgin Media that almost reach 20 million households each, and a handful of much smaller independent ones that reaches between 250,000 and 4 million premises.⁵² A wide range of almost 300 retailers can then pay to access to sell broadband and telecoms services.⁵³

In the energy access space and clean cooking there are many examples of common infrastructure which benefits from some form of public funding. The Indonesian government financed LPG import terminals, bottling plants, cylinder distribution, and last-mile delivery.⁵⁴ The Indian government financed LPG infrastructure through state owned companies including import terminals, over 200 bottling plants, and a vast distribution network. In Brazil, universal electricity access was achieved through a \$7 billion grid extension programme, paid for by federal government;⁵⁵ this itself building out from a core electricity infrastructure initially developed by the state and paid for with public funding. An emerging energy access segment that benefits from public subsidies for common infrastructure is charging infrastructure for electric vehicles, for which governments in countries such as Norway, the US and the UK have provided billions of dollars.

3.1.2. Demand side

D1: Cash transfer (ex ante)

One way to boost ability to pay is to provide a pre-purchase transfer. This could be conditional (i.e. with limits on what it can be spent on), or unconditional, and could be administered in a variety of ways from cash, to bank transfers, to mobile money, to redeemable vouchers. Examples of an unconditional cash transfer include the UK winter fuel allowances, where all eligible households receive a cash transfer, irrespective of whether they spend it on winter fuel. An example of a

⁵⁰ Clean Cooking Alliance, "Inyenyeri", [Link](#)

⁵¹ Ofgem (2025) "State of the market report: Energy retail markets highlights", [Link](#)

⁵² Choose (2025) "Fibre networks in the UK", [Link](#)

⁵³ Ofcom (2026) "Register of persons with powers under the Electronic Communications Code", [Link](#)

⁵⁴ WLGA (2024) "Continued Success in Indonesia Transitioning to LPG New Sectors Targeting Fishing and Farming", [Link](#)

⁵⁵ World Access to Modern Energy, "Luz para todos", [Link](#)

conditional cash transfer is Peru, where households receive a monthly fee for a first LPG refill, which can be redeemed through mobile phones.⁵⁶

D2: Rebates (ex post)

Another way to boost ability to pay is to offer rewards after the acquisition of equipment or to reward ongoing consumption patterns. For example, India's LPG bank transfer policy; benefits are transferred directly to a household bank account after the delivery of the refilled LPG cylinder.⁵⁷ Another example would be ATEC's cook-to-earn tariffs where customers receive a rebate based on usage of their electric cooker,⁵⁸ or Uganda's e-cooking tariff where households get an on-bill rebate based on their electricity usage.⁵⁹

D3: Concessional consumer finance

A third way to boost ability to pay would be to offer subsidised loans to customers to support their purchase or ongoing usage.: For example, Kenya Power's Stima Loan offers low-income households to spread the cost of the initial connection fees in instalments made via the utility's billing system.⁶⁰ There are many examples of such consumer financing initiatives across the world, summarised in the Energy Saving Trust Paper "The Road to Zero Interest".⁶¹

3.2. Targeting

Another consideration for affordability support mechanisms is how they are targeted. This is especially the case for the demand side subsidies (D1, D2, D3) and conditional supply side subsidies (in particular S3 RBF, and S6 preferential tariffs). This sub-section discussion how affordability support mechanisms can be targeted to reach specific customer segments, and the pros and cons of doing so (i.e. the trade off between higher efficiency from directing subsidies to those most in need, against the transaction costs of administering the targeting approach).

In principle, the more a subsidy can be targeted the better. In the same way that (from a provider's perspective) they would ideally charge each individual customer exactly what they are willing to pay and thereby capture all of the consumer surplus, the better an affordability subsidy can be targeted, the less costly it will be.

There is a trade-off between reaching targeted populations more effectively, and the cost and complexity of the subsidy. In ESMAP's design framework targeting is the first step in designing a subsidy, following by setting the subsidy level (which depends heavily on which population is targeted), delivery, verification and exit strategy.⁶² However, there is very little information available on the costs of targeting subsidies.

However, perfect targeting is often not feasible for practical or ethical reasons, or would be too costly to implement. It is not possible to know with certainty the ability and willingness to pay of all customers, and, even if it was there may be ethical considerations and reputational risks around

⁵⁶ IISD (2016) "International Experiences With LPG Subsidy Reform", [Link](#)

⁵⁷ ClearTax (2025) "PAHAL (DBTL) Scheme: Objectives, Benefits, Subsidy Amount, How to Apply Online", [Link](#)

⁵⁸ MECS (2023) "Paying people carbon credits based on usage data: ATEC eCook Cook-to-Earn Case Study", [Link](#)

⁵⁹ Electricity Regulatory Authority (2025) "ERA's Cooking Tariff: A Gentle Flame of Hope for Uganda's Women", [Link](#)

⁶⁰ MECS (2023) "Driving Kenya's eCooking and eMobility revolutions with digital utility-enabled financing", [Link](#)

⁶¹ Energy Saving Trust (2023) "The Road to Zero Interest: The Potential Role of Concessional Consumer Financing in Energy Access", [Link](#)

⁶² ESMAP (2024) "Designing Responsible End-User Subsidies for Energy Access: A toolkit featuring case studies for the design of subsidies in off-grid solar and clean cooking", [Link](#)

over-tailoring a subsidy. Furthermore, the cost of implementing a complex subsidy (or price) differentiation will often outweigh the benefits.

There are five main ways affordability mechanisms could be targeted, set out in Table 3.

Table 3: Affordability support targeting mechanisms and examples

	Targeting type	Examples
	Income or poverty levels. Based on data about household income or poverty status.	In Rwanda, EnDev's RBF offered subsidised off-grid solar products with the subsidy level based on Ubudehe categories, which are the GoR's household socio-economic categories. ⁶³
	Social security registers. Based on households receiving social security / welfare.	Indonesia is targeting fuel subsidies based on their database for social protection programmes. ⁶⁴ In Kenya, an off-grid solar end-user subsidy is integrated with the existing cash transfer system under the Government of Kenya's National Safety Net Programme (NSNP). ⁶⁵
	Geographic location. Eligibility assessed at regional level based on e.g. income levels or other factors	The World Bank off-grid solar KOSAP project in Kenya which targets 14 underserved counties through a combination of results-based financing (RBF) and local currency working-capital financing. ⁶⁶ An off-grid solar RBF in Mozambique used a vulnerability access index and some companies received catalytic grants to expand into new regions and harder-to-reach areas. ⁶⁷
	Customer observables. Specific groups (e.g. women, disabled, youth), or characteristics (e.g. prior fuel usage, asset ownership),	A conditional cash transfer programme in Mexico used a targeting mechanism based on a myriad of characteristics, such as literacy rate, education, access to health services, electricity access, and household income. ⁶⁸ India's PMUY programme only targeted women from poor households. ⁶⁹
	Self-selection. Differential packages and tariffs offered so that customers "select" into a subsidised offer.	Higher subsidies for low-tier energy access products only, or differential tariffs based on usage levels. For example, pricing the smaller 3-kg cylinders lower than the 5-kg and 12-kg which are more often used by wealthier households.

Source: Greencroft Economics

3.3. Conceptual framework to guide the selection of mechanisms and targeting approaches

The most appropriate type (or suite) of affordability support mechanism(s), and the extent of targeting, depends on what the barrier to affordable access is perceived to be.

In general, supply side subsidies in principle are used to overcome a cost constraint, while demand side subsidies address an ability to pay constraint. As shown in Figure 3, supply side subsidies should help companies overcome a prohibitively high cost-to-serve, while demand side

⁶³ GOGLA (2022) "EnDev's Pro-Poor Results-Based Financing in Rwanda", [Link](#)

⁶⁴ IPCID (2015) "Indonesia's Single Registry for Social Protection Programmes", [Link](#)

⁶⁵ GOGLA (2022) "Conditional Cash Transfers in Kenya for Off-Grid Solar Energy Cash Plus / Mwangaza Mashinani Programme", [Link](#)

⁶⁶ GOGLA (2022) "Conditional Cash Transfers in Kenya for Off-Grid Solar Energy Cash Plus / Mwangaza Mashinani Programme", [Link](#)

⁶⁷ BRILHO (2024) "Transforming off-grid energy access in Mozambique: the BRILHO programme contribution (2019-2024)", [Link](#)

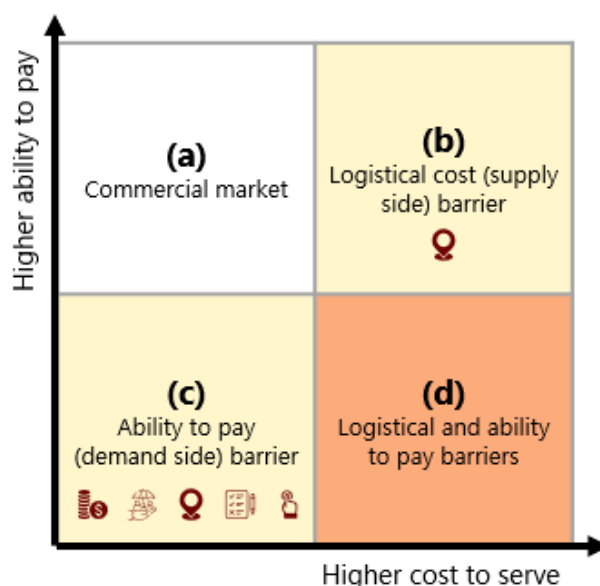
⁶⁸ IISD (2021) "LPG Subsidy Reform in Indonesia: Lessons learned from international experience", [Link](#)

⁶⁹ IISD (2019) "Gender and Fossil Fuel Subsidy Reform in India: Findings and recommendations", [Link](#)

subsidies should help customers overcome a too low ability to pay. For example, universal untargeted subsidies may be preferable where: (1) what is being subsidised benefits all potential customers (e.g. common infrastructure), (2) many (most) customers do not have access and would be unable to afford market prices, (3) the costs of targeting are greater than the “inefficiency” loss from accepting leakage / over-subsidisation of some customers.

The type of barrier being addressed matters when designing the longevity of the affordability support mechanism. Supply side subsidies may be catalytic if they overcome a one-off capital cost (e.g. infrastructure), or permanent if they buy down high systemic costs, such as operational costs. Demand side subsidies may be catalytic if they overcome a liquidity or behavioural constraint, or permanent if they bridge a fundamental and unchanging low ability to pay.

Figure 3: Matrix of market development barriers



Source: adapted from Lighting Global / ESMAP (2024) “Designing Responsible End-User Subsidies for Energy Access”, [Link](#)

4. Effectiveness of Affordability Support Mechanisms

All three affordability tenets – upfront affordability, ongoing affordability, transaction size – need to be addressed for affordability support mechanisms to be effective. Reducing the (upfront) price of a stove or the (ongoing) price of fuel does not necessarily lead to at-scale and sustained uptake. This section discusses the evidence relating to each of the 10 affordability support mechanisms introduced in Section 3.

4.1. Effectiveness

4.1.1. Supply side mechanisms

S1: Concessional corporate finance (e.g. grants or concessional loans)

Many energy access companies rely on substantial influxes of concessional corporate finance.

In the off-grid solar and renewable energy sector, concessional corporate finance has been essential to help companies set up operations and pilot innovative technologies. It has also been a pre-requisite to (some) companies being able to go on to raise more commercial forms of finance.⁷⁰

There is limited (and mainly anecdotal) evidence on the impact of concessional corporate finance on sustained uptake. For example, a study in Nepal found that supply-side subsidies (grant) did not necessarily lead to lower product prices or improve targeting to the rural poor,⁷¹ but (presumably) allowed the company to reach higher-cost-to-serve customer segments that they would otherwise not have served.

A further challenge on the sustainability of concessional corporate finance is the mixed success of companies that have sought to raise more commercial capital. Some of the leading off-grid solar companies that have raised commercial debt too early have paid a high price. For example, Mobisol raised around \$80-90 million (two-thirds in equity and one-third in debt) before going bankrupt in 2019,⁷² and SolarNow (which raised around \$30 million in equity and debt) went bankrupt in 2025.⁷³ These are just two among many examples of off-grid energy or clean cooking companies that have received substantial concessional finance, and have not scaled up sustainably.

In general, energy access markets in low income settings have limited profit potential and high risk exposure. Factors such as inflation, currency depreciation, geopolitical shocks, supply chain disruptions, and both local and global shocks which can drastically affect cost to serve and ability to pay, especially when serving the world's poorest populations. For example, the Covid-19 pandemic affected the world's poorest the most, as their income took a much harder hit than the income of the wealthier population.⁷⁴ This led to rising defaults and a liquidity crisis amongst energy access companies, and highlighted their precarious financial situation, as over half were unable to sustain their business for more than four months without approximately \$3 to \$10 million in relief loans or bridging funds.⁷⁵ These systemic risks and low margin potential mean that it is highly likely that some form of concessional finance is likely to be needed in the long-term – energy access

⁷⁰ GOGLA (2023) "Off-track: Challenging conditions slow progress on off-grid solar investment in 2023", [Link](#) and World Bank (2022) "Blended finance can catalyze renewable energy investments in low-income countries", [Link](#)

⁷¹ Das et al. (2022) "Taxes and subsidies and the transition to clean cooking: A review of relevant theoretical and empirical insights", [Link](#)

⁷² Financial Times (2019) "Mobisol: a cautionary tale for impact investors", [Link](#)

⁷³ TechinAfrica (2025) "SolarNow Goes Dark: East Africa's Solar Pioneer in Liquidation", [Link](#)

⁷⁴ World Bank (2021) "COVID-19 leaves a legacy of rising poverty and widening inequality", [Link](#)

⁷⁵ Cross & Neumark (2021) "Solar Power and its Discontents: Critiquing Off-grid Infrastructures of Inclusion in East Africa", [Link](#)

businesses cannot be expected to be financed in the same way (or on the same terms) as Silicon Valley start-ups.

There is a growing recognition that the hardest to reach and poorest households cannot be served without substantial grants or other forms of concessional finance to companies. An example is SolarAid's off grid solar Energy-as-a-Service pilot in Malawi. SolarAid received a full upfront grant to cover the capital cost for installing the systems in a rural community. Users make small payments to cover the operating costs. Without the full upfront grant, SolarAid would not have been able to install these systems at a fee that the community were able to pay.⁷⁶ The implication is that to serve these communities will need a (permanent or long-term) subsidy to bring prices down to affordable levels. Who pays for this is a separate consideration – it could be through imposing a universal obligation to serve on energy utilities (who would then need to finance this through cross-subsidies within their customer base), or subsidised by states, or by development partners etc. (see Section 6 for a discussion of who pays and sustainability of public finance for affordability support mechanisms).

There is limited evidence on whether limited duration (one-off) concessional corporate finance is successful in achieving sustained energy access, or whether long-term subsidies are needed. If the subsidy is used to overcome initial costs of expansion to new areas, then it should be that they could subsequently be removed. However, if they are used to address a fundamental gap between the cost-to-serve and the ability-to-pay of households then they would need to be sustained (unless household ability and willingness to pay increase).

S2: Tax reductions and exemptions

Reduced taxation could come in many forms – which could have different impacts on uptake.

Tax reductions and exemptions could be made on import duties, on sales tax (such as VAT), or on corporation taxes (i.e. on profit). Each will have a different potential impact. Import duty reductions will lower the cost of imported goods and services only and so does not benefit locally sourced or locally produced goods. Import duties may benefit local production and assembly, if they are used to reduce the import price of key component parts or equipment. Reductions in sales tax apply to all units sold, and so can be expected, to the extent the reduction is mostly or entirely passed on to customers, to increase sales volumes, much like a universal tariff subsidy. Reduced corporation tax may be helpful in increasing the incentive for companies to find customer or product segments with high(er) margins which they can then retain.

