Selected 'Starter Kit' energy system modelling data for Kenya (#CCG)

Authors

Lucy Allington [1], Carla Cannone [2], Ioannis Pappis [3], Karla Cervantes Barron [4], Will Usher [3], Steve Pye [5], Mark Howells [2,6], Constantinos Taliotis [3,7], Caroline Sundin [3], Vignesh Sridharan [3], Eunice Ramos [3], Maarten Brinkerink [8], Paul Deane [8], Andrii Gritsevskyi [9], Gustavo Moura [10], Arnaud Rouget [11], David Wogan [12], Edito Barcelona [12], Holger Rogner [3], Stephanie Hirmer [13]

Affiliations

1. Climate Compatible Growth Programme
2. Loughborough University
3. KTH Royal Institute of Technology
4. University of Cambridge
5. University College London
6. Imperial College London
7. The Cyprus Institute
8. University College Cork
9. International Atomic Energy Agency
10. Federal University of Ouro Preto
11. International Energy Agency
12. Asia Pacific Energy Research Centre
13. University of Oxford

Corresponding author(s)

Lucy Allington (lallington9@gmail.com) and Carla Cannone (c.cannone@lboro.ac.uk)

Abstract

Energy system modelling can be used to assess the implications of different scenarios and support improved policymaking. However, access to data is often a barrier to starting energy system modelling in developing countries, thereby causing delays. This article therefore provides data that can be used to create a simple zero order energy system model for Kenya, which can act as a starting point for further model development and scenario analysis. The data are collected entirely from publicly available and accessible sources, including the websites and databases of international organizations, journal articles, and existing modelling studies. This means that the dataset can be easily updated based on the

latest available information or more detailed and accurate local data. These data were also used to calibrate a simple energy system model using the Open Source Energy Modelling System (OSeMOSYS) and three stylized scenarios (Fossil Future, Least Cost and Net Zero by 2050) for 2020-2050. The assumptions used and results of these scenarios are presented in the appendix as an illustrative example of what can be done with these data. This simple model can be adapted and further developed by in-country analysts and academics, providing a platform for future work.

Keywords

U4RIA, Renewable energy, Cost-optimization, Kenya, Energy policy, CCG, OSeMOSYS

Specifications Table

Subject	Energy
Specific subject area	Energy System Modelling
Type of data	Tables Graphs Charts Description of modelling assumptions
How data were acquired	Literature survey (databases and reports from international organisations; journal articles)
Data format	Raw and Analysed
Parameters for data collection	Data collected based on inputs required to create an energy system model for Kenya
Description of data collection	Data were collected from the websites, annual reports and databases of international organisations, as well as from academic articles and existing modelling databases.
Data source location	Not applicable
Data accessibility	With the article and in a repository. Repository name: Zenodo. Data identification number: v1.0.0. Direct URL to data: https://doi.org/10.5281/zenodo.4650874

Value of the data

- These data can be used to develop national energy system models to inform national energy investment outlooks and policy plans, as well as to provide insights on the evolution of the electricity supply system under different trajectories.
- The data are useful for country analysts, policy makers and the broader scientific community, as a zero-order starting point for model development.

- These data could be used to examine a range of possible energy system pathways, in addition to the examples given in this study, to provide further insights on the evolution of the country's power system.
- The data can be used both for conducting an analysis of the power system but also for capacity building activities. Also, the methodology of translating the input data into modelling assumptions for a cost-optimization tool is presented here which is useful for developing a zero order Tier 2 national energy model [1]. This is consistent with U4RIA energy planning goals [2].

1 Data Description

The data provided in this paper can be used as input data to develop an energy system model for Kenya. As an illustration, these data were used to develop an energy system model using the cost-optimization tool OSeMOSYS for the period 2015-2050. For reference, that model is described in Appendix A and its datafiles are available in the Supplementary Materials. Appendix figure A2 for Kenya is repeated below. This is purely illustrative. It shows a zero-order model of the production of electricity by technology over the period 2020 to 2050 for a least cost energy future. Using the data described in this article, the analyst can reproduce this, as well as many other scenarios, such as net-zero by 2050, in a variety of energy planning toolkits.

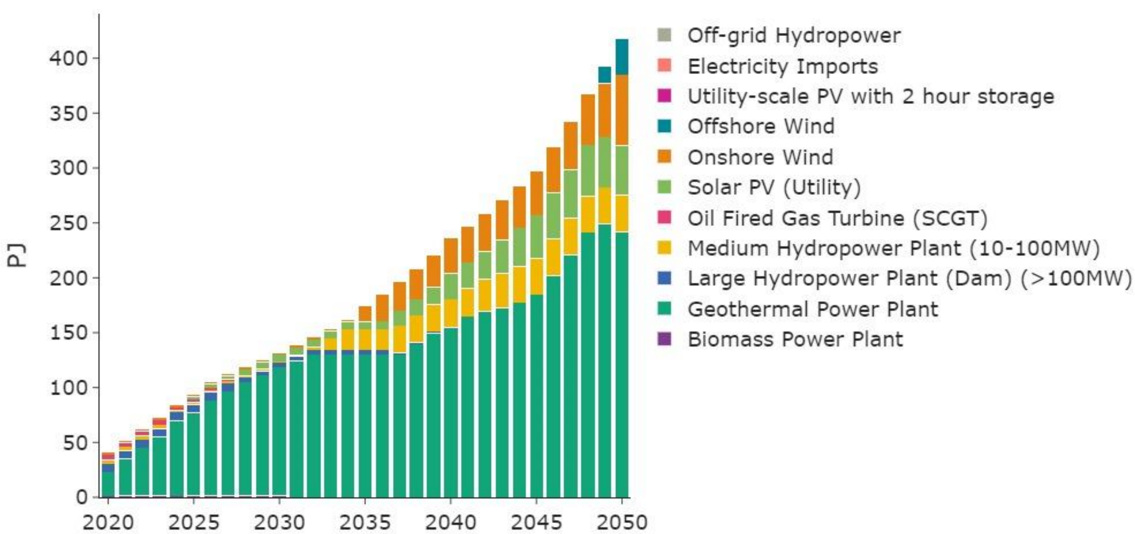

Figure Appendix A2. An illustrative example of a zero-order least-cost energy scenario for Kenya produced using the data presented in this paper.

The data provided were collected from publicly available sources, including the reports of international organizations, journal articles and existing model databases. The dataset includes the techno-economic parameters of supply-side technologies, installed capacities, emissions factors and final electricity demands. Below shows the different items and their description, in order of appearance, presented in this article.

Item	Description of Content
Table 1	A table showing the estimated installed capacity of different power plant types in Kenya for 2015-2018
Table 2	A table showing techno-economic parameters for electricity generation technologies
Table 3	A table showing capital cost projections for renewable energy technologies up to 2050
Figure 1	A graph showing capital cost projections for renewable energy technologies from 2015-2050
Table 4	A table showing cost and performance parameters for power transmission and distribution technologies
Table 5	A table showing cost and performance data for refinery technologies
Table 6	A table showing fuel price projections up to 2050
Figure 2	A graph showing fuel price projections from 2015-2050
Table 7	A table showing carbon dioxide emissions factors by fuel
Table 8	A table showing estimated renewable energy potential in Kenya
Table 9	A table showing estimated fossil fuel reserves in Kenya
Figure 3	A graph showing a final electricity demand projection for Kenya from 2015-2070

1.1 Existing Electricity Supply System

The total power generation capacity in Kenya is estimated at 2369.6 MW in 2018 [3,4,5,6]. The estimated existing power generation capacity is detailed in Table 1 below. The methods used to calculate these estimates are described in more detail in Section 2.1. Data on the installation year of each power plant can be found in the country dataset published on Zenodo.

