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Elaboration of a “Sustainable Low-Income Energy Services” Study to the Benefit of the City of Cape Town

Final Report: Options and Recommendations

Réf. AFD/DOE/EBC/CLD | ACH-2017-026

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PROJECT BACKGROUND

This report is submitted under the French Development Agency (AFD) funded project: Elaboration of a "Sustainable Low Income Energy Services" Study to the Benefit of the City of Cape Town. The project is funded under the CICLIA Framework Agreement for Studies and Technical Assistance for the Cities and Climate Change Initiative in Sub-Saharan Africa, funded by the French Development Agency (AFD), EU and the Swiss State Secretariat for Economic Affairs (SECO). Specifically, this report is submitted on the outcomes of the activities forming Phase 3: Proposals and Recommendations, in accordance with the requirements of the Contract for Réf. AFD/DOE/EBC/CLD | ACH-2017-026. As such, this report constitutes Deliverable 4 under this contract and presents the project team's recommendations for the provisioning of sustainable energy services to Low Income Households by the City of Cape Town.

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Abbreviations and Acronyms

AES	Alternative Energy Services
AFD	*Agence Francaise de Developpement* (French Development Agency)
CCT	The City of Cape Town
CICLIA	Cities and Climate Change in Sub-Saharan Africa Initiative
CoS	Cost of Supply
DoE	Department of Energy
DoME	Department of Minerals and Energy
EE	Energy Efficiency
FBE	Free Basic Electricity
GWH	Gas Water Heating/Heater
J-PAL	Abdul Latif Jameel Poverty Action Lab
IEA	International Energy Agency
INEP	National Electrification Programme
IPP	Independent Power Producer
kWh	Kilowatt Hour
kWhe	Killowatt Hour Equivalent
LGES	Local Government Equitable Share
LIHH	Low Income Household
LINES	Low Income Energy Services (Unit)
LPG	Liquefied Petroleum Gas
M&E	Monitoring and Evaluation
MWp	Megawatt Peak
MFMA	Municipal Finance Management Act
NFMIP	National Framework for Municipal Indigent Policies
PV	Photovoltaic
RCBA	Risk and Cost Benefit Analysis
RCT	Randomised Control Trial
RDP	Reconstruction and Development Programme
REI4P	Renewable Energy Independent Power Producer Procurement Programme
SALGA	South African Local Government Association
SSEG	Small Scale Embedded Generation
SWH	Solar Water Heating
ToR	Terms of Reference
ToU	Time of Use
W	Watt
Wp	Watt peak

Glossary of Key Terms and Definitions

Term	Definition
250 Programme	An intervention proposed by the Low Income Energy Services (LINES) Unit at the City of Cape Town, aimed at providing sufficient electricity to low income households (LIHHs) to reduce energy poverty while optimising the City's investment in electricity infrastructure. The 250 Programme entails the provision of 250kWh of electricity per household per month.
Energy services	A comprehensive spectrum of holistic solutions, including electricity, energy efficiency (including thermally efficient housing) and AES, aimed at meeting the energy needs of the households through the application of an appropriate combination of technologies.
Alternative Energy Services	Energy sources that are alternatives to grid electricity.
Energy stacking	An approach to energy consumption where households combine electricity and other energy sources (usually paraffin and candles) in order to meet their daily needs. Recent studies find that this approach exposes the households to the risk of a dwelling fire, with non-electric energy sources being the main cause (Francioli, 2018), in addition to poor indoor air quality, and poisoning (as a result of children inadvertently drinking paraffin).
kW	A kilowatt: measures capacity for energy generation or energy consumption intensity.
kWp	A kilowatt peak: measures the maximum generation capacity of an energy source. For example, solar PV and wind generators are measured in peak capacity, as they are intermittent and do not always work at 100% of their capacity
kWh	A kilowatt hour: measures the amount of electricity generated by the energy generator or the amount of electricity used by the consumer over a period of time. For example, the amount of electricity a household consumes per day can be between 10 and 15kWh, depending on their specific energy needs.
Lifeline tariff customers	Indigent households with municipal property valuation of R400,000 or less, income below R4,000, with a prepaid meter and receiving less than 450kWh.
LPU LV	Large power user on the low voltage network
LPU MV incl. TOU	Large power user medium voltage including Time of Use (TOU) customer that were already on the TOU tariff as at 30 June 2016
MV TOU	Large power user on medium voltage and time of use (new customers as of 1 July 2016)
Network cost	Costs that are incurred for physical wires in terms of infrastructure.
Randomised Control Trial (RCT)	An RCT is an impact assessment method conducted as an experiment in which subjects are randomly assigned to one of two groups (Kendall, 2003): • the treatment group, which receives the intervention that is being tested; and • the control group, which does not receive the intervention. The impacts of the intervention are measured against this group. Data is collected, at baseline, during and post the intervention, and is then used to analyse any differences in outcome between the two groups. The results are used to assess the impact of the intervention. In economics, RCTs are seen as the most stringent way of testing the existence of a

	cause and effect relationship between an intervention and the observed outcomes.
SPU 1	Small power user with high consumption (>1300 kwh)
SPU 2	Small power user with low consumption (< 1300 kwh)
ToU	Time of Use tariffs change depending on whether electricity is consumed during peak or off-peak periods. Peak periods have higher tariffs.

Introduction

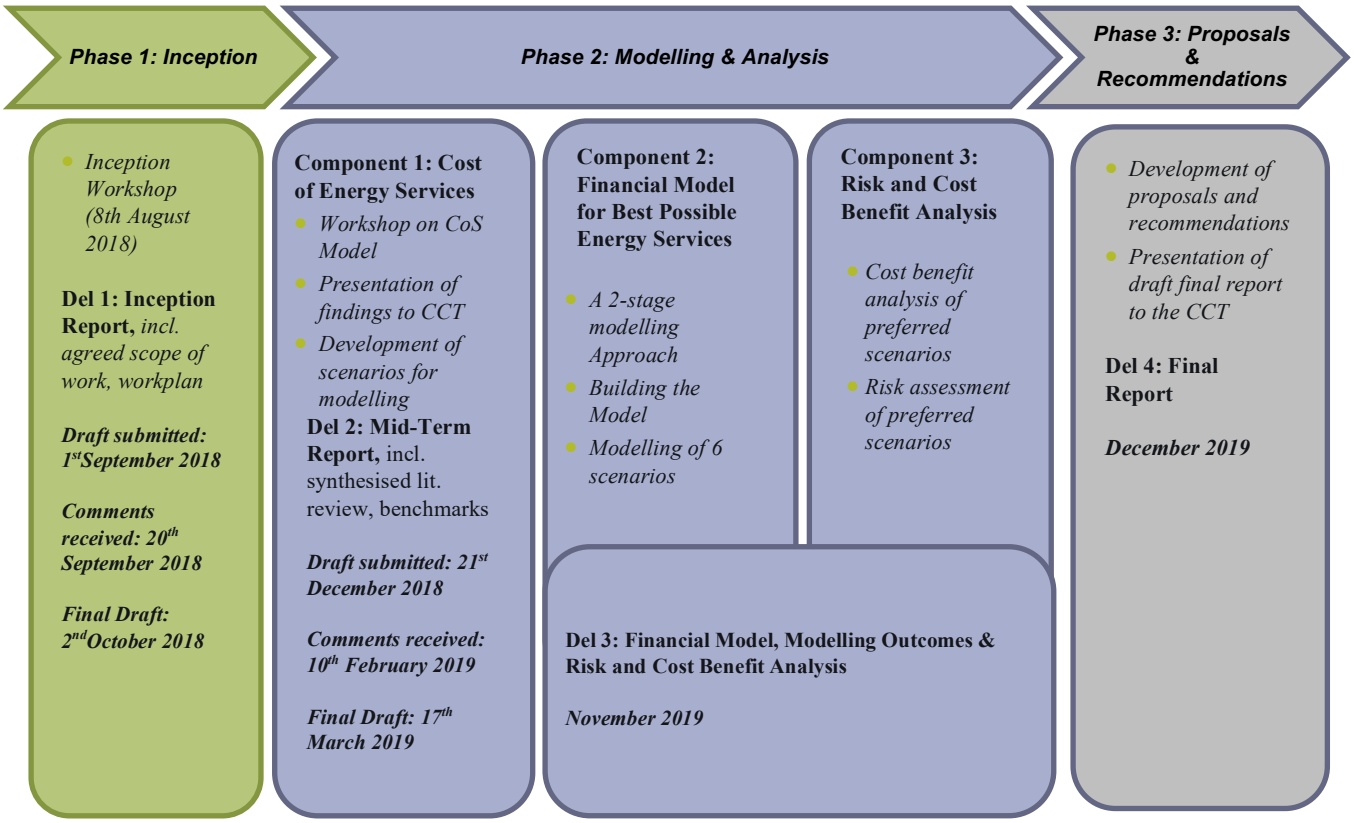
This report is submitted on the outcomes of the activities under Phase 3 of this assignment. It is in accordance with the requirements of the Contract for Elaboration of a "Sustainable Low-Income Energy Services" Study to the Benefit of the City of Cape Town, Réf. AFD/DOE/EBC/CLD|ACH-2017-026, commissioned by the Agence Française de Développement/French Development Agency (AFD) on behalf of the City of Cape Town (CCT or the City). The study is funded under the AFD Cities and Climate change in Sub-Saharan Africa Initiative (CICLIA). The initiative is aimed at assisting between 20 and 25 Sub-Saharan African cities over a 4-year period in the preparation of projects with climate co-benefits, covering a variety of urban planning sectors.

The key research question underpinning this study is: "what is the model which delivers the best possible energy services which are sustainable, affordable (for both the City, the consumers and Eskom [all parties]), safe, clean, offers choice and flexibility and supports inclusivity?.

Project Implementation Structure

The current report marks the finalisation of Phase 3 and the project as a whole, as reflected in Figure 1.

Figure 1. Project Implementation Structure



Structure of the Report

This report starts with a short summary of the key findings and insights emergent from all components of the study. It then outlines the context of poverty and energy poverty in CCT (Section A). This is followed by a section on options and recommendations for the CCT (Section B). All options and recommendations are rooted in a synthesis analysis of the following components to this assignment, and should be read in conjunction with the indicated reports:

- Updated Literature Review (Deliverable 2: MTR, Supplementary Report 1)
- Cost of Supply Analysis (CoS) (Deliverable 2: MTR)
- Financial Modelling (Deliverable 3: Results Report, Section A)
- Risk and Cost Benefit Analysis (RCBA) (Deliverable 3: Results Report, Section B)

The proposals and recommendations further include inputs received from participatory analysis conducted under the CCT's Design-led Thinking Workshop which focused on the question of providing sustainable, affordable energy services to LIHHs across the CCT, conducted in August 2019.

Energy Transitions and Key Insights

A range of key insights have emerged from this project that inform the options and recommendations for the CCT to consider in making decisions around how to optimise energy services for its low-income households. These must be considered against a backdrop of global and national energy transitions, and particularly, against plausible pathways for the transition in South Africa. South Africa's energy transition, driven in part by the global shift toward low carbon energy, and partly by the state the sector has arrived at, characterised by an outdated model, structural inefficiencies, an oversized debt burden of the utility. Since the end state of South Africa's transition is not known, we can only consider the future of the sector in terms of plausible scenarios, pathways for the near and midterm future. Two such scenarios – 'Stuttering Hybrid" and 'Thriving Diversification' – are outlined in Box 1. These scenarios build off established global, national and sub national trends and existing and recent policy such as the recently approved Integrated Resource Plan (IRP) and the Department of Public Enterprises' (DPE) recently launched plan for Eskom. They note that the current state of play is a 'Stalled Hybrid' where only 5% of electricity generation is outside of state control, even though independent power producer programmes have been in place for more than a decade. It should also be noted that the two pathways discussed here are two extreme ends of a spectrum that can contain any number of different outcomes or pathways.

The summarised key insights follow Box 1.

Box 1. The future of South Africa's energy sector – 'Stuttering Hybrid' or 'Thriving Diversification'?

'Stuttering Hybrid'

In this scenario, the South African power sector continues to be dominated by Eskom as the vertically integrated, state-owned, national power utility, albeit unbundled into three separate units under national government control and under improved governance. Privately owned independent power producers (IPPs) continue to enter the market, but at a sluggish pace under the IPP model and the Renewable Energy Independent Power Producer Procurement Programme (REI4P), producing an increased, but small proportion, of the country's electricity requirements. Thus, coal continues to dominate electricity generation and South Africa continues to be a high carbon emitter with implications for global climate diplomacy and with continued local health impacts.