This section focusses on import duties and sales tax reductions, as these are the most common in the energy access sector. In general, energy access companies (electricity and clean cooking) are not high profit makers, so a reduction in profit tax might not be expected to have a large effect on uptake (and may be why we did not identify any such examples). On the other hand, it would sharpen the incentive for companies to serve only customers which are commercially viable and profitable to serve.

There is a limited empirical evidence base on the benefits of tax reductions, as most reports focus on advocacy rather than detailed (and objective) analysis. A survey in Kenya showed that after the removal of the VAT exemption on LPG, around 50% of the households used less LPG than before. This was directly attributed to the price hike occasioned by the imposition VAT on the fuel.⁷⁷ Several studies explore the potential (i.e. estimated) impact of tax exemptions ex ante – often showing that the decline in government revenue is substantially outweighed by the socioeconomic

⁷⁶ Efficiency for Access (2026) "Lighting a Path to Affordability", [Link](#)

⁷⁷ UCL (2021) "COP26 and SDG7 goals under threat: 16% VAT on LPG reverses progress made in clean cooking adoption in Kenya", [Link](#)

benefits.⁷⁸ The impact of tax reductions also depends on if the tax is applied to upfront or ongoing costs, as applying a tax reduction to only one of those does not necessarily lead to sustained uptake if the other is still unaffordable for many households.

Tax reductions are a common and widely used tool in mature markets, especially to boost uptake of new technologies. Many European countries have used tax exemptions to boost uptake of electric vehicles (EVs); when Norway removed exemptions the EV share of new car sales fell from 66% to 25%.⁷⁹ In the Netherlands, domestic solar panels benefited from a 0% VAT tariff and a scheme so households could offset the electricity they put back into the grid against the electricity they consume; this rule is being scrapped in 2027 and since the announcement monthly installations dropped from 70,000 in 2023 to just 10,000 in 2025.⁸⁰ Green tax policies in China significantly promoted the development of new regional energy industry, and this was especially significant in less industrialised regions.⁸¹

Tax reductions have also been used to boost investment in and uptake of renewable energy technologies in emerging markets. In South Africa, between 2023 and 2025 businesses could deduct 125% of capital investment in renewable energy assets from their taxable income, which drove new investment, with installations growing 54% between 2024 and 2025.^{82, 83} Zimbabwe introduced several tax incentives solar energy projects in 2021, including an import duty exemption and an income tax holiday for developers (0% tax on profits in the first five years).⁸⁴ As of 2023, the solar energy sector had grown by over 50% in the past year.⁸⁵ As described in the case study in Annex 1, Kenya has gone through various phases of tax incentives for off-grid energy markets since the early 2010s, with significant impacts on sales volumes each time the tax policy has been changed.

For products with low domestic market penetration, the risk of granting tax reductions may be low relative to the potential gain. In countries where renewable energy sectors are underdeveloped, untargeted incentives may be an appropriate first step; stimulating any form of investment can be critical to kickstarting market development.⁸⁶ Furthermore, taxing a very low volume of sales (or imports or profits) delivers very low revenue. So, to the extent that tax reductions are granted to products that are not yet widely adopted, the cost of foregone fiscal receipts is going to be relatively low. This risk increases if the tax reductions cannot be easily restricted to only the desired product categories and risk “leaking” into other products (for example batteries for an off-grid solar system, versus batteries for all other usages).

However, tax reductions are not guaranteed to catalyse markets. If all countries gave the same tax reductions in an attempt to capture nascent industries aiming to serve demand from export markets, they could not all succeed (green hydrogen could be such an example with many companies positioning to serve global export markets). Even to catalyse consumption in domestic markets, tax exemptions alone may be insufficient to make a product affordable for all customers.

⁷⁸ Clean Cooking Alliance (2021) “Value-Added Tax on Cleaner Cooking Solutions in Kenya”, [Link](#) and ACE TAF studies on tax exemptions (see [link](#))

⁷⁹ Cincotta & Thomassen (2025) “Evaluating Norway’s electric vehicle incentives”, [Link](#)

⁸⁰ AD (2025) “Van maandelijks 70.000 daken naar nog geen 10.000: markt zonnepanelen is volkomen ingestort” (From 70,000 roofs per month to less than 10,000: the solar panel market has completely collapsed”, [Link](#)

⁸¹ Yao et al. (2024) “Study on the Dynamic Analysis of the Evolutionary Game and Influence Effect of Green Taxation in Promoting the Development of New Energy Industry”, [Link](#)

⁸² Topco (2025) “Investing in the sun: Solar tax incentives in the age of green growth”, [Link](#)

⁸³ Carbon Copy (2026) “Africa Records Fastest Year of Solar Growth as Installation Rises”, [Link](#)

⁸⁴ SolarQuarter (2021) “Zimbabwe Announces Tax Exemption For Solar Energy Producers For 5 Years”, [Link](#)

⁸⁵ Solar Financed (2025) “Solar Industry Overview: Zimbabwe Market Analysis”, [Link](#)

⁸⁶ IISD (2025) “The Use of Green Tax Incentives for Renewable Energy Deployment in Emerging and Developing Countries”, [Link](#)

Across products, tax reductions are often a progressive form of taxation – including reductions for access to power and electricity. Sales taxes are often implemented at lower rates on essential goods and services, and are hence progressive in that those essential goods often make up a relatively larger share of a poorer households' budget. Typical examples of low or zero-rated products includes basic and healthy foods (but not restaurants), health and hygiene products, education products etc. Power often benefits from tax reductions – for example rated at 5% compared to the standard VAT rate of 20% in the UK.

Nonetheless, within usage of a product, tax reductions can be regressive. Within a product, tax reductions are often regressive as relatively wealthier households are bigger consumers, and buy more of a given product thereby benefiting most from the tax reduction. Tax reductions are not generally targeted to specific customer segments, in which case wealthier households can purchase more of the good, and reap more of the tax benefits. Tax reductions will also reach customers that would have bought the product without the exemption, making it a relatively cost-ineffective policy tool, although it is also simple (and low cost) to implement.

There is risk of leakage to non-eligible products or applications, especially if customs agencies have limited capacity to deal with complex rules. There is then a risk that the foregone tax revenues could be substantial compared to the benefits in terms of accelerating uptake, if the tax reductions benefit a wider range of products than intended (e.g. batteries for cars instead of batteries for solar systems).

Border and sales taxes combined can add as much as 50% on prices – with a significant potential impact on uptake of energy access products. VAT rates are generally up to 25%, so exemptions only reduce prices by up to 25%. Combined with import duties and levies, this can rise to as much as 50%. This is enough to elicit a significant change in uptake, depending on the extent to which these costs are passed on to end user prices. While tariffs (or exemptions) on clean cookstoves and fuels are typically passed through to consumers at least in part, the pass-through rate can vary significantly by technology and business model. For fuels traded in international markets, such as LPG, pass-through can approach 100%, while for imported improved cookstoves and LPG stoves, interviews with clean cooking enterprises indicate that approximately half of the tax burden is passed on to consumers.⁸⁷

Tax reductions and exemptions alone are unlikely to be sufficient to bridge the affordability gap for the poorest and hardest to reach. There are bigger limitations to uptake than the up to 50% increase in prices that border and sales taxes may result in. For example, serving the most remote and challenging to reach regions can increase costs by a factor of at least four – so the cost-to-serve the hardest to reach communities is going to be a larger contributor to the affordability gap for some communities than tax exemptions. As a result, and by way of comparison, fuel subsidies in the clean cooking sector draw upon subsidy rates of up to 90% of market price.⁸⁸

S3: Outcome-based revenues/finance

RBF programmes can be highly effective at catalysing markets and delivering large volumes of energy access products. As of 2023, donors had invested \$2.6bn in energy access RBFs across 20+ countries, with a tranche of new programmes planned in a final push for the 2030 SDG deadline.^{89,90} Ongoing clean cooking RBFs include RVO's 2019-2026 SDG7 Facility, with \$13.8m allocated to ICS, ethanol and biogas; NEFCO's 2022-2027 Modern Cooking Facility for Africa, with \$31m allocated to

⁸⁷ Clean Cooking Alliance (upcoming) "Trade, taxes and the clean cooking transition"

⁸⁸ Such as the PMUY programme in India with cylinders subsidised at 90% rates (IISD (2021) "How to Target LPG Subsidies in India: Step 2. Evaluating policy options in Jharkhand", [Link](#))

⁸⁹ SEforAll RBF tracker, [Link](#)

⁹⁰ MECS (2025) "Powering Africa's Future: Europe's Role in Advancing Mission 300", [Link](#)

tier 3/4+ stoves, and the World Bank's 2016-2025 \$47m Ci-Dev facility for biogas, ICS and ethanol stoves, each covering multiple countries.⁹¹

However, there is limited evidence that these interventions have resulted in sustained access.⁹²

A study of a DRE and clean cooking RBF in Nepal found that many companies struggled to continue once the subsidies were withdrawn and downsized their operations, cutting back on after-sales support.^{93,94}

Some RBFs have been able to achieve high sales volumes at relatively low subsidy levels, raising the possibility of sustained access without significant further subsidies required. For RBFs with low targeting criteria, companies will (and should) select the relatively higher ability to pay and lower cost to serve customers. There are increasingly sophisticated approaches to determining the subsidy level, (such as reverse auction, market surveys to gauge affordability levels or constant adjustment to reach a desired rate of sale). But there remains no clear single approach that has consistently produced the best outcomes, which can lead to over-subsidisation of products and sales to customers who do not need the support.^{95,96}

Other RBFs seek to reach specific target customer segments, although they come at a higher required subsidy level. For example, EnDev's solar RBF in Rwanda drew upon the country's existing "Ubudehe" socio-economic classification system by providing larger subsidies for systems sold to households from the lowest (poorest) tier.^{97,98} However, these RBFs typically need a much higher subsidy level (up to 90%), which raises the question of how sales can continue to be serviced and scaled up once the subsidy ends.

Carbon credits provide revenue based on sustained uptake of clean cooking fuels and stoves.

The importance of carbon to the cookstove sector is demonstrated by their prevalence; carbon credits are estimated to contribute 35% of total revenues for companies.⁹⁹ Some companies pass on a portion of these revenues directly to customers, for example ATEC through their cook-to-earn model (see Case Study 1).¹⁰⁰ There is little publicly available evidence on how these models promote long-term sustained use.

The challenge of securing reliable prices and buyers is a key risk associated with reliance on carbon credits to address affordability. The voluntary carbon market is notoriously volatile and the cookstove sector has been embroiled in several reputation-damaging scandals in recent years.¹⁰¹ In response, new methodologies have been developed which address quality and integrity issues in and reward providers, including using customer-level usage data.¹⁰² Market uncertainty still makes it difficult for companies to accurately forecast carbon revenues and therefore decide how to share revenues with their customers. This is somewhat mitigated for carbon credits sold under Article 6, which pass through a formal and regulated process, enabling access to a higher-value carbon

⁹¹ Clean Cooking Alliance (2022) "Clean Cooking RBFs: Key Design Principles", [Link](#)

⁹² Perros and Bergman (2025) "Current practices in results-based financing for energy access", [Link](#)

⁹³ IIED (2020) "Energy for all: Better use of subsidies to achieve impact", [Link](#)

⁹⁴ IIED (2020) "Stoking finance for affordable cookstoves: Experience from Malawi and Zimbabwe", [Link](#)

⁹⁵ ESMAP (2020) "Funding the Sun: New Paradigms for Financing Off-Grid Solar Companies", [Link](#)

⁹⁶ Lighting Global / ESMAP (2024) "Designing Responsible End-User Subsidies for Energy Access", [Link](#)

⁹⁷ EnDev (2021) "Giving RBF a voice", [Link](#)

⁹⁸ Stritzke et al. (2021) "Results-Based Financing (RBF) for Modern Energy Cooking Solutions: An Effective Driver for Innovation and Scale?" [Link](#)

⁹⁹ Clean Cooking Alliance (2025) "Clean Cooking Industry Snapshot", [Link](#)

¹⁰⁰ ATEC (2023) "Paying people carbon credits based on usage data", [Link](#)

¹⁰¹ Greenfield (2024) "Ex-carbon offsetting boss charged in New York with multimillion-dollar fraud", [Link](#)

¹⁰² Bricknell and Leach (2024) "The importance of metered methodologies for carbon credit certification of modern energy cooking projects", [Link](#)

market with lower levels of risk due to additional oversight involved in the authorisation and accounting process.¹⁰³

Carbon taxes offer an opportunity for governments to claim a share of revenues but can halt projects if the rates are set too high. Several countries are in the process of drafting carbon frameworks that impose taxes on carbon credits generated within their borders, thus reclaiming some of the revenues from offset markets. These frameworks also play an important role in ensuring that Article 6 projects meet their obligations in delivering community benefits, often by setting up centralised funds to delivery community projects.¹⁰⁴ A range of approaches is emerging; for example, Kenya's 2024 regulations stipulate charges of \$4 per internationally transferred mitigation outcome, administration fees of \$0.10-0.20 per credit project development fees from \$80 upwards depending on project size. The raised revenues are shared between the treasury and Kenya's Climate Change Fund.¹⁰⁵ However, there is a risk that if these charges are too high then they will chase developers away to other markets. This is the problem currently facing Malawi, whose progressive 2025 regulations have higher charges than Kenya's, but have halted a development pipeline of planned tier 4+ clean cooking projects.

These new regulations also pose risks to companies whose business models depend on carbon revenues. This was recently demonstrated by the insolvency of KOKO Networks,¹⁰⁶ one of the largest clean cooking companies in Africa. KOKO relied on carbon credits to subsidise both stoves and fuel for over one million people in Kenya.¹⁰⁷

S4: Price caps

Under a price cap, the customer faces a lower price than the cost-to-serve, with the difference subsidised.

Even setting the upfront price to zero is not sufficient to ensure long-term use, if high fuel costs are expected and unaffordable. For example, even with free supply of LPG stoves in the Indian PMUY programme, which resulted in 80 million new connections,¹⁰⁸ 24% of beneficiaries did not buy a gas refill within the first year.¹⁰⁹ The *Plan Fronteras* pilot project in Ecuador provided households with free induction stoves and cookware and six months of free electricity for cooking (through a dedicated power outlet and power meter). After the pilot, the dedicated power meters and outlets that gave free electricity that were installed for the pilot program were removed. Only 22% of households reported continued use of the stoves, and never as the primary one.¹¹⁰

There are also mixed results for a zero price cap of improved cookstoves, even though fuel can often be collected for free. In the case of free distribution, these products can be allocated to consumers that do not value it and would not have purchased it, hence there is no linear relationship between a free give-away and sustained use. Most of the evidence encountered points towards the ineffectiveness of free giveaways. For example, in Nepal four-fifths of participants in an ICS free distribution programme stopped using their stoves and over a third of them had exchanged them for onions.¹¹¹ Similarly levels of stove dis-adoption have also been observed in India

¹⁰³ MCFA (2025) "Unlocking High-Value Carbon Credits from Clean Cooking: A Guide to Accessing Article 6", [Link](#)

¹⁰⁴ Rentiria et al. (2024) "Uniting the EU's Carbon Border Adjustment Mechanism and Article 6.2 of the Paris Agreement to Accelerate Climate Action", [Link](#)

¹⁰⁵ MCFA (2025) "Unlocking high-value carbon credits from clean cooking: a guide to accessing Article 6", [Link](#)

¹⁰⁶ Pilling & Wallis (2026) "Clean cooking start-up files for insolvency after clash with Kenya", [Link](#)

¹⁰⁷ Osiolo et al. (2023) "The Emergence of Large-Scale Bioethanol Utilities: Accelerating Energy Transitions for Cooking", [Link](#)

¹⁰⁸ Tearfund (2020) "Designing sustainable subsidies to accelerate universal energy access", [Link](#)

¹⁰⁹ Gill-Wiehl et al. (2021) "Is clean cooking affordable? A review", [Link](#)

¹¹⁰ Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

¹¹¹ Lohani et al. (2025) "Rethinking clean cooking solutions: Assessing the impact of subsidy and distribution modality on an improved cookstove program in Nepal", [Link](#)

and Mexico.^{112,113} Conversely, a trial of free distribution of ICS in Senegal shows high uptake and intense usage, even after 3.5 years, as the firewood can be collected for free.¹¹⁴ The differences in effectiveness is context-specific and depends on a wide range of factors such as stove quality, how well the stove meets specific end-user cooking needs, how significant the burden of firewood collection is to households, the ease of use and whether the stove has any labour-intensive fuel preparation requirements.