Table 1: Installed Power Plants Capacity in Kenya [3,4,5,6]

Power Generation Technology	Estimated Installed Capacity (MW)			
	2015	2016	2017	2018
Biomass Power Plant	90.0	90.0	90.0	90.0

Geothermal Power Plant	419.0	419.0	419.0	419.0
Light Fuel Oil Power Plant	287.5	287.5	287.5	287.5
Oil Fired Gas Turbine (SCGT)	447.0	447.0	447.0	447.0
Solar PV (Utility)	24.0	24.0	24.0	24.0
Large Hydropower Plant (Dam) (>100MW)	499.0	499.0	499.0	499.0
Medium Hydropower Plant (10-100MW)	320.8	320.8	320.8	248.8
Onshore Wind	336.0	336.0	336.0	310.0
Off-grid Solar PV	37.84	37.84	37.84	37.84
Off-grid Hydropower	6.44	6.44	6.44	6.44

1.2 Techno-economic Data for Electricity Generation Technologies

The techno-economic parameters of electricity generation technologies are presented in Table 2, including costs, operational lives, efficiencies and average capacity factors. Cost (capital and fixed), operational life and efficiency data were collected from reports by the International Renewable Energy Agency [7,8,9] and are applicable to all of Africa. These cost data include projected cost reductions for renewable energy technologies, which are presented in Table 3. The cost and performance of parameters of fossil electricity generation technologies are assumed constant over the modelling period. In this analysis only fixed power plant costs are considered, which capture variable operation and maintenance costs. Country-specific capacity factors for solar PV, wind and hydropower technologies in Kenya were sourced from Renewables Ninja and the PLEXOS-World 2015 Model Dataset [3,10,11]. Capacity factors for other technologies were sourced from the International Renewable Energy Agency [8,12] and are applicable to all of Africa. Average capacity factors were calculated for each technology and presented in the table below, with daytime (6am - 6pm) averages presented for solar PV technologies. For more information on the capacity factor data, refer to Section 2.1.

Table 2: Techno-economic parameters of electricity generation technologies [3,7,8,9,10,11,12]

Technology	Capital Cost ($/kW in 2020)	Fixed Cost ($/kW/yr in 2020)	Operational Life (years)	Efficiency	Average Capacity Factor
Biomass Power Plant	2500.0	75.0	30	0.35	0.5

Coal Power Plant	2500.0	78.0	35	0.37	0.85
Geothermal Power Plant	4000.0	120.0	25	0.8	0.79
Light Fuel Oil Power Plant	1200.0	35.0	25	0.35	0.8
Oil Fired Gas Turbine (SCGT)	1450.0	45.0	25	0.35	0.8
Gas Power Plant (CCGT)	1200.0	35.0	30	0.48	0.85
Gas Power Plant (SCGT)	700.0	20.0	25	0.3	0.85
Solar PV (Utility)	1378.0	17.91	24	1.0	0.32
CSP without Storage	4058.0	40.58	30	1.0	0.45
CSP with Storage	5797.0	57.97	30	1.0	0.45
Large Hydropower Plant (Dam) (>100MW)	3000.0	90.0	50	1.0	0.48
Medium Hydropower Plant (10-100MW)	2500.0	75.0	50	1.0	0.48
Small Hydropower Plant (<10MW)	3000.0	90.0	50	1.0	0.48
Onshore Wind	1489.0	59.56	25	1.0	0.21
Offshore Wind	3972.4	158.9	25	1.0	0.45
Nuclear Power Plant	6137.0	184.11	50	0.33	0.85
Light Fuel Oil Standalone Generator (1kW)	750.0	23.0	10	0.16	0.3
Solar PV (Distributed with Storage)	4320.0	86.4	24	1.0	0.32

Table 3: Projected costs of renewable energy technologies for selected years to 2050 [7,9]

Power Generation Technology	Capital Cost ($/kW)					
	2015	2020	2025	2030	2040	2050
Biomass Power Plant	2500.0	2500.0	2500.0	2500.0	2500.0	2500.0
Solar PV (Utility)	2165.0	1378.0	984.0	886.0	723.0	723.0
CSP without Storage	6051.0	4058.0	3269.0	2634.0	2562.0	2562.0

CSP with Storage	8645.0	5797.0	4670.0	3763.0	3660.0	3660.0
Large Hydropower Plant (Dam) (>100MW)	3000.0	3000.0	3000.0	3000.0	3000.0	3000.0
Medium Hydropower Plant (10-100MW)	2500.0	2500.0	2500.0	2500.0	2500.0	2500.0
Small Hydropower Plant (<10MW)	3000.0	3000.0	3000.0	3000.0	3000.0	3000.0
Onshore Wind	1985.0	1489.0	1191.0	1087.0	933.0	933.0
Offshore Wind	5000.0	3972.4	3020.9	2450.0	2275.0	2100.0
Solar PV (Distributed with Storage)	6840.0	4320.0	3415.0	2700.0	2091.0	2091.0

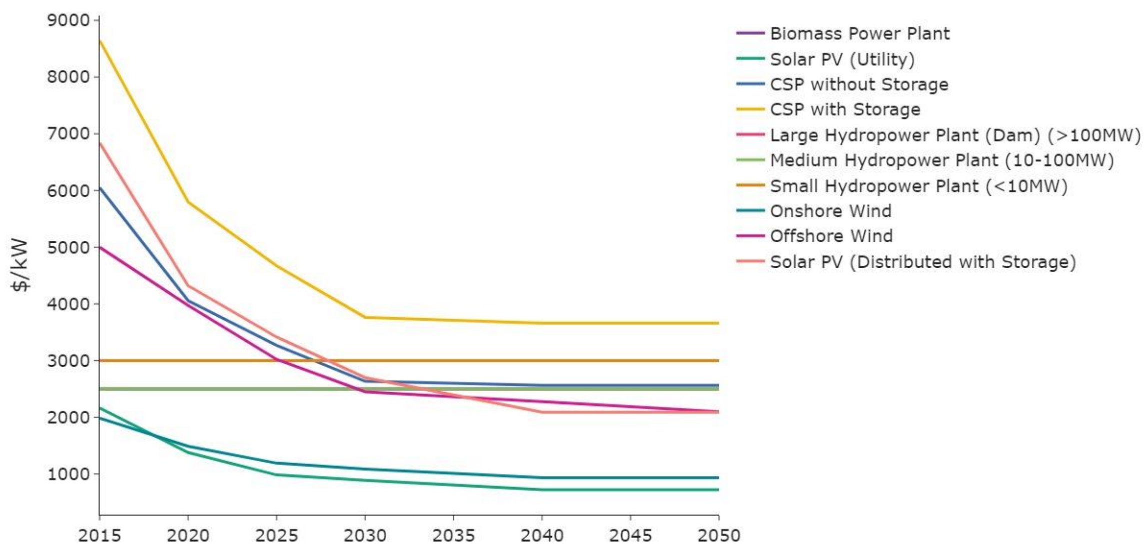

Figure 1: Projected costs of renewable energy technologies for selected years to 2050 [7,9]

1.3 Techno-economic Data for Power Transmission and Distribution

Combined transmission and distribution losses in Kenya are relatively high, with distribution losses currently estimated at 14%, and there is scope for improvement [13]. The techno-economic parameters of transmission and distribution technologies were taken from the Reference Case scenario of The Electricity Model Base for Africa (TEMBA) [13]. According to these data, the efficiencies of power transmission and distribution in Kenya are assumed to reach 95.0% and 88.0% respectively in 2030. In the following table, the techno-economic parameters associated with the transmission and distribution network are presented.

