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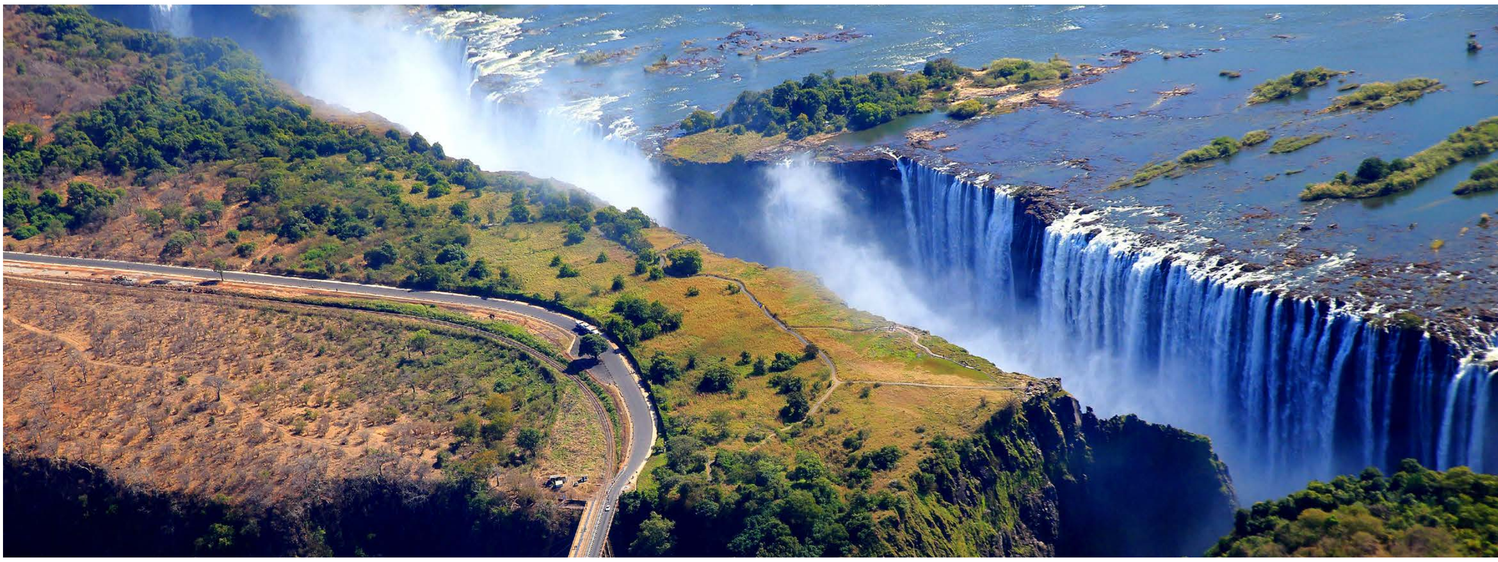

Greening the Recovery in Zambia

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Executive summary

The COVID-19 pandemic had widespread impacts across the world. These impacts have been severe for the health of populations and economies and have prompted calls to re-think the direction of economic and social development. Arguments for a more sustainable, green model of development have been strengthened by the increasing impacts of climate change and the global energy crisis.

This report sets out some results and recommendations from a two-year research project on *Greening the Economic and Social Recovery in Ghana and Zambia*. The project was carried out by research teams at the University of Ghana in Ghana, University College London in the UK, and the Zambia Institute for Policy Analysis and Research in Zambia. The teams analysed stakeholder views on the options for a green recovery from the pandemic, co-developed future scenarios with these stakeholders, analysed the energy system implications using quantitative models, and developed recommendations for decision-makers. This report focuses on results and policy recommendations for Zambia.

Three potential pathways for greening the recovery in Zambia were co-developed with stakeholders, which were distinguished by their envisaged role for government. The first scenario, *Centralised,* gravitates towards policy approaches that reflect the government's stated interest in an export-led trade strategy, and for investment in large-scale infrastructure which leverages investment in public-private partnerships. The second scenario, *Decentralised,* reflects efforts to drive decentralisation of various government functions and places a greater emphasis on local solutions for local challenges. The *Hybrid* Scenario explores the potential for Centralised and Decentralised approaches to operate in tandem.

The energy system implications of these scenarios were modelled and revealed that, if other strategies such as energy efficiency and clean cooking strategies are implemented, then the *Decentralised* scenario has the potential to meet energy demands at lower cost and emissions. Under *Centralised*, the consumption of fossil fuels, such as gas and coal, is expected to accelerate and drive growth in the transport and residential sectors. However, Zambia's potential for green transition will require the use of efficient and innovative technologies to limit resource depletion. Across all scenarios, significant investment is needed to provide access to clean energy and support energy sector development over the coming decades.

To support a green recovery in Zambia, the report makes four recommendations for decision-makers:

It is essential to coordinate across sectors in planning and preparedness to enhance resilience, and to take advantage of emerging opportunities. Climate or pandemic-related disruptions affect multiple economic sectors and social lives in complex and unpredictable ways. There is a need to rethink governance mechanisms to address these interlinked challenges.

There is a need to devolve decision-making and planning as provided for under the Constitution. This will require planning and budgeting approaches that incorporate a greater diversity of stakeholders at multiple levels of governance. There is a need for capacity building of local authorities, investment in R&D to support local economic activities, promotion of decentralised energy systems, and mechanisms to facilitate dialogue across different levels of government.

Attract green finance for making investments that will contribute to transitioning Zambia into a climate-resilient and inclusive green economy. To achieve this, state and non-state must work together, as required by the policy framework on green financing for Zambia. In addition, an enabling environment is key to promote green investment in climate-sensitive sectors, such as energy and agriculture. Capital needs to be channelled towards climate adaptation and mitigation for Zambia to aim for ambitious climate goals that can bear fruit. Green finance is therefore essential to scale-up the deployment of renewable technologies in a way that will meaningfully diversify energy supply and reduce climate-related risks.

There is a need to build human capacity, invest in skills, and support innovation in the green economy. A green recovery represents an opportunity to generate the skills and capacity needed to support, amongst other things, innovation in renewable energy technologies that will contribute to green growth and job creation. In turn, this will contribute to critical development goals, including quality of life and wellbeing.

1. Introduction

The COVID-19 pandemic has affected most sectors of the economies worldwide arising largely from the disruption of the global supply chain. Countries the world over, including Zambia, are still grappling with how best they can recover with many taking an inward-looking approach with respect to economic recovery. At the same time, the concept of a green recovery has emerged with a view of ensuring that countries take into consideration concerns about the environment and climate change whilst fighting the effects of the pandemic. This type of recovery will not take a one-size-fits-all approach as each country has unique challenges and circumstances. However, it is important for a country to ensure that as the recovery from the pandemic takes effect, the socio-economic aspirations are carried out in an environmentally friendly and sustainable manner.

The COVID-19 pandemic triggered disruptions in supply chains, increases in food insecurity, closure of businesses, and loss of livelihoods (Tembo et al., 2021). For instance, in May 2020, the Nakonde-Tunduma Border (bordering Zambia and Tanzania) was closed after Nakonde District in Zambia recorded 76 new cases of COVID-19. This action resulted in over 1,500 trucks getting stranded at the border due to inactivity that lasted for over five days (Kamazima et al., 2020). Furthermore, other productive sectors like tourism, education, manufacturing, construction, and wholesale and retail trade suffered severe losses. Many of these sectors were also affected by disruptions in supply chains. Particularly for the tourism sector, the closure of borders and travel restrictions led to massive losses of foreign exchange earnings for both the government and business entities (Tembo et al., 2021). Not only that, many people, mainly women and youths, were either permanently or temporarily laid off.

In addition, Zambia had been experiencing effects of climate change before the COVID-19 outbreak. The Zambia National Adaptation Programme of Action (NAPA) 2007 highlights that some districts in Southern Province, such as Gwembe, experienced devastating floods in 2003 whilst Mazabuka District was faced with drought during the 2004/2005 farming season. In 2014, the Disaster Management and Mitigation Unit (DMMU) reported that heavy rains "wreaked havoc" in Kitwe and other districts on the Copperbelt. Extreme weather events such as floods and droughts are negatively affecting the economy and livelihoods (GRZ, 2020). Increased temperature and fluctuations in rainfall are impacting several sectors such as agriculture (crop failure and increase in animal disease outbreaks due to floods and droughts), transport (non-climate resilient roads and bridges are washed away or damaged during floods) and health (outbreaks of diseases such as cholera). For instance, crop failures in the western and southern regions of the country, high volatility in maize production, electricity rationing, and load shedding have all been attributed to rainfall variability (Ngoma et al., 2020). Tembo et al. (2020) found that the impact of climate change on the roads network could also ultimately affect the overall growth of the economy due to a reduction in value-added activities in sectors such as agriculture, mining, processed foods and manufacturing sectors. The poor performance of the electricity sector has also been attributed to climate change among other factors. This is because Zambia's electricity output continues to be heavily reliant on hydropower.

The COVID-19 pandemic triggered disruptions in supply chains, increases in food insecurity, closure of businesses, and loss of livelihoods

As a State party to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Accord, Zambia submitted an updated Nationally Determined Contribution (NDC) in July 2021. In this reaffirmation, the country developed indicators on adaptation actions that will allow tracking its progress with respect to resilience in both the human and physical systems. The updated NDC outlines a broadened approach to mitigation in sustainable agriculture, renewable energy, transport, liquid waste and coal (production, transportation and consumption).
The policy and legislative framework governing climate change-related aspects witnessed the development of the National Policy on Climate Change (NPCC) 2016. The NPCC provides the framework for coordinating climate change programmes to ensure climate resilient and low carbon economic pathways for sustainable development towards the attainment of Zambia's Vision 2030. The NPCC also promotes mainstreaming of climate change into policies, plans and strategies at all levels in order to account for climate change risks and opportunities in decision making and implementation (GRZ, 2016).