A price cap on ongoing fuel costs can be targeted or untargeted, and feasibility may depend on who pays the difference between the price cap and the cost-reflective price. Fuel price caps are common in developed economies; often to reduce energy poverty (rather than to encourage uptake of a new technology). In the Netherlands a price cap on the first tranche of energy consumption was introduced in 2023.¹¹⁵ In the UK, the government capped electricity and gas bills with the Energy Price Guarantee in 2022.¹¹⁶ A key consideration with a price cap is who pays the difference between the cost-reflective price and the cap; does the energy provider bear this cost (recovered by cross-subsidy), or does a public funder such as the government pay the difference.

Price caps can be progressive if they are targeted to household-specific characteristics and administered directly to the electricity bill or specific households. The programmes in India and Ecuador were targeted to specific end users and only they received the free technology. Research in Europe shows that untargeted price caps can help reduce the negative distributional effects driven by the increase in energy prices and reduce energy poverty, but targeted measures, both price caps and lump-sum benefits, are substantially more efficient to reduce inequality and poverty.¹¹⁷

The impact of price caps on market development depends on the extent of the price reduction, where free distribution is assumed to harm market development. Policy makers often oppose free distribution, arguing that reference dependence spoils the willingness to pay and thus market potentials in the long run. Customers do not observe the actual market price and could be reluctant to pay that price if a price cap were removed. However, a pilot in Senegal finds that one-off free distribution did not harm a market-based approach and that consumers' willingness to pay is not reduced.¹¹⁸ The free distribution was important in boosting learning and willingness to adopt. Willingness to pay is in many cases below the market price, such as for ICS in Ethiopia,¹¹⁹ and in Kenya,¹²⁰ which indicates that a price cap or reduction is necessary to boost uptake and develop the market, but free distribution might not be necessary.

S5: Universal price subsidy

Universal price subsidies are generally effective at increasing the uptake of a specific fuel but come at a high price. A number of countries (e.g., Indonesia, India, Ecuador, Peru) have sought to

¹¹² Hing et al. (2023) "Sensors show long-term dis-adoption of purchased improved cookstoves in rural India, while surveys miss it entirely", [Link](#)

¹¹³ Schilman et al. (2019) "A follow-up study after an improved cookstove intervention in rural Mexico: Estimation of household energy use and chronic PM2.5 exposure", [Link](#)

¹¹⁴ Bensch & Peters (2015) "The intensive margin of technology adoption – Experimental evidence on improved cooking stoves in rural Senegal", [Link](#)

¹¹⁵ CBS (2024) "Energy poverty reduced by compensation and energy savings", [Link](#)

¹¹⁶ Pollitt et al. (2024) "Recommendations for a future-proof electricity market design in Europe in light of the 2021-23 energy crisis", [Link](#)

¹¹⁷ Amores et al. (2025) "Limiting Prices or Transferring Money? An ex ante assessment of alternative measures to cope with the hike in energy prices", [Link](#)

¹¹⁸ Bensch & Peters (2019) "One-Off Subsidies and Long-Run Adoption—Experimental Evidence on Improved Cooking Stoves in Senegal", [Link](#)

¹¹⁹ Bersisa et al. (2021) "Households' willingness to pay and preferences for improved cook stoves in Ethiopia", [Link](#)

¹²⁰ Berkouwer & Dean (2019) "Credit and attention in the adoption of profitable energy efficient technologies in Kenya", [Link](#)

accelerate household cooking transitions by subsidizing LPG, with considerable success.¹²¹ But, these subsidies put a large burden on government budgets; for example up to 2010 the Indonesian government spent more on energy subsidies than it spent on defence, education, health and social security combined.¹²²

Universal subsidies are often highly regressive. Internationally, only about 8% of energy subsidies reach the lowest income quintile. LPG subsidies can be highly regressive; in Indonesia only 4% of subsidies reached the lowest income quintile, with 50% going to the highest income quintile.¹²³ In India, only 0.07% LPG subsidies in rural areas went to the poorest quintile, with 53% going to the richest quintile.¹²⁴

They can be very hard to phase out, which can lead to sliding back to polluting fuels, and can even cause social unrest. In Brazil, LPG consumption decreased by more than 5% after the removal of the subsidy and fuelwood consumption increased after years of decreasing consumption.¹²⁵ Evidence from Ghana found that the removal of LPG subsidies led to backsliding to polluting options by 2-3% of the population.¹²⁶ In 2022, subsidy reforms in Bangladesh, Haiti, Indonesia, Kazakhstan, and Sri Lanka, almost all triggered social unrest. The level of unrest is highest for kerosene or LPG subsidy removal, and governments may be more likely to succeed by keeping fuels such as kerosene and LPG subsidized while focusing on reforming transport fuels like gasoline and diesel.¹²⁷

Universal subsidies for one market segment can risk leakage and black market development.

With the LPG subsidy in India and Ecuador, there were different prices for households and commercial purposes. This dual price incentivized a black market and caused leakage. In Ecuador, the highly subsidised LPG was also smuggled to neighbouring countries Peru and Colombia.¹²⁸ Nigeria had to close its border with Benin due to the smuggling of numerous goods, including subsidised petrol, to its neighbouring country. Since the subsidy removal in 2023, the black market fuel trade has further collapsed.¹²⁹

S6: Preferential tariffs

Preferential tariffs have been used to try to improve clean cooking affordability. For example, both Kenya and Uganda have implemented new electricity tariff bands that are explicitly intended to improve the affordability of cooking with electricity.^{130,131}

Poor targeting can hinder the effectiveness of several key documented clean cooking preferential tariffs. For example, the Indonesian LPG conversion programme subsidised LPG sold in 3kg cylinders, on the assumption that only low-income households would purchase 3kg cylinders. In practice, there was leakage to higher-income consumers and cross-border trade (see

¹²¹ Das et al. (2022) "Taxes and Subsidies and the Transition to Clean Cooking: A Review of Relevant Theoretical and Empirical Insights", [Link](#)

¹²² IISD (2011) "A Citizen's Guide to Energy Subsidies in Indonesia", [Link](#)

¹²³ Thoday et al. (2018) "The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion", [Link](#)

¹²⁴ Tripathi et al. (2015) "Promoting Clean and Affordable Cooking: Smarter Subsidies for LPG", [Link](#)

¹²⁵ Coelho et al. (2018) "The energy transition history of fuelwood replacement for liquefied petroleum gas in Brazilian households from 1920 to 2016", [Link](#)

¹²⁶ Das et al. (2022) "Taxes and subsidies and the transition to clean cooking: A review of relevant theoretical and empirical insights", [Link](#)

¹²⁷ Gasim et al. (2025) "Lessons from an International Review of Successful and Unsuccessful Consumer Energy Subsidy Reforms", [Link](#)

¹²⁸ Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

¹²⁹ Reuters (2023) "As Nigeria scraps fuel subsidy, a vibrant black market collapses", [Link](#)

¹³⁰ A2EI (2025) "Findings from a study on the adoption of electric pressure cookers in Uganda", [Link](#)

¹³¹ Leary et al. (2023) "Kenya Power implements a new tariff band designed to promote demand growth in clean cooking", [Link](#)

Case Study 4). Similarly, India's rural LPG subsidy programme led to dual pricing which incentivised a black market for illegally diverted subsidised fuel. The government eventually curbed this leakage by over 10% by implementing a biometrics-based unique ID system for beneficiaries.¹³²

Similar, complex targeting and complex tariffs have limited the effectiveness of early trials of e-cooking tariffs. A study on the Ugandan tariff found that most eligible households did not use enough electricity to reach the subsidy threshold, and even those that did, did not alter significantly alter their consumption as a result of the tariff (see Case Study 5). This example demonstrates how poor targeting can undermine the effectiveness of eCooking tariffs and underscores the need for more research about the impacts of well-implemented clean cooking tariffs. It also mirrors some of the lessons learned from utility scale electricity tariffs (see Section 4.3).

S7: Subsidised common infrastructure

Functional and affordable access to common infrastructure is a pre-requisite for sustained adoption of some clean cooking technologies. For example, e-cooking needs a reliable electricity supply, while LPG needs a supply chain to reach households including LPG importation facilities through to safe cylinder replacements.

There are examples where subsidised national infrastructure has been highly effective in supporting energy access transitions. The roll-out of electricity transmission lines in the US corresponded with a rapid increase in the productivity of all sectors including agriculture and rapid economic growth and improvements in quality of living. The same has been demonstrated in Brazil (see Case Study 2). Almost all mature energy markets rely at least to some extent on a, at least initially, public-funded core infrastructure backbone. Where LPG programmes have been promoted, they have often relied on access to some subsidised core infrastructure (see Case Study 4 and Case Study 6).

However, there are also plenty of cautionary tales. A core methodological challenge in analysis of the impact of infrastructure on development and growth is reverse causality – it is a two-way relationship. Better infrastructure may drive economic growth, on the other hand economic growth and increased purchasing power may drive demand for (and ability to pay for) better infrastructure. Investing in subsidised common infrastructure is likely to be most effective where the broader macroeconomic conditions are favourable, as part of a holistic programme of economic growth.

4.1.2. Demand side mechanisms

D1: Cash transfer (ex ante)

Uptake of the desired technology will depend on the spending constraints of the cash transfer, as beneficiaries can decide to use the transfer for other purposes. In India, PMUY beneficiaries received an advance payment equal to the retail price of one LPG cylinder refill to their bank account, and two subsequent ones if the advance payment had been used to purchase an LPG cylinder, but survey data revealed that 36% of beneficiaries used the advance payment for other purposes.¹³³

Cash transfers can be an efficient compensatory mechanism where universal subsidies are removed. Energy subsidy reform may be more likely to succeed when implemented with such a replacement policy. In cases where energy subsidy reform was not coupled with compensatory

¹³² Barnwal et al. (2024) "Curbing leakage in public programs: Evidence from India's direct benefit transfer policy, [Link](#)

¹³³ IISD (2021) "LPG Subsidy Reform in Indonesia: Lessons learned from international experience", [Link](#)

measures, reform reversal occurred at a rate of 13%. However, when compensation was used, the rate of reversals fell to 0%.¹³⁴

Targeted delivery mechanisms can help improve the cost effectiveness of cash transfer programmes. El Salvador replaced a universal price subsidy for LPG with targeted unconditional cash transfers in 2011, and then made the cash transfers conditional on LPG purchase in 2014, reducing the fiscal bill by 46%.¹³⁵

Even when this mechanism is designed to be well targeted, regressive impacts can arise. Direct LPG subsidies in India were inequitable as relatively richer and administratively more efficient states could obtain a larger share of consumer subsidies, and weak LPG distribution networks in rural areas were an additional barrier.¹³⁶

Well-targeted transfers are less harmful to market development than universal schemes, but can still lead to leakage. One of the broader benefits with cash transfers, is that the technology or appliance can be offered at commercial price, to reduce market distortion. Well-targeted demand-side subsidies, including conditional cash transfers and vouchers, are more likely to be cost-effective and less distortive to further market development than untargeted approaches.¹³⁷ There is a risk of leakage if targeted consumer resell the subsidised good against the subsidised price.

D2: Rebates (ex post)

Rebates can be effective in encouraging uptake, but there is limited evidence on usage duration after the rebate period and possible leakage. A solar lantern study in India found that households receiving a voucher were willing to pay 34% more than other households, but their willingness to pay was still below the retail price of lanterns. Vouchers were more effective than microfinance or unconditional cash programmes to increase WTP.¹³⁸ Research from a pilot study in Cambodia shows that households' use of an improved cookstove was responsive to financial incentives based on stove use, with recipients using the stoves more frequently and for longer periods of time. Solid-fuel use and time spent collecting or preparing fuels also declined, but this effect diminished over time, which could indicate that usage is not sustained (although the study does not report this finding).¹³⁹ Another pilot from India, where rebates were delivered only at the time of the third payment instalment if a household had visibly used the new ICS, found that larger rebates increased purchase rates.¹⁴⁰ On the other hand, an ongoing study in Kenya found that providing induction stove users with rebates had no effect on adoption, although this result could be attributed to delays in the rebate issuances.¹⁴¹

India replaced a universal LPG subsidy with a targeted rebate policy, which reduced leakage, increased efficiency and resulted in fiscal savings. With the PaHal scheme in India consumers place an order for LPG with their gas distributor, after which they receive an amount equivalent to the current subsidy amount via electronic transfer to their bank account, then pay the full

¹³⁴ Gasim et al. (2025) "Lessons from an International Review of Successful and Unsuccessful Consumer Energy Subsidy Reforms", [Link](#)

¹³⁵ Kojima (2021) "Subsidizing Bottled Gas: Approaches and Effects on Household Use", [Link](#)

¹³⁶ Mittal et al. (2017) "Fuel Subsidy Reform in Developing Countries: Direct Benefit Transfer of LPG Cooking Gas Subsidy in India", [Link](#)

¹³⁷ Pengwern Associates (2025) "Ensuring the Sustainability of Clean Cooking Programs: Identifying good practices in subsidy provision", [Link](#)

¹³⁸ Yu Wong et al. (2022) "Increasing microsolar technology adoption: Efficacy of vouchers, cash transfers, and microfinance schemes", [Link](#)

¹³⁹ Usmani et al. (2017) "Can economic incentives enhance adoption and use of a household energy technology? Evidence from a pilot study in Cambodia", [Link](#)

¹⁴⁰ Pattanayak et al. (2019) "Experimental evidence on promotion of electric and improved biomass cookstoves", [Link](#)

¹⁴¹ [reference forthcoming – not yet published]

unsubsidized price for the cylinder.¹⁴² This targeted policy has reduced leakages, eliminated ghost users and has increased efficiency compared to the previous LPG price subsidy regime, resulting in significant fiscal savings of almost \$2 billion for the government at fraction of the cost of the program.¹⁴³ There is still a risk of leakage if the rebate is easily transferred and ends up being used by an ineligible household or in an ineligible geographical location.