Table 4: Techno-economic parameters for transmission and distribution technologies in Kenya [13]

Technology	Capital Cost ($/kW in 2020)	Operational Life (years)	Efficiency (2020)	Efficiency (2030)	Efficiency (2050)
Electricity Transmission	365	50	0.95	0.95	0.95
Electricity Distribution	2502	70	0.86	0.88	0.93

1.4 Techno-economic Data for Refineries

Kenya has currently no domestic refinery in operation [14] The only crude oil refinery that existed was operated by the Kenya Petroleum Refinery Limited and stopped in 2013 [15]. In the OSeMOSYS model, two oil refinery technologies were made available for investment in the future, each with different output activity ratios for Heavy Fuel Oil (HFO) and Light Fuel Oil (LFO). The technoeconomic data for these technologies are shown in Table 5.

Table 5: Techno-economic parameters for refinery technologies [14,16]

Technology	Capital Cost ($/kW in 2020)	Variable Cost ($/GJ in 2020)	Operational Life (years)	Output Ratio
Crude Oil Refinery Option 1	24.1	0.71775	35	0.9 LFO : 0.1 HFO
Crude Oil Refinery Option 2	24.1	0.71775	35	0.8 LFO : 0.2 HFO

1.5 Fuel Prices

Assumed costs are provided for both imported and domestically-extracted fuels. The fuel price projections until 2050 are presented below. These are generic estimates based on an international oil price forecast [17] and cost estimates for Africa [8]. A detailed explanation of how these estimates were calculated is provided in section 2.2.

Table 6: Fuel price projections to 2050 [17,8]

Commodity	Fuel Price ($/GJ)					
	2015	2020	2025	2030	2040	2050
Crude Oil Imports	13.14	12.2	12.76	14.27	16.9	19.53
Crude Oil Extraction	11.95	11.09	11.6	12.97	15.36	17.75
Biomass Imports	1.76	1.76	1.76	1.76	1.76	1.76
Biomass	1.6	1.6	1.6	1.6	1.6	1.6

Extraction						
Coal Imports	4.9	5.1	5.3	5.5	5.9	5.9
Coal Extraction	3.3	3.4	3.5	3.6	3.8	3.8
Light Fuel Oil Imports	15.89	14.75	15.43	17.25	20.43	23.61
Heavy Fuel Oil Imports	9.56	8.87	9.28	10.38	12.29	14.2
Natural Gas Imports	8.6	8.6	9.45	10.3	11.0	11.0
Natural Gas Extraction	7.1	7.1	7.8	8.5	9.9	9.9

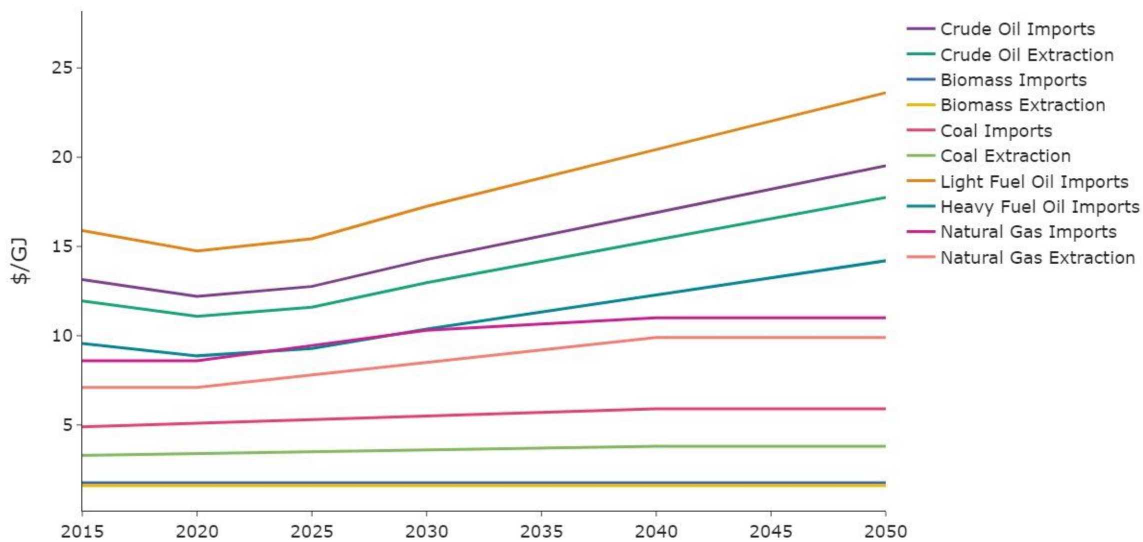

Figure 2: Fuel price projections to 2050 [17,8]

1.6 Emission Factors

Fossil fuel technologies emit several greenhouse gases, including carbon dioxide, methane and nitrous oxides throughout their operational lifetime. In this analysis, only carbon dioxide emissions are considered. These are accounted for using carbon dioxide emission factors assigned to each fuel, rather than each power generation technology. The assumed emission factors are presented in Table 7.

Table 7: Fuel-specific CO2 Emission Factors [18]

Fuel	CO2 Emission Factor (kg CO2/GJ)
Crude oil	73.3

Biomass	100
Coal	94.6
Light Fuel Oil	69.3
Heavy Fuel Oil	77.4
Natural Gas	56.1

1.7 Renewable and Fossil Fuel Reserves

Tables 8 and 9 show Kenya's estimated domestic renewable energy potentials and fossil fuel reserves respectively.

Table 8: Estimated Renewable Energy Potentials in Kenya [19,20,21]

	Unit	Estimated Renewable Energy Potential
Solar PV	TWh/yr	23046
CSP	TWh/yr	15399
Wind (CF 20%)	TWh/yr	22746
Wind (CF 30%)	TWh/yr	4446.4
Wind (CF 40%)	TWh/yr	1749.6
Hydropower	MW	6000
Small Hydropower (<10MW)	MW	3000
Geothermal	MW	10000

Table 9: Estimated Fossil Fuel Reserves in Kenya [22,23]

	Estimated Reserves
Total Recoverable Coal (mil. short tons, 2017)	0
Crude Oil Proven Reserves (billion barrels, 2019)	0
Natural Gas Proven Reserves (trillion cubic feet, 2019)	0

1.8 Electricity Demand Projection

Final electricity demand in Kenya was estimated at 34.54 PJ in 2018 and is forecasted to reach 72.09 PJ by 2030 and 269.14 PJ by 2050 [24] in a reference scenario. Figure 3 below shows the electricity demand projection.

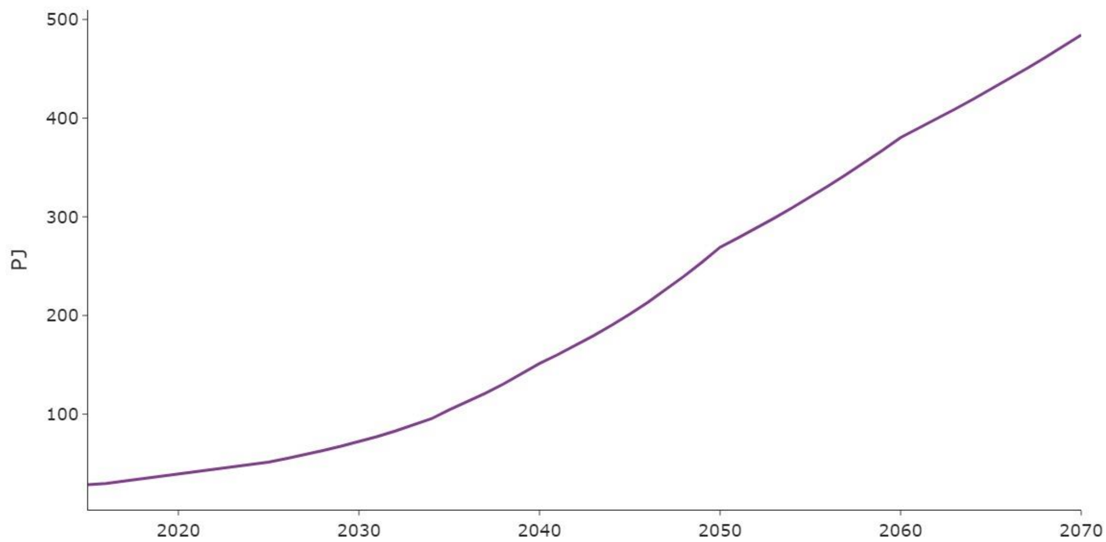

Figure 3: Final Electricity Demand Projection (PJ) for Kenya [24]

2 Experimental Design, Materials, and Methods

Data were primarily collected from the reports and websites of international organizations, including the International Renewable Energy Agency (IRENA), the International Energy Agency (IEA), and the Intergovernmental Panel on Climate Change (IPCC). Additionally, data were sourced from The Electricity Model Base for Africa (TEMBA), an existing OSeMOSYS model of African electricity supply [13].