Eskom's crippling debt is difficult to service in an economy that does not grow. Coupled with increasing costs of supply, this results in continued annual tariff increases, negatively affecting consumers around the country, and particularly the poor. Municipalities who continue to be involved in the distribution of electricity, are also affected with some making increasingly erratic and inadequate payments to their bulk supplier, Eskom.

Energy intensive industry places increasing pressure on the regulatory environment to allow them to generate their own electricity and sell the surplus, to meet their needs for energy security at affordable prices. This forced regulatory reform does not extend to municipalities because of their own capacities and because government remains resistant to devolving its control over the energy sector. This is critical in the CCT context, as the CoS Analysis has revealed that it is intensive users in CCT who cross-subsidise Lifeline customers (LIHHs).

Distributed generation, or small-scale embedded generation (SSEG) continues to change the landscape of the power sector at both the consumption and the distribution level of the value chain as a decentralised option. Municipalities and electricity consumers increasingly become prosumers, or consumers that also produce electricity, reducing dependence on Eskom supply. This has the potential to contribute to increasing tariffs as supply outstrips demand.

'Thriving Diversification'

In this scenario, thorough reform of the South African power sector is established through creating complete governance and financial independence between the transmission, distribution and generation components of the sector. Regulatory reform and accelerated policy implementation unlock significant investment in the energy sector enabling substantially increased adoption of low-cost renewables and optimal leverage of the country's natural resources, including its national gas fields. The combination of a significant proportion of natural gas and renewable energy in the country's energy mix reduces costs and tariffs and increases energy security.

SSEG adoption is also accelerated by policy and regulatory reform, empowering consumers through increasing choices and control over efficiencies. Municipalities, along with households, participate as prosumers and regulate according to their own requirements. This, coupled with regulations that allow municipalities to purchase power directly from IPPs, provides them with greater flexibility and ability to regulate consumer tariffs.

The high diversification of the sector creates enormous potential for new jobs and skills, which could absorb a large proportion of the job losses from a dwindling reliance on coal, should the right reskilling mechanisms be put in place. Coupled with reduced costs of energy supply, this enables a just transition to a low carbon energy future that produces significant health benefits for local populations and reduced global carbon emissions.

Despite high levels of access to the national electricity grid, 47% of South African households are categorised as energy poor. Population growth and urbanisation rates continue to challenge service delivery in the CCT as poverty and inequality are perpetuated by the legacies of segregation. Although 97% of CCT's population are connected to the grid, energy poverty persists. Lifeline customers consume well below the Lifeline tariff maximum threshold of 450kWh and the Free Basic Electricity (FBE) policy threshold of 250kWh. The national FBE Policy has not resolved energy poverty. In addition, little work has been done towards assessing the effectiveness of FBE and the sufficiency of the minimum allocation of 50kWh in meeting basic energy needs. As a result, many LIHHs households still use candles and paraffin to supplement their energy needs, which negatively impacts safety (due to fires), exacerbates indoor air pollution affecting health and well-being, education outcomes, and overall socio-economic development. Underusage of energy, use of unsafe energy sources and dire energy poverty – despite significant access to electricity by LIHHs – therefore remains an extremely serious concern for CCT.

The institutional, operational and financial weaknesses of Eskom (the sole bulk supplier of electricity for CCT) have exacerbated the problem. This coupled with the utility's huge debt burden have led to unsustainable costs, resulting in escalating and unaffordable tariffs for consumers. This tends to impact the poor the most. These challenges are exacerbated by the impacts of climate change. LIHHs are most vulnerable to these impacts, as they have the lowest adaptive capacity due to low levels of access to services, among other factors.

Access to clean, safe and affordable energy is a widely recognised and critical precondition for socioeconomic development and building resilience of the most vulnerable communities. Technological change has enabled combinations of grid electricity and alternate options which can potentially deliver solutions that are lower cost than the status quo. Awareness raising, educational activities, and promoting efficiency measures that empower LIHHs to optimise behaviour to achieve cost savings, are integral measures to reducing energy poverty. Furthermore, holistic and integrated solutions have achieved better results in addressing the issue compared to solutions which focus on electrification only.

Today, the most cost-effective energy services solution for LIHHs is 250kWh of electricity for R100 per household per month. However, there are significant associated risks, as highlighted in this study's financial modelling and cost benefit analysis. This option may not be feasible or sustainable in the long term due to escalating financial costs for the CCT to implement it. Furthermore, the small group of energy intensive industry users – with significant incentives to implement own generation projects – are currently cross-subsidising Lifeline tariff customers (LIHHs), putting the current cross-subsidisation model at severe risk. Increasing the subsidy of the energy needs of LIHHs means that some customers somewhere in the broader CCT system, such as ratepayers or water and sanitation customers, will pay more for a service or tax so that the City can afford an additional subsidy and/or subsidy top-ups. Critically, if electricity tariff increases exceed 10%, then other options, such as gas for cooking and water heating, become more efficient. These options become even more efficient as capex costs for rolling out alternative energy services capital goods improves, given a projected decrease in the capital cost of AES. The electricity option also becomes less cost effective if the City need to extend its grid infrastructure, which would incur significant capital costs.

It will be critical to weigh up these risks against the current key barrier to solar water heating (SWH) - the capital and maintenance costs. This option yields the biggest long-term operational savings for customers and would result in the lowest costs for customers if the CCT were to cover the maintenance costs for its LIHH customers.

The three most feasible scenarios – electricity only (E); electricity + gas for cooking (E+GC); electricity + gas for water heating (E+GWH) demonstrate greater costs than benefits, with some critical considerations. The E+GC scenario is the most preferable relative to the other scenarios as, while all had higher costs than benefits, it has the lowest cost benefit difference and therefore offers the best return on investment. The second most preferable scenario is E+GWH, as it has the highest capital provision but also the highest benefits. The two options which have AES components offer the additional benefits of providing opportunities for enterprise development and employment. *The electrification only scenario reflects the largest absolute cost benefit difference: although it is the scenario with the lowest cost, it also results in the lowest benefit value.*

While any of the proposed scenarios will incur significant financial costs to the CCT, there is a wide range of benefits from the interventions proposed, for both LIHHs and CCT. These include annual savings for LIHHs of R11-12m through eliminating damage and losses to their dwellings and contents incurred from open flame fires; as well as ~R18m in direct annual savings in public health costs and over R300,000 annually for LIHHs by preventing pneumonia in children ages 0-5 alone, as a result of the use of cleaner fuels. Public health cost savings of approximately R58m per year result from

eliminating burns caused by paraffin use. LIHHs collectively will benefit from an increase in their annual disposable income of approximately R300m; and an estimated potential annual increase of R110m in spending on food. Improved connectivity and access to information through the inclusion of a data package has estimated employment benefits to the amount of R1.7 billion per year. Finally, the scenarios which include AES (gas for cooking and for water heating), yield annual employment benefits of R96m and R120m respectively. It is important to note that, had the full set of socioeconomic benefits been quantified in Rand values, these may have exceeded the financial costs of the proposed interventions.

The end state of the national energy transition is unknown, however recent policy developments point toward the Stuttering Hybrid over the Thriving Diversification pathway. Both have implications for the sustainability of this project's proposals due to expectations of significant tariff increases, among other impacts. A Stuttering Hybrid does not bode well for the already high levels of energy poverty in South Africa and CCT. The provision of energy services to LIHHs through the national grid is less sustainable under current business models and in the context of current trends. These trends impact CCT's current service delivery and financing models, threatening its current cross-subsidisation models, particularly for LIHHs on Lifeline tariffs. The path dependence which characterises the South African electricity sector creates the risk of making a 100% electricity option potentially unaffordable to remaining consumers and blocking LIHHs from emerging out of energy poverty.

In this context and given the constant trade-offs that the CCT decision makers are faced with when making decision for the future sustainability of basic services provision, this report sets out two main options: the provision of an electricity only package, and a diversified energy mix option. We note here that gaps remain in the knowledge about household energy needs and consumption patterns, as well as in the data on affordability and willingness to pay for various types of energy services of LIHHs.

The outcomes from the work conducted under this project was unable to give unequivocal support and justification for a 250kWh program. However, the outcomes confirmed the presence of a significant gap between current FBE allocations in CCT and a level of energy services, which is sufficient to meet the basic needs of LIHHs. In addition, detailed quantitative work was developed which has important implications and significant potential to inform future work in addressing energy poverty in CCT. The data gathered and perspectives developed on the factors at play can serve as a platform for anyone expanding on this using a quantitative approach.

The recommendations are therefore focused on highlighting these gaps and proposing a way forward for obtaining the required knowledge, which will assist the City not just in identifying the optimal solution but also in making sure that it is designed in a sustainable way.

A. Framework for Improving Energy Services

Improving energy services, and in particular, targeting LIHHs in CCT, cannot be addressed within a vacuum. Energy and energy service delivery is at the nexus of some of South Africa's most challenging problems, with energy, land and water having been recognised by the recent National Planning Commission-led Just Transition process as being at the heart of South Africa's sustainable development, going forward (NPC, 2019). This context is thus key when considering the options and recommendations for improving energy services to LIHHs in CCT.

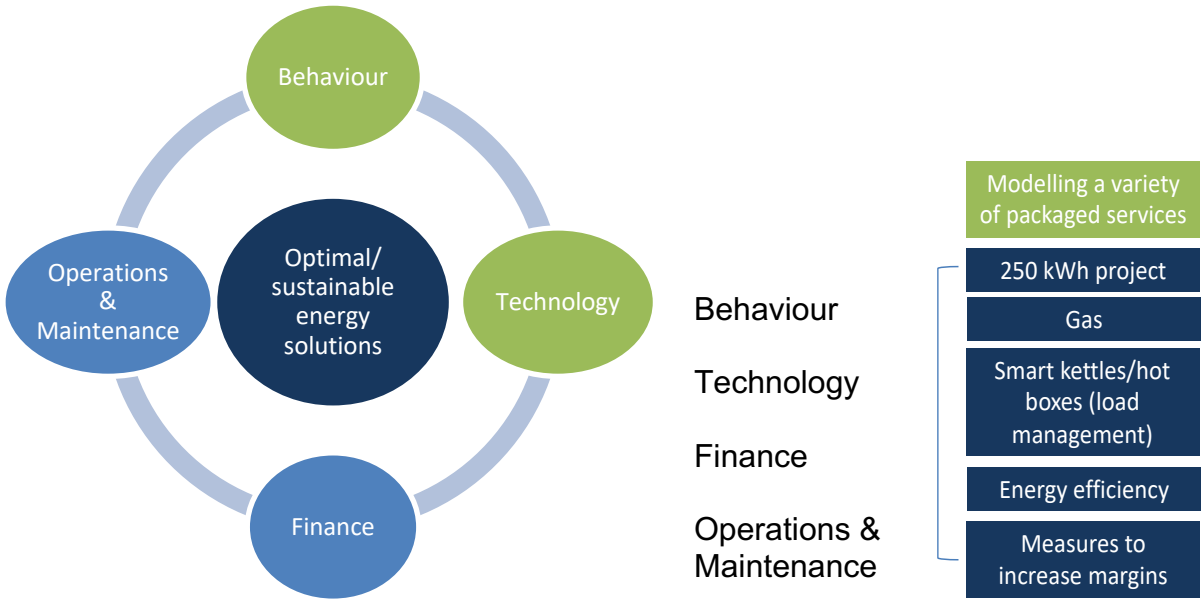
This section provides a framework for addressing the key issues that the Low-Income Household Energy Services aims to address. It sets out an Energy Services Conceptual Framework that underpins the approach for energy service delivery. It further addresses the national regulatory and institutional framework and governance factors that directly affect delivery of energy services and concludes with an outline of infrastructure and behaviour aspects.

A.1 Conceptual Framework

The Energy Services Conceptual Framework (Figure 2) which underpins this study (first included in Deliverable 2: MTR), identifies a holistic suite of solutions which can deliver an affordable, quality, sustainable, constant supply of energy to LIHHs. This conceptual framework underpins the options and recommendations (Section B). The framework is rooted in the principle that a holistic and comprehensive solution needs to address three central aspects of service delivery in order to provide optimal and sustainable energy solutions, namely:

- Technology (viable technological solutions)
- Behaviour (energy consumption behaviour patterns)
- Finance (sustainable financial solutions for improving the affordability of energy services to LIHHs both for CCT and the households).