A well-targeted and efficiently implemented voucher system in Peru that targeted poor or extremely poor households encouraged sustained LPG use. In Peru, the government aimed to reduce the use of solid fuels by offering LPG vouchers for 50% of the price of a cylinder; LPG stoves were previously given away for free. The programme was funded by cross-subsidies from other (industrial) customers in the energy sector. Almost 90% of households who received vouchers exchanged them for LPG cylinders, and 75% of the vouchers distributed were used. Beneficiaries were significantly more likely to use an LPG stove, of 96.5% compared to 24.8% of non-beneficiaries. However, while exclusive biomass use declined steadily, almost 95% of beneficiaries and non-beneficiaries reported stacking with biomass.¹⁴⁴ A beneficiary is allowed to combine two vouchers at a time but no more than two, and to avoid leakage, the programme detects if a household exchanges more than two vouchers in a month.¹⁴⁵

D3: Concessional consumer finance

Consumer finance can increase willingness to pay, even in the absence of subsidies. In Uganda, combining a free trial, payments spread over time and the ability to return the stove increased adoption of improved cookstoves from 4% to 46% in Kampala and 5% to 57% in rural Mbarara.¹⁴⁶ In Kenya, offering loans for the purchase of improved cookstoves doubled willingness to pay from \$12 to \$25.¹⁴⁷ For entry-level electricity access, it is estimated that the PAYGo business model could mean 56% of unconnected households in Sub-Saharan African could afford a Tier 1 solar system, rising to 66% with a 12 month zero-interest loan, and 99% with this loan extended to five years.¹⁴⁸

There is an issue with offering credit to the hardest-to-reach population with cyclical incomes and being vulnerable to economic shocks. For example, during and since Covid-19, many off-grid solar companies have reported rising default rates. In 2023, about half of PAYGo customers were either written off or had delayed payments by more than 30 days.¹⁴⁹

The transaction costs of concessional consumer may be prohibitive for low-cost products. A micro finance institution in Malawi piloted consumer financing for \$2 designed to support ICS purchases. It was ultimately unsuccessful because the transaction costs were too high relative to the loan amount and members were uninterested in such small loan amounts.¹⁵⁰

Consumer finance can be used to accelerate uptake among early adopters, but the impact is questionable for the poorest consumers. A study by Energy Saving Trust finds higher repayment

¹⁴² IISD (2015) "Ghost savings: Understanding the fiscal impacts of India's LPG subsidy", [Link](#)

¹⁴³ Mittal et al. (2017) "Fuel Subsidy Reform in Developing Countries: Direct Benefit Transfer of LPG Cooking Gas Subsidy in India", [Link](#)

¹⁴⁴ Pollard et al. (2018) "An evaluation of the Fondo de Inclusión Social Energético program to promote access to liquefied petroleum gas in Peru", [Link](#)

¹⁴⁵ Kojima (2021) "Subsidizing Bottled Gas: Approaches and Effects on Household Use", [Link](#)

¹⁴⁶ Levine et al. (2018) "What impedes efficient adoption of products? Evidence from randomised sales offers for fuel-efficient cookstoves in Uganda", [Link](#)

¹⁴⁷ Berkouwer & Dean (2019) "Credit and attention in the adoption of profitable energy efficient technologies in Kenya", [Link](#)

¹⁴⁸ Energy Saving Trust (2023) "The Road to Zero Interest: The Potential Role of Concessional Consumer Financing in Energy Access", [Link](#)

¹⁴⁹ Energy for Growth Hub (2023) "Off-Grid Solar's Poverty Premium", [Link](#)

¹⁵⁰ IIED (2020) "Stoking finance for affordable cookstoves: Experience from Malawi and Zimbabwe", [Link](#)

rates when programmes targeting households on higher incomes.¹⁵¹ In general consumer finance through business models like PAYGo significantly raises the total cost for customers, and has resulted in significant issues around the quality of consumer credit portfolio.¹⁵² Indeed (unsubsidised) PAYGo for SHS is often concentrated in more urban and wealthier regions. For LPG business models, the evidence on the effectiveness of spreading payments is mixed – in the long-term risk of seeing high churn with customers “switching” to more affordable (larger) canisters. For customers receiving regular bills (e.g. from an electricity utility), on-bill financing offers a way to allow customers to spread some payments; for example, Tanzania offers newly connected electricity customers to repay the cost of their e-cooking appliance through their electricity bill.¹⁵³

4.2. Targeting approaches

Well-targeted subsidies are more likely to be cost-effective and cause less market distortion.¹⁵⁴

Across multiple countries, replacing blanket fuel subsidies with targeted affordability mechanisms has helped cut diversion, black marketing, and fiscal burdens on governments, LPG suppliers, or both. Examples of success here come from countries as diverse as Indonesia (see Case Study 4), Senegal, El Salvador, Peru and Ghana.¹⁵⁵

Targeting using income/poverty levels or social security registers are shown to be effective in reaching the most in need, but there is limited evidence on long-term uptake. In Rwanda, an RBF programme using social security registers reached 22,000 low income households, of which 71% were classified in Ubudehe 1, the lowest poverty category.¹⁵⁶ A Kenyan RBF programme using national safety nets to target eligibility exceeded its target, and reached households of which 64% were headed by women.¹⁵⁷ There is low risk of market distortion, as long as verification is carried out and systems are not sold on to other households. The success of targeting depends on its accuracy, but that requires significant effort, administrative capacity and data.

Geographic targeting can be used to achieve economies of scale, although serving harder to reach regions often makes results harder to deliver (or sustain). Many energy access RBF programmes use geographic targeting to determine eligibility, or differing subsidy levels. For example, in Kenya, KOSAP supports companies serving households in 14 underserved counties. In Mozambique, BRILHO targets regions based on a vulnerability index, while in Zambia the Beyond the Grid Fund for Zambia included targets for hard-to-reach communities. However, in practice RBFs such as BGFZ still tend to serve households that have higher income than national averages,¹⁵⁸ underlining the challenge in striking the balance between (1) value for money, (2) commercial sustainability, and (3) reaching the most in need. A study on the geographical concentrations of development aid in Nigeria, Senegal, and Uganda found that aid is often not specifically targeted to regions where extreme poverty is highest, and indeed reversely correlates with distance to these

¹⁵¹ Energy Saving Trust (2023) “The Road to Zero Interest: The Potential Role of Concessional Consumer Financing in Energy Access”, [Link](#)

¹⁵² [add references to latest PAYGo Lab publications]

¹⁵³ MECS blog (20th October 2025) “Tanzania’s TANESCO launch on-bill financing for new customer connections to acquire eCooking appliances: a milestone for the sector”, [Link](#)

¹⁵⁴ Pengwern Associates (2025) “Ensuring the sustainability of clean cooking programs”, [Link](#)

¹⁵⁵ Kojima (2021) “Subsidised bottled gas: Approaches and effects on household use”, [Link](#)

¹⁵⁶ GOGLA (2022) “EnDev’s Pro-Poor Results-Based Financing in Rwanda”, [Link](#)

¹⁵⁷ GOGLA (2022) “Conditional Cash Transfers in Kenya for Off-Grid Solar Energy Cash Plus / Mwangaza Mashinani Programme”, [Link](#)

¹⁵⁸ Greencroft Economics (2024) “Ex-post Evaluation of the Beyond the Grid Fund for Zambia (BGFZ)”, [Link](#)

areas.¹⁵⁹ While there is limited research in this area, there are concerns that once subsidy programmes end, companies stop serving the target regions.¹⁶⁰

In rural Ghana geographic targeting worked well where the necessary infrastructure was in place. Ghana supplemented their national LPG policy with a targeted rural policy. The program provided eligible rural beneficiaries with one free 6 kg LPG cylinder, a single burner stove, and accessories, to stimulate demand and incentivizing private companies to enter rural areas. However, 58% of households had not refilled their LPG cylinders at all nine months after the delivery of their first cylinder, and only 8% were still using LPG 18 months after distribution, due to high cost and distance to filling stations.¹⁶¹

A risk of geographic targeting is if systems end up reaching non-intended regions and distorting (more commercial, unsubsidised) markets there. The example of Brighter Life in Myanmar highlights this risk, where subsidised solar home systems intended only for specific target regions were subsequently found being (re)sold in the other regions competing alongside unsubsidised products. This significantly reduced demand for the unsubsidised products and Brighter Life cited this as the reason for their exit from the Myanmar market at a loss of \$2 million.¹⁶² This risk can be managed by digital technologies that enable location tracking of usage of devices, or regular verification that systems are in use in the intended regions only (although both options come at a cost).

4.3. Lessons from utility scale tariffs

Subsidised connection fees are a common way of ensuring affordability (combined with universal obligation to serve). Subsidised connection fees inherently target relatively poorer customers, as it benefits those currently excluded from access to electricity networks. The lower the baseline rate of access, the less “pro-poor” subsidised connection fees are.¹⁶³ As illustrated in Case Study 2, once a relatively high rate of nationwide access has been achieved, requiring companies to connect all remaining communities, and not passing on the full marginal cost of those connections, can be highly effective.

Progressive tariff regimes including free allowances, lifeline tariffs, and increasing block tariffs are widespread internationally, but the impact on consumption for low income households is often low.¹⁶⁴ Research in South Africa shows that low income households adjust their budgets to maintain a level of electricity consumption, rather than change consumption in response to price changes.¹⁶⁵ This finding is mirrored in several studies which find low price responsiveness among poorer households, with little change in consumption and cost savings allocated to other essential goods and services.¹⁶⁶

As a result, electricity tariff subsidies are often captured by relatively wealthier households. The poorest households will be excluded from subsidised tariffs if they do not have a connection in the first place. Furthermore, in some settings poorer households may have larger household size and be large consumers, so when IBTs are used they tend to disproportionately consume in the higher

¹⁵⁹ Briggs (2018) “Leaving No One Behind? A New Test of Subnational Aid Targeting”, [Link](#)

¹⁶⁰ See for example Greencroft Economics (2024) “Ex-post Evaluation of the Beyond the Grid Fund for Zambia (BGFZ)”, [Link](#)

¹⁶¹ WHO (2022) “Increasing Access to Clean Cooking through Subsidies”, [Link](#)

¹⁶² NextBillion (2018) “The Danger of Subsidized Solar: How Government and Donors Unwittingly Hobbled Our Business”, [Link](#)

¹⁶³ Komives et al (2005) “Water, Electricity, and the Poor : Who Benefits from Utility Subsidies?”, [Link](#)

¹⁶⁴ Komives et al (2005) “Water, Electricity, and the Poor : Who Benefits from Utility Subsidies?”, [Link](#)

¹⁶⁵ Qeque et al. (2022) “The Relationship between Electricity Prices and Household Welfare in South Africa”, [Link](#)

¹⁶⁶ BII and Greencroft Economics (2024) “How does investing in electricity support inclusion?”, [Link](#)

volume blocks at higher unit tariffs. In India 87% of electricity subsidies went to people living above the poverty line.¹⁶⁷

When it comes to electricity access, it may be that the highest impact in terms of changing financial poverty outcomes comes from providing energy access to the poor but not the poorest. This is because the ability to use a reliable electricity supply to transform livelihoods and create economic opportunities offering higher income to households depends on a host of other factors, not least access to markets and supporting infrastructure.¹⁶⁸

Complex tariff structures often see an initial reaction to the “novelty effect”, but sustained change is harder to achieve. Access to real-time energy data alone is insufficient to achieve long-term behaviour change, with a decline in engagement over time.¹⁶⁹ On the other hand, there are examples of sustained behavioural change in response to information campaigns, such as a significant and sustained drop in per person water usage in Cape Town following the severe drought and risk of water supply being cut off around 2019.

Higher income households are more likely to respond to complex tariffs. Time-of-use tariffs changed behaviour of a quarter of higher-income households, while lower income groups resisted due to inflexible schedules and risk aversion of increased energy bills.¹⁷⁰

¹⁶⁷ Banerjee et al (2014) “Elite Capture: Subsidizing Electricity Use by Indian Households”, [Link](#)

¹⁶⁸ BII and Greencroft Economics (2024) “How does investing in electricity support inclusion?”, [Link](#)

¹⁶⁹ Samancioglu et al (2026) “The role of smart meter feedback in enhancing inhabitants’ energy efficient behaviour in residential buildings”, [Link](#)

¹⁷⁰ [Need to add reference]

5. Implementation Considerations

Each of the affordability mechanisms introduced in Section 3 and discussed in Section 4 have different pre-requisites to be implemented effectively. This section describes the complexity involved in implementing each approach in different contexts. It covers both the infrastructure required to deliver each affordability support mechanism, and the governance and administration pre-requisites. The objective is to understand when a particular approach may be less effective in practice than in theory, to help identify “second-best” options where there are practical constraints to the “first-best” option.

Large state-financed programmes require strong and effective coordination among different government entities and stakeholders. Different ministries will have diverse objectives and resource allocation possibilities. Clean cooking planning involves complex cross-sectoral considerations. For example, e-cooking policies will have to be integrated within wider electrification efforts and planning. For tax reductions, the Ministry of Finance should lead the design and implementation, while being supported by other ministries. For example, the Ministries of Energy, Environment, or Industry play a supporting role by identifying sector-specific investment needs, advising on technical design, and contributing to monitoring efforts. On top of that, investment promotion agencies are critical in the link between government and business.¹⁷¹

While strong governance is needed for effective implementation of affordability support mechanism, the same holds for removal of such subsidies. Subsidy removal can be met by strong resistance and social unrest. It is important to design an exit strategy at the outset to prevent market collapse once subsidies have been dispersed.

Different affordability mechanisms can cost vastly different amounts to achieve accelerated uptake. For example, VAT exemptions typically act upon 10-20% of product price at the point of purchase. Preferential tariffs can be larger, for example the Uganda eCooking tariff which provides a ~46% electricity subsidy within a certain band (see case study in Annex 1). Carbon credits can be even larger and even serve as sources of revenue. For example, high quality biogas carbon credits can save up to 5 tonnes of CO₂e/year, which corresponding to £90/year/unit for one project example found online, which far exceeds ongoing costs (which are limited to maintenance as biogas producers produce cooking fuel for free).¹⁷²

5.1. Pre-requisites for the affordability support mechanisms

S1 – S6: supply side subsidies

- **S1: Concessional corporate finance (e.g. grants or concessional loans):** many grant and concessional loan programmes require private sector beneficiaries to meet eligibility requirements such as having audited accounts, a minimum level of scale, and company-level policies (waste, gender, sourcing etc). For electrical infrastructure, a strong and capable national utility is needed to administer schemes effectively.
- **S2: Tax reductions and exemptions:** needs a well-functioning tax administration. Where exemptions are for a specific subset of products only, requires well-capacitated and transparent customs processes, predicated on the feasibility of defining eligibility (HS codes / simple product characteristics / authorised product list).

¹⁷¹ IISD (2025) “The Use of Green Tax Incentives for Renewable Energy Deployment in Emerging and Developing Countries”, [Link](#)

¹⁷² Circular Ecology (2025) “Gold Standard Biogas and Clean Cooking Project in Kenya”, [Link](#)

- **S3: Outcome-based revenues/finance:** need reliable and cost-effective monitoring and verification mechanisms; best suited to technologies that can be remotely monitored, i.e. the higher-tier metered systems, or where fuel sales can be monitored cost-effectively.
- **S4: Price caps:** if administered through a utility then needs a well-functioning utility that can place price caps on utility bills.
- **S5: Universal price subsidies:** depends on the technology; LPG and electricity both require reliable supply for an ongoing price subsidy to be effective in increasing usage.
- **S6: Preferential tariffs:** the supplier needs to be able to accurately differentiate between groups paying different prices (the method will depend on the targeting mechanism) and to vary prices accordingly. If financed through a cross-subsidy, the utility needs a broad customer base with a large enough base of higher ability to pay customers. For complex tariffs it needs customers that are likely to respond to tariff options; in Europe for example the direct savings to householders of time of use tariffs and smart meters are small and may not outweigh the costs of investment.¹⁷³

S7: Common infrastructure subsidies

Requires either a high quality ecosystem of upstream and/or downstream providers able to utilise the common infrastructure. This could be a competitive supplier landscape (as in e.g. retail services for electricity or telecoms in the UK), or a single supplier that is highly competent to service customers.

Subsidising common infrastructure may be particularly effective if it results in access to an (improved) product or service, that is cost-competitive with existing technologies. For example, if expanding access to reliable electricity networks can enable customers to use e-cooking, there is evidence that (at least in some settings) this can be cheaper than alternative cooking technologies in urban areas.