2.1 Electricity Supply System Data

Data on Kenya's existing on-grid power generation capacity, presented in Table 1, were extracted from the PLEXOS World dataset [3,4,5] using scripts from OSeMOSYS global model generator [25]. PLEXOS World provides data for 2015, including the capacity and commissioning date of each power plant. These data were used to estimate installed capacity in future years based on the operational life data in Table 2. Data on Kenya's off-grid renewable energy capacity were sourced from yearly capacity statistics produced by IRENA [7]. Cost, efficiency and operational life data in Table 2 were collected from reports by IRENA [7,8,9], which provide generic estimates for these parameters by technology. These reports also provide projections of future costs for renewable energy technologies. These data are presented in Table 3 and Figure 1, where it was assumed that costs fall linearly between the data points provided by IRENA and that costs remain constant beyond 2040 when the IRENA forecasts end (except for offshore wind, where the IRENA forecast continues to 2050).

Country-specific capacity factors for solar PV, wind and hydropower were sourced from Renewables Ninja and the PLEXOS-World 2015 Model Dataset [3,10,11]. These sources provide hourly capacity factors for 2015 for solar PV and wind, and 15-year averages monthly capacity factors for hydropower, the average values of which are presented in Table 2. These data were also used to estimate capacity factors for 8 time slices used in the OSeMOSYS model (see detail in Annex 1). Capacity factors for other technologies were sourced from reports by IRENA [8,12], which provide generic estimates for each technology. The costs and efficiencies of power transmission and distribution were sourced from TEMBA reference case [24], which provides generic cost estimates and country-specific efficiencies which consider expected efficiency improvements in the future. Techno-economic data for refineries were sourced from the IEA Energy Technology Systems Analysis Programme (ETSAP) [16], which provides generic estimates of costs and performance parameters, while the refinery options modelled are based on the methods used in TEMBA [13].

2.2 Fuel Data

The crude oil price is based on an international price forecast produced by the US Energy Information Administration (EIA), which runs to 2050 [17]. The price was increased by 10% for imported oil to reflect the cost of importation. The price of imported HFO and LFO were calculated by multiplying the oil price by 0.8 and 1.33 respectively, based on the methods used in TEMBA [13]. The prices of coal, natural gas and biomass were sourced from an IRENA report [8], which provides generic estimates for costs to 2030. Again, a linear rate of change was assumed between data points from IRENA, and the forecast was extended to 2040 using the rate of change between 2020 and 2030. Prices were then assumed constant after 2040. The cost of domestically-produced biomass was increased by 10% to estimate a cost of imported biomass.

2.3 Emissions Factors and Domestic Reserves

Emissions factors were collected from the IPCC Emission Factor Database [18], which provides carbon emissions factors by fuel. Domestic renewable energy potentials for solar PV, CSP and wind were collected from an IRENA-KTH working paper [19], which provides estimates of potential yearly generation by country in Africa. Other renewable energy potentials were sourced from a regional report by IRENA [20] and the World Small Hydropower Development Report [21], which provide estimated potentials in MW by country. Estimated domestic fossil fuel reserves are from the websites of The World Bank and US EIA [22,23], which provide estimates of reserves by country.

2.4 Electricity Demand Data

The final electricity demand projection is based on data from the TEMBA Reference Scenario dataset [24], which provides yearly total demand estimates from 2015-2070 under a reference case scenario.

3 Ethics Statement

Not applicable.

4 CRediT Author Statement

Lucy Allington: Data curation; Investigation; Methodology; Writing – original draft; Visualisation. Carla Cannone: Data curation; Investigation; Software; Formal analysis; Visualisation. Ioannis Pappis: Data Curation; Investigation; Validation; Writing - Review & Editing. Karla Cervantes Barron: Data Curation; Software; Visualisation. William Usher: Software; Supervision. Steve Pye: Supervision; Project Administration. Mark Howells: Conceptualisation; Methodology; Writing – Review & Editing; Supervision. Constantinos Taliotis: Conceptualisation. Caroline Sundin: Conceptualisation. Vignesh Sridharan: Conceptualisation. Eunice Ramos: Conceptualisation. Maarten Brinkerink: Data curation. Paul Deane: Data Curation. Gustavo Moura: Data Curation. Arnaud Rouget: Conceptualisation. Andrii Gritsevskyi: Conceptualisation. David Wogan: Conceptualisation. Edito Barcelona: Conceptualisation. Holger Rogner: Conceptualisation. Stephanie Hirmer: Writing – Review & Editing.

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Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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Appendix A – Zero-Order Tier 2 OSeMOSYS Model

The data described above were used to create a simple zero-order Tier 2 energy systems model. As it is open source and free an OSeMOSYS model is calibrated and run with three example scenarios. Note that these scenarios in no way represent development trajectories of the country. This model and its results are intended to act as an example of what can be produced using the data in this article and a starting point for further model development.

U4RIA are goals to improve energy modelling [2]. They are short for Ubuntu (meaning community focused), retrievability, reusability, repeatability, interoperability and auditability. The model moves to partially meet U4RIA goals in that:

- We develop examples of results that can be used by other research communities, including energy and transport, and to aid mitigation strategies.
- The illustrative analyses are retrievable, reusable, repeatable.
- As data are defined, elements of interoperability are feasible.
- And by virtue of the above the analysis could be audited or verified (that is not to say that it is 'accurate' but simply reproducible).

In the OSeMOSYS model, the electricity supply system is represented by importing and extraction technologies, conversion technologies, power plants, transmission and distribution network systems and final energy demands for the different available fuels considered. The Reference Energy System is shown below. The main modelling assumptions consist of power generation capacity per type of technology (centralized, decentralized), fuel prices, emissions, transmission and distribution network capacity and losses, and refineries, which are exogenous parameters into the model. Furthermore, the final energy demands which are exogenously entered into the model are disaggregated by fuel and sector. The data described in this article were used as input data to define these assumptions in the model.