Figure 2. Energy Services Conceptual Framework, OneWorld (MTR: OneWorld 2019)



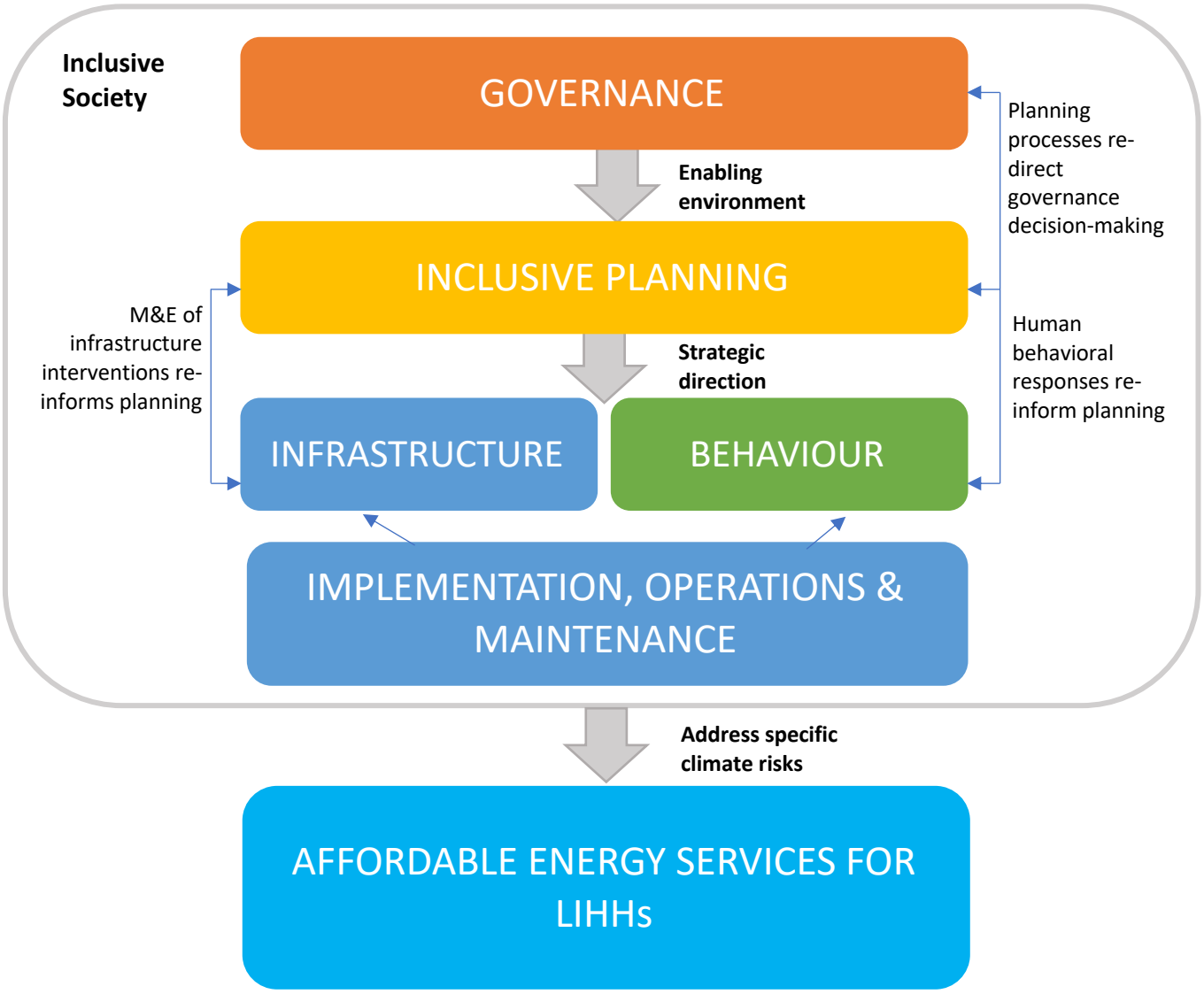
Planning in the face of risk and uncertainty

This study has highlighted a range of risks and uncertainties related to the future of the South African electricity sector (Deliverable 3: Results Report, Section B.2). Planning for the sustainable provision of energy services to LIHHs in the face of uncertainty and risks requires an iterative, flexible approach, which allows decision makers to adapt to a fast-changing electricity sector and, simultaneously, to changing development conditions. Figure 3 represents the assessment framework used for selecting/identifying scenarios for modelling (Deliverable 3: MTR). Against this background, the framework presents

incremental approaches to transforming the provision of energy to LIHHs which are aimed at maximising the benefits and minimising the costs of investing in energy service provision.

As seen from Figure 3, the proposed options and recommendations need to be considered in the context of the CCT and national level governance framework, as the recommendations are conditional upon CCT having the mandate to implement them. In addition, holistic solutions require planning across sectors as some of the solutions require cooperation across CCT departments. Technological options and recommendations are integrated within CCT existing infrastructure, with the option of incorporating AES, where these have the potential to improve the effectiveness of energy services and bring additional benefits. Options aimed at raising awareness and changing consumer behaviour are a critical success factor.

Figure 3. Framework for Identification of Options and Recommendations



Source: OneWorld, 2020

Planning for the improved provision of energy services to LIHHs needs to be embedded in the broader social, political and economic systems of CCT. As such, the proposed options and recommendations are aimed at achieving the critical, broader objective of an inclusive economy and society. As guided by the proposed framework, the options and recommendations considered are aligned with relevant existing policies and strategies, such as the CCT Energy 2040, and are intended to complement the interventions and actions presented in these documents.

A.2 Governance and Planning

The City has the necessary policy framework and institutional arrangements in place to support the changes to its energy services provisioning going forward.

Energy Services Policy Framework

The CCT is mandated through existing legal and regulatory frameworks to deliver inclusive and sustainable energy services to all households, including those in Eskom supply areas. The South African Constitution states that local governments' mandate is to deliver services to all residents while also contributing to local socioeconomic development, specifically through their redistributive role. Further, the National Framework for Municipal Indigent Policies (NFMIP) directs the provision of FBE services to the poor by municipalities and the Municipal Finance Management Act (MFMA) defines the oversight role that National Treasury (NT) must play on the pricing structure of bulk provisions such as electricity. The MFMA governs all municipal contracts, including power purchase agreements (PPAs) with Small Scale Embedded Generation (SSEG) systems. Specifically, the MFMA determines that municipalities can only enter into contracts that incur financial obligations for a period longer than three years under certain conditions, including a comprehensive consultation process with National Treasury, other relevant departments and members of the public (Filipova, 2018). This is an important consideration should the City need to enter in a service contract with the private sector for providing AES.

At the city level, CCT's Energy and Climate Change Strategy (2006) and Action Plan (2011), as well as the Integrated Development Plan (IDP) (2017-2022) and Energy 2040, envision a resilient, low-carbon and resource efficient city, while mainstreaming excellent basic service delivery in general, and to informal settlements and backyard dwellers in particular (CCT, 2017).

Additional Challenges

Additional challenges to the successful provision of sufficient energy to LIHH include coordination and regulatory issues:

- Different departments in CCT are responsible for different aspects of energy services that the City should target to achieve a comprehensive approach to LIHH energy services. Improved coordination between departments can help to support a comprehensive, integrated approach to providing sustainable low-income energy services (*Literature Review, section B.3. p30*).
- The inability of South Africa's legislative and regulatory environment to adapt to the current industry trends is having negative financial implications for municipalities and Eskom alike (van der Merwe and de Beer, cited in Creamer, 2018).

A.3 Infrastructure, Operations, and Behaviour

Solutions for the provision of energy services are dependent on the existence of physical infrastructure to support service provision and on the awareness of CCT customers about the range of available solutions and their operation and maintenance.

The National Electricity Grid and Energy Poverty

CCT and Eskom have made significant investments in strengthening and extending the grid to enhance access. Investments have included laying out cables, increasing the number of sub-stations and installing meters in order to provide electricity services to more households. The Integrated National Electrification Plan (INEP) has dominated the household energy access agenda, "crowding out" any other options and considerations relating to energy access in South Africa (Deliverable 2: MTR, Supplementary Report 1: Literature Review). Electrification in South Africa has historically followed the global electrification models of a centralised system that is governed and operated by a vertically integrated electricity utility. With energy security issues being both complex and of high priority for national governments, as well as involving high capital costs, this model was associated with lower risk.

Recent decades have seen a shift away from the vertically integrated model, with more and more countries around the world introducing decentralised governance as well as greater levels of independent power production. Although these global trends have entered into the policy discourse in South Africa, with the most tangible outcome being REI4P, change continues to stagnate, and even this flagship procurement programme has been floundering in the past few years. With stagnating change, in the last two decades, INEP has achieved significant success in terms of increasing the number of households

connected to the grid. Through this, it has locked municipalities like the CCT, into infrastructure that must be serviced and maintained, irrespective of the level of use and sales, and at a fixed cost to the City. It has not however concomitantly eliminated, or significantly reduced energy poverty.

Unfortunately, the high levels of electrification in CCT have not translated into LIHH households consuming sufficient electricity to cover their energy needs. This has highlighted that providing electricity as an equitable basic public service requires more than physical infrastructure and a fit-for-purpose electricity service – it also requires this to be affordable for all. While the CCT has the infrastructure to supply electricity to almost 100% of all of its customer groups, this study, and the previous work of the LINES team, has shown that many LIHHs cannot afford the service and that FBE is far from enough. At the same time, CCT depends on Eskom for the bulk purchase of its electricity. This has made the City – and its households – vulnerable to the effects of the utility's ongoing and escalating operational and financial crisis, resulting in increasing electricity costs and unreliable supply.

Innovative approaches are clearly needed to address energy poverty, and these should take into account the evolving global paradigm for providing energy services. While AES are available at increasingly affordable costs, two key factors – one political and one household-level – block the way toward using these. Firstly, the political difficulties in reforming the electricity sector, largely evident once again in recent months, cannot be underestimated. As with other failing State Owned Enterprises (SOEs) the lack of political will to restructure and unbundle Eskom and to enable increased introduction of independent power production onto the national grid, is seeing change stagnate, while inconclusive processes around energy planning and diversification continues to compromise the country's energy security, with all of South Africa in the grips of a medium term load shedding programme. Secondly, households who aspire to national grid-provided electricity, under post-apartheid promises, perceive alternative options as inferior solutions.

The Private Sector and Energy Poverty

As discussed, REI4P has paved the way for independent or private sector power production. Although this programme is stuttering in the current political climate (securing South Africa's coal-based electricity supply is dominating), it has demonstrated the meaningful role the private sector, including the financial services sector, can play in securing South Africa's energy supply, and with the competition it has introduced, at affordable rates. With this, SSEG is proving to be a disruptive force in South Africa's energy space, particularly through private sector uptake at the household and the industry level. However, here too, the lack of political will is hampering necessary reforms in the regulatory environment.

In its progressive energy strategy, the CCT has identified itself as is a strong promoter of diversification of electricity generation, at the municipal level, in its vision for a meaningful contribution of renewable energy to its energy mix, and for greater levels of energy independence within the South African context. Under this strategy, CCT seeks to access renewable energy in partnership with independent power producers. The regulatory environment is however a significant obstacle, and thus, as a means to achieving its objectives, the City is currently in litigation to remove the legal obstacles to the generation of its own renewable energy electricity or procuring electricity from IPPs. Under the current regime, public sector actors are able to engage in electricity generation, but only for systems of up to 1MW. Systems with a capacity above this require a ministerial determination to allow the applicant to deviate from the regulations. This restrains municipalities from participating directly in the opportunities presented under REI4P and for scaling up SSEG.

In addition to REI4P, the private sector plays another role in providing energy services within the context of Eskom's electricity domination. The private sector provides a range of AES, for example gas and the equipment to use it, and technologies for SWH and SSEG activities. This market is growing in response to Eskom's rising tariffs and unreliable supply, helping to drive down the cost of AES technologies and thus increasing their appeal. In addition to these welcome disruptions to traditional electricity and energy service supply in South Africa, the private sector continues to feed the growing low-income market with health compromising and dangerous fuel sources and equipment for AES, particularly paraffin and candles. In the case of paraffin, private sector accountability to the regulations is not being held. Consequently, very low prices and ease of access is enabling increased access to the energy services low income households need but cannot afford through the grid.

