RWANDA: COUNTRY LEVEL LIFE CYCLE ASSESSMENT

An assessment of impacts on health, ecosystems and resource use of the transition to e-cook.

Authors own image.

Recipe ingredients, Beans Porridge and Fried Plantain.Copyright of Ekomobong Samuel, Nigeria eCookbook, 2024

The transition to e-cook from traditional cooking fuels can deliver a range of benefits (and possible impacts) to human health, ecosystems and resource use. Using a Life Cycle Assessment approach, these have been analysed across the full life cycle of cooking, from raw material extraction to final disposal of the cooking devices and the different fuels used. This analysis takes into account the split between rural and urban populations, and their access to electricity.

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BACKGROUND INFORMATION

Taking 2019 as the base year, Rwanda had a population of 13 million, with an average family size of 4.53 people. The population was split 87.2% rural and 17.3% urban, with 38.3% of the rural population having access to electricity and 86.4% of the urban population able to access electricity (World Bank). The main fuels used for cooking were firewood, charcoal, LPG and electricity, see Table 1 below.

	% Rural pop	% Urban pop	% Total pop
LPG	0.2	4.9	01
Electricity	0	0.1	0
Firewood	93.7	25.7	81.9
Charcoal	5.6	67.4	16.3

(WHO: Primary reliance on fuels and technologies for cooking, 2021)

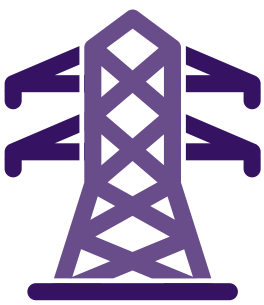
Table 1: Fuel type used per % of population

Table 2 shows the daily fuel consumption per household, assuming no fuel stacking.

	Per HH per day
LPG	0.43 Kg
Electricity	2.89 kWh
Firewood	5.04 Kg
Charcoal	2.03 Kg

(Calculated from Leach et al, Energies 2021, 14, 3371. https://doi.org/10.3390/en14123371)

Table 2: Daily single fuel consumption per household



38.3% RURAL ACCESS TO ELECTRICITY

86.4% URBAN ACCESS TO ELECTRICITY

ASSUMPTIONS

Eleven different scenarios were analysed in comparison to the base case (S0) using the following assumptions:

(a) it was assumed that each household utilised a single fuel for cooking (i.e. no fuel stacking),
(b) access to electricity is synonymous with suitable supply to use electricity for cooking,
(c) for rural population, if 38.3% have access and only 0% currently use electricity for cooking, then there is capacity for a further 38.3% of rural population to transition to electricity,
(d) for urban population, 86.4% have access and only 0.1% currently use electricity for cooking, then there is capacity for a further 86.3% of the urban population to transition to electricity,
(e) two hypothetical scenarios have been evaluated: 100% LPG cooking and 100% electric cooking. These are not realistic scenarios and have been included to provide an indication of the maximum possible benefits that could be achieved,
(f) this analysis was undertaken using a model generated from IEA figures for Rwanda's specific energy generation sources.

SCENARIOS EVALUATED

- Base case, in 2019 (S0)
- Shift all charcoal to electricity (S1)
- Shift rural charcoal to electricity (S2)
- Shift urban charcoal to electricity (S3)
- Shift all firewood to electricity (S4)
- Shift rural firewood users to electricity (S5)
- Shift urban firewood users to electricity (S6)
- Shift urban charcoal and as many firewood users as possible to electricity (S7)
- Shift rural charcoal and as many firewood users as possible to electricity (S8)
- Shift LPG users to electricity (S9)
- All LPG cooking (S10)
- All electric cooking (S11)

IMPACTS ASSESSED

The impacts evaluated were improvement in CO_2 emissions, effect on human health, ecosystems and resource use. These are defined as:

- **CO_2e emissions,** expressed as the change in CO_2 equivalent emissions for the country as a whole. Negative change suggests an improvement in CO_2 emissions, a positive change suggests an increased impact from CO_2 emissions
- **Human Health,** expressed as the number of year life lost and the number of years lived disabled. These are combined as Disability Adjusted Life Years (DALYs). The unit is years.
- **Ecosystems,** expressed as the loss of species over a certain area, during a certain time. The unit is years.
- **Resource scarcity,** expressed as the surplus costs of future resource production over an infinitive timeframe (assuming constant annual production), considering a 3% discount rate. The unit is USD2013.