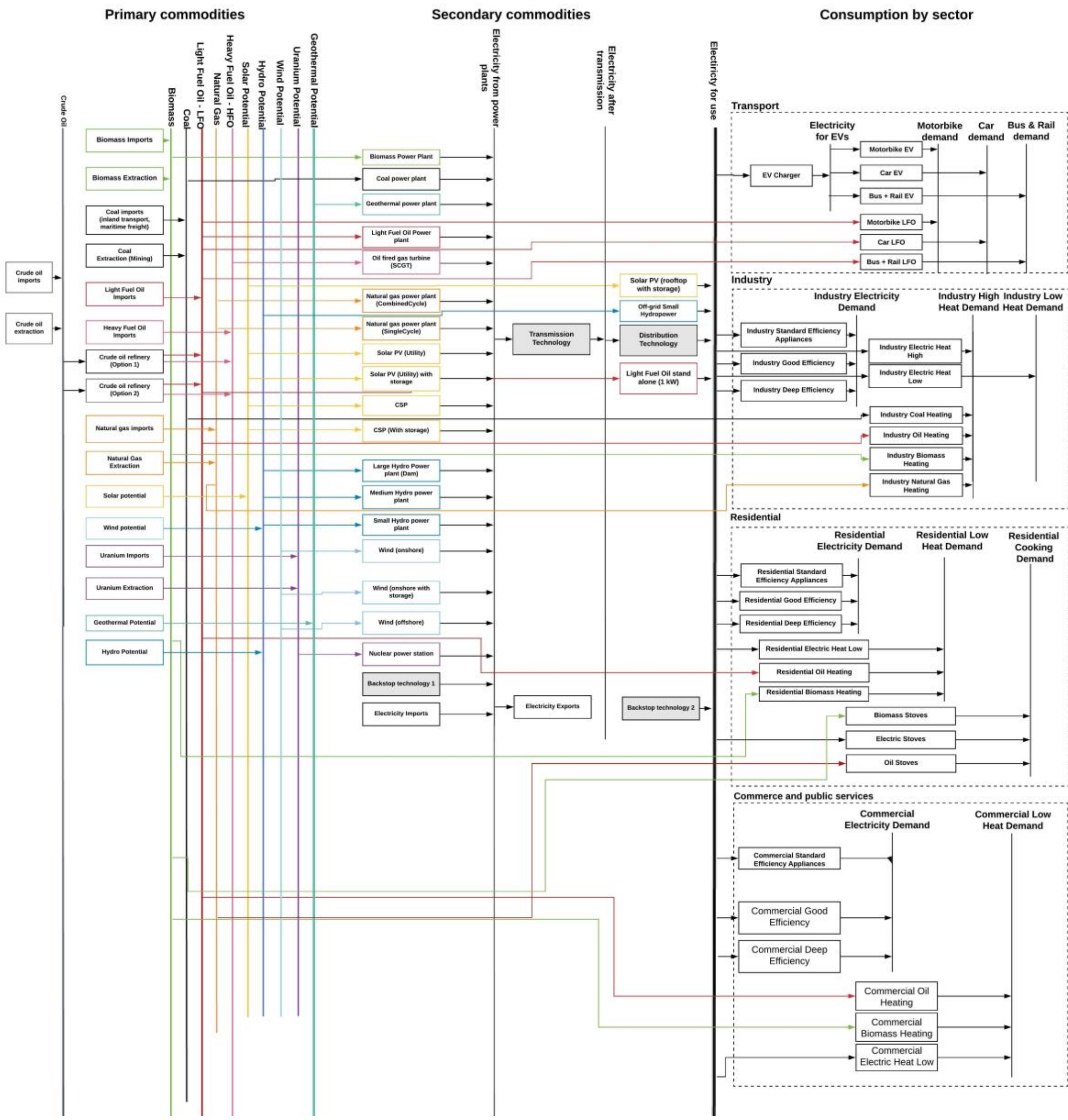

Figure 1: Reference Energy System

A1 Model Assumptions

Key assumptions used in model development are outlined below.

Supply-Side Assumptions

The share of total demand that can be met by off-grid solar PV is constrained based on the optimal balance of on- and off-grid provision in a least cost scenario for 100% electricity access by 2030 from the Global Electrification Platform [26]. Additional technologies were modelled to represent utility-scale solar PV and onshore wind with storage capacity. Utility-scale PV with two-hour storage and onshore wind with half-hour storage were modelled, with the additional costs of storage estimated based on data from the NREL ATB 2020 Database, which provides cost projections for different durations of storage up to 2050 [27].

The maximum share of total demand that can be met by variable renewables is constrained as follows: utility-scale PV, onshore wind and utility-scale PV with storage are each permitted to meet up to 15% of demand; offshore wind can meet up to 10% of demand and onshore wind with storage can meet up to 25% of demand. This analysis is not intended to offer a detailed study of system flexibility; however these constraints are included to ensure the system is operational under high renewable shares. Biomass is permitted to meet up to 30% of electricity demand. Electricity imports and exports were modelled in a simplified manner whereby single import and exports technologies are constrained to import and export electricity in line with energy balance data [28].

Demand-Side Assumptions

Generic techno-economic data for demand-side technologies (cooking, heating and transport) were used [29,30]. The total electricity demand shown in Figure 3 was split by sector based on the proportions of demand in historical energy balance data [28]. In each sector, moderate and high energy efficiency technologies were modelled, with input activity ratios of 1 and output activity ratios of 1.15 and 1.3 respectively. This is a simplified way of allowing the model to invest in energy efficiency in each sector, with costs estimated based on the costs of electricity generation by a coal power plant in the model. In the Least Cost and Net Zero scenario (detailed in Section A2), there is a constraint on the speed at which fuel switching and energy efficiency investments can occur to better align results to reality. This is done by limiting the annual investment in electric vehicles, stoves, heating technologies and energy efficiency to 5% of the 2050 capacity.

Time Representation and Discount Rate

Within each model year, four seasons, each with two 12-hour dayparts, are defined. Daypart 1 starts at 06:00 and finishes at 18:00, while daypart 2 starts at 18:00 and finishes at 06:00. The seasons are defined so that season 1 runs from December to February, season 2 runs from March to May, season 3 from June to August and season 4 from September to November. A discount rate of 10% is used.

A2 Scenario Definitions

Three stylized scenarios are modelled: Fossil Future, Least Cost and Net Zero by 2050. These scenarios are defined in the table below. Nuclear power is not considered in any of these scenarios; however it can be added using the techno-economic data provided in the main article.

Table A1: Definitions of the three model scenarios.

Scenario	Definition
Fossil Future	No new investments in renewable or nuclear power generation, electric stoves and heating, electric transport or energy efficiency are permitted.
Least Cost	No new investment in nuclear power is permitted. Gradual investment constraints

	are applied to demand-side fuel-switching and energy efficiency, whereby only up to 5% of each technology's 2050 capacity in a run without demand-side investment constraints can be invested in annually. No additional constraints are applied to find the cost-optimal solution.
Net Zero by 2050	Domestic production and imports of fossil fuels and biomass gradually decline to 0 in 2050, beginning in 2021. No new investment in nuclear power is permitted. Gradual investment constraints are applied to demand-side fuel-switching and energy efficiency, whereby only up to 5% of each technology's 2050 capacity in a run without demand-side investment constraints can be invested in annually from 2021-2039, rising to 10% from 2040-2050 to reflect greater ambition.

A3 Kenya Scenario Results

The graphs below show selected results for the three modelled scenarios, including yearly electricity generation and supply capacity, fuel use in the transport sector and total annual carbon dioxide emissions for 2020-2050.