Lastly, the private sector plays an important, if often underestimated role, in operating and maintaining AES. Whether it implements and operates a REI4P wind power project, installs and operates SSEG on a factory or household rooftop, or supplies gas or paraffin to the market, it thereby takes responsibility for maintenance to some or other extent. Under REI4P this is to a greater extent, in that Power Purchase Agreements (PPAs) demand continuity of supply, which relies in part, on adequate maintenance.

Similarly, adequate maintenance is central to reliable SSEG supply, whether limited to own use, or also fed into the grid. Gas suppliers typically own the gas bottles used to supply gas to households for cooking or heating. The capital cost and maintenance of these bottles is usually the responsibility of the private sector supplier, who recovers the costs in the gas sales. Paraffin equipment is cheap and often unsafe, while its low-cost nature is driven by the private sector to increase the sales of the fuel and to maintain its foothold in the energy sector.

Behaviour and Energy Poverty

South Africa, and the CCT's history of rolling out AES solutions to low income households over the last ~15 years, has brought the need for behavioural adaptations, perception management and comprehensive business, or operations and maintenance, models, into sharp focus. Most often, the focus in the roll out of these programmes, such as mass roll out of SWHs in Alexandra, Johannesburg, or on the N2 Gateway in Cape Town, has been on getting the technology in place, with little emphasis, or inadequate approaches to educating the user in its use and maintenance, or enabling long term, viable operations and maintenance solutions. The literature clearly indicates that good quality operation and maintenance are a critical factor for the perceived quality of services provided. It also highlights the potential for job creation through SME stimulation in providing these aspects of a comprehensive AES solution.

A significant learning from programmes such as those mentioned above, is that the absence of adequate education and awareness and consistent maintenance solutions, can see the technology fail. This is often because a comprehensive solution is lacking, relying too heavily on the technology alone to close an energy poverty gap, whereas the other components of a comprehensive AES, a s shown in Figure 2 above, are absent, or less adequately addressed. This can, and in some instances, has, resulted in the perception that these technologies are inferior to the national grid, limiting or preventing their future uptake and/or success.

The same applies to grid supplied energy services. Realising efficiency measures for delivering optimal LIHH energy services, both in terms of reducing the amount of energy required to access particular services, as well as empowering LIHHs to optimise behaviour to achieve cost savings, relies on education and behaviour change. For example, it is estimated that the cheapest way of reducing spending on electricity for lighting is through inducing behaviour change through incentivised utilisation of efficient light bulbs. This is a further example that the technology alone cannot provide a comprehensive solution.

Evidence thus points to the importance of awareness and education activities, promoting efficiency measures, and incentivising enabling business models that can ensure the sustainability of the AES. Awareness raising and education aimed at behaviour change are also cost-effective options, while incentivising, and possibly regulating SME and larger scale private sector activities, can create jobs and reduce inequality, while leaving the CCT to focus on the business model it knows and understands – being grid electrification for providing energy services – noting that the CCT is locked into expensive grid infrastructure operations and maintenance.

B. Options for Reduced Energy Poverty

Early in this project, and in the context of a general scarcity of data on LIHH energy needs in the CCT, the study assessed the amount of energy that could be sufficient to meet the energy needs of LIHHs. The best estimate was that 250kWh could provide LIHHs with the means to meet all the aspects of energy services required to live with a level of dignity and to enable a level of socio-economic advancement. While this amount should be re-assessed and verified through studies that yield better energy consumption data for CCT. For the purposes of this study however, and with the data limitations in mind, the 250 programme was applied as the basis for the development of different energy scenarios for this study's financial modelling (and noting that the financial model is set up for the user to alter inputs, such as scenarios, to establish alternative pathways and answers).

Through FBE, the City currently provides 60kWh per qualifying customer per month. This is significantly lower than what the current study considers sufficient. This should be seen in the context of the data limitations outlined above, as well as the experiences of Eskom. Eskom believes 250 to be too high, stating that in their experience, the national average consumption level for LIHHs in Eskom supply areas is 113kWh per month (Eskom, personal communications, 1 August 2019). This belief is based on their experience of consumption patterns under the different tariff structures that act as a subsidy to enable increased consumption – with the FBE limit in mind. It is not predicated by research that yields data on what could happen if the gap between consumption levels in LIHHs lifeline and domestic tariff groups were to narrow considerably or be eliminated.

In an attempt to answer the latter question and noting the complexity of the energy poverty problem in the CCT urban context, the focus of this study has evolved through its implementation. Whereas, at the outset, the question to resolve was on providing optimal and sustainable energy services to LIHHs, it has emerged that the key objective of the CCT LIHH energy programme is to close or minimise the gap between the current level of CCT support for energy-poor households (in the form of FBE and Lifeline tariffs), and LIHH actual energy demands. This noting that the latter is likely to be higher than the amount of energy currently consumed by LIHHs, due to supressed demand.

At current FBE levels and the significant financial costs associated with increasing FBE to a level that could start closing the energy poverty gap, it is clear that this gap is unlikely be closed through an intervention that simply involves increasing the FBE subsidy to the 250-programme level. Systematic, well-planned, better informed (e.g. through increasing consumption patter data in LIHHs), and innovative measures are required. For this reason, the options and recommendations discussed in this document, are aimed at assisting the CCT LINES team in using existing tools and data as well as those yielded by this study to further the work towards closing the energy poverty gap. These options and recommendations can be implemented incrementally, either as stand-alone projects, or combined in a holistic and programmatic approach.

The intervention modelled across the scenarios developed in this study aimed to show how energy poverty could be reduced through providing a 'package of energy services', equivalent to 250kWh at a subsidised cost of R100 per month. Noting the earlier described 'lock in' to the grid, the perceptions surrounding AES and the aspirational nature of grid electricity, and the risks associated with Eskom dominated energy security, all scenarios considered in this project include varying amounts of electricity as a base, with alternatives to the 250 electricity only scenario including a mix of AES options (gas for cooking and/or water heating, and SWH). As discussed, behaviour change needed to drive the uptake and efficient utilisation of proposed energy solutions is a critical precondition for the success of any of the scenarios proposed, or any other modelled scenarios. This is are also relevant to cross cutting aspects of the options and recommendations outlined such as smart meters, energy efficiency, and connectivity.

B.1 The Four Conditions of Success

Addressing four foundational pillars in evolving solutions for eradicating energy poverty in the CCT will, together, allow the various financial and technical options proposed to work, and to be sustainable in the long term. Establishing these foundational pillars is therefore considered a critical first step and a precondition for the success of any further interventions for providing improved energy services to LIHHs. Establishing the foundation requires the CCT to address four pillars of the private sector, behaviour change and incentives, operations and maintenance models, and energy efficiency and time of use delivery together, as a package for creating the conditions for success of future interventions.

Blended Public and Private Sector Solutions

Although the CCT is locked into providing centralised electricity solutions to all consumer groups, to the extent that it needs electricity sales from all groups to cover its costs, the market is, and will likely continue providing alternate solutions to customers. The main drivers are affordability and reliability and until the CCT can take some control of this situation, and then reduce electricity costs and sustain these, these drivers show every likelihood of continuing, if not increasing in impetus.
This study has highlighted the significant risk to the CCT, and therefore to LIHHs, of the current subsidisation of the lifeline tariff structures enjoyed by low income households coming exclusively from a small group of Energy Intensive Users (EIUs). It is well-publicised fact across South Africa that the EIU group of companies is seriously considering its alternatives for securing reliable and affordable electricity and energy supplies. Alternatives range from disinvestment to securing their own source of energy supplies. Reduced sales from this group will affect the subsidy currently afforded to LIHHs in the CCT, while continued disruptions to supply will push all customer groups toward AES, allowing suppliers, for example of gas, to further cement their markets. As it is, LIHHs are locked into a level of low cost fuel supplies such as candles and paraffin. Many also rely on gas for cooking and space heating.

Partnerships between the CCT and the private sector will be critical to managing the City's mandate to provide adequate and safe basic services while these could also enable socio-economic development. This is particularly important in situations where the City wants to ensure safety and security of supply but cannot adapt its business model to the AES that the market is providing. In other words, if, for example, the uptake of gas increases among LIHHs, and the CCT does not want to get involved in gas sales and distribution, it could, instead, protect the consumer through regulating the supplier base, while it could ensure improved levels of safety for consumers through targeted education and awareness campaigns, conducted in partnership with a registered supplier base that is compelled to co-invest in such activities.

Public private partnerships in targeted sub sectors of the AES sector, are thus seen as a critical condition of success in reducing energy poverty across Cape Town. Partnerships may be established to stimulate behaviour change, as discussed, for effective, affordable, and safe(r) installations, operations and maintenance, and for technological developments, such as smart meters, batteries, or improved AES systems, such as SWHs.

Behaviour Change and Incentives

A vital component of introducing any new programme is ensuring that people know about it, and particularly, how to use it. This includes awareness of the programme and its benefits, how to access its modalities, what its qualification requirements are, and so on. This an education and awareness campaign needs to be built into any option the CCT chooses to roll out. Awareness is also crucial in using the proposed option to incentivise people to stop, limit, or change the way they use dangerous energy sources such as paraffin and candles. Such campaigns would need to highlight both the dangers of unsafe energy practices, as well as all the alternatives. This would enable the proposed intervention to realise the full, intended socio-economic benefits, such as reduced spending on health or reduced loss due to fires, among others, as outlined in the Risk and Cost Benefit Analysis (RCBA) to this study.

Current energy use practices such as energy stacking are engrained behaviours and households have invested in their current energy practices through purchasing equipment. Also, the current tariff structure disincentivises increased consumption and so specific awareness raising and education interventions need to be implemented to ensure the best chance of households taking up any proposed interventions.

Awareness is also a critical factor in maintaining the CCT's social contract with its electricity customer base. This is central pillar to alleviating energy poverty in the long term, noting that the CCT must ensure that the support it provides goes directly to those that need it the most – and that this is understood by the LIHH consumer.

Designing Incentives to Induce Appropriate Behaviour Change

Raising awareness alone is insufficient. Households use energy within established path dependencies, for example through their investment in equipment such as paraffin stoves (noting the huge gap between the cost of a paraffin stove and an electric stove). Structuring a programme to reduce energy poverty in a way that it can feasibly be used by LIHHs and developing an incentive structure that encourages its uptake will increase the likelihood of success, as appropriate incentives will increase the opportunity cost of not switching. An example of a potential incentive is a Direct Rewards programme. Direct Rewards designs marketing programmes that change behaviour and provide tangible value to customers at a

monthly fee of between R5 and R15, paid by CCT. The programme entitles customers to discounts on important items such as food, clothing and entertainment. If CCT were to implement such a solution, its related costs could be subsidised indirectly by increased cashflow, decrease in debtor days and decrease in losses due to non-payment. While this is likely to increase programme uptake, it also carries a danger of increasing consumption of unnecessary items (e.g. less nutritious, or non-essential food items are part of the rewards system) and so its adoption should be carefully considered.

Structuring Tariffs to Incentivise Increased Energy Demand

Given that the current tariff structures applied to LIHH customers disincentivise increased consumption, an important measure for incentivising behaviour change is through altering the electricity tariff structures. As FBE is provided to Lifeline customers free of charge, they experience a sharp price increase once their monthly FBE allocation is finished (typically on or before the 7th day of the month) when the Lifeline Block 1 tariff (104c/kWh) kicks in. This 'price shock' suppresses demand in households for energy. Additionally, the Lifeline Block 2 rate is higher than the Domestic tariff Block 1. This is designed to incentivise households to move to domestic tariffs if they are consuming over the Block 1 threshold of 350 kWh/month. However, switching to the Domestic tariff results in households no longer receiving FBE, thus suppressing their demand in response. Households automatically move to the Domestic tariff if they consume over 450 kWh per month on average over a 12-month period.

When considering changing tariff structures, it is important to understand the LIHH elasticity of demand for electricity. This is a key metric in tariff setting and is especially important in the context of setting tariffs that affect LIHH. The level of elasticity of demand indicates how consumers' behaviour will change in response to a change in tariff level:

- Where demand elasticity is low (i.e. LIHHs are less likely to significantly change behaviour due to tariff changes, as they have a highly constrained budget), electricity tariffs need to be low, as LIHHs are only consuming the electricity they need to meet essential energy needs.
- Where demand elasticity is high, households have more flexibility around their consumption decisions as their budget is less constrained.

The elasticity of demand must be used to determine where the switching points need to be set when restructuring tariffs, both between Lifeline block 1 and 2 and between Lifeline and Domestic tariffs. Both should be set at consumption levels that are considered to be "sufficient" to meet basic energy needs and should be designed so as to not result in households suppressing their demand in order to remain on the cheaper rate.