Shared infrastructure must be appropriately regulated to avoid creating monopolies able to extract excessive rents. For example, in Morocco, LPG marketers have formed shared companies to provide filling activities. However, these filling companies are not allowed themselves to be LPG marketers. This approach has enabled economies of scale that have reduced costs for LPG marketers whilst protecting a competitive market downstream.¹⁷⁴

Otherwise, to be cost effective without the need for substantial long-term subsidies, requires either economic growth or increasing customers with sufficient existing ability to pay. For example, expanding grid infrastructure in low-income contexts often results in utility companies failing to recover their costs and suffering substantial losses, with newly connected customers using only a minimal amount of the services enabled by the infrastructure due to affordability constraints. A lot of projects and financing in SSA had been focused on building energy supply, without considering the need for demand enhancement to match and pay for this supply. There is a growing focus in the sector on boosting this demand through the productive use of renewable energy (PURE), which can increase the commercial viability of electrification.¹⁷⁵ Demand stimulation should be better integrated in the design phase of electrification projects.¹⁷⁶

¹⁷³ CERRE (2015) "Affordability of utilities' services: extent, practice, policy – Research Paper 13: Review of Evidence on the Effectiveness of Policies Tackling Fuel Poverty and Digital Exclusion", [Link](#)

¹⁷⁴ WLPGA (2013) "Guidelines for the Development of Sustainable LP Gas Markets: Early-Stage Market Edition", [Link](#)

¹⁷⁵ GEAPP (2026) "It is time to turn megawatts into markets in Africa", [Link](#)

¹⁷⁶ Africa Energy Portal (2022) "Improving Mini-Grids' Sustainability Via Demand Stimulation", [Link](#)

If neither of the previous conditions are met, it needs committed long-term public funding. As has been the case in jurisdictions that have provided long-term subsidies for LPG (see Case Study 6)

A challenge in comparing the effectiveness of different affordability support mechanisms is linking the subsidies to prices faced by households for adoption. For example, relevant to common infrastructure, many customers do not face cost reflective electricity tariffs with for example almost all Sub-Saharan Africa utilities operating at a financial loss, with ongoing support from national government budgets to bridge the gap between their costs and revenues generated. The same is true of other technologies however, where the prices of standalone solar companies bake in years of supply side subsidies, while mini-grids often have a mix of (sometimes 100%) capital cost subsidies and ongoing operational subsidies.

Demand side subsidies (D1, D2, D3)

These require, depending on the delivery mechanism for the transfer:

- A physical agent network if payments are made in cash.
- Widespread access to bank accounts if transfers are made via bank transfer.
- Digital finance regulations and telephone network coverage if mobile money is used.
- Reliable billing systems if on-bill financing is administered through e.g. utility.

5.2. Pre-requisites for the targeting of affordability support mechanisms

Each of the targeting mechanisms has different requirements:

- **Income or poverty levels:** Database with household income levels, or survey instruments e.g. poverty propensity scores; biometric identification.
- **Social security registers.** Existing and well-maintained social security registers; strong data protection to preserve anonymity of those receiving welfare support.
- **Geographic location.** National database on demographic and economic indicators per geographic area; need to be able to prevent “leakage” of sales into non-eligible regions (e.g. geo-tagging devices, robust verification).
- **Customer observables.** Database with household observables – or extensive survey exercises.
- **Self-selection.** Insights and data into how different customer groups can afford different tiers or have different usage levels; ability to structure product<>price bundles that exclude higher ability to pay customers.

Targeting of customers, especially using geographic targeting, will often be a political as much as a technical consideration.¹⁷⁷ Both the decision to target particular regions and how the processes are implemented will have political implications.¹⁷⁸

¹⁷⁷ Van Domelen (2007) “Reaching the poor and vulnerable: Targeting strategies for social funds and other community driven programs”, [Link](#)

¹⁷⁸ INCLUDE (2022) “Targeting strategies in development policies and programmes – From design to practice A literature review”, [Link](#)

5.3. Technology-specific considerations

The pre-requisites for effectiveness of affordability support mechanisms also depends on the characteristics of the technology:

- **Electric cooking**, requires well developed network infrastructure, with a (sufficiently) reliable electricity supply that meets the voltage requirements for appliances.
- **LPG**, requires national distribution infrastructure for safe cylinder replacements (or re-fills, although this may raise safety concerns); including import facilities, storage facilities across a national backbone / hub-and-spoke, down to bottling, and adequate road networks.
- **Improved cookstoves**, needs customers to be able to access stoves and a reliable supply of improved fuel (e.g. processed biomass pellets).
- **Ethanol**, needs a reliable supply of and distribution network for the ethanol fuel. This may mean a reliable local production of ethanol, although noting this may compete with agriculture for food and drink production.
- **Biogas (biodigester waste-to-fuel)**: are typically local closed distribution systems, so need local suitability for producing and distributing biogas.

Technologies that require imported fuel also need access to foreign exchange. For example, where LPG or ethanol is imported, supply will depend on being able to access hard currency to import (which has been a challenge for example for using ethanol for cooking in Ethiopia).

5.4. Other considerations

Of course, a household's decision to adopt clean cooking technologies depends on many other factors beyond affordability. In particular it depends on the cost and availability of alternatives; even if clean cooking is affordable it may not be adopted. There are (less clean) alternatives that may provide a preferred customer experience, or are cheaper. Clean cooking technologies do not play on a level-playing field in many emerging economies, where electricity connection and unit pricing are often not cost-reflective, and where fossil-fuel subsidies remain commonplace.

Some countries have trialled banning production or consumption of firewood and charcoal.

These policies intend to push consumers towards cleaner, more sustainable energy sources in the absence of alternatives. For example, Malawi has outlawed charcoal production without permits,¹⁷⁹ Kenya has a long history of logging ban, Uganda has prohibited commercial charcoal production in certain areas,¹⁸⁰ and Rwanda has proposed charcoal use bans in Kigali.¹⁸¹

Without adequate enforcement and affordable alternatives fuel bans are highly unlikely to achieve their intended outcomes. Illegally produced charcoal remains the near-ubiquitously used urban cooking fuel in Malawi a decade after being banned. The Kenyan logging ban simply displaced deforestation to Uganda, with likely no overall impact on total forest stocks. It thus exported tax revenues to Uganda and caused job losses in Kenya. The rise in cross-border trade increased charcoal prices. These costs were largely absorbed by households, who allegedly continued to use charcoal despite its resulting lower relative affordability to cleaner alternatives,

¹⁷⁹ Ministry of Natural Resources, Energy and Mining (2017) "National Charcoal Strategy 2017-2027", [Link](#)

¹⁸⁰ Okot (2024) "An ecological war is going on: Uganda charcoal booms despite ban", [Link](#)

¹⁸¹ Woolley et al. (2022) "Domestic fuel affordability and accessibility in urban Rwanda: policy lessons in a time of crisis?", [Link](#)

and thus negatively affected the ability of a large proportion of the Kenyan population to cook their food and heat their homes.^{182,183}

5.5. Digital technologies

Digital technologies have been used to improve targeting and delivery of affordability support mechanisms. They are most applicable to targeted mechanisms, as they allow for more efficient targeting and delivery of the intended affordability support. They can ensure that only the targeted beneficiaries are receiving the subsidy or other benefit, and that it can be delivered automatically, without cost to beneficiaries or manual payments. It can also reduce misuse of funds and corruption.

For supply side mechanisms, these technologies are useful for affordability support that is conditional on achieving targets or uptake, or to administer the affordability support more efficiently. In the first case, these can be, for example, metered stoves if payments are to be based on customer usage, or digitisation that is used to streamline the monitoring, reporting and verification of RBFs or outcome-based finance programmes. When administering universal or preferential tariffs, digital IDs can be used to identify targeted customer to apply a price cap to their bill, and smart meters to implement differential tariffs for different usage levels.

For demand side mechanisms, digital technologies are relevant to identifying the beneficiaries and delivering the cash transfer or rebate directly into their bank accounts. Indonesia developed a pilot where eligibility is verified through a facial biometric mechanism. This can reduce leakage, as only the intended beneficiary can pick up the LPG cylinder. Mobile banking allows for payments made directly into end users' bank accounts. It also facilitates concessional end-user finance, as payments can be made efficiently online, and the provider can use the online bank for credit screening. In India, for example, websites and text messages were used to track the order and delivery of LPG cylinders. If a mechanism is geographically targeted, GPS technology can be used to verify that the mechanism has been administered, and that the systems remain in use only in the target area.

Digital monitoring and verification technologies offer exciting opportunities to more accurately target preferential tariffs. A flagship example from the off-grid solar sector is Togo's CIZO programme, which subsidised electricity for rural populations without access to the grid. Eligible solar home system customers received the subsidy directly to their solar wallets; upon payment, the mobile operator would automatically check whether the customer qualified for the subsidy and top up the customer's payment with the subsidy before sending it to the solar provider.¹⁸⁴ There is little evidence of such approaches being trialled with clean cooking, although there have been rumours of the Kenyan government planning to partner with PAYG LPG providers to mobilise targeted LPG subsidies.

¹⁸² Bartlett et al. (2024) "The unintended consequences of production bans: the case of the 2018 Kenya logging moratorium", [Link](#)

¹⁸³ Wekesa et al. (2023) "Effects of charcoal ban on value chains and livelihoods in Kenyan coast – Stakeholders' perceptions", [Link](#)

¹⁸⁴ GOGLA (2024) "Togo CIZO Cheque Program", [Link](#)

6. Broader Finances of Affordability Support

A key question for affordability support mechanisms is who pays and bears the overall cost and the financial risk? Broadly three possible actors could bear these costs and risks:

- **Cross-subsidies within an operator's customer base**, this occurs when for example preferential tariffs (for connection or usage) are borne by a national energy utility (or any other operator) and therefore paid by some sort of cross-subsidy between their customers.
- **National governments**, where affordability mechanisms are delivered through tax reductions and exemptions, through nationally funded end user subsidies, or through subsidised common infrastructure.
- **Development partners**, where supply side or demand side mechanisms are paid for by grants or concessional finance, as is for example often the case for RBF programmes.

Relying on cross-subsidisation depends on having a sufficiently large majority of customers who can afford to cross-subsidise others. It has been noted that for African utilities, “connecting an additional household is unprofitable”.¹⁸⁵ Utilities across Sub-Saharan Africa are typically not financially sustainable,¹⁸⁶ so cannot be expected to bear the cost of subsidising customers who generate less revenue than they cost to serve. In general, cross-subsidies are only feasible when there is a large enough majority of the customer base that can afford to pay cost-reflective tariffs plus a cross-subsidy markup.¹⁸⁷

There may be ways to combine cross-subsidies with national government funding to raise public funds to implement cross-subsidies for energy access. In Ghana, remote unelectrified communities want (and expect) the same mini-grid tariff as national rates. However, they are higher cost to serve; the solution could be a combination of cross-subsidies and (externally funded) subsidies. Indeed, for the mini-grid to provide electricity at the national tariff, on-going recurrent cost subsidies would be needed in addition to a 100% capital cost subsidy.¹⁸⁸ In Moldova a study found that increasing VAT on electricity and implementing an income-based voucher system to compensate poorer households was administratively and fiscally most efficient, with an estimated \$77 million to be gained from the rise in VAT rate, and \$47 million spent on the social transfer.¹⁸⁹ As noted above, this sort of cross-subsidy from one set of customers to another relies on their being a large enough base of customers who can bear the higher prices (in this case the VAT rise).

Where government funding is used primarily to address affordability, it can be highly costly as is often very hard to remove. As has been discussed elsewhere in this paper, LPG subsidies have often tended to need to be sustained (potentially for decades) to ensure uptake, resulting in a high burden on public finance. Measures such as tax reductions which require the government to forego resources are also typically permanent, reducing much needed fiscal resources.

In the case of equipment or fuels that require importing, the affordability mechanisms funder may be exposed to substantial risk of commodity price volatility and in consequence balance of payments problems and indebtedness where the exposure is significant. For example, LPG price fluctuations make whoever pays the price to import LPG highly exposed. If governments aim

¹⁸⁵ Blimpo & Cosgrove-Davies (2019) “Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact”, [Link](#)

¹⁸⁶ [add references to UPBEAT reports]

¹⁸⁷ BII and Greencroft Economics (2024) “How does investing in electricity support inclusion?”, [Link](#)

¹⁸⁸ ESMAP (2017) “Ghana: Mini-Grids for Last-Mile Electrification”, [Link](#)

¹⁸⁹ OECD (2018) “Energy Subsidy Reform in the Republic of Moldova: Energy Affordability, Fiscal and Environmental Impacts”, [Link](#)

to keep LPG prices fixed for their population, they bear the risk of having to cover a changing price differential. This makes it difficult to plan properly and to know how much of the government's budget will need to be allocated to the subsidy. If prices increase suddenly, the government needs to immediately find the budget to cover this price differential. The impact of energy price fluctuations on a country's balance of payment depends on certain factors, where energy price shocks have a greater impact on countries with structural deficits, middle-income countries suffer more from energy price shocks than high-income ones, and energy-importing countries suffer more.¹⁹⁰

It could be more effective to target other development practices instead of clean cooking affordability support mechanisms, depending on the desired outcome. There is a range of literature that discusses the effectiveness of affordability support mechanisms versus direct development transfers to poorer households. For example, research in Ecuador shows that if all energy subsidies are removed, this funding could be used to increase the *Bono de Desarrollo Humano* (BDH), a development transfer scheme, which increases the income of the lowest quintile and significantly reduces the public deficit.¹⁹¹ This highlights an important opportunity cost question for clean cooking policy: where transition pathways require large and sustained fuel subsidies, their benefits should be considered against alternative uses of the same resource.

¹⁹⁰ Nashi & Ouakil (2025) "Energy price shocks and current account balances: What role for economic structure, energy dependency and renewable energy development?", [Link](#)

¹⁹¹ Schaffitzel et al. (2020) "Can government transfers make energy subsidy reform socially acceptable? A case study on Ecuador", [Link](#)

7. Data Availability and Energy System Modelling Capacity

7.1. Overview of a selection of common energy system toolkits

There is an ongoing shift towards more advanced consideration of clean cooking in energy systems modelling. Historical modelling efforts have focussed more on electricity and tended to feature a simplistic treatment of cooking.¹⁹² However, there have been several recent efforts to integrate clean cooking more systematically across energy planning. New models are emerging that are specifically tailored to cooking, and clean cooking policies increasingly draw upon models to inform their transition pathways.

Energy models are typically used to simulate future pathways for energy systems and their associated impacts, but they also have important shortcomings. Models are simplified versions of reality and they rely on good quality and quantity of input data. Numerous platforms now provide open access to data, from sources such as World Bank, IEA, SEforALL, IRENA, MECS.

We reviewed some of the main energy system models used in the electricity access and clean cooking sectors. A table mapping the main data inputs of each model is provided in Annex 2, with a summary of each model in the bullets below followed by a discussion of the ability of these models to factor in affordability considerations:

- **Integrated Clean Cooking Planning Tool (ICCPT):** developed by ESMAP and is the most advanced clean cooking model to date.¹⁹³ It uses a least-cost approach, considering economic, social, and environmental factors to determine transition pathways with default and user-defined fuel-mix percentages and access targets.¹⁹⁴
- **The Benefits of Action to Reduce Household Air Pollution (BAR-HAP) model:** is a WHO planning tool that analyses how policy interventions can support the transition to cleaner cooking fuels and technologies.¹⁹⁵
- **OnSTOVE:** estimates net benefits, comparing stove and fuel transition costs with monetised benefits, such as time savings, emission reductions, and improved health outcomes.
- **IEA Global Energy and Climate (GEC):** defines pathways for urban and rural areas in Sub-Saharan African countries. It assesses the availability and cost of clean cooking solutions at square kilometre grid level and selects the most affordable option relative to household income, and maximises consumer benefits for convenience and health.¹⁹⁶
- **Global Electrification Platform (GEP):** a scenario-based model of least-cost electrification that integrates grid, mini-grid, and off-grid solutions. It calculates the cost to serve unelectrified settlements to identify the least-cost solution, taking into estimates of poverty and income levels.¹⁹⁷

¹⁹² (2024) "Sustainable Scaling: Meeting the Clean Cooking Challenge in Africa", [Link](#)

¹⁹³ AFREC (2024) "Sustainable Scaling: Meeting the Clean Cooking Challenge in Africa", [Link](#)

¹⁹⁴ Leach (2022) "Scale up analysis: modelling method and assumptions", [Link](#)

¹⁹⁵ Das et al. (2025) "The Costs and Benefits of Clean Cooking Policies in Low- and Middle-Income Countries Under Real-World Conditions", [Link](#)

¹⁹⁶ IEA (2025) "Universal Access to Clean Cooking in Africa – Progress update and roadmap for implementation", [Link](#)

¹⁹⁷ World Bank (2024) "The Global Electrification Platform 3.0: More data for more accurate, least-cost electricity access plans", [Link](#)

- **Open Source Energy Modeling System (OSeMOSYS):** an open-source model generator which uses a cost-optimization framework to generate scenarios based on techno-economic information as well as policy, environmental, and other constraints.¹⁹⁸
- **Integrated Energy Planning Tool (IEPT):** a geospatial platform that uses several data layers to model least-cost access to electricity and clean cooking.¹⁹⁹

7.2. Integrating affordability considerations into energy system models

All of these tools can at least to some extent integrate (universal) affordability mechanisms but few are able to account for complex or highly-targeted mechanisms. Most models use a single representative stove and fuel price, and therefore have an initial, even if crude, assessment of affordability tenets 1 and 2 (upfront and ongoing costs) but not tenet 3 (transaction size). Models with geospatial layers, such as OnStove and GEP, can be used to inform geographical targeting, although they are not explicitly designed to design or model these types of approaches and while they might include data on differing ability to pay by community, they typically do not have data on the variation in cost to serve (or they are based on assumptions). This is of course understandable, as geographically granular data on the cost to serve customers is complex; even geographically disaggregated fuel price data is relatively scarce.