A3.1 Electricity Generation Results

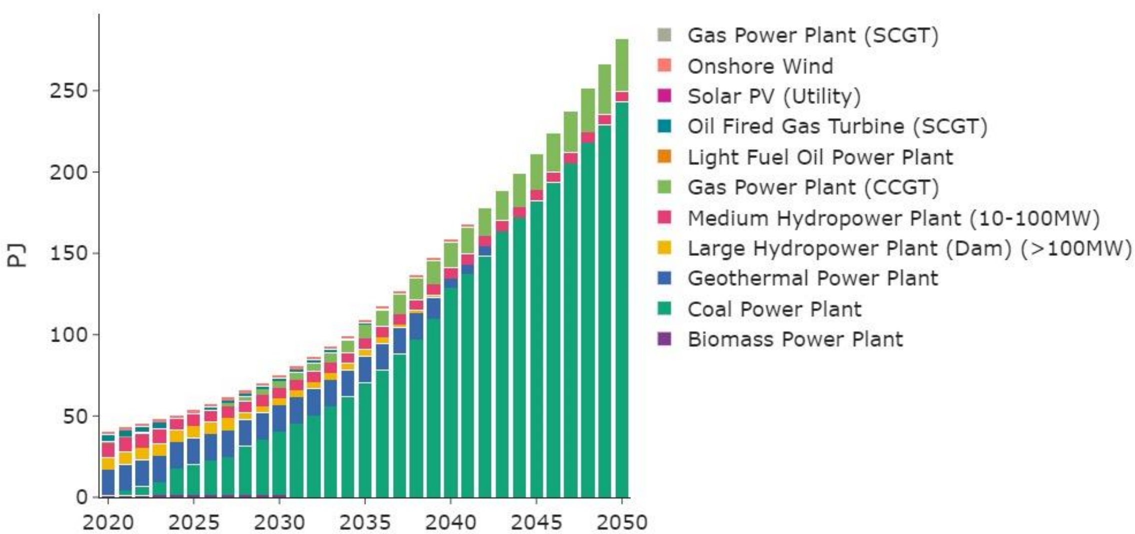

Figure A1: Electricity Generation in the Fossil Future scenario for Kenya

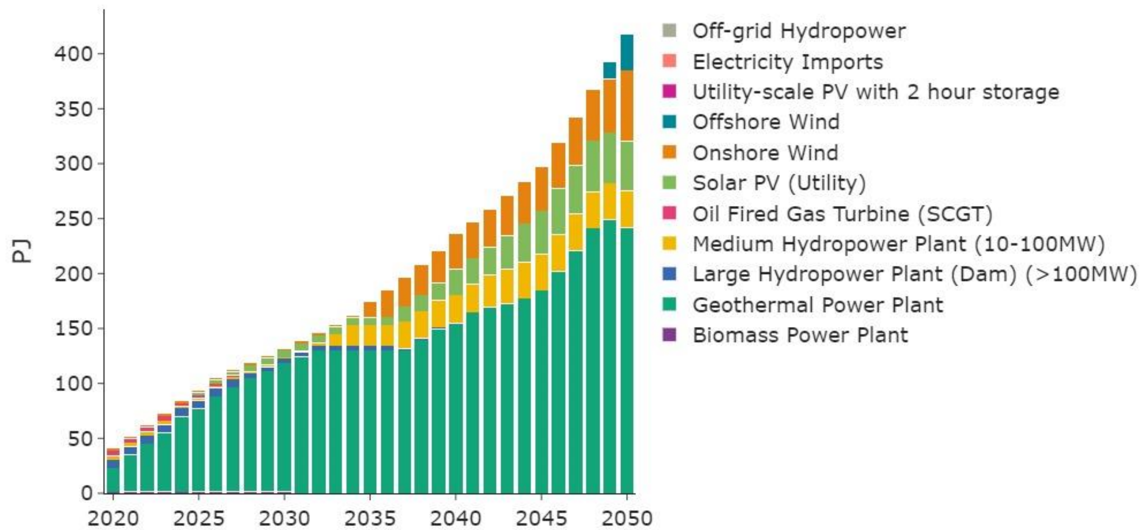

Figure A2: Electricity Generation in the Least Cost scenario for Kenya

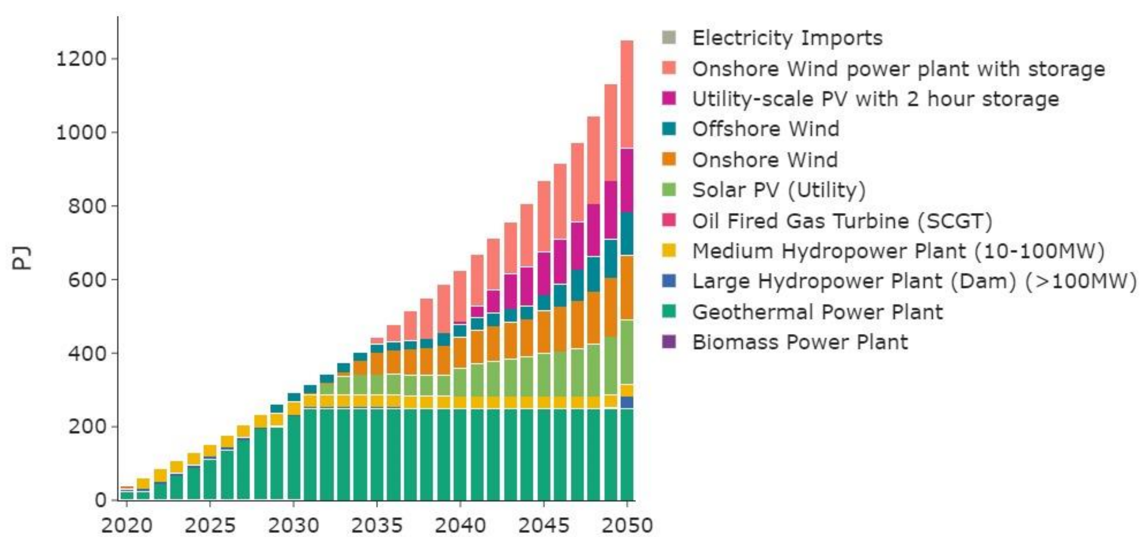

Figure A3: Electricity Generation in the Net Zero by 2050 scenario for Kenya

A3.2 Capacity Expansion Results

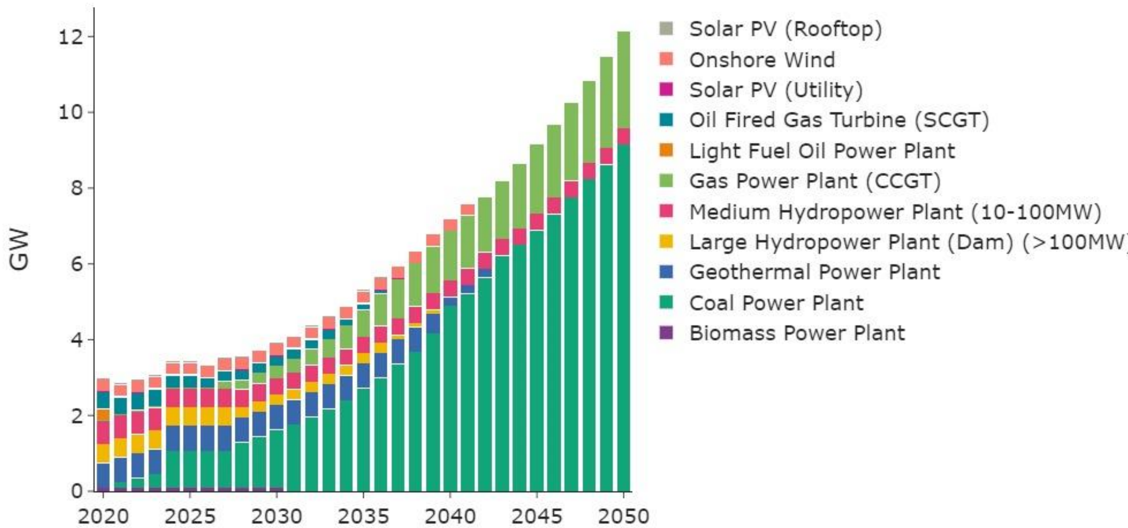

Figure A4: Installed capacity in the Fossil Future scenario for Kenya

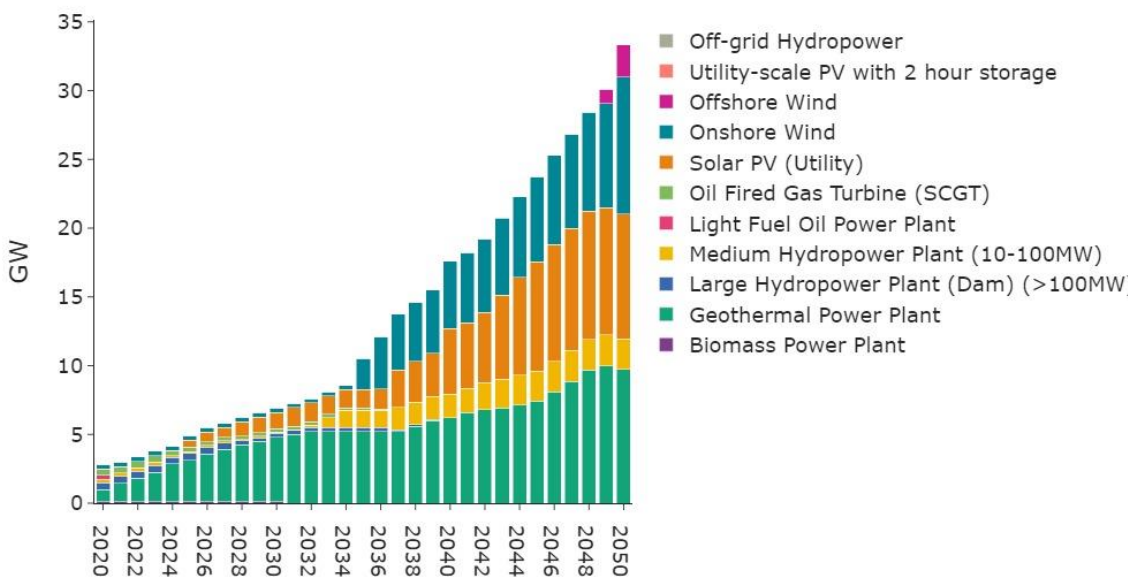

Figure A5: Installed capacity in the Least Cost scenario for Kenya