Increasing connectivity to Incentivise Increased Energy Demand

Increasing access of LIHH to data is an important incentive for increasing energy consumption in LIHHs. In today's world, digital connectivity is an important part of being a connected member of the social, political and economic community. The scenarios proposed in this project for energy services designed to reduce energy poverty therefore include the provision of a monthly WiFi data package. This incentive recognises that cell phone data in particular is relatively expensive in South Africa and may be prohibitive for LIHH. The advent of other options for improving connectivity allows this incentive to be considered, particularly through low cost Wi-Fi modems. One organisation, available to Cape Town, claims to deliver affordable internet to homes and businesses in underserved urban communities. This system typically has a capital and installation cost of R1,000 for a router that can be shared amongst a few households. Each household will then be able to buy its own data/internet packages at a cheaper rate than cell phone data. Packages take the form of an unlimited bundle for a certain period (i.e. a week or a month) or a limited bundle which is valid for 30 days (TooMuchWiFi, n.d.).

Gathering Behavioural Data to Understand Energy Demand

Any education and awareness raising interventions that aim to either shift energy consumption patterns or to incentivise the uptake of energy poverty reduction measures, also need to be designed to yield reliable behavioural data. Such data is currently lacking, particularly on energy stacking patterns, as well as overall energy demand and the elasticity of LIHH energy demand. Obtaining such data is therefore a critical towards designing/refining effective solutions for reducing energy poverty and inequalities in CCT.

Waiting until 'sufficient' data has been collected to support the choice and implementation of interventions to reduce energy poverty is however not an option. For various reasons, articulated elsewhere in this study, the number of LIHHs is increasing and with this, so is energy poverty. Energy poverty is also thought to be increasing as households increasingly struggle to meet the growing costs of other essentials

such as transport and food. Rather, the CCT needs to adopt, or continue, a learning by doing approach that ensures that data collection is strategically designed and built into each intervention rolled out in LIHHs.

Operations and maintenance

Similarly, as with electrification, simply providing an enhanced and diversified energy package is likely to be insufficient to ensure its uptake and sustain its use. In addition to raising awareness of the programme, AES options require education on the use, operation and maintenance of AES and stimulation of sustainable business models to support the sustained use of the programme.

For example, while gas has perceptibly become a safer fuel over the past 10-15 years, there is still a risk of fires and burns as discussed in the RCBA of this study. Educating households to ensure that they understand how to correctly and safely manage their gas usage is vital. Such an education programme could be conducted, on an ongoing basis, in partnership with gas suppliers. Moreover, the CCT could regulate gas suppliers through vetting them and placing them on a CCT recognised service provider roster, as has been done in the past with SWH suppliers and more recently with suppliers of fibre services for enhanced Internet services.

Lastly, as discussed earlier, there are opportunities for job creation and SME stimulation in various aspects of an AES sector, such as installation and maintenance of SWHs and gas. Furthermore, partnerships with and/or incentives for private sector low income household property developers could see for example, ring fenced, holistic property development solutions that in turn enable SME participation in installations, operations and maintenance, including of SSEG. Similarly, CCT enabled partnerships and incentives of this nature in preferred AES, could act as a disincentive for unwelcome AES such as paraffin and candles. Encouraging and enabling the participation of SMEs in the AES sector is also well in line with CCT and Western Cape Provincial strategic priorities.

Energy Efficiency and Time of Use Delivery

Improving the energy efficiency of low-income housing is a critical foundation for reducing energy poverty at the household level, while Time of Use (ToU) based delivery of energy services can improve costs and efficiencies at the CCT level.

Increasing the number of kWhs a household has at its disposal is unhelpful if the members still cannot efficiently heat their homes. Ensuring that houses, especially new developments, have adequate thermal insulation, ceilings and efficient lighting is a vital to sustainably alleviating energy poverty. In some parts of CCT, this is already being done through the installation of thermal ceiling retrofits. Improving energy efficiency will also ensure that households are able to maximise the benefit of being able to access and afford 250 kWhs of electricity, or equivalent energy, per month, as wastage due to inefficiencies will be greatly reduced. In order to implement this, the LINES team needs to coordinate with government departments, particularly the Department of Human Settlements, to ensure that their policies and strategies align, as well as with large scale, low income housing developers in the private sector, to incentivise their compliance with such local government policy. Increased energy efficiencies also have important human health and climate change benefits – in terms of improving local air quality and contributing to reduced greenhouse gas emissions.

At the CCT scale, ToU-based energy services delivery is central to ensuring efficiencies across the supply system as customers are incentivised, through related tariff structures, to use, where possible, energy intensive services outside of peak electricity delivery timeframes, noting that delivering electricity is more expensive during peak times than off peak times. At present, the data available on ToU in LIHHs is very low and this is needed to enable ToU tariffs. Installing smart meters at scale will yield this data among other important benefits for energy services delivery. Smart meters make it possible to collect rich data on a variety of aspects of energy use in households, which is currently unavailable. Having this data would better inform planning through improved understanding of LIHH energy consumption pattern and needs. Smart meter technologies are being improved on continuously, but incentives for the private sector to further upgrade their products are hampered by low demand, while a lack of direction by the client, in this case a municipality such as the CCT, means that developers are not optimising the functionality of the smart meters they are producing. CCT is well positioned to incentivise optimal, fit for purpose smart meters through the procurement process thereof, and could, at a minimum, include the installation of smart meters in the specifications for new low income housing developments.

B.2 Options for Reducing Energy Poverty

Broadly speaking, four options for reducing energy poverty are outlined in this section. The first is an ***electricity only option***, which seeks to replace all current and future forms of AES through 100 percent electrified services; the second covers a range of diversified energy options collectively referred to as the ***diversified energy option***; while the third outlines a tariff structure option, particularly to incentivise ToU, hence an ***increasing cross-subsidisation of LIHH energy option****, and;* the fourth outlines options for promoting behaviour change, the ***nudging behaviour change option***.

In addition to the foundational pillars described in B.1 above, this study has explored a range of alternative scenarios, or packages for substantially reducing energy poverty and related inequalities in the City of Cape Town, across both City and Eskom supply areas. As indicated, the benchmark applied for 'sufficient' energy, or enough energy to substantially reduce energy poverty, is 250 kWhs in summer, whereas 350 kWhs is used as the proxy for winter when demand increases due to the need for space heating. In order to provide options to mitigate the risks associated with the (E) option, this project also considered AES options including Liquid Petroleum Gas (LPG or gas) and Solar Water Heating (SWH). These packages of diversified energy mixes include the energy equivalent of 250 kWh, but the energy sources differ as outlined in Table 1.. All scenarios include a base amount of electricity, with some being supplemented by gas and others by SWH. Including AES options in a diversified energy package is appealing in the prevailing uncertainty surrounding Eskom and the ongoing tariff increases that result. SWH provides 'free' energy once installed and the regulation of the gas price and recent expansion of the gas industry has stabilised supply, making these AES options viable alternatives.

Each of these scenarios was modelled in this study to allow comparative analysis between them in relation to the critical and integrated aspects that need to be considered in evaluating their feasibility. It should be noted that the third and fourth options outlined were not modelled for under this study and are therefore discussed in a different way.

Because there are similarities between the first two options, driven by their common target of 250 kWhs or equivalent per month, per household, these two options are comparatively discussed under the headings of each of the feasibility aspects of: funding models; business models, and; long term sustainability and risks thereto. Affordability for the consumer and affordability for the CCT are critical cross cutting feasibility questions, discussed under each of these headings.

Behaviour nudges and incentives are outlined as cross cutting options that could be funded separately to, but on top of, the central energy services options implemented

Table 1. Model scenarios

Scenario	Description	kWh subsidised	Consumer price
Base Case	Electricity only, all year, inclusive of free basic electricity (FBE)	Up to 250kWh, with 60kWh provided free	Current Lifeline tariffs
Scenario 1 (E) Or 250 Programme	Electricity (E) only, all year	250 kWh	Total cost of R100 for Lifeline customers (or 40c per kWh). Any kWh over 250kWh charged at domestic block 1 tariff in CCT supply areas and Homelight block 2 tariff in Eskom supply areas
Scenario 2 (E+GC)	Electricity, Gas for Cooking (GC) plus data	Summer: 250kWh Winter: 350kWh	Total cost of R104.50: R100 for energy and a subsidised R4.50 for 2G monthly data bundle kWh over 250kWh or 350kWh charged at domestic block 1 tariff in CCT supply areas and Homelight block 2 tariff in Eskom supply areas
Scenario 3 (E+GC+ SWH)	Electricity, Gas for cooking, Solar water heating (SWH, or S) plus data		
Scenario 4 (E+SWH)	Electricity, SWH plus data		
Scenario 5 (E+GWH)	Electricity, Gas water heating (GWH) plus data		

Options for provisioning sufficient energy

As indicated, the first two options outlined above, for ***electricity only***, and for ***diversified energy***, are compared below under the three key feasibility aspects considered in this study.

Funding Models

If rolled out simultaneously to all LIHHs in the administrative boundaries of the CCT, all the modelled interventions for reducing energy poverty through enabling the affordability of 'sufficient' energy services would incur significant financial costs to the CCT, thus placing pressure on the Total Municipal Account (TMA). The complex interlinkages between the various line items that make up the TMA, as well as how these may be affected by any increase in spending on energy poverty reduction measures as provided by CCT, are presented in detail in the outcomes of the financial modelling (available in Deliverable 3, Section A.2). Critically, reducing or eradicating energy poverty will require trade-offs in terms of reallocating financial resources from one use to another. *The recommendations that follow this section consider how to broach the trade-offs in decision making for energy poverty eradication*.

Electricity Only Option

CCT, through the LINES team, has been considering providing 250 kWh of electricity (only), as above, in the form of what has been labelled the '250 Programme'. The financial modelling results show that this proposed programme would cost the City R483 million in 2019, increasing to R1.56 billion by 2029. This amounts to approximately 0.9% of the total anticipated City revenue in 2019, increasing to 1.4% of anticipated revenue in 2029. If this cost is not absorbed or compensated for through an increase in City revenues (e.g. property rates, increased electricity sales), the addition of the 250 Programme will have a significant impact on the City's projected operating surplus. In considering how the programme could be funded, four possibilities were evaluated: i) cross-subsidisation on the electricity account; ii) a reduction in the Contribution to Rates from the City's Equitable Share Grant from National Treasury; iii) subsidisation from the revenues from the Water and Waste department, and; iv) improved efficiencies in current electricity provisioning by the CCT.

With the exception of improved efficiencies, it is clear that under each of these financing options, someone will have to pay for the 250 electricity only Programme, or diversified equivalent. Put another way, either other electricity customers, or ratepayers, or water, sanitation and solid waste customers will bear the cost of the programme, constituting a trade-off between one service and another, and necessitating a serious commitment and strategy on the City's part, to eradicate energy poverty as a vehicle for reducing the pervasive inequalities that divide the City.

The impacts on the tariffs or rates paid by these customer groups will be substantial. Hence the implementation of any related decisions would need to be 'sold' to the consumer group concerned, necessitating a different level of education and awareness raising to that discussed earlier. Furthermore, CCT's current and future context includes a number of other pressing factors that are likely to place further pressure on its financial resources. These include an increasing indigent population, the need to ensure medium- and longer-term water resources in a rapidly changing climate, increasing vandalism and cable theft, the recent increase in property rates and the plan to contain rates and tariffs in the medium term. Successful proposals for additional rates and tariff increase or finding sufficient efficiencies to fund the 250 Programme are unlikely to be approved by the City's financial team without strong support from other affected provincial and CCT departments such as public health, and human settlements.

Diversified Energy Option

The alternative scenarios consider varying proportions of electricity consumption, coupled with alternative energy as part of a 250 Programme equivalent. The amount of electricity consumed is important because it is a key driver of variable operational costs. The more electricity is consumed, the higher the costs to the service provider (in this case the CCT) due to increased bulk purchases. However, since the modelled cost to the customer is 40 cents per kWh, the greater the amount of electricity in the energy mix, the more revenue the service provider can collect. The equivalent kilowatt hours substituted by other energy sources reduce revenue for the service provider since these are provided by the private sector.