Many of the models could support estimation of subsidy levels to support accelerated adoption, but do not differentiate on how to design and implement subsidies. For example BAR-HAP, OnSTOVE, ICCPT can be used estimate the price change needed to achieve adoption targets. However, they are not designed to differentiate between the types of affordability mechanisms discussed in this report, and rely on a (relatively simple) relationship between product pricing and adoption.

While all of the models include some assessment ability to pay, but none have detailed assessments of willingness to pay. Ability to pay is often reasonably well proxied, as there is (often geospatially granular) data available on poverty and income levels – although this data is often relatively dated. This means models can estimate benchmarks such as the 5% or 10% of current expenditure reasonably well. However, they often do not have detailed assessments of current expenditure on alternative technologies, and they do not include other factors that would affect willingness to pay such as availability and price of alternatives.

Few models incorporate stacking of technologies, or any detailed analysis of willingness to pay. Models generally assume “complete” adoption of one fuel per household, except for BAR-HAP, which assumed that half of cooking is performed on the intervention technology. The model estimates of what a consumer should choose is also often not matched by consumer preferences in practice. For example, the OnSTOVE modelling present-day baseline in Nepal is very different to Nepal’s current fuel mix, signalling that the current policies, subsidy packages and infrastructure improvements are falling short.²⁰⁰

¹⁹⁸ Barnes et al. (2022) “OSeMOSYS Global, an open-source, open-data global electricity system model generator”, [Link](#)

¹⁹⁹ SEforAll (2022) “Malawi Integrated Energy Plan”, [Link](#)

²⁰⁰ Ramirez et al. (2024) “Achieving Nepal’s Clean Cooking Ambitions: An Open-Source and Geospatial Cost-Benefit Analysis”, [Link](#)

8. Findings and Areas for Further Research

8.1. Summary of findings

All of the affordability mechanisms described in this report can be effective in different contexts. It is difficult to draw conclusive answers to rank one mechanism against another – a combination of all will be needed depending on the nature of the affordability challenge and on local contextual factors.

We make four overarching findings:

- **Different mechanisms and delivery modalities will be needed depending on the context.** There is no generalisable first-best solution – all of the mechanisms can be effective depending on the nature of the affordability challenge, and the context. For example, preferential tariffs relying on cross-subsidies may be the best solution where access is widespread, the main consideration is energy poverty (rather than usage levels) and where there is a large majority of customers who can afford to cross-subsidise a preferential tariff for a minority of customers. Tax reductions may be relatively more effective in very nascent markets with low penetration levels, where the objective is to encourage a rapid scale up of sales and private sector activity. Targeted demand side subsidies are better used to complement (and eventually replace) universal subsidies, to make sure the lowest income customer segments are served.
- **A key question is who funds affordability mechanisms.** Tax reductions decrease the vital resources of governments in developing countries, while development partner funding is a scarce (and becoming scarcer) resource. Cross-subsidies are common in mature energy market systems, but are only practical where there is a large majority of customers with surplus ability to pay that can bear the cost of cross-subsidising a minority of lower ability to pay (or higher cost to serve) customers.
- **Energy system models are well suited to estimating clean cooking pathways, but less so for designing affordability support mechanisms.** There are by now a wide range of systems that can estimate different pathways for electricity or clean cooking access. However, they are less well suited to designing the financing mechanisms to implement the transition pathways, or to have the data to design subsidies to accelerate access.
- **Untargeted mechanisms, such as universal price subsidies, and even preferential tariffs are likely to benefit relatively wealthier customer segments.** This is because relatively wealthier population segments tend to have higher access to and consumption of clean technologies. However, this can be a positive outcome; there is likely to be a middle customer segment – the poor but not the poorest – where there is the most potential for affordability support mechanisms to drive impactful changes in consumer behaviour, at good value for money and potentially only short-term interventions. However, where the affordability gap is large, mechanisms to accelerate access to clean cooking are likely to be expensive, and sustained in the long term.

8.2. Priority research areas

From this rapid desk review, we identify ten priority for further research:

- Defining affordability in different contexts, and better affordability metrics.** While widely used for consistency and simplicity, neither the 5%-10% expenditure thresholds, nor current fuel expenditure levels, provide a definition of affordability that works in all contexts. This especially holds when different technologies offer different types and quality of cooking, and when households often combine multiple cooking solutions. For example, affordability has a very different meaning for rural households reliant on free firewood compared to urban dwellers paying for polluting fuels, and it may have different definitions across the three proposed affordability tenets (upfront, ongoing and transaction size).
- Developing a better understanding of what affects willingness to pay and sustained adoption rates.** Willingness to pay is likely to vary widely – for example between rural households (who do not pay for fuel) versus urban households (who do). More studies are required on the factors that make households willing to (continue) to pay for cleaner technologies, and the extent of adoption, acknowledging that technology is stacking (across electricity and clean cooking access).
- Generating more datapoints on price elasticity of demand in different contexts, and setting subsidy levels.** How consumers respond to price changes is complex and a single price elasticity of demand does not represent all customers along a demand curve. More studies testing different price levels and both short- and long-term demand response would be highly valuable to better calibrate subsidy levels.
- Differentiating between internalized value to households and external benefits which are valuable but do not make clean cooking technologies more affordable.** Estimates of affordability often seem to be more than what households are revealed to be willing to pay. This is because they place economic values on benefits which may not be captured as a financial benefit, and therefore perhaps not internalised in the decision making of a household. For example, time saving in a context of high un- and under-employment may not unlock extra cash, and health benefits may be too uncertain, abstract, or far into the future to influence purchasing decisions.
- Structured evaluations of the impact of affordability support mechanisms on sustained energy access, and when a subsidy “exit plan” is feasible.** There is limited research on whether energy access gains are sustained after the affordability support mechanism is reduced or withdrawn. While design documents commonly recommend subsidy programmes should have an “exit plan”, there is little evidence on what this means in practice, and indeed in some cases it may be more helpful to acknowledge that a subsidy is not a one-off, catalytic mechanism and will need to be sustained.
- Transparency about the delivery costs for different affordability support mechanisms.** There is limited information on how much it costs to administer different types of mechanisms, particularly when it comes to targeted subsidies. More transparency is needed on the additional costs associated with business models and affordability support mechanisms, and who is expected to bear these costs; for example, allowing customers to spread payments over time can introduce significant additional costs (PAYGo remote activation technology, customer payment mechanisms, working capital finance, customer bad debt, repossession of systems etc.).
- How (short-term or sustained) tax reductions and exemptions affect the (sustained) uptake of clean cooking solutions, and net fiscal outcomes for governments.** Since tax reductions are typically untargeted, little is known about who benefits, and whether it is more effective to support clean technology uptake through targeted subsidies for specific customer segments. While advocacy studies estimate high benefits from tax exemptions,

there is limited robust ex poste assessments of the benefits delivered by tax reductions. It is also not clear whether tax reductions are temporary measures to kick-start a nascent market, or permanent measures for essential goods. It would be helpful to identify examples where tax reductions have played this role. It would also be interesting to explore if tax exemptions on stoves recover that foregone fiscal revenue through taxes on ongoing usage.

- **Developing a decision tree or framework to guide when different subsidy mechanisms should be used.** This would depend on a combination of the affordability barrier, and local contextual factors.
- **Consider how to extend existing energy system models to integrate a more detailed understanding of affordability.** For example, working on more granular estimates of the cost to serve of different technologies in remote communities, and on the willingness to pay to reduce reliance on the overly-simplistic ability to pay thresholds.
- **Run structured trials to explore the welfare outcomes of conditional energy subsidies, versus unconditional cash transfers.** While access to energy is clearly an important objective, it would be helpful to understand to what extent this is the first priority of targeted communities, what they would choose with an unconditional transfer of equal value, and the welfare implications of conditional versus unconditional transfers.

Annex 1 – Case Studies

Case Study 1: Bangladesh cook-to-earn

	Affordability support mechanism <i>Rebates (ex post)</i>		Affordability tenets <i>Upfront and ongoing</i>
	Targeting mechanism <i>None</i>		Delivery mechanism <i>Electronic transfers</i>

ATEC combines advanced appliance innovation with carbon finance. ATEC is a leading clean cooking company working to accelerate the transition from polluting biomass fuels to modern electric cooking solutions across emerging markets. Through its flagship eCook technology, ATEC's innovation aims to make clean cooking affordable, scalable, and sustainable for low-income households. The company is currently implementing large-scale carbon credit programmes in Malawi, Nepal, and Bangladesh, while also conducting pathfinding and early market development activities in Rwanda and other countries such as Ghana. Over the next three years, ATEC aims to deploy more than 200,000 electric cooking stoves across its priority markets, generating substantial climate, health, and livelihood benefits.

To address the primary barrier to eCooking adoption, the high upfront cost of modern electric appliances, ATEC has transitioned its business model from conventional hardware sales to an advanced carbon-financed delivery system. Rather than relying on customer repayment models such as PAYGO, ATEC now leverages carbon subsidies to significantly reduce the purchase price of its eCook stoves. By embedding patented IoT technology into every appliance, ATEC generates real-time cooking and usage data that enables the issuance of high-integrity carbon credits backed by verified emissions reductions. This integration of climate finance allows ATEC to offer stoves at a much more accessible price point, accelerating the shift toward clean cooking.

A central feature of this model is ATEC's user-focused incentive mechanism, the "Cook to Earn" initiative. Because every stove is digitally monitored through robust digital Monitoring, Reporting, and Verification (dMRV) systems, ATEC is able to directly link carbon revenue to actual stove usage. Households are not only able to access the technology through subsidised pricing, but they are also rewarded for sustained and consistent electric cooking. Through Cook to Earn, users receive recurring payments directly into their mobile money accounts based on verified cooking activity and associated carbon savings. Over the lifetime of the stove, households can receive up to \$15 in cashback, ensuring that the financial value of carbon finance is shared directly with end users. This approach strengthens long-term behavioural adoption, improves customer engagement, and makes clean cooking both affordable and rewarding.

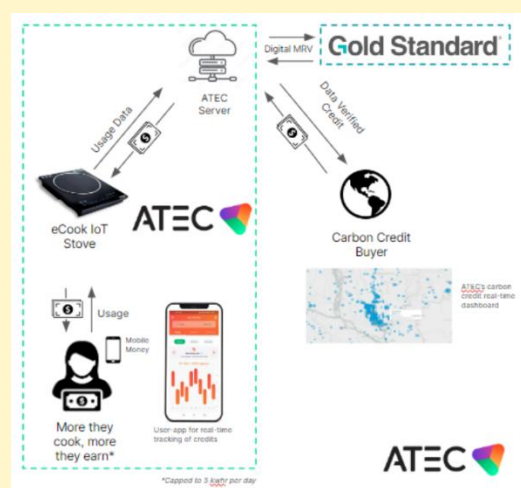


Image: ATEC business model with carbon finance

ATEC eCook is further supported by a dedicated mobile application, available on both Android and iOS platforms. The app enables users to track cooking usage, monitor energy consumption, understand cost savings, and access other key performance insights. Together,

ATEC's combination of IoT-enabled appliances, carbon-backed affordability, and direct consumer incentives represents a scalable and high-impact approach to expanding electric cooking access in underserved communities.

In Bangladesh and other countries, this model has the potential to deliver wider national benefits beyond household affordability. By reducing reliance on biomass and traditional fuels, ATEC's eCooking deployment supports improved public health outcomes, lowers pressure on forest resources, and contributes directly to the country's climate mitigation commitments. The availability of verified dMRV data also strengthens the evidence base for integrating eCooking into national clean cooking strategies, carbon market frameworks, and electrification planning. As most of the countries in Asia and Africa where ATEC is operational are advancing policies around renewable energy, emissions reduction, and sustainable household energy access, ATEC's approach demonstrates how carbon finance and digital innovation can support the government's long-term transition toward modern, low-carbon cooking solutions at scale.

Cook-to-earn resulted in higher induction stove usage rates for both new and already-existing ATEC customers in Bangladesh. MECS and ATEC partnered on a study to compare the impact of C2E on induction stove adoption and found that enrolling customers in C2E resulted in 38% higher usage for new customers in Bangladesh and 21% higher usage for already-existing customers.²⁰¹ This suggests that C2E successfully addressed affordability barriers that were previously limiting stove adoption. Further research is needed to better understand the long-term effectiveness of C2E and its efficacy in other locations. ATEC have since raised \$15.5m to scale its IoT stoves, including C2E, in other markets, demonstrating investor appetite for novel benefit-sharing mechanisms and transparent, high-quality carbon projects.²⁰²

This example shows how combining different sources of finance (impact-based, debt and equity) with novel business models and digital technologies can effectively address multiple affordability barriers at no cost to the government. However, such interventions need to be supported by the enabling environment in the country with access to requisite infrastructure. As of early 2026, Bangladesh is currently preparing its carbon market framework, which sets out rules for how the country will generate, authorise and trade emissions reductions.²⁰³ This poses a significant risk to initiatives like ATEC's as it could create opportunities and costs for carbon projects.

²⁰¹ ATEC & MECS (2023) "Paying people carbon credits based on usage data: ATEC eCook Cook-to-Earn Case Study", [Link](#)

²⁰² ATEC (2025) "ATEC raises USD \$15.5m to scale tech-driven clean cooking and emissions reduction across Asia & Africa", [Link](#)

²⁰³ Carbon Pulse (2025) "COP30: Bangladesh "pre-launches" carbon market framework, lays ground for Article 6 trade by 2026" [Link](#)

Case Study 2: Brazil Light for All – universal electrification

	Affordability support mechanism <i>Preferential tariffs, subsidised common infrastructure, grants/concessional corporate finance, price caps</i>		Affordability tenets <i>Upfront, ongoing</i>
	Targeting mechanism <i>Social security registers, geographic locations</i>		Delivery mechanism <i>None</i>

Prior to the introduction of *Luz para Todos* in 2003, 13 million people lacked access to electricity in Brazil. While only 3% of urban households did not have electricity, 30% of rural households lacked access,²⁰⁴ and this could be far higher for example in the Amazon region due to dense rainforest, challenging topography and low population density.²⁰⁵ A series of reforms aimed to reach universal access,²⁰⁶ including laws to oblige electricity distribution companies to respond to requests for connections.

The intervention consisted of two phased programmes: ‘*Light for all*’ since 2003 and the ‘*Social Tariff*’ since 2010. ‘*Light for all*’ subsidised connection costs, starting with communities near the grid then expanding to more remote communities. Community targeting was driven by regulations that required energy distributors to prioritise remote communities and “traditional” groups in line with categories already defined by the Ministry of Environment. Providers could provide connections to remote regions through minigrids and off-grid solar as long as they could demonstrate that they were cost-competitive with grid extensions.