FINDINGS

1) The effect of the cooking devices was seen to be negligible, and the results are dominated by the fuel type.
2) Transitioning charcoal users to electricity (S1) will deliver some benefit in CO_2e emission reductions (approximately 15%), and this is driven by shifting the urban users of charcoal (S3). This shift also results in a corresponding improvement in human health, ecosystems, with little change in resource use impact.
3) Shifting firewood users results in a nearly 40% improvement in CO_2e emissions, (S4); in this case it is driven by transitioning the rural community (S5). Whilst health and ecosystem outcomes are improved, this scenario results in an increase in resource use impact.
4) The increase in resource impact that results from the shift to electric cooking from firewood could be explained by the assumption in the model that firewood is essentially a ‘free’ resource, i.e.: it is collected via natural wood harvesting (fallen wood) as opposed to a system where wood is managed and harvested in an plantation type environment as part of a business, (with associated material and energy inputs). Thus, shifting from the ‘free’ resource to that of resources needed for electricity production (infrastructure, materials and fuels) leads to the negative impact for resource use.
5) Transitioning either only rural communities (S8) or only urban communities (S7) does not

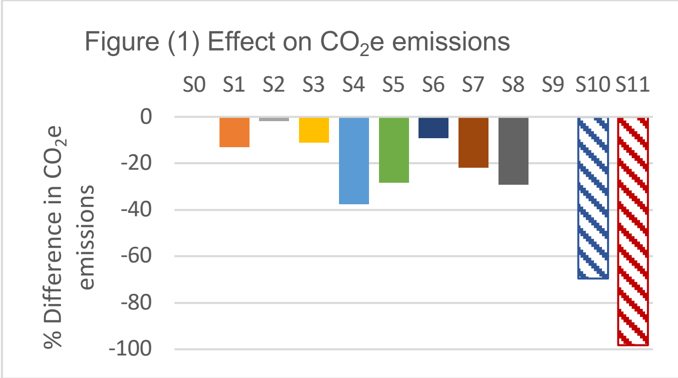


Figure (1) Effect on CO_2e emissions

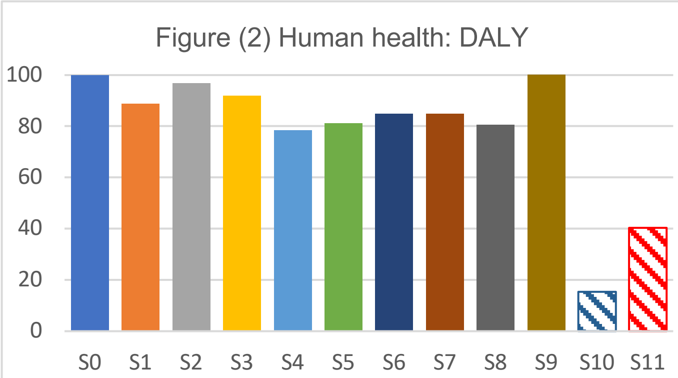


Figure (2) Human health: DALY

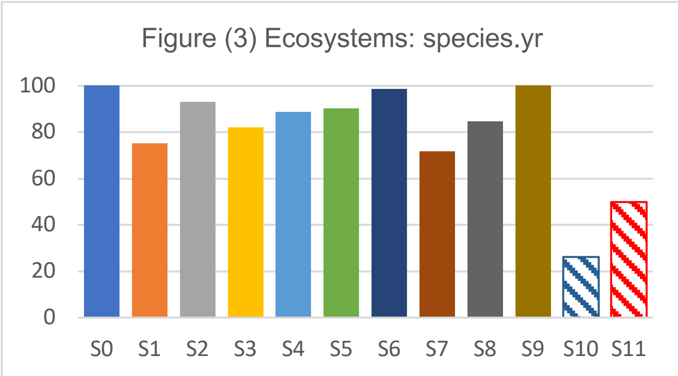


Figure (3) Ecosystems: species.yr

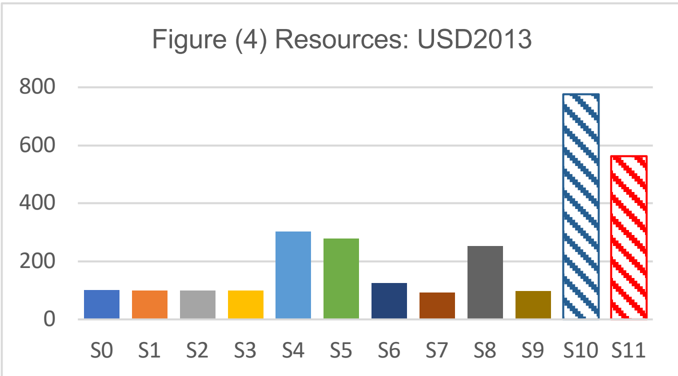


Figure (4) Resources: USD2013

For figures (2), (3) and (4): Base case (S0) = 100 deliver the same level of savings as transitioning firewood users, but is more effective than a focus on charcoal users.

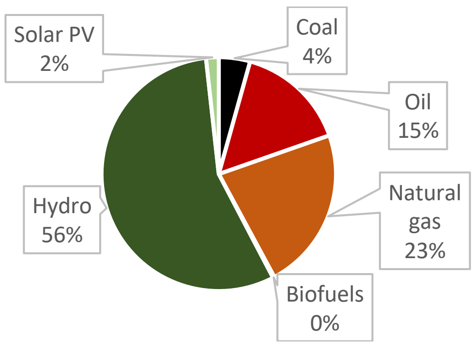
6) Shifting LPG users only (S9) shows little benefit for any impact category.
7) Comparing the hypothetical scenarios of all LPG (S10) or all electric cooking (S11) shows that grid connected electric cooking would deliver better CO_2e savings and improved health, and ecosystem outcomes. This suggests that rural users could be connected to the grid electrical system, rather than local mini-grids.