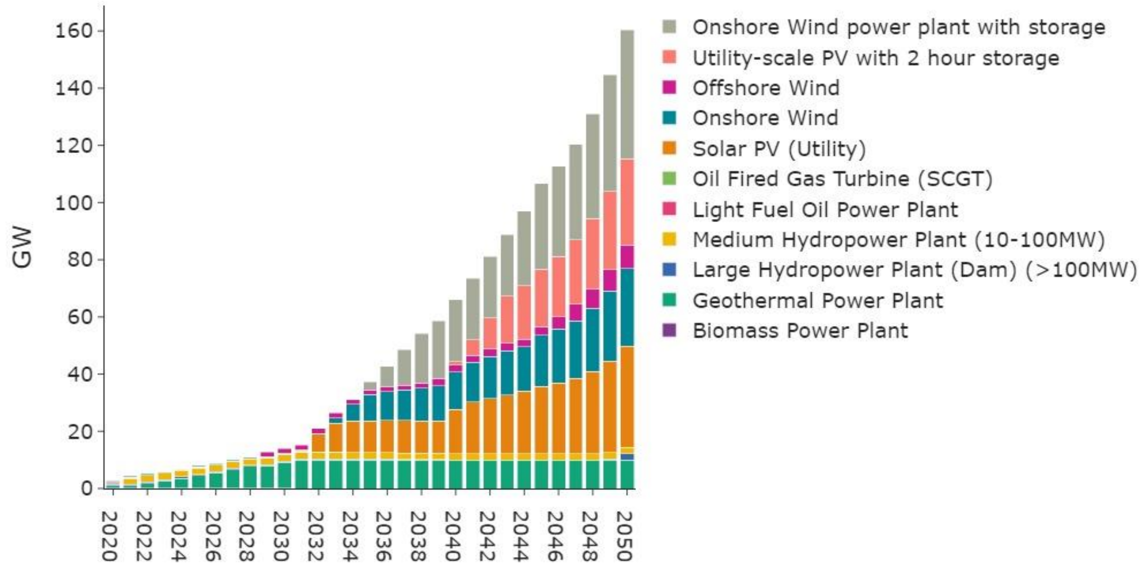

Figure A6: Installed capacity in the Net Zero scenario for Kenya

A3.3 Transport Results

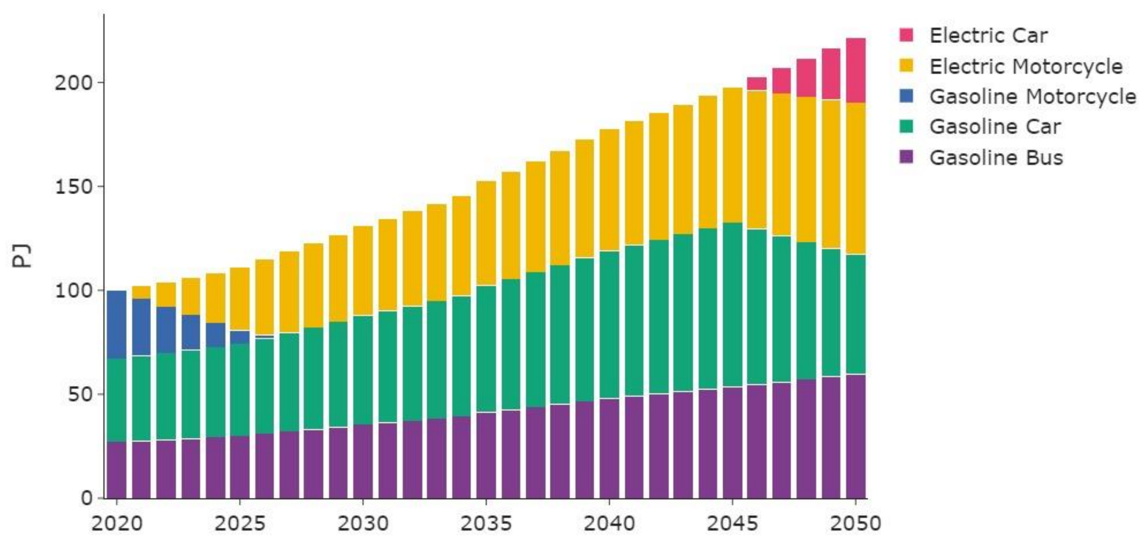

Figure A7: Transport demand[1] met by each technology type for the Least Cost scenario for Kenya

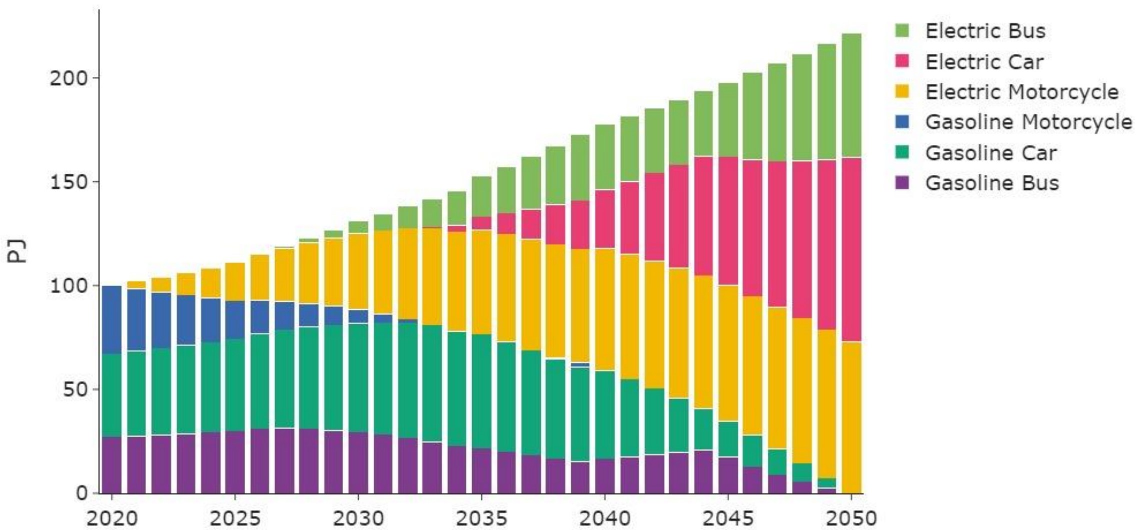

Figure A8: Transport demand[1] met by each technology type for the Net Zero scenario for Kenya

[1] Note that the underlaying model spilt data from which this graphic is calculated uncertain and based on authors' estimates. However, the insights relating to the timing of phasing of transitions (rather than the magnitude of the transition) is of value.