The main difference in funding AES options and electrification only lie in the capital costs of AES. LPG requires gas bottles and equipment such as a gas water heater (GWH), a stove or a space heater. The high cost of SWH capital (approximately R14,000 per household in today's terms) makes it prohibitively expensive for LIHH to finance the technology. CCT would therefore have to carry this cost, or source outside investment in the solution. The GWH capital cost is about 25% of the SWH costs and gas for

cooking is only about 4% of SWH costs. These options are more affordable for LIHH and so the cost burden could be shared.

The cost of AES options to CCT depends on the share of capital expenditure the City wants to finance in order to achieve its objectives. Subsiding part of the initial capital expenditure and requiring a contribution from households could make the option cheaper for the City. Additionally, extending the roll out period of the capital goods will make the transition cheaper for the City as households will remain on the Lifeline tariff until they receive their capital goods. A delay in rollout, while cheaper, will be slower in bringing people out of energy poverty as they will only see the benefits of the programme once the capital component has been invested.

While some households will already have the necessary capital for SWH, most do not. More are likely to be able to invest, or co invest in gas, as some LIHHs have already. Implementing SWH based programmes involves the purchase of a SWH, and installation and maintenance costs. Additionally, this study has modelled the cost of AES based on assumptions about current penetration rates. If these rates are higher or lower in reality than the rates used in the model, this will affect the pricing of the options.

Business Models

As discussed in the Updated Literature Review, the electrification model has dominated energy supply in CCT. This model has historically been underpinned by a centralised system, governed and managed by Eskom as the vertically integrated electricity utility. Governance and technological trends are however nudging South Africa toward shifting this status quo. The pressure to shift toward decentralised delivery structures and more transparent governance systems is global, creating the space for technologies to disrupt regulatory environments and energy services delivery models. In South Africa, particularly in its larger metropolitan municipalities (metros), the rising force of distributed generation (such as SSEG), smart grid technologies and energy efficiency are putting pressure on these municipalities, and on the national utility, to come up with innovative business models in order to remain relevant. However, the national utility as discussed is embattled, rendering innovation impossible under the current crisis management modality. This leaves the space for metros to take the lead in establishing innovative solutions and business models for enabling these.

Electricity Only Option

A sharp rise in the Eskom bulk tariff for electricity to local government is squeezing out the surplus that municipalities utilise to fulfil their redistributive mandate, while at the same time municipalities are struggling to fulfil maintenance and infrastructure obligations (SACN, 2018). The municipal distribution business is therefore facing significant economic and technical challenges, leading municipalities to re-think their role in the electricity value chain and adapt their entire business and operating models. This is already underway across metros. The 2018 SALGA Energy Summit Declaration recommended the optimisation of municipal business through improved operational efficiency, increased energy efficiency, adequate maintenance, and improved revenue management, amongst others. Another important intervention identified was rationalising and unbundling electricity tariffs (separating fixed and variable charges), according to actual CoS. Most importantly, the Declaration noted that “municipalities cannot keep relying on the sale of kWh for their revenue” and the funding model of local government has to be reviewed to include innovative solutions and new sources of revenue (SALGA, 2018). One alternative form of revenue proposed was the sale of services related to the use of existing infrastructure, such as charges for “wheeling” or transporting energy for third parties. Municipalities also need to take measures to decrease theft losses and bulk purchase spending by purchasing electricity from IPPs, for example, and to increase revenue from electricity trading and grid/time-of-use charges, as well as take advantage of the increasing affordability of alternative energy sources (SACN, 2018).

If CCT adopts the 250 Programme or a similar one, this will provide further impetus for the updating of its business model. The CCT has been one of the strongest proponents for diversifying municipal opportunities for electricity generation and supply and in 2014, requested the determinations needed to enable it to purchase electricity directly from renewable energy IPPs. When these requests were denied, the CCT commenced court action to force these determinations. Successful legal proceedings would enable the City’s objectives of enhanced energy independence and decarbonised energy services supply, as defined in Energy2040. (It would also set an important precedent for other metros in the country). It could also assist the City in achieving its objectives for climate resilience and enhanced energy security as reduced energy poverty and energy security will increase the resilience of the poor and the CCT respectively. Notably, resilience of the poor to climate change is significantly lowered by reduced access

to adequate energy services (OneWorld, 2019). Rising Eskom electricity tariffs are thus contributing to reduced climate resilience as more and more people are unable to afford electricity.

Diversified Energy Option

LPG and SWH require expensive capital equipment, as well as installation and maintenance costs, in addition to distribution costs for gas. The lowest cost option for the customer is AES, when the CCT covers the full cost of the AES. However, this is also the highest cost option for CCT. Opportunities to share this cost should therefore be considered. In an appropriately structured business model for AES packages, through partnerships between the CCT and the private sector, capital costs can be shared between the customers the supplier and the household (the supplier and the household together comprise the private sector).

Sharing the capital costs with customers would mean that the LIHHs have to pay more. While SWH, as discussed, are prohibitively expensive, the energy source is free, reducing these costs over time. Furthermore, the capital expenses associated with gas are lower providing an opportunity for either the customers to buy their own gas equipment or for them to contribute towards it. However, when consumers are paying more for this intervention, the process of them moving out of energy poverty is delayed. This is because they have to pay more which sets them back financially and because it will likely take longer to adopt the intervention if households have to self-fund it.

An additional option is to work with the supplier, and the financial services sector in developing financial mechanisms to fund the capital portion of the AES, particularly in the case of SWHs. For gas, a supplier driven solution could involve the CCT in concluding a deal with gas distributors, where the latter provides the equipment at a subsidised rate in return for households receiving coupons for their gas. This would decrease the cost to CCT without shifting the upfront capital burden to LIHHs.

Regarding distribution of gas and the maintenance of both gas and SWH equipment going forward, there is opportunity for local enterprises (in LIHH areas) to become important stakeholders. CCT can facilitate this by creating an enabling environment, through targeted policy and incentives, that supports small enterprise development in these areas, and in turn benefits by the income generation and employment opportunities that arise.

Long Term Sustainability

The sustainability of any of the scenarios modelled is in question given that electricity is a component of each scenario, to a full or large extent, as shown in Table 1. The future of South Africa's energy sector is described in Box 1 in terms of a 'Stuttering Hybrid' or 'Thriving Diversification'. Each of these projections would have a different bearing on the sustainability of the interventions chosen for reducing energy poverty in the CCT, although a 'Thriving Diversification' future could unlock greater potential for achieving such objectives. However, the prevailing political and economic climate points toward the 'Stuttering Hybrid' projection.

Electricity Only Option

This study has highlighted a number of risks associated with an electricity only intervention. These are detailed in the Risk Analysis to this study (Deliverable 3, Section B.2). The 'Stuttering Hybrid' projection, reveals a number of risks and vulnerabilities associated with a decision by CCT to rely significantly on electricity generated by Eskom in providing energy services. Two key risks threaten the sustainability of this option. First, the risk of significant increases in electricity tariffs is high reducing affordability for CCT in subsidising LIHHs in accessing the 250 Programme. Secondly, prolonged periods of load shedding, due to insufficient generation capacity and poor maintenance of the national grid in the past is also very high, potentially forcing LIHHs to either spend income prioritised for other needs on energy, or to go without. If they do spend, which is likely at least to provide minimal energy services during load shedding, such as for cooking, on alternate energy sources, it is highly likely that they would revert back to the unsafe fuel sources the 250 programme seeks to avoid, namely paraffin and candles, simply because they are the cheapest.

The updated literature review and the risk analysis conducted under this study confirms that an electricity only (E) option is not sustainable in the long term. The literature review in particular revealed that tipping points for switching to AES, such as gas for cooking, has already been reached for some LIHHs and this is only expected to intensify going forward.

Diversified Energy Option

Following the above, the sustainability of any of the diversified energy packages is increased by the extent of a given packages reliance on AES in its composition. The diversification mitigates the outlined risks facing electricity services. In addition, the costs of AES reduce in accordance with increasingly electricity tariffs, noting however that gas prices are subject to the vagaries of international pricing trends. Most importantly, a critical sustainability factor of diversified energy packages, is that their implementation will prepare the household for increased future use if required. In other words, a household that uses gas for cooking under scenarios 2 and 3 in Table 1, will be familiarised with gas thus enabling future uptake of additional gas services, such as for space heating, should the need arise.

Options for promoting Behaviour Change

As discussed in the introduction to this section, cross cutting options for reducing energy poverty are considered below on top of the 250 kWH or equivalent scenarios that were modelled under this study. The two specific options outlined are for ***increasing cross subsidisation of LIHH energy***, and for ***nudging behaviour change***.

Increasing Cross-subsidisation of LIHH Energy Option

An option for increasing consumption at reduced cost in LIHHs is through alternate tariff structures, in particular, through a demand side management driven ToU tariff. CCT buys electricity from Eskom at a ToU rate. As most electricity consumption occurs at peak times, CCT is at risk of making a loss when they charge their customers a flat rate during peak times, depending on the load profile of the customer. A ToU rate design features prices that vary by time period, being higher in peak periods and lower in off-peak periods. Introducing a ToU structure at the household level would save CCT money in two ways. First, it would incentivise customers (primarily middle and high income) to shift consumption to off-peak times, resulting in CCT buying fewer expensive peak kWhs. Second, increasing the price of peak consumption would better cover the cost of CCT buying peak kWhs from Eskom. In addition, customers will benefit, if they can shift consumption to off-peak times, thus reducing their electricity bill.

Municipalities already have a mandate to implement ToU tariffs. The December 2008 Electricity Pricing Policy supports the use of ToU tariffs in municipalities, stating that they should be “actively promoted”. Currently, in CCT there is an optional ToU tariff for medium voltage (MV) commercial customers. Making ToU tariffs compulsory for MV customers could result in significant savings for CCT.

CCT’s current ToU tariff is based on Eskom’s MegaFlex tariff. Customers requested the creation of a ToU tariff because large national and multinational companies, who were supplied by municipalities were being charged different tariffs or were exposed to different tariff structures in their different branches/plants, depending on which municipality they are located in. In order to develop the tariff, CCT went through a customer engagement process where they demonstrated to customers how the ToU tariff would change their electricity bill. For 95% of customers, the ToU tariff would result in a cheaper or equal cost to the flat rate tariff at current consumption trends. If customers shift their demand towards more off-peak consumption, there is an opportunity to reduce their costs. While not the aim of this tariff, a shift by large customers to off-peak consumption does save CCT money as well. CCT is further incentivising customers to move to the ToU tariff by increasing the flat tariff by 8% above the annual increase. Currently, 100 commercial customers (just under 7% of all MV customers) have switched to the ToU tariff, with 120 more in the process of transition. Customers who are not transitioning are reportedly hesitant because of a lack of trust in local government’s models and savings predictions.

An option therefore is for the CCT to extend the ToU tariff structure to other customer groups. The Cost of Supply study (CoS) in this study shows that the LPU MV customers are the largest consumer group in terms of projected energy sales (3,079 million kWh), followed by domestic (2,282 million kWh) and SPU 1 (1,709 million kWh). There is thus scope to introduce and benefit from a ToU tariff in multiple customer categories. In the Western Cape, the Beaufort West and George municipalities provide examples of this. The former has a domestic, commercial and green energy ToU tariff and the latter - domestic, industrial and SSEG ToU tariffs (NERSA, 2018).

CCT notes that the barrier to changing these tariffs at a domestic level is the cost of installing new, smart meters and the inelasticity of the electricity demand peaks. Regarding the latter, examples in other municipalities and countries show that there is scope to shift demand. Many European countries, such as Bulgaria, have had ToU domestic tariffs for many years and customers shift their demand to accommodate that by, for example, doing laundry later in the evening, noting that several household appliances now allow for automated timing of the process. The meters needed for ToU tariffs are

expensive to install and so may be prohibitive for many domestic consumers. However, there may be scope for high- and middle-income consumers to adopt this technology, if incentives, such as a well-designed ToU tariff, are introduced.

Nudging Behavioural Change Option

Enabling behavioural change can be achieved in a number of different ways, with success usually relying on a combination of approaches, such as education and awareness campaigns (discussed in section A hereto) and incentives, such as the one outlined above. A behavioural nudges approach is a further route that has seen traction in other parts of the developed and developing world where cities are trying to increase energy efficiencies. This is the approach outlined in this option.