The ‘*social tariff*’ consists of a volume-differentiated tariff, with discounts for households enrolled in Brazil’s registry for social programmes, the *Cadastro Unico (CAD)*. Households received discounts on their electricity bill depending on how much they consumed, with lower consumers receiving higher discounts of up to 65%. Households receiving benefits for specific vulnerable groups (e.g. elderly or disabled) received further discounts on their total energy bill.

The interventions were funded through a combination of government reserves, electricity companies’ own resources and cross-subsidies. The cross-subsidisation operated on two levels: 1) high consumers of electricity subsidising low consumers of electricity; 2) regions with lower costs of generation and distribution subsidise their counterparts.²⁰⁷ The estimated total federal policy cost was 7 billion euros.²⁰⁸

‘*Light for all*’ and the ‘*social tariff*’ are widely considered to have been highly successful.²⁰⁹ ‘*Light for all*’ aimed to reach 10 million people by 2008, and has since been extended to run until 2022, having already reached over 16 million people by 2017. It contributed to improvements in human development, income improvement, educational and health access and electric appliance use. However, its benefits were initially not evenly distributed throughout the population, with a 2010 evaluation finding that wealthier communities were better able to exploit productive uses associated with the advent of electricity which caused more transformational developmental benefits.²¹⁰ As of 2017 this had been somewhat addressed through the introduction of the ‘*social tariff*’ and corrective targeting but remote communities with no access to electricity persisted.

²⁰⁴ IBGE (2000) “Censo Demográfico 2000 [Demographic Census 2000]”, [Link](#)

²⁰⁵ Gómez and Silveira (2015) “The last mile in the Brazilian Amazon—a potential pathway for universal electricity access”, [Link](#)

²⁰⁶ De Silva Bezerra et al (2017) “The power of light: socio-economic and environmental implications of a rural electrification program in Brazil”, [Link](#)

²⁰⁷ SEforAll (2020) “Energy Safety Nets: Brazil Case Study”, [Link](#)

²⁰⁸ World Access to Modern Energy, “Luz para todos”, [Link](#)

²⁰⁹ Matosinhos et al (2020) “Evaluation of the Effectiveness and the Efficiency of the Luz Para Todos Program”, [Link](#)

²¹⁰ Slough et al. (2015) “Light for all? Evaluating Brazil’s rural electrification progress, 2000-2010”, [Link](#)

As of 2017 there were 9 million households (11% of country total) benefitting from the ‘social tariff’. It has supported electricity consumption for low-income households during times of relative economic hardship. However, the programme appears to be insufficient to support the modern electricity demands of most poor households, such as powering computers, washing machines and appliances that alleviate household labour.²¹¹ Millions of eligible families cannot access the tariff reductions due to bureaucratic barriers and registration difficulties, and the programme does not adequately consider differences in cost of living and consumption patterns (e.g. the need for air conditioning in urban heat islands).²¹² A more equitable tariff structure would account for these heterogeneities in setting the subsidy levels and eligibility criteria.

²¹¹ Mazzone et al. (2019) “Decentralised energy systems and sustainable livelihoods, what are the links? Evidence from two isolated villages of the Brazilian Amazon”, [Link](#)

²¹² PSR and GEAPP (2025) “Pathways to justice in the Brazilian electricity sector” [Link](#)

Case Study 3: Kenya: Impacts of VAT on affordability of energy access products

	Affordability support mechanism <i>Tax exemptions</i>		Affordability tenets <i>Upfront and ongoing</i>
	Targeting mechanism <i>None</i>		Delivery mechanism <i>None</i>

Kenya has made significant strides in increasing energy access in recent years, but substantial deficits remain. As of 2023, 24% of the population lacked access to electricity and 68% to clean cooking.^{213,214}

Kenya has some of the strongest off-grid solar (OGS) and LPG markets in Africa. This can in part be attributed to long-standing favourable policies supporting these technologies. VAT exemptions for solar equipment and LPG were introduced in 2014 and 2016 respectively with a view to making these goods affordable for low-income households.^{215,216} However, in 2020 the government reinstated VAT at the standard rate of 16% for both LPG and solar products in response to the need to raise revenues to cushion businesses and citizens from the economic impacts of COVID-19.²¹⁷

The impact of the reinstatement of VAT on OGS and LPG was immediate and regressive. Most (70%) OGS providers had to pass the VAT directly on to end-users, resulting in an 11% drop in sales in the first half of 2020, and two-thirds of providers reporting severe disruptions to their supply chain due to the changes. There was also a decline in LPG use in 50% of studied households, with households reverting to using wood and charcoal.

The energy access sector responded through evidence-based lobbying demonstrating that the overall costs of the VAT reinstatement would outweigh the benefits. VAT on OGS products was forecast to raise just \$13 million of tax revenues per year and VAT on LPG \$45 million per year – just 0.1% of Kenya's national revenue combined.²¹⁸ The VAT on OGS was projected to result in half a million fewer households gaining access to electricity by 2025, creating new jobs by 2,500 FTE and slowing economic activity of households to the tune of up to \$40 million per year. For LPG, it is estimated that the VAT imposition would generate nearly double the cost in negative socio-economic outcomes – higher morbidity and mortality, increases in CO₂ emissions, time losses and wood fuel stock losses – and result in reversion to polluting fuels.⁶ In both cases, the VAT policy was expected to disproportionately impact resource-poor families with lower ability to pay.

The VAT exemption was eventually reinstated for both LPG and OGS products. VAT on renewable energy products was removed again in 2021 for renewable energy products following an appeal led by the Kenya Renewable Energy Association (KEREa).²¹⁹ On the LPG side, VAT was reduced to 8% in 2022 and again to 0% in the 2023 Finance Bill.²²⁰

²¹³ World Bank "Access to electricity (% of population) – Kenya, [Link](#)

²¹⁴ World Bank "Access to clean fuels and technologies for cooking (% of population) – Kenya, [Link](#)

²¹⁵ Africa Clean Energy "Imposition of VAT on Solar Products Defeats the Intended Purpose", [Link](#)

²¹⁶ CLEAN-Air Africa et al. (2022) "COP26 and SDG7 goals under threat: 16% VAT on LPG reverses progress made in clean cooking adoption in Kenya, [Link](#)

²¹⁷ Africa Clean Energy (2021) "Economic Impact Assessment on Removal of Tax Exemptions on Stand-Alone Solar Products in Kenya", [Link](#)

²¹⁸ Clean Cooking Alliance (2021) "Value-Added Tax on Cleaner Cooking Solutions in Kenya", [Link](#)

²¹⁹ GOGLA (2021) "A big win for Kenya: Government reinstates VAT exemptions on renewable energy products", [Link](#)

²²⁰ IEA "Cooking gas consumer support", [Link](#)

Case Study 4: Indonesia: from kerosene to LPG

	Affordability support mechanism <i>Universal price subsidy</i>		Affordability tenets <i>Upfront and ongoing</i>
	Targeting mechanism <i>Product-based targeting</i>		Delivery mechanism <i>None</i>

In 2007 Indonesia launched a kerosene to LPG conversion programme with a universal subsidy for 3kg cylinders. Free LPG starter packs were distributed to all households and micro-businesses, comprising a cylinder and a stove, which addressed upfront affordability (free kits) and ongoing affordability by both (1) offering the small 3kg cylinders so that payment increments were reduced, and (2) subsidising replacement of the 3kg cylinders. Larger cylinders (5.5kg and 12kg) were not subsidised. Since 2024, only registered users can purchase 3kg cylinders.²²¹

The programme utilised the distribution network of Pertamina, the national petroleum company, to ensure LPG availability nationwide. Pertamina was given the sole license to supply LPG, building on their existing kerosene infrastructure. Customers exchange their empty cylinders for filled ones at local retailers. In many areas, kerosene was withdrawn by removing kerosene sale licenses once the LPG starter kits were distributed.²²²

The programme increased LPG uptake, with the 3kg cylinders accounting for 84% of cooking in 2024, while kerosene use fell from 40% in the mid-2000s to 2.5% by 2023.²²³ Primary fuelwood usage reduced from 50% to 25% between 2007 and 2015.²²⁴ Consumers saved 30% on cooking fuel by switching from kerosene to LPG.²²⁵ These gains were most marked in urban areas. In more rural and low population provinces, where LPG distribution channels remain underdeveloped, kerosene still accounts for between 16%-52% of household fuel use.²²⁶ The national scale unlocked economies of scale in LPG infrastructure investments (bulk storage, filling plants, transportation and cylinder inventory).²²⁷ The political backing and parliamentary approval, as well as effective coordination between ministries, have been noted as success factors.²²⁸

The subsidy did not reduce pressure on government expenditure, as while the kerosene subsidy reduced substantially, this was offset by high demand for LPG and fluctuating global prices. The LPG subsidy cost the government more than \$5 billion in 2024, around 0.4% of GDP and 2.5% of government expenditure.²²⁹ Initially, the LPG subsidy was less costly than the kerosene subsidy, and the government saved \$15.6 billion between 2006 and 2016.²³⁰ Since 2016 the LPG subsidy cost has risen rapidly, and overtook the 2008 kerosene subsidy cost in 2019. The cost of the

²²¹ Government of Indonesia (2023) "Gov't Urges Subsidized 3-kg LPG Consumers to Sign Up for Well-targeted Distribution", [Link](#)

²²² Thoday et al. (2018) "The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion", [Link](#)

²²³ IISD (2025) "Indonesia's Next Cooking Transition: Shifting to non-fossil cooking", [Link](#)

²²⁴ Thoday et al. (2018) "The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion", [Link](#)

²²⁵ Budya & Arofat (2011) "Providing cleaner energy access in Indonesia through the megaproject of kerosene conversion to LPG", [Link](#)

²²⁶ Thoday et al. (2018) "The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion", [Link](#)

²²⁷ Thoday et al. (2018) "The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion", [Link](#)

²²⁸ Das et al. (2022) "Taxes and Subsidies and the Transition to Clean Cooking: A Review of Relevant Theoretical and Empirical Insights", [Link](#)

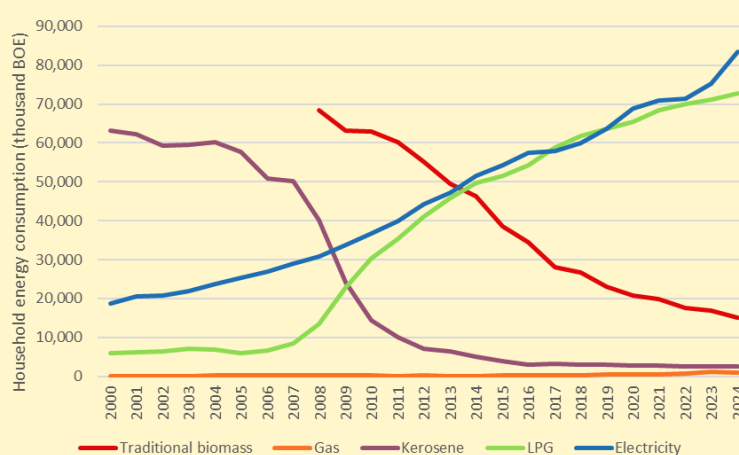
²²⁹ IISD (2025) "Indonesia's Next Cooking Transition: Shifting to non-fossil cooking", [Link](#)

²³⁰ Thoday et al. (2018) "The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion", [Link](#)

LPG subsidy also remains highly unpredictable as it fluctuated with crude oil price; it was almost twice as much in 2014 (\$4 billion) as in 2015 (\$2.1 billion).²³¹ Most (75%) of the LPG is imported, resulting in a large import cost of \$4.8 billion in 2023.²³²

The universal LPG subsidy has been regressive and has benefited higher income households more than poorer ones. All households across all income deciles rely significantly on the subsidised 3kg LPG cylinders. Wealthier households consume more LPG and hence benefit from a higher total subsidy per household. In addition, in rural areas where many poor households are located, access to the subsidised LPG cylinders is limited. The growing LPG consumption among higher-income households also poses a mounting fiscal risk.

While LPG demand has increased rapidly, fuel stacking persists. While primary fuel usage statistics are encouraging and show a significant switch to LPG, field studies show that LPG is used alongside solid fuels rather than as a full substitute. Total energy consumption figures indicate a continued high use of biomass after the implementation of the subsidy in 2007.



Source: Government of Indonesia (2007-2024), "Handbook Of Energy & Economic Statistics Of Indonesia", [Link](#)

Note: Up to 2007, biomass use was calculated differently and reported amounts not in line with the other data trends.

There has been significant "leakage" of the subsidised 3kg cylinders to non-intended customer segments. A large subsidy placing a significant strain on the government budget was effectively used to provide LPG to households that could already afford it, and even to hotels and other large businesses.²³³ The substantially lower (subsidised) price of the 3kg sales also resulted in people using these small cylinders to fill and larger cylinders which were then resold at higher prices. This practice results in wastage of the intended subsidy to non-intended recipients, and creates safety risks as tampering with the cylinders can cause them to explode.²³⁴ Pertamina has tried to encourage wealthier consumers to consume non-subsidised LPG by introducing the new 5.5kg cylinder, which is branded in pink, lighter in weight and promoted as safer than the 3kg ones.²³⁵ Due to the increasing price disparity between subsidised and non-subsidised cylinders, the annual volume of 3kg cylinder refills has consistently grown by an average of 4.5% each year, while those of non-subsidised LPG decreased by 11%.²³⁶

²³¹ Thoday et al. (2018) "The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion", [Link](#)

²³² IISD (2025) "Indonesia's Next Cooking Transition: Shifting to non-fossil cooking", [Link](#)

²³³ Jakarta Globe (2025) "Pertamina Criticizes Hotels, Restaurants for Using Subsidized 3-kg LPG", [Link](#)

²³⁴ Kojima (2021) "Subsidizing Bottled Gas: Approaches and Effects on Household Use", [Link](#)

²³⁵ Thoday et al. (2018) "The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion", [Link](#)

²³⁶ Government of Indonesia (2023) "Gov't Urges Subsidized 3-kg LPG Consumers to Sign Up for Well-targeted Distribution", [Link](#)

Case Study 5: Ugandan eCooking tariff

	Affordability support mechanism <i>Preferential tariffs</i>		Affordability tenets <i>Ongoing</i>
	Targeting mechanism <i>None</i>		Delivery mechanism <i>On-bill financing</i>

In 2021, 94% of Ugandan households relied primarily on woodfuels for cooking, with electricity the most common clean cooking fuel but used as the main cooking technology by just 1.4% of households.²³⁷ Increasing uptake of electric cooking is a national priority, as a viable, scalable and cost-effective alternative to charcoal for urban populations.²³⁸

Since January 2022, the Ugandan Electricity Regulatory Authority has implemented a cooking tariff.²³⁹ Under the new tariff, electricity consumed by households between the 81st to 150th kilowatt hour block reduced from the standard rate of 756 shillings to 412 shillings per kWh.²⁴⁰ The tariff was untargeted, meaning it benefited households without access to eCooking appliances as well as those with them, and was thus underpinned by an assumption that power within this band would be used for electric cooking. It is unclear how the tariff was calculated.

In a 2024 study of a sample of 1,500 electric pressure cooker users, households on used their EPC once a day for 40 minutes on average, corresponding to 9.84 kWh per month. There was a large and significant reduction in charcoal use, down 50% to 24-hours per month, and cooking fuel expenditure, down 25% to 84,000 shillings per month.²⁴¹

However, these benefits appear unlikely to have been driven by the e-cooking tariff. Three-quarters of customers who were not Umeme employees were unaware of the cooking tariff, despite it having existed for two years. On average, households used 73 kWh of electricity per month, so most households did not qualify for the eCooking tariff. Furthermore, no correlation was found between overall electricity consumption and EPC usage.