A3.4 Annual Carbon Dioxide Emissions Results

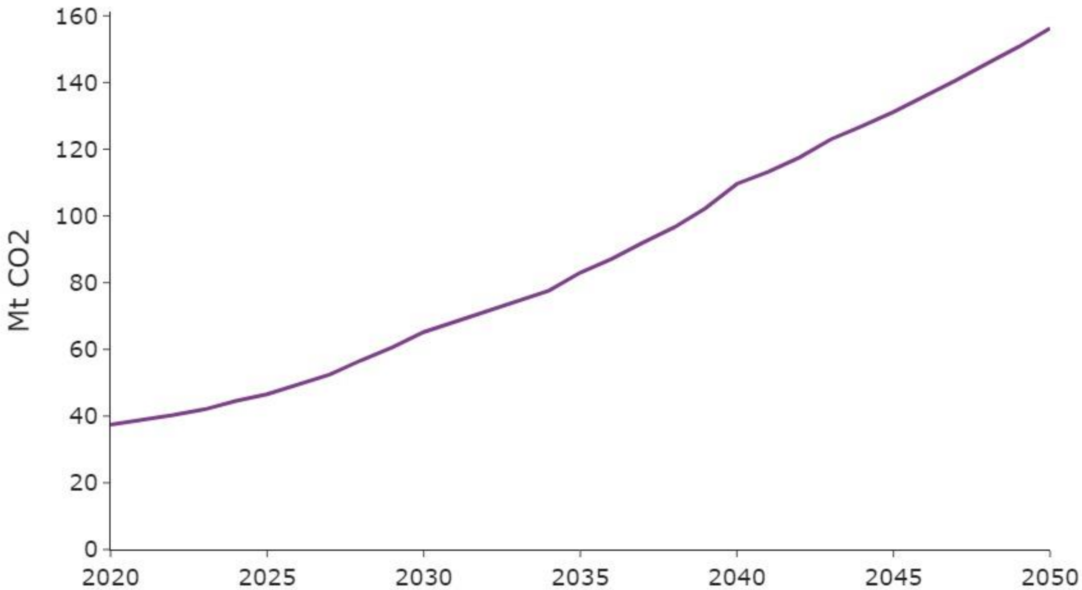

Figure A9: Annual Carbon Dioxide emissions in the Fossil Future scenario for Kenya

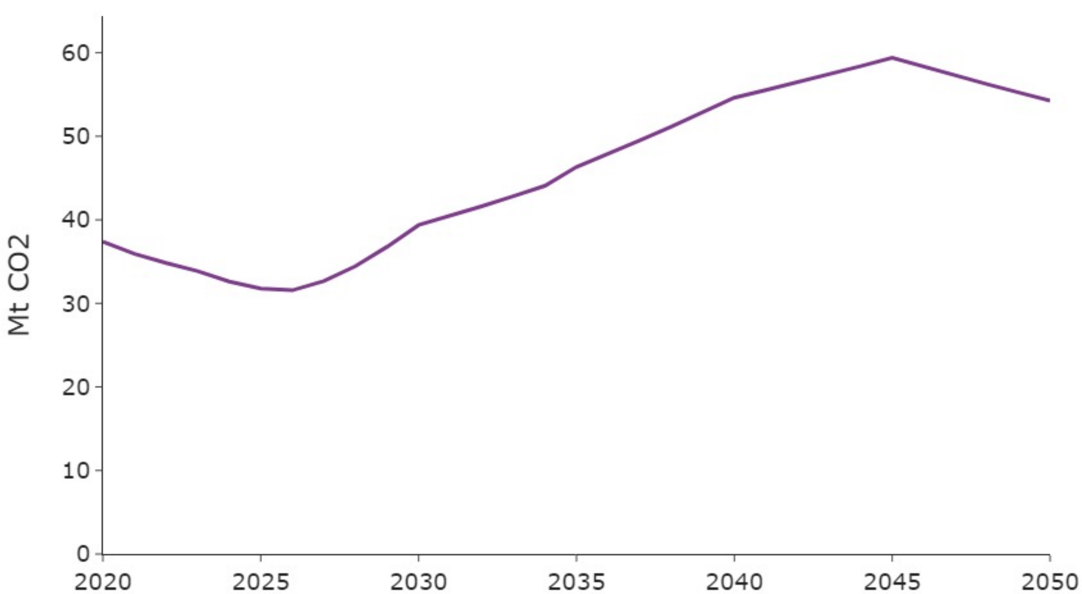

Figure A10: Annual Carbon Dioxide emissions in the Least Cost scenario for Kenya

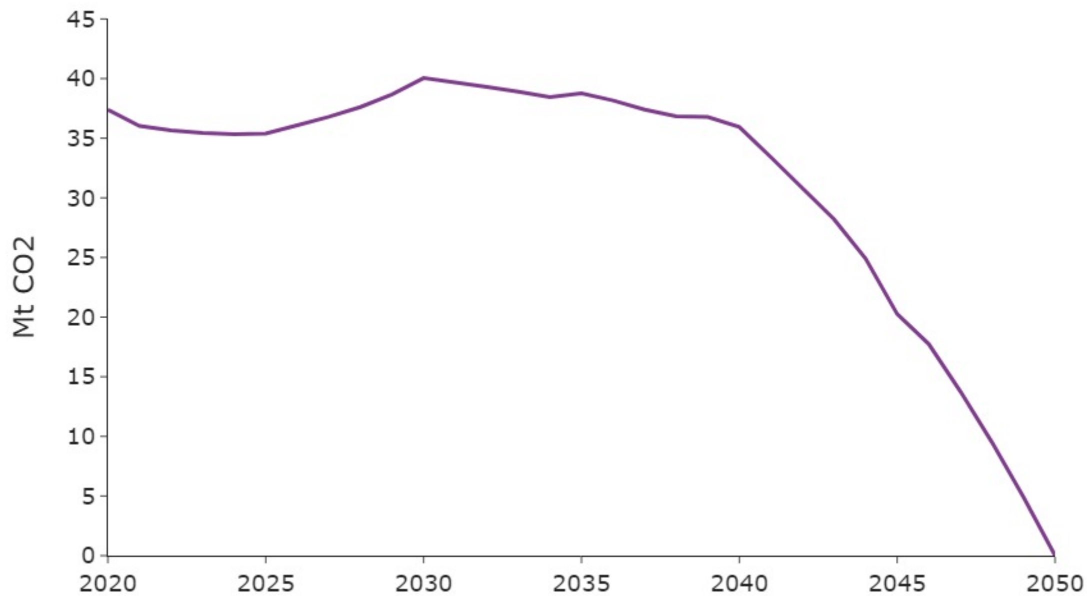

Figure A11: Annual Carbon Dioxide emissions in the Net Zero scenario for Kenya

A4 Further Work

These example results represent zero-order model and were generated using the clicSAND Interface [31] and OSeMOSYS code [32]. Those interested in further developing this work are directed to the dataset available on Zenodo [33] and guidance on model development using clicSAND and OSeMOSYS [34].