8) Shifting to LPG cooking does deliver significant savings for CO_2e, health and ecosystems, but also leads to an 8-fold increase in resource use impact. Shifting to electric cooking results in a nearly 6-fold increase in resource use impact.
9) The results normalised against global damage shows that human health impacts are more significant than those for ecosystems or resources.

CONCLUSIONS

Rwanda generates its domestic electricity from an almost equal split between hydro and fossil reserves. (IEA: https://www.iea.org/countries/rwanda/electricity) and with the current grid mix, it suggests that users should be grid connected.

This assessment suggests that, despite the current relatively low levels of access to electricity in the rural population, initial efforts should be guided towards shifting rural firewood users (S5) to electric cooking, followed by urban users of both charcoal (S3).

The limited CO_2e benefits, human health and ecosystem impacts of switching from kerosene and LPG to electric cooking (S9) suggest that these users should not, at the current time, be the primary focus for transitioning to electric cooking.



Domestic electricity generation sources 2021, IEA

How to use the data

This analysis uses a number of very broad assumptions that are not necessarily representative of all situations; no fuel stacking, that access to electricity is synonymous with a supply that is suitable and can support electric cooking, and that access will be via the grid system. In addition, it is assumed that the grid supply will expand using similar sources for energy generation, e.g. if electricity is mainly produced by hydro sources, then the increase in supply needed to match the uptake in electric cooking will also be supplied from hydro sources.

The results themselves are a combination of influencing factors: access to electricity (the number of households that can transition), and carbon intensity of the fuels.

As such, these results should be viewed as generic trend data, as opposed to specific values for the country assessed. The results aim to provide a broad brush assessment of the likely direction of travel for the impact categories chosen (CO_2e emissions, human health, ecosystem degradation, and resource use), as a result of a transition to electric cooking.

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