The Government of the Republic of Zambia (GRZ) has recognised climate change as a development challenge. In this regard, in 2021 the GRZ created the Ministry of Green Economy and Environment, which is fundamental to setting policy guidance with respect to climate change. This ministry is expected to facilitate climate actions not only at national level, but also sub-national levels (provincial, district and sub-district). It is also responsible for integration of climate change in policies, plans and strategies at all levels, including resource mobilisation for climate action, and monitoring and evaluation at a strategic level of climate change interventions that are implemented at the national level. Stakeholders engaged stated the need for communities in Zambia to be integrated in the execution of climate action. This would, in the medium to long term, foster community driven climate actions.

Despite the considerable effort by the government to respond to the COVID-19 pandemic, the project noted that the identified priority areas have limited integration to the broader sustainable development and climate action agenda. It was observed that climate change has thus far been recognized as a development challenge, whose discourse should occupy a greater public attention. However, a more sustainable approach in the mainstreaming of climate change at all levels of the development planning process is required. This is critical to facilitate climate actions not only at national level, but also sub-national levels (i.e., provincial, district and sub-district) in line with the decentralisation trajectory Zambia is presently pursuing. While the country recognises the adverse effects of climate change on Zambia's key economic sectors (agriculture, energy, tourism and transport), it is important to have a consistent and coherent policy and legislative framework with respect to climate change. The framework should be multi-sectoral and inclusive to incorporate gender considerations, youth participation and green investments.

Research Objectives

The *Greening the Recovery* project was carried out by research teams in Ghana, Zambia and the UK. The interdisciplinary team included researchers with backgrounds in policy and governance analysis, energy system modellers and futures analysis. The project had four overarching objectives:

- To understand the drivers, challenges, and opportunities for a clean and resilient recovery from COVID-19 in Ghana and Zambia
- To use participatory scenarios development methodology to investigate options for a clean and resilient recovery through the co-creation of participatory scenarios for future development
- To use quantitative energy systems modelling methods to quantify the socioeconomic, climate and energy related implications of green recovery (strategies and policies) and,
- To develop policy priorities and recommendations to support decision makers and decision making on recovery from the economic impacts of COVID-19, and towards an economic development plan that considers climate action.

Research approaches and methodologies

The *Greening the Recovery* project involved multiple research methods and tools, including policy reviews, participatory scenario building, key informant interviews and systems modelling.

For policy reviews and context analysis, the team interviewed experts from different government agencies, such as agriculture and energy, academics, and international development cooperating partners. Some of the policy documents reviewed included the National Adaptation Programme of Action (NAPA), the NPCC, as well as sector specific policy documents and national development plans. The policy review focused on socio-economic sectors that have been identified by government as priority for climate action under Zambia's NDC.

The scenarios work adopted a participatory approach involving a workshop with stakeholders drawn from different sectors. The project team then undertook a mixed-method participatory scenarios process built around the question: How can long-term social and economic development priorities, and near-term recovery from COVID-19, be integrated with climate change policies in Zambia? The scenarios process built on the policy and context analysis to identify key challenges as well as aspirations for its future development pathway. The scenarios had a decadal timeframe, looking out to the year 2063, to coincide with the target year of the African Union's Agenda 2063.

Finally, to quantify the implications of the scenarios on the energy system, the systems modelling team developed the Zambia Open Source Energy Modelling System (OSeMOSYS) model. OSeMOSYS is a modelling platform which is used to explore the evolution of different energy system futures to meet specified energy service demands (Howells et al., 2011). Modelling was used to quantify key elements of the participatory scenarios related to energy, such as the level of energy supply, the types of technologies needed, investment requirements of those future systems, and the emissions associated with the different pathways.

The rest of the report is structured as follows: section two discusses how COVID-19 impacted social and economic life in Zambia and the government response; section three gives an overview of the mixed-method participatory scenarios work and outcomes; section four discusses the findings and analysis the modelling results; and finally, under sections five and six, the report provides a synthesis of key messages and sets out our policy recommendations.

How can long-term social and economic development priorities, and near-term recovery from COVID-19, be integrated with climate change policies in Zambia?

2. Impacts of and responses to COVID-19 in Zambia

Zambia is a landlocked country and experienced COVID-19-induced lockdowns which affected several social and economic sectors. The country is import dependent and when countries like South Africa, Zimbabwe and Tanzania enforced lockdown measures, this affected the normal flow of goods and services in various trading routes. This severely affected sectors such as agriculture, mining, manufacturing, wholesale and retail. For example, the delay in procurement of farmer inputs under the Farmer Input Supply Program (FISP) adversely affected input distribution to smallholder farmers. Consumable products such as fresh vegetables and fruits from South Africa were also in short supply (Nalwimba, 2021).

In the health sector, the pandemic brought about both direct and indirect effects. The direct effects include increased morbidity and mortality burdens on the already constrained healthcare system (Cheelo and Mungomba, 2020), as well as the associated monetary and socio-economic costs. Saasa and James (2020) reported that most Zambian families lost income (via a reduction in the size of both the formal and particularly the informal sectors. Many businesses struggled with increased costs and reduced revenues. The healthcare system, particularly in rural areas, was placed under considerable strain. Indirect effects included the spillover consequences or side effects of the policy, regulatory and programmatic response measures to prevent, detect, and diagnose, treat and care, and mitigate the COVID-19 pandemic.

Another social sector that was affected by the pandemic was education. Due to the COVID-19 pandemic, centers of learning witnessed episodes of school closures, resulting in unprecedented disruption to education for most of the student population. Although an Education Contingency Plan for the Novel Coronavirus (COVID-19) was launched in the weeks that followed to provide for a response and eventual reopening of schools, the schools remained closed for most part as the virus surged. As such, the government encouraged e-learning platforms as alternative modes of learning via television, radio, and the internet. However, these forms of learning seemed inadequate owing to various reasons such as lack of electricity, internet accessibility, and lack of knowledge by parents and guardians on how to assist learners to access the e-learning materials, teaching aids, and non-engagement by learners themselves.

The social protection system in Zambia plays an important role in terms of safeguarding livelihoods, particularly for vulnerable citizens. However, even prior to the pandemic, the social protection budget as a share of the total budget had been in decline due to an economic slowdown that had reduced funds available to the social sector (ZIPAR, 2020). The onset of the COVID-19 pandemic meant that social protection measures had to take a backseat as the GRZ grappled with meeting immediate needs across various sectors. The socio-economic impacts of the pandemic will undoubtedly have placed increased pressure on social protection programmes, as many more households will be worse off as a result of income shortages and insufficient nutrition (ZIPAR, 2020).

In March 2020, when the first case of the COVID-19 pandemic was reported in Zambia, the government instituted various public health safety and economic measures to help ameliorate the situation leading to the eventual partial shutdown of the country. On the public health front, the government, through the Ministry of Health issued two Statutory Instruments (SI) to enforce provisions of the Public Health Act. These were:

- SI 21 of 2020 to designate COVID-19 as a notifiable disease; and
- SI 22 of 2020 to provide additional regulations to facilitate the management and control of COVID-19.

Notably, the public was encouraged to self-isolate, wear masks always when in public, wash hands/ sanitise regularly, and maintain social distance. The GRZ also directed water utilities to suspended disconnections to provide relief to households, as well as for hygiene requirements. As the pandemic surged, most government institutions such as public schools and markets were placed on partial shutdown. This was intended to limit and contain the contagion of the coronavirus.

Economic measures were also instituted aimed at giving relief to the most impacted segments of the economy, such as small and medium-sized enterprises (SMEs). In this regard, the government released K2.5 billion (US$137.2 million) with the view of reducing arrears owed to various suppliers of goods and services in response to the immediate shocks of the pandemic. Further, the government, through the Cabinet Office, approved a COVID-19 Contingency and Response Plan with a budget of K659 million (US$36.2 million) under the Disaster Management and Mitigation Unit (DMMU) and went on to mobilize more resources from various local and international stakeholders. Additionally, the government offered some tax measures – direct and indirect – including payment deferrals and rate reductions across sectors.

Similarly, the Bank of Zambia instituted several measures by cutting lending rates to access credit from the central bank. In addition, the government through the Central Bank announced a number of measures to encourage the use of digital financial services. For example, these measures include, among others:

1. Waived charges for person-to-person electronic money transfers of up to K150 (US$8.23). These transactions are now free of charge; and,
2. Revised upwards transactions and balance limits for individuals, small-scale farmers and enterprises. The limits by agents have since been revised upwards to give agents more float to deal with transactions. This is made to decongest banks.

Furthermore, the government through the central bank established an economic stimulus package that was financed through the issuance of a COVID-19 bond. This was in addition to other economic measures instituted by the Government such as the availing of K2.5 billion (US$137.2 million) in financial relief for businesses, and the Bank of Zambia's K10 Billion (US$548.8 million) Medium-Term Refinancing Facility made available to eligible commercial banks and non-bank financial institutions to access in order to restructure, refinance or extend credit to businesses and households impacted by COVID-19 on more favourable terms while ensuring that financial institutions adhere to set objectives.