Behavioural science tells us that it is possible to 'nudge' people towards switching consumption to off-peak times. By creating an intervention that nudges middle- and high-income consumers to shift their electricity consumption away from peak periods, CCT can increase its savings, as discussed above. Examples of previous successful nudge programmes include the use of social norms. In Virginia, US, sending letters to customers comparing their energy use to comparable households in the area, resulted in annual savings of $300 million. This approach was applied to CCT households during the drought in 2017 and proved to be very effective in decreasing water consumption and meeting water use restrictions or consumption targets. The implementation of these nudges decreases the financial risk of an intervention such as this by only requiring payment for their services if the intervention works (i.e. people shift their electricity consumption times). Using this model, CCT would be able to implement an intervention (non-tariff) at a very low risk premium and cost.

C. Recommendations for the CCT

The various components of this study, as outlined in the introduction, have all contributed to advancing the body of knowledge and tools at the disposal of the CCT for identifying the best, or optimal model for delivering sustainable LIHH energy services that are affordable for all Parties.

A key finding of this study is that it is not possible to identify a single 'optimal' model for delivering sustainable energy services to LIHHs that are affordable for all parties (CCT, Eskom, LIHHs). As discussed, each option has significant, associated trade-offs which would need to be addressed to enable the sustainability and efficacy of the option(s) under implementation.

This finding is underpinned by several other findings arising from this study. This study has consistently shown that while electricity is currently the most cost-effective option for CCT, there is considerable uncertainty as to its ongoing affordability and its sustainability for both LIHHs and for the CCT. Noting the range of systemic factors surrounding the provision of energy services, and that the socioeconomic context is a critical determining factor, the study has particularly highlighted that the electricity-only option brings the most significant risk in terms of the future viability of the service. Including AES in the energy services delivery model does however have the potential to increase the range and value of socioeconomic benefits, such as employment and enterprise development, compared to electricity only.

There are also a range of cross-cutting solutions, such as energy efficiency, which are foundational for any kind of service delivery model, and without which no solution can be sustained in the long term. Energy poverty reduction as a result of the proposed 250 programme will be measured in terms of the energy services that 250kWh confers. With more efficient appliances, the same services can be delivered at a lower level of energy consumption, resulting in decreased cost to the service provider. From the CCT's perspective it makes sense to promote energy efficiency particularly amongst subsidised customers, as well as the capitalisation of more efficient appliances.

The tools and knowledge produced under this study has improved the ability of the CCT to estimate the financial and socioeconomic implications of a range of energy service options and has provided the basis for it to continue to evaluate other future identified options in its quest to find workable solutions that can meaningfully reduce energy poverty in CCT, rather than an 'optimal' or 'best' model.

The recommendations suggested below are made with above key findings in mind. They are intended to support the CCT as it continues to navigate potential solutions to the current and growing energy poverty problem in a climate of low economic growth and high risk of continued dependence on electrification. These recommendations further recognise that it is for the CCT to make decisions in line with its mandate to deliver adequate basic services for all and to enable socioeconomic development, while it also considers its broader objectives of building resilience to the shocks caused by climate change and unemployment. Increasing the affordability of energy so that LIHHs can access enough, thus reducing energy poverty and increasing resilience to shocks, is an important pathway for the CCT to consider, among its other pressing priorities.

Lastly, the recommendations recognise one of the key limitations for achieving the outcomes of this study, being the lack of quality and consistent data and information about LIHH energy needs and consumption patterns, and on affordability for LIHHs, and their willingness to pay for various types of energy services. The recommendations are therefore focused on highlighting these gaps and proposing a way forward for obtaining the required knowledge, which will assist the City not just in identifying the optimal solution but also in making sure that it is designed in a sustainable way.

Recommendation 1: Collect and Manage Critical Data

The collection of primary data was not part of the scope of this current study. While some progress has been made in collecting data (the Sustainable Energy Africa work which was done in 2017-2018, including a household survey, refers), good quality data on the behavioural patterns of LIHHs in CCT, related to energy use (such as the extent of energy stacking, and ToU data), is not available. This is likely to compromise continued work to determine the 'best model'. A better understanding is needed of the ability and willingness of LIHHs to pay for different types of energy services and sources to inform the choice of the optimal energy service. We therefore recommend that CCT dedicates the necessary resources to improving the understanding of LIHH behaviour related to energy use, through collecting primary data.

The Randomised Control Trial

Importantly, the CCT, together with the Abdul Latif Jameel Poverty Action Lab (J-PAL) at the University of Cape Town (UCT) have been in the process of designing a Randomised Control Trial (RCT) with the LINES team. Although still in early stages, and without funding, the RCT was intended to test the socioeconomic impacts of implementing CCT's preferred solution for providing energy services to LIHHs, from the ones suggested in this study. In this way, the outputs of the Financial Modelling and the RCBA would feed into the design of the RCT. However, given our data findings from early on in this study and the difficulties the lack of data gave rise to, we strongly recommend that….

….the RCT take place and that the objectives are reconceptualised to enable the CCT to generate additional information on the current energy use patterns of LIHHs and on the implications of having predictable access to 'sufficient' energy services each month. The RCT could be an essential tool in providing evidence on the range and extent of benefits for CCT and LIHHs associated with an increase in the level of support provided by the CCT (in the form of FBE or Lifeline tariffs) in alleviating energy poverty of LIHHs.

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The specifics of the design of the intervention, to be identified by the CCT, with J-Pal during the RCT design process, should build on the analysis and decision-making tools provided by this study, namely the Financial Model and RCBA framework.

Recommendations for design of the RCT

Several recommendations emerge from the current analysis for the design of the RCT.

1) **Collect data on energy use patterns in LIHHs**

   This is the most important requirement. A lot of data is available on consumption and spending on electricity. However, little is known of the levels of consumption and spending on other energy sources, such as paraffin, gas and candles (including on capital goods or equipment), especially in terms of shares of overall energy consumption and spending. The majority of LIHHs continue to apply an energy stacking approach due to the unaffordability of electricity. Having this data available will significantly improve the City's ability to assess the impact of proposed interventions and compare them. This data will for example inform assumptions about the penetration rate of AES, such as LPG, and the willingness of LIHHs to stop using unsafe sources, such as paraffin and candles.

- **Understand demand elasticity:** Good quality data on energy needs and use patterns of LIHHs will be central to understanding the price elasticity of demand for electricity/energy of these households. In the context of projected rising real electricity prices, this will be an important consideration for the design of any energy poverty reduction programme of CCT. The RCT can assist CCT in answering whether the City can reasonably assume that price elasticity of demand for electricity rises as income diminishes.
- **Understand uptake:** There is currently no evidence in the literature to indicate the expected rate of uptake by LIHHs of any of the proposed interventions. This has introduced a significant degree of uncertainty in the outcomes from both the Financial Modelling and the RCBA. It will therefore be critical for the RCT to examine related behavioural aspects and gather data on the share of households which would take up the proposed interventions.

2) **Collect baseline data on household income and spending patterns**

   This will be important for optimising the targeting mechanism of the intervention (targeting LIHHs that would be potential beneficiaries of the intervention), by taking into account their budgetary constraints and ensuring that the intervention reaches the households most in need. This will be critical in ensuring that benefits and costs are optimised and will improve the effectiveness of the intervention.

3) **Understand the concept of 'sufficient' energy services in LIHHs in Cape Town**

   As discussed, 250kWh has been tested to a limited extent during this study through updating relevant findings from the literature. However, the amount is contested and until concrete

evidence is available, it will continue to be difficult to refute such contestations with any form of certainty.

4) **Test various options for timing of the provision of the service, such as monthly or weekly**

   This will give an understanding of whether LIHHs can and want to spend a once-off amount of R100 per month for electricity, as opposed to spending smaller amounts several times a month, to avoid significant financial outlays.

Recommendation 2: Take Bold Steps to Eradicate Energy Poverty

The recent CCT water crisis brought the inequalities within the CCT into sharp focus. Although these inequalities are often talked about, and the Gini coefficient for the CCT is difficult to face, the water crisis demonstrated how this plays out in the context of access to a vital resource such as water. For much of the population of the CCT, living in the so-called "Day Zero" conditions was a normal way of life – and still is. Although data is lacking, we know enough from this study and what has come before, to know that too many people have inadequate access to energy services – not because they can't connect to the resource, but because they cannot afford to use it. Thus, quality and sufficient energy services is out of reach for those that cannot afford to supplement FBE once it runs out early in the month. Those that supplement, do so to a very limited extent, spending, on average, 214kWh per month (including the FBE allocation of 60 or 25kWh).

We also know from the RCBA conducted in this study, what it would mean for people's safety, health and dignity not to have to run the substantial risks of using paraffin and candles at times when nothing else is affordable. We also have a better idea of what the related costs for the CCT in response to an energy-induced fire event and the public health impacts of high levels of respiratory diseases attributed to poor air quality. These include annual savings for LIHHs of R11-12m through eliminating damage and losses to their dwellings and contents incurred from open flame fires; as well as ~R18m in direct annual savings in public health costs and over R300,000 annually for LIHHs by preventing pneumonia in children ages 0-5 alone, as a result of the use of cleaner fuels.

As indicated earlier, there are compelling reasons to resolve the energy inequalities in the CCT through reducing, and ultimately eradicating energy poverty. While data is needed to explain the extent of the energy poverty problem and how it could best be resolved, there is enough evidence to begin constructive interventions and to invest in solutions. However, integral to achieving *optimal* solutions is co-ownership through inclusive processes. Recent literature highlights that inclusivity is not only about the outcomes but also about the process to reach those outcomes:

An inclusive economy and society is characterised by equitable participation in growth across the formal and informal sectors - in decision making in growth processes, and in the benefit of the growth itself. Participation of vulnerable population groups in growth processes is via non-discriminatory employment, while participation in the benefits manifests in income improvement and in increased social expenditure benefits that reduce disadvantages, such as education and human capacity development. (Ramos et al. 2013; Fourie, 2014).

We therefore recommend that…

> …interventions to reduce energy poverty are designed and implemented in the near future, under an incremental approach (discussed below). Moreover, we recommend that interventions such as the option to introduce a ToU tarrif, and/or the recommendation to conduct an RCT are co-designed and implemented with a sample beneficiary group. This should be the basis of a co-created social compact between the CCT and the communities in energy poverty, where mutual expectations and constraints are discussed, and the project is designed with these in mind. We further recommend that this approach become cemented as part of what will be an incremental and long-term process for reducing energy poverty.

Recommendation 3: Learn by Doing in an Incremental Approach

Implementation of any selected intervention(s) should be rolled out incrementally. This is both because the need to start reducing energy poverty now, and that not all of the data required to support a full roll out of a comprehensive solution is available.

An incremental approach can be adopted in different ways. One way is to gradually increase the amount of energy supplied per month, per household, testing consumption patterns along the way and collating and applying this data. In other words, the rollout could commence with the full target group, i.e. all LIHHs,

but initially with a smaller programme, such as 130kWhs per household per month. Under this 'low regret' approach, where benefits will be yielded for LIHHs within a context of uncertainty, the costs can be minimised while optimising the benefits. A phased approach will also allow for M&E of the rollout at strategic points and will support ongoing, co creation and further refinements to the roll out of the programme. In this way, the social compact between the CCT and LIHH communities can be evolved and further cemented.

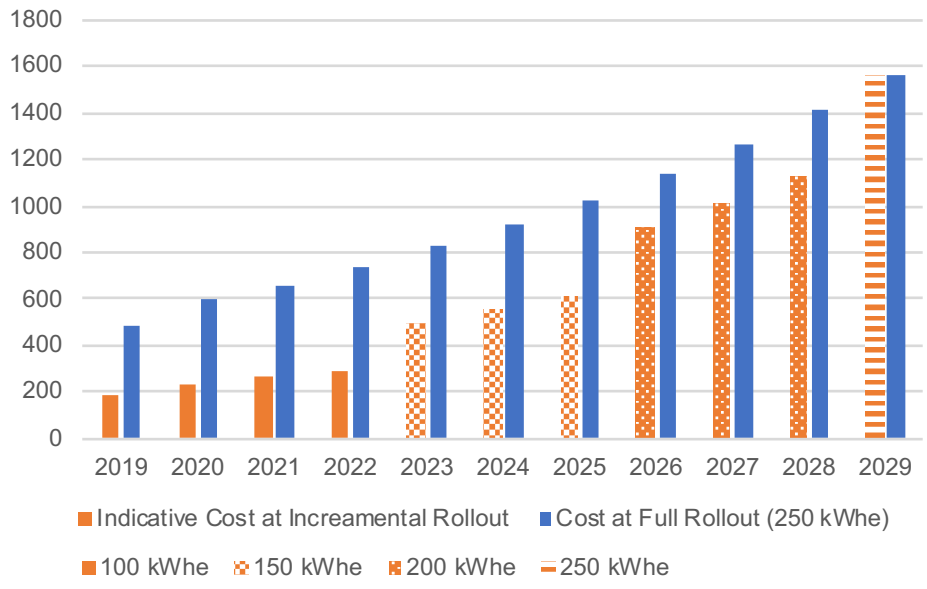
The RCT will be a critical factor in this process, as it can serve as a pilot. Based on its outcomes, the intervention can be scaled up and findings and learnings can be re-integrated into the design of the programme and its rollout. Each phase of implementation will feed into the design of the following activity or phase, allowing for review and update of the findings accordingly.