This case study illustrates the challenges of targeting eCooking tariffs. The success of the tariff has been undermined by three factors: 1) the challenges of getting customers to engage with and respond to complex tariff mechanisms; 2) leakage emerging from the subsidy being applied to non-cooking end-uses for higher-consuming households; 3) low baseline electricity use which meant that the block subsidy approach failed to incentivise appliance usage. This would be even more challenging if using similar approaches for more vulnerable customer groups; research from informal settlements showed average monthly electricity consumption of just 20-30 kWh, far below what would be eligible for the e-cooking tariff.²⁴²

The eCooking tariff has played an important role at the ecosystem level as it signals strong government support for electric cooking. There is yet to be a formal evaluation of the eCooking tariff outside of the A2EI pilot, so its overall impact remains unclear. However, the tariff has catalysed a number of eCooking related activities in Uganda, including the development of a National eCooking Strategy, efforts to reduce taxes on appliances, creation of national standards and funding to develop a nationwide sustainable supply chain for eCooking appliances.²⁴³

²³⁷ UBOS (2021) "The Uganda National Household Survey", [Link](#)

²³⁸ MECS (2022) "Uganda eCooking Market Assessment", [Link](#)

²³⁹ Electricity Regulatory Authority (2021) "Energy Minister launches Reviewed Electricity Tariff Structure", [Link](#)

²⁴⁰ UEDCL (2025) "Electricity Retail Tariffs for the Third Quarter of 2025", [Link](#)

²⁴¹ A2EI (2025) "Findings from a study on the adoption of electric pressure cookers in Uganda", [Link](#)

²⁴² Kersey et al., (2024) "Cooking with electricity is for the rich" – Considerations for ensuring that the benefits of eCooking reach the urban poor" [Link](#)

²⁴³ Clements 2024. Uganda's Modern Energy Cooking Journey: A timeline. <https://mecs.org.uk/blog/ugandas-modern-energy-cooking-journey-a-timeline/>

Case Study 6: Ecuador: from universal LPG subsidies to e-cooking

	Affordability support mechanism <i>Universal price subsidy, concessional consumer finance</i>		Affordability tenets <i>Upfront, ongoing.</i>
	Targeting mechanism <i>None.</i>		Delivery mechanism <i>On-bill financing</i>

In the 1970s, Ecuador launched a nationwide LPG subsidy that resulted in almost universal use of LPG, costing the government around 1% of GDP.²⁴⁴ The price of LPG in a 15kg cylinder is around 90% subsidised and there is no restriction on how many someone can purchase.²⁴⁵ The subsidies were part of social welfare efforts spurred by Ecuador's petroleum boom. This period also saw a rapid rise of electricity demand and construction of electricity generation facilities. The electricity access rate increased quickly, from 41% in 1979, to 50% in 1984 and 90% by 1995.^{246 247 248}

Since 2014, Ecuador has also implemented a programme to support e-cooking. Household access to electricity was already almost universal in Ecuador by 2014, but electricity was barely used for cooking.²⁴⁹ To reduce costs and leverage domestically produced hydropower, the government launched a nationwide initiative to transition 3.5 million households (80% of the population) to cooking on induction stoves by 2018.

The e-cooking programme addresses the affordability of ongoing costs and the liquidity constraint of the upfront costs. It consists of up to 80 kWh of free electricity per month, after which households pay the 55% universally subsidised electricity tariff for power used on the induction stove.²⁵⁰ The amount of electricity eligible for the tariff subsidy was calculated based on comparing electricity use before and after the household had access to their induction stove. The programme offered on-bill credit for stove and cookware purchases.

Results:

The LPG subsidy significantly increased LPG use and in 2018 almost all households used it for cooking. In the 1970s LPG use was almost non-existent, around 20% of households used kerosene for cooking and around 70% used wood. In 2018, around 90% of households cooked with LPG, due to the subsidy, urbanization, and overall increases in wealth.²⁵¹ LPG demand exceeds domestic supply and Ecuador relies on expensive imports. Efforts to remove the subsidy in the past were met with major public protests.²⁵²

Uptake of the induction stoves has been slow; it reached only 20% of the target by 2018. In total 740,000 induction stoves were sold (12% of the population),²⁵³ well short of 3.5 million target, which was subsequently pushed back to 2023. The target was not reached because of delays in the construction of hydro plants, and the lack of sales of induction cooktops.²⁵⁴ In 2017 annual sales fell, while LPG cylinder purchases kept increasing. This has been attributed to the lack of

²⁴⁴ Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

²⁴⁵ Gould et al. (2024) "In praise of cooking gas subsidies: transitional fuels to advance health and equity", [Link](#)

²⁴⁶ World Bank (1981) "Ecuador Economic Development Issues", [Link](#)

²⁴⁷ Hanratty (1989) "Ecuador: A Country Study", Washington: GPO for the Library of Congress

²⁴⁸ World Bank, "Access to electricity (% of population) – Ecuador", [Link](#)

²⁴⁹ Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

²⁵⁰ Martínez et al. (2017) "Analysis of energy, CO2 emissions and economy of the technological migration for clean cooking in Ecuador", [Link](#)

²⁵¹ Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

²⁵² Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

²⁵³ Gould et al. (2023) "Climate and health benefits of a transition from gas to electric cooking", [Link](#)

²⁵⁴ Guayanlema et al. (2024) "Modeling the Benefits of Electric Cooking in Ecuador: A Long-Term Perspective", [Link](#)

promotion of induction stoves, concerns over the quality, and rising electricity bills.²⁵⁵ Uptake of the induction stoves is concentrated in urban and suburban areas. Consumer credit for induction stove purchases and the electricity subsidies for induction stove use has been popular; 75% of stove purchases have used the government credit.²⁵⁶

One of the challenges to uptake of e-cooking is the ongoing LPG subsidy. In the current scenario, monthly energy costs for LPG are around 1.3x higher than for electricity – but this does not include the upfront cost of purchasing an induction stove. If the LPG subsidy is removed, monthly LPG costs could be 16x higher than those for electricity usage.²⁵⁷

For the government, the per unit electricity subsidies are less costly than those for LPG, but the government had to invest significantly in infrastructure. The LPG subsidy costs around \$700 million per year, around 2% of annual government expenditure and 1% of GDP.²⁵⁸ The electricity subsidies for induction stove users cost \$37 million annually, although if scaled to nationwide usage this would be \$200 million.²⁵⁹ Between 2014 and 2022 the government also invested \$12 billion in new hydroelectric plants and transmission infrastructure.²⁶⁰

The universal subsidy is regressive, as households from all income quintiles can access the subsidy at the same rate. Wealthier households, with a household size half of those of the poorest ones, purchase more LPG per capita per month: 23% of the wealthiest quintile buy two cylinders per month, compared to 11% of the poorest quintile.²⁶¹ Most of the e-cooking stove uptake was in urban areas, where the households benefited more from the subsidy in place.

Fuel stacking remains high among LPG and induction users. Households adopting the induction cookers tend to continue to use LPG some of the time, to have a flexible and resilient energy system. For rural households, LPG use and satisfaction is high, but more than 75% still use wood fuel. Among the 17% of rural households who own induction stoves, only 1% use them as their primary cooking device.²⁶²

²⁵⁵ Serrano (2018) "Demanda de gas crece y venta de cocinas de inducción se reduce (Demand for gas increases and induction stove sales fall)", [Link](#)

²⁵⁶ Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

²⁵⁷ Martínez et al. (2017) "Analysis of energy, CO2 emissions and economy of the technological migration for clean cooking in Ecuador", [Link](#)

²⁵⁸ Global Good Practice Analysis (GIZ UNDP) (2015) "Promoting Induction Cooking in Ecuador", [Link](#)

²⁵⁹ Valarezzo et al. (2023) "Resilient clean cooking: Maintaining household clean cooking in Ecuador during the COVID-19 pandemic", [Link](#)

²⁶⁰ Martínez et al. (2017) "Analysis of energy, CO2 emissions and economy of the technological migration for clean cooking in Ecuador", [Link](#)

²⁶¹ Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

²⁶² Gould et al. (2018) "Government policy, clean fuel access, and persistent fuel stacking in Ecuador", [Link](#)

Annex 2 – Energy System Models Review

Model	Relevant data inputs and assumptions	Affordability data and relevance	Opportunities to improve relevance to affordability support design
OnSTOVE	<p>Geospatial layers on²⁶³</p> <ul style="list-style-type: none"> Population density (for urban/rural divide) Current electrification rate Travel time by foot or vehicle Relative wealth index or poverty Household size Meals per day Minimum wage Value of statistical life (VSL) Capital cost, fuel cost, O&M cost Infrastructure connection costs Assumes full uptake of a fuel: “if LPG is the highest net benefit, a household will switch”. Model does not assume an expansion of electricity access i.e., whoever has electricity access currently can cook with electricity and whoever does not, cannot. <p>Five years for full benefits to arise.</p>	<p>Granular data on income (ability to pay).</p> <p>Includes three cost components for stoves; could model impact of affordability support mechanisms on the capital cost, fuel and O&M.</p> <p>Could be used for a targeted subsidy, as it produces maps with regional differences.</p>	<p>Calculates net benefits in terms of health, time saved and avoided emissions per stove technology. It aims to answer the question: “Which clean cooking technology should go where to maximize social and economic benefits?”.</p> <p>It is a social welfare optimization model, not a household affordability or credit constraint model.</p> <p>It can simulate capital or fuel subsidies, but the outcome is not the impact on demand or uptake, but the net cost-benefits of the stoves. It recalculates the net benefits under altered cost structures. It is a spatial model, so this subsidy can be applied to specific regions.</p> <p>It does not include fuel stacking or credit constraints.</p>
BAR-HAP	<p>For 137 LMICs:</p> <ul style="list-style-type: none"> Population Income Wage rate VSL Subsidy leakage Effectiveness of financing 	<p>The model is used to compare the costs and benefits of different clean cooking policy interventions (stove subsidies, fuel subsidies, stove financing, behaviour change communication, and technology or fuel ban) and</p>	<p>Review output from several different technology and policy scenarios determine which stoves and fuels to promote.</p> <p>All national values, so no specific geographic targeting possible.</p>

²⁶³ OnStove documentation, [Link](#)

Model	Relevant data inputs and assumptions	Affordability data and relevance	Opportunities to improve relevance to affordability support design
	<ul style="list-style-type: none"> Price elasticity for four fuels Scenario modelling in which entire, or share of population make a certain transition. Demand assumptions on uptake per price point/intercept. Slope and intercept of demand curve. 	16 different stove and fuel transitions. The outcome breaks down costs to governments and individuals.	
ICCPT	<p>For 71 LMICs:</p> <ul style="list-style-type: none"> Population by urban/rural Income level Urbanization Electrification RISE score Price of stove and fuel, incl. O&M Cost of marginal distribution of infrastructure per household Demographic health surveys and MTF surveys Includes stacking of fuel 2030 uptake estimates in business-as-usual scenario Archetype matching to determine rates for traditional, ICS and MECS use, based on a set of archetype countries Maximum household fuel distribution is 5% of household's monthly income ICCPT uses outcomes from Reference Electrification Model (REM) Assumptions on value of women's time, time spent cooking, collecting fuel and cleaning stove, social cost of carbon, air pollution due to fuel mix 	Enables flexible adjustment of pricing structures based on strategic policy interventions (e.g., subsidies, fiscal incentives, regulated tariffs) promoting affordability of certain cooking technologies, and within different timeframes.	<p>The input variable in the model is the ideal targeted transition by the user; they select the % of ICS and MECS for urban and rural population.</p> <p>While with affordability support design, this % is the <i>output</i> of the model when the <i>input</i> of the model is the price change.</p> <p>The public sector cost is calculated using the price of the stove paid by the public sector to fill the affordability gap and incentivize adoption.</p> <p>All national values, so no specific geographic targeting possible.</p>
GEC	<ul style="list-style-type: none"> Policy data: Global policy inputs from the Global Energy Policies Hub Socio-economic data: GDP, GDP annual growth rates, technology costs, fuel costs, population 	Whole energy system approach accounts for cross-subsidisation effects with other sectors (industry, transport, buildings,	

Model	Relevant data inputs and assumptions	Affordability data and relevance	Opportunities to improve relevance to affordability support design
	<ul style="list-style-type: none"> Draws upon an additional geospatial model for clean cooking under the ACCESS scenario. However, cannot find information about how this model works. Assumes costs for new fuels and technologies fall over time. 	<p>agriculture) considering costs throughout the supply chain.</p> <p>Long-term scenario analysis allows modelling of different policy and technology impacts on the global system.</p>	
OSEMOSYS	<ul style="list-style-type: none"> Energy demand for the activities included in the model (e.g. energy required to cook) Technology-specific factors e.g. electrical generation capacity, availability, lifetime. Technology costs (capital, fixed and O&M); fuel costs (local and imported) Resource potential e.g. fossil fuel reserves. Fuel specific emissions factors. Population projections, rural/urban split. User defines the geographical scope. Computes the energy supply mix which meets the energy services demand every year, minimising total discounted costs. 	<p>Designed to model the whole-system impacts of policy pathways e.g. subsidies and taxes.</p> <p>Because users define the geographical scope and time horizon, this could be used to model the impact of geographically targeted affordability support mechanisms.</p>	<p>Mainly compares system cost across different scenarios (driven by certain policies).</p> <p>Generally works on cost basis (vs price basis), e.g., cost for electricity is endogenously derived based on the power sector of the model and would not include margins/profits/etc. – and hence not necessarily the actual tariffs paid by households.</p>
IEP	<p>For Madagascar, Malawi and Nigeria, at district, regional and country level.</p> <p>For Nigeria²⁶⁴:</p> <ul style="list-style-type: none"> Population and density Electrification status Settlement type Urban / rural Consumption potential (Number of households in settlement that can afford annual expenditure of NGN 250,000 in 2019) 	<p>Includes interesting indicators for Nigeria. Determines uptake not based on price or cost but on adult female education.</p> <p>Includes data on ability to pay. The Nigerian model has consumption potential (<i>Number of households in settlement that can afford</i></p>	<p>It is not a single tool, but evolves with each country's application. The Nigeria example can be used for further national extensions, as it includes a broad range of indicators.</p> <p>The Nigeria example has data on ability to pay, so this can be applied to different subsidy levels to determine the total market.</p> <p>Also includes other socio-economic indicators on settlement type, female education, and current cooking situation.</p>

²⁶⁴ SEforALL (2022) "SEforAll Integrated Energy Plan for Nigeria: Geospatial modelling approach – Data definitions and standards", [Link](#)

Model	Relevant data inputs and assumptions	Affordability data and relevance	Opportunities to improve relevance to affordability support design
	<ul style="list-style-type: none"> • HH demand per tier (# of households with a demand of ... kWh/year) • Electricity demand • Access to clean cooking • LPG/e-cooking affordability • Number of households that can afford and are likely to adopt LPG/e-cooking (using adult female education as a proxy to determine likelihood of adoption) • LPG infrastructure 	<i>annual expenditure of NGN 250,000 in 2019</i> and has energy demand.	It has granular district data, so can allow for targeting – although it is unclear what data is available at what level of granularity.
GEP	Geospatial layers on <ul style="list-style-type: none"> • Road networks • Renewable energy potential (e.g. solar/ wind) • Grid electricity infrastructure • Population size • Poverty level / potential energy demand • Mobile phone coverage • Topography • Cost per unit to extend grid. • Penalty ratios for grid for certain terrains. • But, single cost of off-grid by for all locations 	Provides a strong start on estimating the affordability gap, with granular data on both income (ability to pay) and cost to serve.	Granularity of data on ability to pay in specific regions is somewhat included but would need deeper analysis. Limited data on the actual cost to serve, especially of the lower-tier energy access technologies – i.e. cost premium to serve remote regions with standalone solar, including factoring in consumer finance costs if using PAYGo etc. Limited data on willingness to pay – would be particularly relevant in clean cooking context. No data on income seasonality to support design of instruments that reflect lumpy income. For D3 no granular geographic data on credit risk assessment to understand variation in costs of offering e.g. PAYGo / concessional consumer finance.

Source: Greencroft Economics

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