Overall, there are two observations to be made about the effect of the pandemic in Zambia as well as the government response that is relevant to this research project. First, the pandemic and its impact on livelihoods, health systems and infrastructure demonstrate the need to invest and build social and economic resilience. This means better short and long-term planning and preparedness to shocks and uncertainties. Furthermore, efforts must be made to ensure that during times of crisis, other long standing socioeconomic issues do not get overlooked. For instance, HIV/AIDS, Tuberculosis, and Malaria programmes were negatively impacted as resources had to be channelled towards the fight against COVID-19.

Second, despite the considerable effort by the government to respond to the advent of the COVID-19 pandemic, the project noted that the identified priority areas have limited integration to the broader sustainable development and climate action agenda. Thus, a more sustainable approach in the mainstreaming of climate change at all levels of the development planning and budgeting process is required. This is critical to facilitate climate actions not only at national level, but also sub-national levels in line with the decentralization trajectory Zambia is pursuing. It is also important to consider and ensure the resilience of different sectors through multisectoral coordination. For instance, if we take the case of the energy and agricultural sectors, both are essential to the Zambian economy. The agricultural sector is a source of livelihoods, whereas energy is a development enabler. However, both sectors are vulnerable to the adverse effects of climate change. It is therefore important to make both sectors resilient to climate and economic shocks; for example, making energy efficient technologies affordable and accessible to the agriculture sector could contribute towards making the sector more resilient.

3. Scenarios for a greener recovery

Scenarios are tools which can help to improve decision making in respect of an uncertain future. Scenarios can also help inform strategic decisions, improve resilience to uncertain external risks, and contribute to building consensus amongst diverse social actors.

In addition, analysis of ongoing political developments identified the issue of decentralisation as being one of considerable political salience within the country. This led the project team to propose "*Centralised*" and "*Decentralised*" as scenario themes through which to explore routes towards the aspirations highlighted by stakeholders. This structure was proposed at the start of a three-day multi-stakeholder scenario development workshop held in Chilanga, Zambia. Stakeholders approved the basic approach, but also suggested to name a third "Hybrid" scenario, to reflect the possibility of pursuing both centralised and decentralised strategies in tandem. At this workshop, the stakeholders were asked to identify strategies that would be conducive to addressing current challenges and achieving future aspirations, and to cluster these according to their suitability for a *Centralised*, *Decentralised*, or *Hybrid* approach. These clustered strategies formed the building blocks of the scenarios that are now described below.

Centralised

The *Centralised* scenario gravitates towards policy approaches that reflect the government's stated interest in "an export-led trade strategy", and for investment in large-scale infrastructure, leveraging 'public-private partnership investment'. Accordingly, in this scenario, the government makes strong efforts to create an enabling environment for foreign private investment in mining, using fiscal revenue for investments in social services. Investments focus on urban areas, in anticipation of growing urbanisation trends. The key elements of the *Centralised* scenario are captured in Table 1.

Table 1. Snapshot of Centralised scenario in 2063

Diverse, resilient and inclusive economy	Substantial inward investment in mining activities, and in flex-fuel vehicle manufacturing. Highly urbanised population, increased services activities in cities and tourism at major sites.
Universal and equitable access to social services	Mineral rents are used for investments in health, water and sanitation, education services, with a particular focus on urban areas.
Universal access to sustainable energy	Large scale electricity system meets domestic demand (including cooking), and exports via high voltage cross border transmission.
Sustainable and integrated transport	Public-private funded road and rail infrastructure investments, focussed on the central transport corridor, to facilitate export of minerals and agricultural products. Biofuel supplies a high proportion of transport fuel.
Sustainable agriculture, land use and forestry	Large scale, high-input, export-oriented agriculture, supported by large scale public-private funded irrigation projects coordinated with hydro reservoirs. Large scale land transfer into private leasehold. Foreign investments in biofuels.
Climate resilient infrastructure	All infrastructure investment plans to pass climate resilience test. Invest in early warning systems.

Contracts for electricity grid expansion and large-scale electricity generation are offered on a competitive auction basis, and a road building and rail investment plan, funded through public-private partnerships, aims to ensure that minerals and agricultural products have easy access to export corridors. Promotion of access to clean cooking fuels and technologies focuses on gas and electricity, initially in urban areas.

Climate resilience in agriculture focuses on ensuring access to irrigation, through large-scale projects integrated with hydro power, and on domestic fertiliser production. Measures to enhance land security focus on expediting the processes of transferring customary land into private leasehold tenure. Foreign investment in large-scale sugarcane production, biofuel refineries, and flex-fuel vehicle manufacturing, helps to promote biofuels in the transport sector.

By the end of the scenario period Zambia's GDP is driven by high value exports, and its highly urbanised population contributes to a strong services sector. Its electricity system is almost entirely based on large-scale generation and has achieved universal coverage. Zambia is an electricity hub, exporting to neighbouring countries in the region, and a significant proportion of its transport fuel demand is supplied by biofuels.

Climate resilience in agriculture focuses on ensuring access to irrigation, through large-scale projects integrated with hydro power, and on domestic fertiliser production

Decentralised

The *Decentralised* scenario gravitates towards policy approaches that reflect the President's stated interest in "decentralisation and devolution of various central government functions… that will be better managed at the local level with appreciation for local challenges" (Presidential speech to National Assembly, 10th September 2021, p.44). The key elements of the *Decentralised* scenario are captured in Table 2.

Private mining companies make a greater social contribution through resource taxes, greater workers' rights, and direct investments in domestic value-addition supply chains. The fiscal income from mineral extraction is largely directed to local authorities via the Constituency Development Committee (CDC), who are empowered to make decisions about local investment needs. Democratic accountability is increased at the local level, and local authorities pursue a multi-stakeholder approach that includes traditional authorities. Commodity development associations are set up to bring together related resources and businesses for small-scale manufacturing at local levels, including for agricultural products.

In order to support the development of domestic value-addition activities for minerals, a National Research Institute (NRI) is established to support knowledge and skills in batteries, electromobility and climate smart agriculture (CSA). CSA focuses on small scale, agroecological approaches that use a combination of innovative techniques and traditional knowledge, to deliver productive agriculture with minimal input.

Local authorities coordinate with local businesses and energy providers to create small scale renewable energy hubs based on "anchor-business-community" models. These off-grid hubs create niche demands for the growing domestic battery production industry. Supported by the NRI, this innovation system further expands into electric mobility manufacturing. Promotion of clean cooking takes a region-specific approach, and involves a range of technologies and fuels, in accordance with local authorities' development plans.

By the end of the scenario period Zambia has developed low-carbon manufacturing capability connected to its mineral resources, as well as small and medium scale agricultural value-added activities through commodity associations. Economic activity is diverse and includes strong contributions from tourism and services. Mineral revenues remain a significant contributor to government revenues, but as the economy grows and diversifies, there are growing receipts from general taxation. The electricity system has a significant contribution from decentralised energy.

Table 2. Snapshot of Decentralised scenario in 2063

Diverse, resilient and inclusive economy	Zambia's extractive sector spans a range of minerals and value-added manufacturing including batteries and electromobility manufacturing, supported by a National Research Institute.
Universal and equitable access to social services	Fiscal income from mineral extraction is directed to local authorities, via the Constituency Development Committee, supporting full coverage of health, water and sanitation, education services. Rural livelihoods are increasingly viable.
Universal access to sustainable energy	Proliferation of small-scale renewable energy hubs based on "anchor-business-community" models. Local energy hubs have spun out into electromobility. Clean cooking is achieved through a mix of technologies, including locally produced sustainable biomass and biogas.
Sustainable and integrated transport	Local authorities are empowered to plan regional transport infrastructure development. Electric mobility of various kinds is displacing fossil fuels, and infrastructure to support active travel modes has been developed in cities and towns.
Sustainable agriculture, land use and forestry	A climate smart-agriculture approach focussed on small scale, agroecological approaches combining innovative techniques with traditional knowledge. Commodity associations add value to local agricultural production.
Climate resilient infrastructure	All infrastructure investment plans to pass climate resilience test. Invest in early warning systems.

Hybrid scenario

The *Hybrid* Scenario explores the potential for Centralised and Decentralised approaches to operate in tandem.

In a *Hybrid* scenario, the development of small-scale decentralised energy occurs in tandem with the continued development of large generation and bulk electricity transmission infrastructure, enabling bulk export of electricity to neighbouring countries. Such a dual approach would require careful regulatory and institutional design, that is able to give due reward to the positive characteristics of both small and large-scale infrastructure.

A *Hybrid* scenario sees investments in road infrastructure in regions occurring in tandem with investments in the bulk central transportation corridor. Transparency would be important to make clear a fair allocation between national and regional budgets, and between allocations to different regions.

A *Hybrid* scenario could also see a mixed approach on land use and agriculture. Some areas of land could be transferred to private ownership, including via farm blocks, to enable and incentivise high-input large-scale agriculture, while in other areas small-scale, low input agriculture could be supported through agro-ecological extension services. Particular attention may be needed to ensure that the scale and high-input advantages of large-scale agriculture do not make small-scale livelihoods unable to compete. There may also be complex land use governance arrangements to engage with, in order to resolve claims to land of both large scale and small-scale customary users.

The ability in a *Hybrid* scenario to invest at multiple scales may also require leveraging various kinds of international partnerships. A *Hybrid* scenario may in part be dependent on continued international investment in mining and value-added activities, whilst still gaining sufficient fiscal revenue to invest in broader social services. This depends on the ability to persuade international companies to continue to invest within a "recalibrated" fiscal system. The ability to operate at multiple levels could also be enhanced by leveraging climate finance and international donors.