As discussed, there is an ongoing debate as to what quantum of energy is sufficient to meet LIHHs basic energy needs, while also enabling their socio-economic advancement. There is emerging consensus that 50kWh is long out of date and thus, FBE does not provide enough energy for household basic needs. We therefore recommend that….

> ….. the CCT and LIHHs test different packages as part of the design of the RCT and assess the impact of these on LIHH energy consumption. We propose three packages of 100kWhe, followed by 150kWhe, 200kWhe, before rolling out the full package, as determined from the trials. We recommend that in doing so, the outcomes of the project team's estimations of LIHH demand for energy – see Figure 4 below (MTR, Section C.2). This approach will also enable measurement of the elasticity of demand for energy. By observing the changes in consumption as the relative price of energy decreases, an estimate of demand elasticity can be obtained. This can then be used to inform the final rate or programme design.

Figure 4 below demonstrates the gradual increase in costs based on calculations in Phase 2 of the Financial Modelling (Results Report, Section A.2). The blue bars indicate the annual increase in the cost of a full rollout of a 250kWh electricity only package, while the orange bars indicate the incremental estimates, where programme rollout is increased gradually to the full amount of 250kWh each year.

Figure 4. Cost of full versus incremental programme rollout (R million)



Recommendation 4: Approach the Implementation Strategically

As already established, increasing the quality (safe and clean) and amount of affordable energy that LIHHs are able to access will undeniably have positive socioeconomic implications, both at the household and the wider societal level. However, while the electrification only and diversified energy mix options both bring a range of socioeconomic benefits, they also incur significant costs to CCT. This programme therefore cannot be considered in isolation, but rather as part of the CCT's broader strategy for development and redistribution and therefore with its overarching finance and budgeting process. Among

the CCT's strategic objectives is to prioritise options investments in improved service delivery and to reduce inequalities. Enhanced service delivery investments are often associated with trade-offs between different aspects of service delivery and between service delivery and socio-economic development, all of which require increased investment.

Engagements between the project team and the CCT Finance Department clearly recognised the benefits of reducing energy poverty and enabling affordable and sufficient energy services for LIHHs. The same engagements also highlighted that the current timing is not appropriate for an intervention such as the proposed 250 programme to land. The roll out costs presented to this team (discussed earlier in this report) for implementing such a programme were considered to be prohibitively expensive for the City's budget. A discussion on the various options considered available for paying for this programme with the Finance Team highlighted the following barriers:

- Taking money from the rates budget would incur increases in property rates at a time when property rates have just increased to the dissatisfaction of many, and in a property market that is on a downturn.
- Water rates have recently increased and so this opportunity has recently been exhausted in an environment where water tariffs, electricity tariffs and property rates have increased in similar timeframes, and in a no/low growth economy.
- Efficiencies in cost of supply of electricity services have also been exhausted, not least because of increasing vandalism and theft at sub stations across the CCT (a recent example of a 22 million Rand loss resultant to vandalism at one local substation was cited – as one of many examples).

It is important to note that the above represents the views of the budget team in the finance department, and not the full Executive decision-making body of the CCT. Other, and integrated and holistic views are critical in thinking through the rationale for decisions that improve equality in society through interventions that do so at the expense of other interventions. The populations of Cape Town have competing priorities for City resources, some of which, such as security, are shared across all strata (although there are also strong inequalities in how security affects and is managed across the different strata). While this study included a cost benefit analysis of reducing energy poverty in the CCT, for example through examining the benefits for health and safety, conducting a comprehensive analysis of the costs of all possible trade-offs resultant to choosing one intervention, such as this, over another was outside the study's ambit.

Making the Case for Optimal LIHH Energy Services

The study has yielded important qualitative and quantitative data that can serve as a basis for future work in this area. As noted above, the RCBA highlighted a range of potential benefits associated with reduced energy poverty in CCT, ranging from health, safety and security, to education and income. This highlights the cross-sectoral significance of the benefits of reducing energy poverty. There is, therefore, an opportunity for the Sustainable Energy Markets (SEM) department to coordinate with other relevant departments, such as the City Health Department and Fire and Rescue Services in advocating for increased levels of support for alleviating energy poverty among LIHHs.

This could also be extended to cooperation across levels of governance by bringing in the Western Cape Department of Health, which is primarily responsible for delivering a comprehensive package of inclusive health services to the people of the Western Cape Province. This process would involve sharing knowledge obtained through this study with relevant departments, with a particular focus on the shared benefits, such as reduced spending on healthcare and fire services, which are among the significant benefits quantified by the RCBA.

The Financial Model and RCBA are also in themselves useful tools for decision making at the CCT, going forward. The Financial Model is designed to allow for key parameters to be changed, such as the amount or the cost of the energy services provided to LIHHs. This allows the user to observe how the outcomes (financial costs) change as a result. It is therefore recommended that the LINES Team conducts a knowledge sharing campaign within and across the CCT, including in the wider Sustainable Energy Markets Department and Electricity Services Department. Such a campaign will be aimed at raising awareness of the findings of this study, as well as enabling a wider range of CCT stakeholders to utilise the tools provided by the study to support future decision making.

With the above in mind, coupled with the need for collecting additional primary data (especially behavioural), it is recommended that:

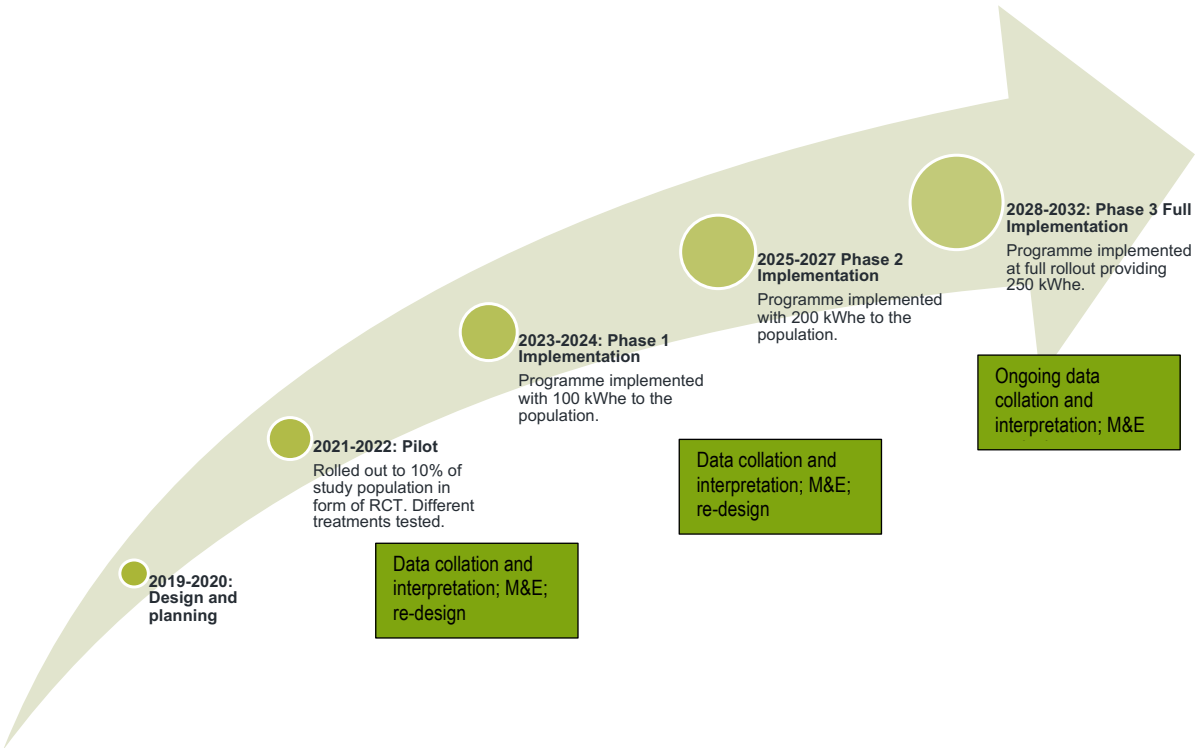
i) The City first targets the RCT project and designs it to gather primary data and to test critical assumption. The RCT could be structured as a project for testing 'sufficient' energy services in a pilot LIHH area(s). Based on the findings and assuming these strengthen arguments for rolling the selected/amended intervention across all LIHH groups, the LINES team could continue to advocate for full scale, implementation.

ii) Following the RCT, the CCT uses this data and the tools provided by this project (Financial Model and RCBA) to inform the redesign of the next phase of the roll out, in participatory design with LIHH stakeholders.

iii) The CCT continues to roll the intervention out incrementally, and in phases (see Figure 5 for an indicative phased approach), monitoring and evaluating progress, uptake, behavioural change and cost benefits at each critical juncture, so as to re-inform subsequent phases.

iv) The SEM management team campaigns the proposed intervention with each relevant department head, such as housing, fire, health, within the CCT and the Western Cape Government, with a view to obtaining buy in to the intervention because of the knock-on benefits for the targeted department's mandate delivery. The objective of this advocacy work within the CCT Executive responsible for contributing to budget decisions, is to ensure that wide and holistic views inform the decision-making process for required budget approval.

Figure 5. Indicative timeline for incremental intervention rollout



Conclusions

This study, like others before it, has sharply highlighted that the provision of energy services is integral to the wider context of inclusive sustainable development. The literature review identifies that designing energy solutions must be integrated in the wider urban sustainability planning and policy framework. Energy service delivery to LIHHs is a City-wide problem, requiring integrated, strongly collaborative and systems thinking solutions that are considered in the context of a municipal business model under pressure from numerous local national and global trends.

There is evidence that a combination of technological, financial and behavioural solutions, combined in an holistic approach, can yield better outcomes than implementing one technology or option in isolation. In turn, this can help to deliver optimal energy services while maximising the potential benefits. A holistic approach can thus be economically viable, while providing a range of benefits for households, communities and the broader economy.

Alignment of the selected solutions with broader CCT Energy Policy, as well as the policies of other relevant departments will be a critical success factor. The CCT's strategy to realise 60% renewable energy in its energy mix by 2050, in an important response to global energy transition and climate change response trends, should also be taken into account. As discussed earlier, the CCT's quest for energy independence is in line with global trends for shifting away from centrally generated electricity for meeting energy needs as well as from fossil fuels toward a diversified energy mix. Solutions for providing improved energy services to LIHHs need to align with this broader strategic focus.

It is also important to note that while providing improved energy services has the potential to improve the wellbeing of LIHHs and has benefits for socioeconomic development, it is not expected that this intervention on its own will be able to achieve the objectives in the CCT mandate to enable socioeconomic development and reduce energy poverty, and poverty in CCT more broadly. An approach which is integrated with other urban resilience solutions, such as energy efficient housing, access to affordable and convenient transport and support for local businesses, among others, will need to be implemented in parallel for the impact to be maximised.

This study has further specifically revealed that although they come at a cost, the options under consideration also potentially have a wide range of socioeconomic benefits. The outcomes from this study, in the absence of data, cannot yet point to a single solution or option for delivering optimal energy services to LIHHs. However, the study's approach and findings, as well as the financial modelling and RCBA tools, can serve as decision-support framework for CCT, allowing for the SEM department to weigh up options as these continue to be identified, along with associated trade-offs in providing optimal energy services to LIHHs, and within the relevant context, policy and strategic direction of the City as a whole.

The study has also highlighted significant gaps in data and information which need to be urgently closed before deciding on the best way option going forward. The findings of the Financial Modelling and RCBA are a product of a series of underlying assumptions which are highly dependent on the availability of good quality data and the future of the CCT energy mix, as well as the structure of the national electricity sector more broadly. Going forward the City, and the Sustainable Energy Markets Department in particular, need to adopt an approach to solving this issue, which is flexible enough to account for any future uncertainties, while being strongly rooted within the broader CCT strategic context.

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All the reports that have emerged from this study also act as important reference material for this report.