Comparison of scenarios

The scenarios show alternative routes by which the fundamental priorities identified by stakeholders can be addressed. Neither a *Centralised* nor a *Decentralised* paradigm is inherently antithetical to decarbonisation. However, other risks and opportunities may apply to both approaches. A comparison of the scenarios helps to highlight some important areas for reflection, in relation to Zambia's way forward.

Risks and resilience are important to consider. In *Centralised*, risks may occur from dependence on large-scale, water-intensive power sources, such as hydro and coal, from a power system requiring more large-scale transmission, which could be subject to heat stress, and from an agriculture sector highly dependent on irrigation. The export-led economic strategy of *Centralised* entails greater exposure to the risks of future downturns in global export markets, both for minerals and agricultural products.

Each scenario is dependent on sustainable financing. Whereas *Centralised* seeks to attract foreign capital by creating a low tax business environment, *Decentralised* seeks greater supply chain investment and tax contribution from investors. Either scenario may also seek to leverage donor funding and climate finance for activities consistent with a long-term green transition; however, a challenge in *Decentralised* may be in securing finance for a heterogeneous landscape of projects, many of which will be small scale. A *Hybrid* scenario requires investment at several levels, and hence may be dependent on leveraging all the above funding sources. In any case, finance and funding partnerships should not simply replicate debt traps and donor dependence but should lead towards self-reliance in the long term.

Long-term scenarios can help to **emphasise actions with long-term outcomes.** In *Decentralised*, investments in R&D through a National Research Institute seek to maximise the value of domestic resources in the long-term by developing capacities in low carbon innovation including batteries and micro-mobility.

Broad based economic growth is essential to achieving equitable development. *Centralised* risks a more uneven and less equitable development path, with rural communities left behind, and the low tax regime may result in insufficient revenue collection from minerals to adequately fund social development. Broadening development geographically might be supported through developing commodity development associations across the country, to support local economies in developing commercial networks that help to add value to local resources.

The governance implications are important to consider. *Centralised* requires a stable investment environment for large-scale international investors. But *Decentralised* does not mean lack of control or coordination from central Government – the devolution of power in a transparent and effective way requires active planning, new institutional arrangements, and the provision of appropriate capacity and skills at the local level. A *Hybrid* scenario would require many of the same institutional innovations as *Decentralised*, but its particular challenge would be one of multi-scale governance, and in ensuring that there are transparent and clear processes for governing the co-existence of large scale centralised, and small scale decentralised, systems.

The success of any future development scenario is dependent on **good governance, and trust in political institutions.** This includes financial transparency, clear conflict of interest rules and independent monitoring of public interest investments. Democratic participation within local decision making is also crucial to improving accountability, particularly in scenarios where greater spending power and responsibility is devolved to local levels. Coordination between local and customary authorities may require innovative approaches to governance, such as forms of deliberative and participatory democracy.

For some stakeholders a key recommendation was to increase consistency in policy delivery, in order to clarify the direction of travel for public bodies, private investors as well as wider society. Scenarios can play a useful role in this regard, by telling a long-term story that has a consistent ethos and a desirable direction of travel, providing a basis for discussion and helping to enlarge the area of common ground.

A comparison of the scenarios helps to highlight some important areas for reflection, in relation to Zambia's way forward.

4. Modelling the implications for the energy and transport sectors

To complement the participatory, qualitative scenarios detailed above, quantitative energy modelling was undertaken. This involved quantifying key elements of the *Centralised* and *Decentralised* scenarios which focused on the energy system. This included energy demand in industry (i.e. mining), transport and residential sectors, the impacts on overall electricity demand, investment needs, primary energy demand, and emissions.

The *Hybrid* scenario has not been quantified; this is because it was determined that it would fall within the range of metrics provided by *Centralised* and *Decentralised*, from which insights could be inferred. In addition to the two main scenarios, a *Reference* case has also been modelled, which provides a further basis for comparison. It represents a continuation of current trends in respect of underlying drivers of energy demand, such as economic growth and demographics, and the mix of energy used to supply demand. Further information on the key assumptions used in the modelling can be found in Appendix 2.

To analyse the energy implications of the scenarios, the Zambia Open Source Energy Modelling System (OSeMOSYS) model was developed. This is a modelling platform for exploring the evolution of different energy system futures to meet specified energy service demands (Howells et al., 2011). It can provide insights under the different scenarios described above as to the level of energy supply needed, the types of technologies that will be needed, the investment requirements of those future systems, and how this impacts the environment, for example CO_2 emissions. It uses a linear optimisation approach to determine least cost pathways, considering policy objectives and other factors, such as resource and technology availability. This particular version of the model builds on the starter model, referenced in Allington et al. (2022), and has been developed to improve the representation of energy service demands and supply technologies as appropriate for Zambia.

Industrial demand.

Increased focus on capital investments in the mining sector translate to increased demand in all forms of energy (electricity, oil and coal).

In both scenarios (*Centralised* and *Decentralised*), there is a 3-8 fold increase in mining sector electricity demand (Figure 1). The sector (which accounts for the largest share of industrial demand) continues to dominate overall electricity demand. This is in part due to low diffusion of energy efficient technology.

By 2050, *Centralised* sees an 8-fold increase in electricity demand due to substantial inward capital investment in mining activities. However, focusing on the manufacturing (i.e. value addition) sectors and diversification from extractive sector (*Decentralisation*) sees increased diffusion of energy efficient technologies. This results in two-fold less in electricity demand, relative to *Centralised* scenario. The electricity demand pattern for the *Reference* case is similar to the *Centralised* scenario trajectory, projected to be 70% of *Centralised* by 2050.

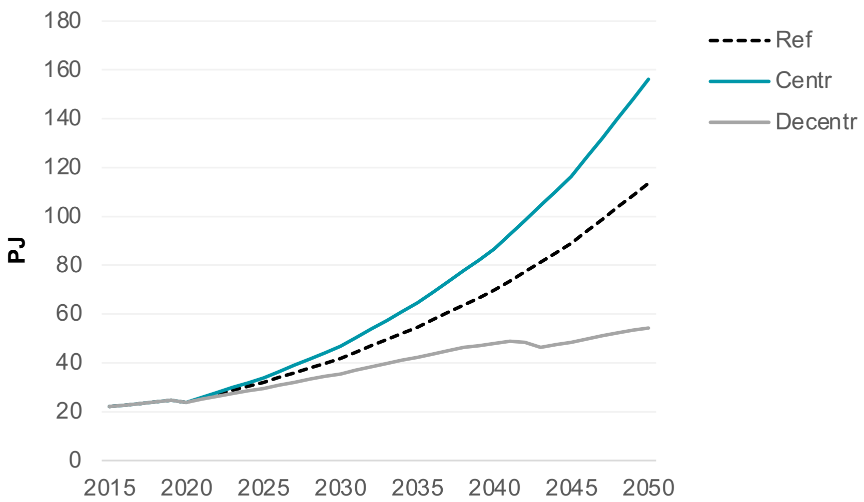


Figure 1. Electricity demand for mining and non-ferrous metals sector, 2015-2050

Transport demand.

Transport growth is rapid. Without intervention, reliance on petroleum products is likely to grow. E-mobility, biofuels and increased active transport provide opportunities for preventing increased reliance on oil.

In all the scenarios, the transport sector experiences strong growth in mobility demand, and energy requirements over the coming decades (Figure 2).

The *Reference* case sees an oil dominated sector, with only small amounts of e-mobility by 2050. In contrast to this, uptake of biofuels alongside e-mobility feature in *Centralised*. Comparable energy levels to *Reference* are observed in 2050, despite *Centralised* having higher GDP growth. This is because *Centralised* uses energy more efficiently, due to the uptake of electric vehicles. *Decentralised* has much lower energy use in 2050, due to the lower GDP growth (which is an important driver for road freight) but also due to assumptions about the uptake of more active travel and a stronger roll out of pooled transport (i.e. a modal shift from cars to buses). In both scenarios, oil use in freight and cars does persist in 2050. As can be seen in Figure 3b and c, most of the growth in car demand is met by alternatives to oil products, biofuels and electricity in *Centralised*, and electricity in *Decentralised*.

Figure 2. Final energy consumption in the transport sector by vehicle type. 'Mcy' is two-wheelers, 'Fre' is road freight, and 'Oth' is non-categorised transport.

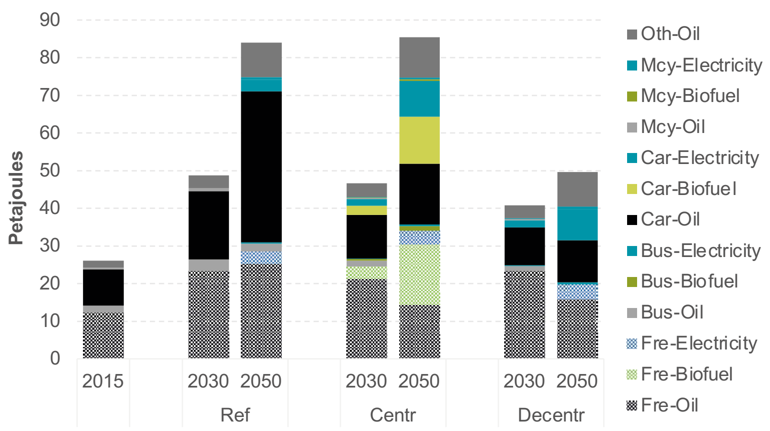
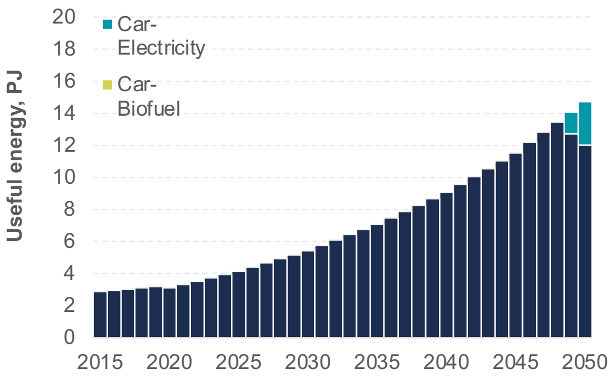
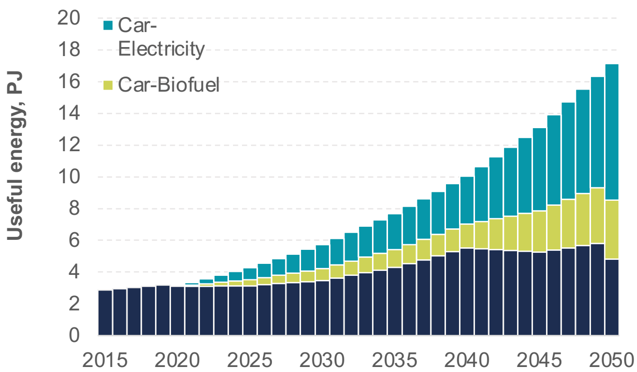


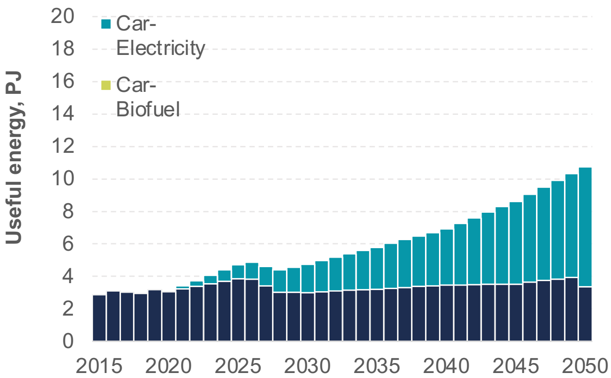
Figure 3. Useful energy demand for passenger cars, 2015-2050. This metric of 'useful energy' is a proxy for energy services needed to meet car demand, and is the energy delivered for mobility after efficiency losses have been accounted for.



a) Reference



b) Centralised



c) Decentralised

Residential demand.

Clean cooking strategies can be rolled out alongside increased electrification and meet growing demand whilst reducing reliance on traditional biomass. This is likely to have large co-benefits for health and environment through, for example, reducing deforestation.

As reflected in the narratives, there is effective action towards clean cooking in both *Centralised* and *Decentralised* scenarios, while *Reference* sees the continued use of traditional biomass (Figure 4). In *Centralised*, there is a stronger focus on the use of LPG, particularly in rural areas, and e-cooking in urban areas. In *Decentralised*, a broader mix of cooking types is deployed, including sustainable biomass and biogas, based on more localised initiatives. For lighting and cooling services, *Decentralised* sees faster and higher levels of electrification but manages to moderate a larger increase in electricity demand through stronger uptake of efficient appliances. The overall energy consumption in 2050 under the two scenarios of focus is much lower than in the *Reference* case due to much more efficient use of energy due to lower levels of traditional biomass use. Overall energy use is higher in *Decentralised* than *Centralised*, mainly due to the higher use of sustainable biomass, as mentioned above.

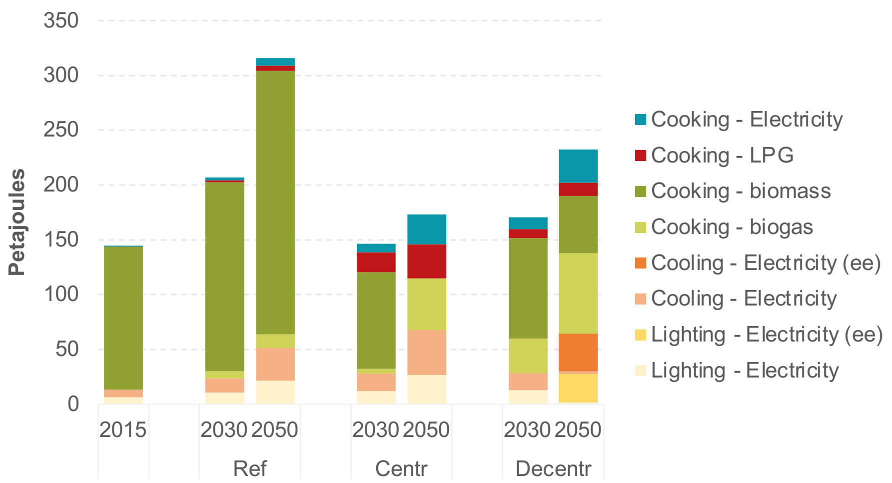


Figure 4. Final energy consumption for the residential sector by energy type. Note that 'Electricity (ee)' refers to more energy efficient appliances.

Overall electricity demand.

If other strategies (such as increased energy efficiency and clean cooking strategies) are successfully implemented, the Decentralised scenario has the potential to meet energy demands at lower cost and emissions.

Due to lower mobility demands, a more diverse mix of cooking fuels, more uptake of efficiency measures, and a smaller mining sector, the overall electricity demand in *Decentralised* is much lower by 2050, compared to *Centralised*. For example, electricity demand for mining is more than double in *Centralised* compared to *Decentralised*, highlighting the stronger role that the mining sector continues to play in driving industrial growth under this scenario (Figure 5).

To meet this growing demand for electricity, high levels of investment are required in the sector (Figure 6), but with the system evolving in different ways under each scenario. The electricity generation sector is dominated by hydro power, and this continues to dominate to 2030 under *Reference* and *Centralised*. Post 2030, expansion of the generation system in *Centralised* is striking, with a five-fold increase in the total electricity production driven by strong demand growth, particularly in mining (Figure 5).

The system mainly grows through the addition of utility-scale solar, wind and gas generation. *Decentralised* sees similar growth to *Reference*, with a focus on solar and wind, including distributed generation. The role of large-scale hydro is constrained, but the system remains very low carbon based on renewable generation, including battery storage to support such technologies to meet demand.

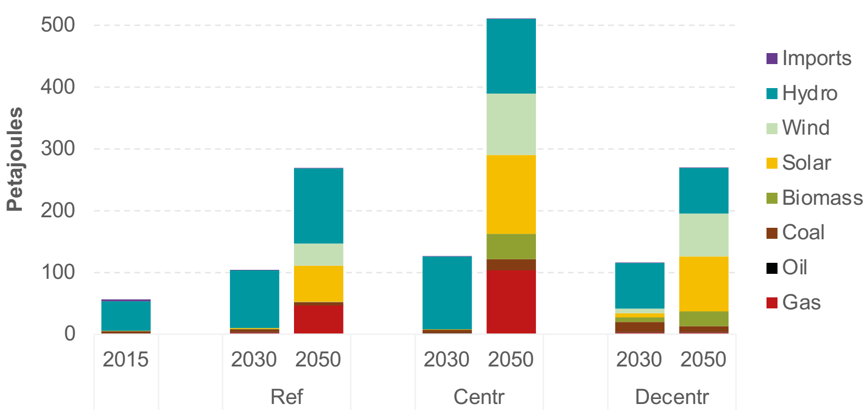


Figure 5. Electricity production by generation type

Investment.

Large investment is needed for providing access to clean energy over the coming decades, particularly in terms of electricity generation. Support for investment in renewable technologies will be important, allowing Zambia to diversify away from reliance on hydro power, and avoid uptake of fossil fuel generation.

The cumulative required investment by 10-year period is shown in Figure 6. It highlights the four-to-six-fold increase by 2050 under *Decentralised* and *Centralised* scenarios, and the importance of investment in the sector over the coming decades to meet Zambia's growing electricity needs. Investment requirements for the power sector are 45% lower in *Decentralised* than *Centralised*.

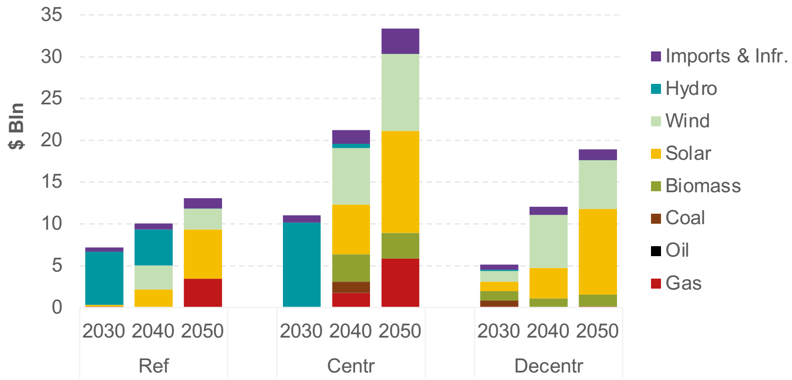


Figure 6. Electricity generation capacity investment (cumulative over 10-yr periods). Each year represents the cumulative investment for the previous 10-year period e.g. 2030 represents 2021-30.

Primary energy.

The consumption of fossil fuels such as gas and coal, under the Centralised scenario, is expected to accelerate and drive growth in the transport and residential sectors. However, Zambia's potential for green transition will require the use of efficient and innovative technologies to limit resource depletion.

As shown in Figure 7, the overall energy system size on a primary energy basis, is smaller in *Decentralised* than *Centralised*, with growth in demand moderated in transport and households by efficiency and other energy reduction measures. This also reflects a slightly lower level of overall economic growth (see Appendix 2). *Centralised* sees a stronger role for fossil fuels, notably gas and to a much smaller extent, coal in generation.

Across all scenarios, biomass levels do not rise substantially above the current levels in any of the scenarios, capped at around 300 PJ/yr for domestic resource.

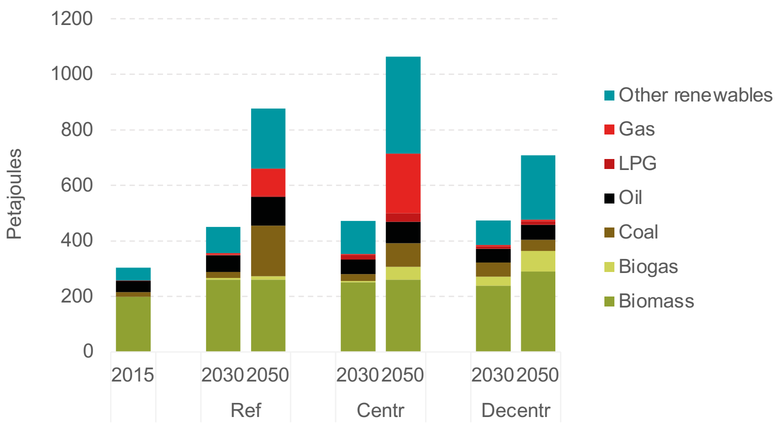


Figure 7. Primary energy consumption. 'Other renewables' includes wind, hydro and solar PV, and is based on the physical energy content method for primary energy accounting.

Emissions.

Zambia can maintain its low carbon energy system whilst growing its economy, but this requires demand side interventions such as energy efficiency measures in addition to investment in clean energy using technology.

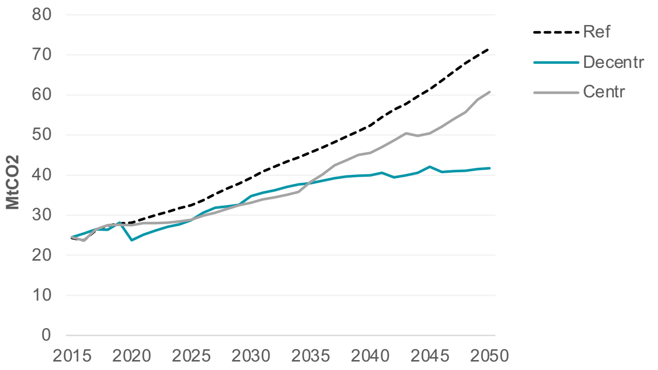
The smaller system size and lower carbon intensity of *Decentralised* results in very low CO_2 emissions from the energy system (10.7 MtCO2 in 2030 and 12.7 MtCO2 in 2050). This compares to 13.3 (2030) and 43.8 MtCO2 (2050) under *Reference* (Figure 8b). While the total emissions do rise slightly in *Decentralised*, this represents a negligible increase in per capita terms, from 0.3 tCO_2/capita in the historical time series to less than 0.4 tCO_2/capita in 2050 (Figure 8d).

This compares to a rise to 0.9 tCO_2 and 1.2 t tCO_2 /capita under *Centralised* and *Reference* respectively, by 2050. Whilst higher than *Decentralised*, this still represents a very low carbon energy system in 2050 compared to most other countries. Figures 8a and 8c show emissions trends including biomass emissions.

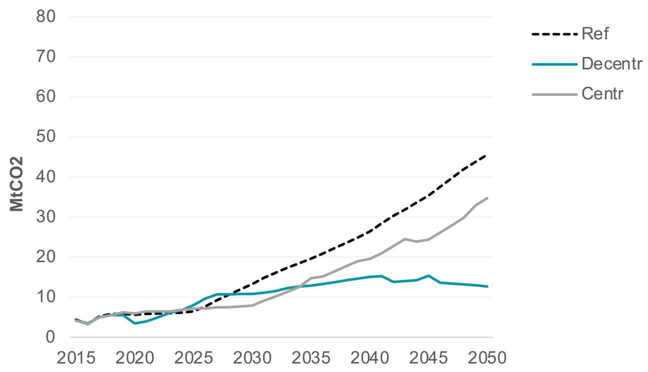
It is challenging to compare Zambia's NDC ambition with the emission estimates in this analysis, mainly because the NDC includes all GHGs across all sectors[1], while this analysis only considers energy sector CO_2 emissions. Energy sector emissions (excluding biomass) are less than 7 MtCO2 so make up a small share of the total inventory. The NDC GHG targets for Zambia are reductions in 2030 relative to a 2010 base year level of 120 MtCO2e (Government of Zambia, 2021). They are a reduction in annual GHG emissions of 25% and 47% for unconditional and conditional targets respectively.

For the energy sector, due to its growth, such reductions are not observed for example relative to the 2015 base year (as shown in Figure 8). What can be seen is that *Decentralised* and *Centralised* do lead to substantial reductions relative to the *Reference* case. In 2030, 18% and 41% reductions are estimated when no biomass emissions are included, for *Decentralised* and *Centralised* respectively. (With biomass emissions included, reductions are 12% and 16% respectively). While *Decentralised* is the more ambitious scenario in terms of emission reductions, these increase relative to *Reference* after 2035.

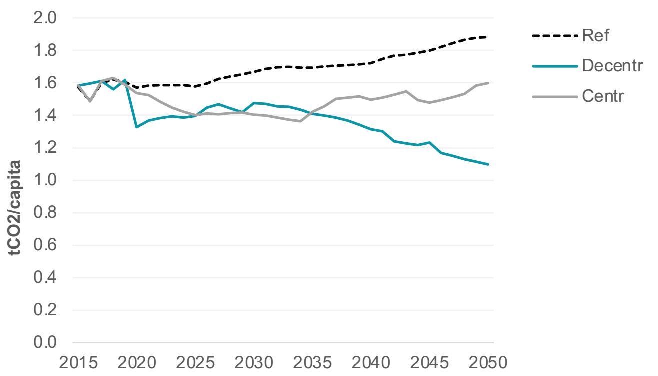
Figure 8. Energy sector CO2 emissions a) including biomass and b) excluding biomass, and per capita emissions c) including biomass and d) excluding biomass, 2015-2050. An assumption is made that the fraction of non-renewable biomass (fNRB) is at 99% based on information from the IPCC's CDM guidance.



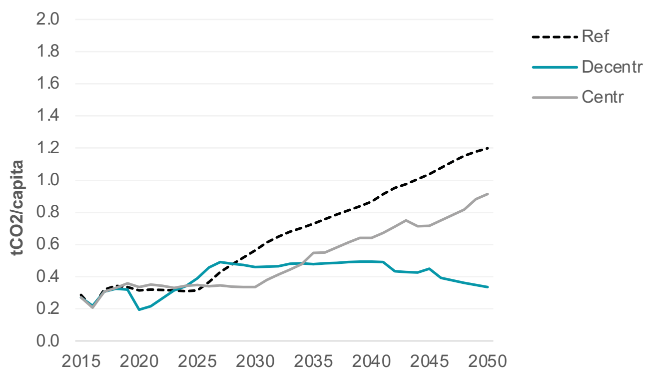
a)



b)



c)



d)

1 The Third National Communication (2020) estimates that in 2010 the energy industries accounted for 0.17% of Zambia's total emissions.

5. Key messages and conclusions

Through an interdisciplinary approach, this research has investigated the opportunities for and barriers to a green recovery from the COVID-19 pandemic in Zambia. It draws the following key messages from the research:

Climate change and policy in Zambia

A well coordinated and consistent policy environment should underpin climate action. Due to Zambia's geographical and economic structure, the country is vulnerable to disruptions in the supply chain for goods and services. Further to this, the advent of COVID-19 pandemic exposed the inadequacies of the social systems (e.g. health, education) and infrastructure. This, therefore, calls for the need to build internal capacity to cushion such effects in a way that is also climate compatible.

Scenarios for a green economy.

The participatory scenario process drew attention to infrastructure, planning and investment issues which require further consideration. This includes the implications for risk and resilience, as well as the need for sustainable financing for low carbon development pathways. The scenarios also demonstrated the need for longer-term planning to support R&D that promotes domestic resources and strengthens capacity. Finally, promoting greater participation in decision-making will be vital to ensure inclusive development.

Insights from energy modelling.

To support sustainable economic growth, substantial investment in energy and transport sectors are key. These investments should focus on promoting access to clean energy, diffusion of energy efficient technologies, and enhancing electricity generation. In particular, investment in renewable technologies will allow diversification of electricity supply thus promoting energy sector resilience.

In conclusion, this research has demonstrated the opportunities for a clean and resilient recovery from COVID-19 pandemic. This will provide ample benefits across multiple sectors and to multiple stakeholder groups whilst supporting the delivery of sustainable, inclusive and resilient development in Zambia.

Policy recommendations

The following key recommendations emerge from the research:

Promote cross-sectoral policy harmonisation and coherence.

It is essential to coordinate across sectors in planning and preparedness to enhance resilience, and to take advantage of emerging opportunities. Climate or pandemic-related disruptions affect multiple economic sectors and social lives in complex and unpredictable ways. There is a need to rethink governance mechanisms to address these interlinked challenges.

Decentralise planning.

There is a need to devolve decision-making and planning as provided for under the Constitution. This will require planning and budgeting approaches that incorporate a greater diversity of stakeholders at multiple levels of governance. The pathways co-developed with stakeholders highlight the need for capacity building of local authorities, investment in R&D to support local economic activities, promotion of decentralised energy systems and mechanisms to facilitate dialogue across different levels of government.

Attract green finance.

Attracting green finance for making investments that will contribute to transitioning Zambia into a climate-resilient and inclusive green economy. To achieve this, state and non-state must work together, as required by the policy framework on green financing for Zambia. In addition, an enabling environment is key to promote green investment in climate-sensitive sectors, such as energy and agriculture. Capital needs to be channelled towards climate adaptation and mitigation for Zambia to aim for ambitious climate goals that can bear fruit. Green finance is therefore essential to scale-up the deployment of renewable technologies in a way that will meaningfully diversify energy supply and reduce climate-related risks.

Invest in capacity, skills and innovation.

There is a need to build human capacity, invest in skills, and support innovation in the green economy. A green recovery represents an opportunity to generate the skills and capacity needed to support, amongst other things, innovation in renewable energy technologies that will contribute to green growth and job creation. In turn, this will contribute to critical development goals, including quality of life and wellbeing.

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Appendix 1. List of interviewees

1. Bank of Zambia (BoZ)
2. BioCarbon Partners (BCP)
3. Council of Churches in Zambia (CCZ)
4. Energy Regulation Board (ERB)
5. European Union Delegation to Zambia and COMESA (EU)
6. Indaba Agricultural Policy Research Institute (IAPRI)
7. Innovations for Poverty Action (IPA)
8. Jesuit Centre for Theological Reflection (JCTR)
9. Ministry of Agriculture (MoA)
10. Ministry of Energy (MoE)
11. Ministry of Finance and National Planning (MoFNP)
12. Ministry of Labour and Social Security (MLSS)
13. National Designated Authority (NDA)
14. National Resource Sensing Centre (NRSC)
15. Pilot Programme for Climate Resilience (PPCR) Zambia and Transforming Landscapes for Resilience and Development (TRALARD)
16. Non-governmental Gender Organisations' Coordinating Committee (NGOCC)
17. Office of the Vice President
18. Policy Monitoring Research Centre (PMRC)
19. Rural Electrification Authority (REA)
20. Swedish Embassy in Zambia
21. Women for Change (WfC)
22. World Bank (WB)
23. Zambia Climate Change Network (ZCCN)
24. Zambia Environmental Management Agency (ZEMA)
25. Zambia Institute for Policy Analysis and Research (ZIPAR)
26. Zambia Statistics Agency (ZamStats)
27. University of Zambia – School of Agriculture

Appendix 2. Modelling assumptions

The process of implementing the narratives in the OSeMOSYS model is shown in Figure A1. The first step was to identify distinctive features of the narratives of relevance to the energy system. These can be split into two different categories of assumption to be parameterised; i) underlying drivers such as GDP or population that will impact on the projections of energy service demands, such as mobility, industrial production etc., and ii) specific assumptions related to technology and fuel assumptions in the model itself.

Once features have been selected and parameterised, these were discussed with the scenario narrative team to ascertain whether the implementation was correct, and whether all necessary features were identified. The scenarios were then run in the model to produce the relevant metrics around technology deployment, investment, fuel use and emissions.

Based on a review of the scenario narratives for Zambia, the key characteristics that impact the energy system were identified and parameterised for implementation in the model. In addition to ***centralised*** and ***decentralised***, a scenario called ***reference*** was also included, which essentially maintains historical / current trends.

Table A1 and Table A2 list the assumptions considered to reflect elements of the narratives. These are split into the two categories – exogenous drivers and model parameters (that determine the role of technologies and fuels in the system). Exogenous drivers (Table A1) refer to those that are used to estimate energy service demand projections. These time series, which are fed into the model, are needed to set the future level of demands which are then met by the system constructed in the OSeMOSYS model. Energy service demands include mobility services, household cooking and appliance use, and industrial processes. Table A3 provides a mapping of what drivers are used to project energy service demands. Model parameters (Table A2), on the other hand, are specific assumptions or constraints that are integrated into the model itself, to determine how the energy system itself configures to meet those energy service demands.

Figure A1. Scenario implementation in OSeMOSYS

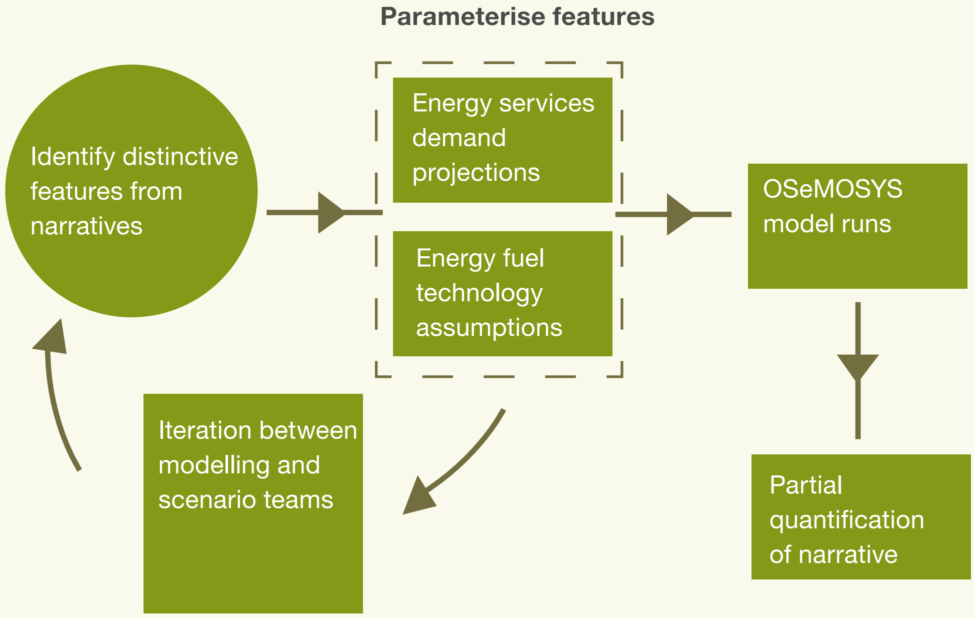


Table A1. Drivers for energy service demand projections. Table A4 provides additional information on the drivers listed below.

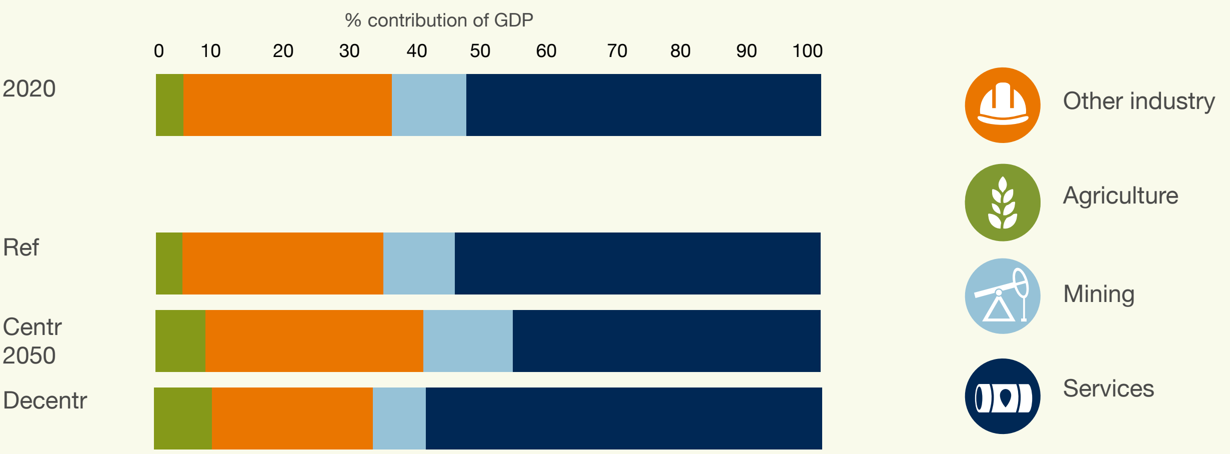
Assumption type	Assumption	Reference	Centralised	Decentralised
Demographics	Population	ZamStat + UN (for post-2035 trend)		
	Urban population	UN	UN (+ high multiplier)	UN (+ low multiplier)
	Household occupancy	Zambia data portal – Living Condition statistics Urban: 5.0 (2015) to 4.5 (2050); Rural: 5.2 (2015) to 4.8 (2050)		
Economy	GDP	Reference	High	Reference
	GDP shares by sector (Figure A2)	Reference	Centralised	Decentralised
Household energy (lighting, appliances)	Electricity access (connectivity and use) (Figure A3)	Low	Mid	High

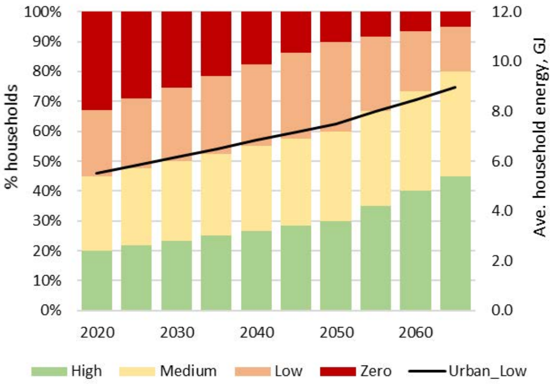
Starting with the exogenous drivers in Table A1, the demographic drivers used only differ across the scenarios in terms of urban population growth, with ***centralised*** assuming a higher share and ***decentralised*** a lower share. These are variants on the ***reference*** urbanisation trajectory, which is sourced from the UN Urbanisation Prospects dataset. For GDP growth, historical estimates are based on World Bank data, with projections taken from (Tembo et al., 2020). The ***centralised*** case has a slightly higher rate of economic growth because of an assumed increase in export orientated industries e.g. copper and agri-business. The structure of the economy differs, in terms of sectoral contribution across all three cases (Figure A2). The ***reference*** case assumes similar shares as seen today while ***centralised*** sees strengthening shares for agriculture, which becomes more industrialised, and for mining and other industry, which increase value added of goods produced. As a result, the services sector share decreases. For ***decentralised***, an even stronger focus on agriculture and tourism (in services) increases the shares of those sectors by 2050, with a relatively smaller other industry sector.

On electricity access for households, the assumption is that ***decentralised*** sees stronger progress on access in rural areas, while this takes longer in ***centralised*** due to the reliance on grid infrastructure role out. Urban areas see similar rates of electricity access and uptake (see Figure A3). The uptake in the ***reference*** case is slower, with still some rural households without access in 2065.

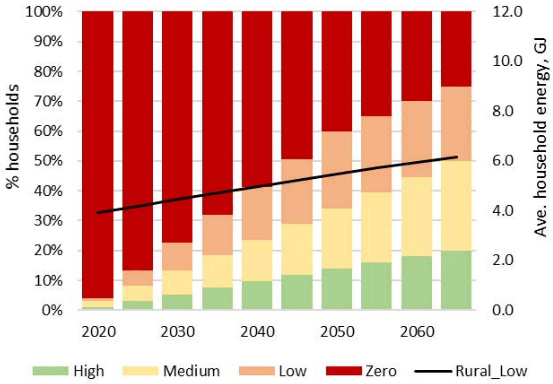
Energy technology-fuel assumptions by sector are listed in Table A2, and provide information on the main sector-based assumptions. Note that for the reference case, the model was allowed to run on a cost-optimal basis, with no additional constraints on technology take-up.

Figure A2. Sectoral contribution to GDP under different scenarios

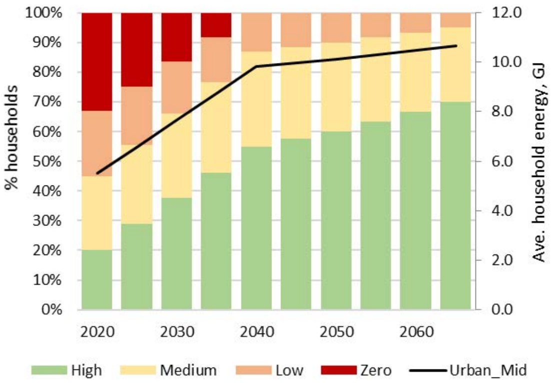




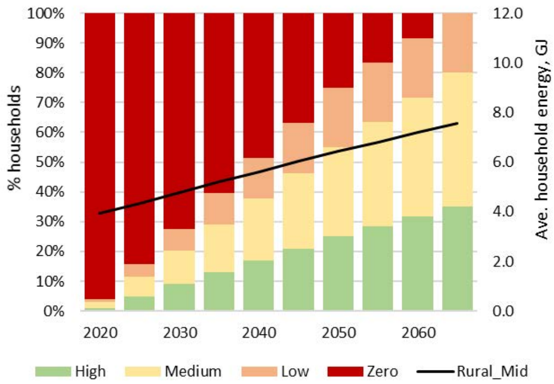
a) Urban – Reference (Low)



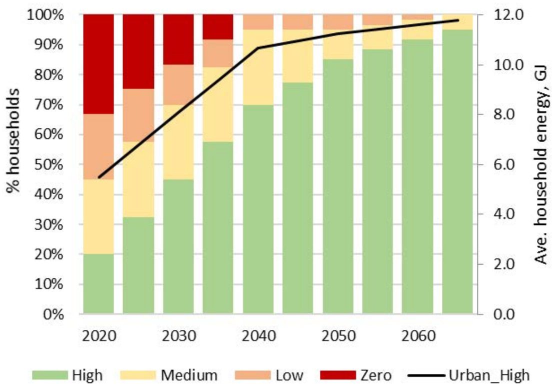
b) Rural – Reference (Low)



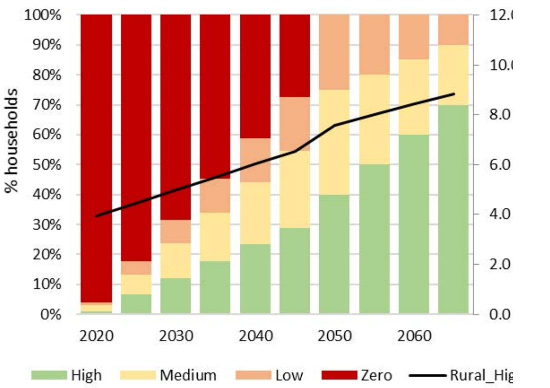
a) Urban – Centralised (Mid)



b) Rural – Centralised (Mid)



a) Urban – Decentralised (High)



b) Rural – Decentralised (High)

Figure A3. Household access to electricity, and level of use. The red bars indicate no access. Orange (low) through green (high) bars indicate increasing levels of consumption. The black trend line shows average household energy use, based on the shares of different household use levels.

Table A2. Energy technology-fuel assumptions by sector. No specific assumptions are introduced into the model for the Reference scenario.

Sector	Assumption	Centralised	Decentralised
Power generation	Technology type	Reliance on hydro and other large thermal plant, some renewables	Focus on the role of renewables, particularly off-grid
Household energy	Clean cooking	LPG as a transition fuel, with strong push to e-cooking in LT	More mix of clean cooking fuels, including e-cooking, biogas and sustainable biomass
Transport	Technology type	Push towards biofuels (15% blend), with push towards e-mobility	Focus on e-mobility
Transport	Active travel / mode shift		10% reduction in car travel, and shift to bus 10% overall reduction due to active travel

Table A3. Mapping of energy service demands to projections drivers

Sector	Energy service demand	Driver
Households (differentiated by rural/urban as needed)	Lighting	Households, household electricity access
	Cooling &Other appliances	Households, household electricity access
	Cooking Heating	Households
Commercial	Electrical appliances	Commercial GDP
	Heating	Commercial GDP
Industry – Mining	Electrical appliances	Industry Mining GDP
	Heat	Industry Mining GDP
	Vehicles	Industry Mining GDP
Industry - Other	Electrical Appliances	Industry Other GDP
	Heat	Industry Other GDP
Agriculture	Electrical Appliances	Agriculture sector GDP
	Machinery/vehicles	Agriculture sector GDP
	Heat	Agriculture sector GDP
Transport	Passenger cars	Population, GDP / cap
	Passenger 2&3 wheelers	Population
	Passenger Bus	Urban population
	Freight	GDP
	Other Transport	GDP

Table A4. Projection driver data

Driver	Units	Scenario	2015	2020	2025	2030	2035	2040	2045	2050
Population	Millions	All	15.5	17.9	20.6	23.6	26.9	30.4	34.1	38.0
Population - Urban	Millions	Reference	6.48	7.98	9.77	11.9	14.4	17.2	20.3	23.71
Population - Urban	Millions	Centralised	6.48	7.98	10.2	13.0	15.8	18.9	22.3	26.08
Population - Urban	Millions	Decentralised	6.48	7.98	9.47	11.0	12.9	15.4	18.2	21.34
Population - Rural	Millions	Reference	8.99	9.91	10.8	11.6	12.5	13.2	13.8	14.30
Population - Rural	Millions	Centralised	8.99	9.91	10.2	10.4	11.0	11.5	11.8	11.93
Population - Rural	Millions	Decentralised	8.99	9.91	11.1	12.5	13.9	14.9	15.8	16.67
Households	Millions	Reference	3.02	3.50	4.09	4.77	5.54	6.37	7.27	8.25
Households	Millions	Centralised	3.02	3.50	4.10	4.78	5.55	6.39	7.30	8.28
Households	Millions	Decentralised	3.02	3.50	4.09	4.76	5.52	6.35	7.25	8.21
Households - Urban	Millions	Reference	1.30	1.60	1.99	2.46	3.03	3.69	4.43	5.27
Households - Urban	Millions	Centralised	1.30	1.60	2.09	2.71	3.34	4.06	4.87	5.80
Households - Urban	Millions	Decentralised	1.30	1.60	1.93	2.29	2.73	3.32	3.99	4.74
Households - Rural	Millions	Reference	1.73	1.90	2.10	2.30	2.50	2.68	2.84	2.98
Households - Rural	Millions	Centralised	1.73	1.90	2.00	2.07	2.22	2.33	2.43	2.48
Households - Rural	Millions	Decentralised	1.73	1.90	2.16	2.47	2.79	3.03	3.26	3.47
GDP	% annual growth	Reference / decentralised	2.9%	-2.8	6.0%	5.5%	5.5%	5.0%	5.0%	5.0%
GDP	% annual growth	Centralised	2.9%	-2.8	6.6%	6.1%	6.1%	5.5%	5.5%	5.5%
GDP	Constant 2015 US$	Reference / decentralised	21.25	23.4	31.3	40.9	53.5	68.3	87.2	111.2
GDP	Constant 2015 US$	Centralised	21.25	23.4	32.2	43.2	58.0	75.8	99.0	129.4

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2021/sep/greening-recovery-ghana-and-zambia